Exmouth Beach Management Plan Update

Leading Options Report

East Devon District Council

Project number: 60717806

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Delivering a better world

Quality information

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Revision	Revision date	Details	Authorized	Name	Position
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1. Introduction

1.1 Overview

AECOM has been commissioned by East Devon District Council (EDDC) to provide an update to the 2015 Beach Management Plan (BMP) for Exmouth (Devon) and to identify long term options for managing the flood and coastal erosion risk along the frontage.

The Study Area for the project extends from the Mamhead Slipway in the west to the eastern end of the beach near Orcombe Point. The frontage has been split into four sub-areas, referred to as Management Units (MUs):

- Management Unit 1 extension (Esplanade Area)
- Management Unit 1 (Beach Gardens Area)
- Management Unit 2 (The Maer Area)
- Management Unit 3 (Queen's Drive Area)

See Figure 1-1 for location of these sub-areas.

The option appraisal for the frontage has taken into account the recent Exmouth Tidal Defence Scheme that was completed in 2023. This scheme spans the western end of the study area, including the coastal frontage at Management Unit 1 and Management Unit 1 extension and provides a 1 in 200 year standard of protection to the benefit area. The eastern extent of the completed scheme is between the Clock Tower and the Premier Inn within Management Unit 1.

Outside of the Scheme area, including the eastern part of Management Unit 1, Management Unit 2 and Management Unit 3, no improvements to the defences have been made in recent times, except for the emergency works to approximately 250m of seawall in 2023 to address a seawall failure as a result of storms over the winter of 2022/23. There continues to be a reliance on the existing frontline sea wall structures and no raised flood defences. The main focus for this appraisal has therefore been on developing and appraising the long term management options for the area to the east of the 2023 scheme, from the eastern part of Management Unit 1 to the east.

Figure 1-1: Map of the Exmouth Beach Study Area (frontage shown in red outline).

1.2 This Report

This report provides details of the option development and appraisal process that has led to the identification of the draft proposed Leading Options presented herein. The options under consideration are focussed on managing the flooding and coastal erosion risks for the BMP frontage over the next 100 years.

This report has the following key Sections:

1. Introduction
2. Overview of Option Development and Appraisal Process
3. Short List Options
4. Economic Appraisal
5. Social and Environmental Appraisal
6. Leading Option Selection.

Details of the previous phases of option appraisal are presented in the Option Appraisal Report (AECOM, 2024 (b)).

The draft proposed Leading Options presented in this report will be subject to a formal consultation during the Autumn / Winter of 2024, where stakeholders and the public will have an opportunity to provide feedback on the draft options. The options will then be updated as required and confirmed.

1.3 Stakeholder Engagement

Stakeholder engagement has informed the development and appraisal of the options. To date, two rounds of stakeholder engagement have been carried out, as described below:

- Engagement round one: raising awareness of the project and to seek data to inform the baseline.
- Engagement round two: presentation of the proposed Short List options to key stakeholders to seek views on the proposed Short List before undertaking further detailed appraisal.

Each stage of the stakeholder engagement has provided valuable information to the project team that has informed and fed into the option development and appraisal process. More details of how the engagement has shaped the option appraisal can be found in Section 5.1

One further engagement drop-in session with stakeholders and the public is planned during a further (Round 3) consultation period for the project (Autumn / Winter 2024).

2. Option Development and Appraisal

2.1 Overview of the Approach

The development and appraisal of the long term sustainable and viable options for managing coastal flood and erosion risks along the frontage has been undertaken in stages, as shown in Figure 2-1. Stages 1 to 4 have been undertaken previously and are summarised in the Baseline Summary Report (AECOM, 2024 (a)) and Long List Option Appraisal Report (AECOM, 2024 (b)).

This report summarises stages 5 and 6, which have involved:

- Further development of the Short List Options, including details of the areas defended, combinations of interventions, and the timing of said interventions over the next 100 years.
- Appraisal of the Short List Options, considering the economic viability (option costs, option benefits and funding potential), potential environmental impacts and potential social impacts.

A draft National Economic Leading Option, a Local Aspirational Leading Option and Backup Option have been identified. A description of these different types of options is provided below.

National Economic Leading Option

- The National Economic Leading Option is the leading option identified by following the Environment Agency's Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG, 2022). This guidance provides a comprehensive step by step approach for selecting leading options for managing coastal flood and erosion risks.
- By following FCERM-AG, the National Economic Leading Option will be eligible for an amount of public FCERM-Grant in Aid (GiA) funding, although this will be limited and will need to be topped-up by other non-GiA sources. An indication of how much public funding from FCERM-GiA may be available has been calculated for the National Economic Leading Option. The public GiA funds are distributed on a national basis according to the Outcome Measures that each option delivers, as defined by the UK Government.

Local Aspirational Leading Option

- The National Economic Leading Option may not be preferable for local decision makers and / or stakeholders and therefore a Local Aspirational Leading Option has also been identified.
- The Local Aspirational Leading Option takes into account the local opportunities, wants and needs to provide a more comprehensive option that delivers broader outcomes and wider benefits to the frontage. The Local Aspirational Option has a higher cost than the National Economic Leading Option and therefore represents an aspirational option that could be delivered instead of the National Economic Leading Option should additional funding be secured from non-GiA sources. The Local Aspirational Option is typically an enhancement of, or works with, the National Economic Leading Option and fits into an adaptive approach.

Backup Option

- Funding availability is a key constraint for delivering FCERM options and schemes. Both the National Economic Leading Option and Local Aspirational Leading Option would not be fully funded by FCERM-GiA. It is the aspiration of EDDC to work with funding partners to secure the additional funding to deliver the options, however, it is recognised that this may not always be possible. Therefore a Backup Option has also been identified in case funding cannot be secured.

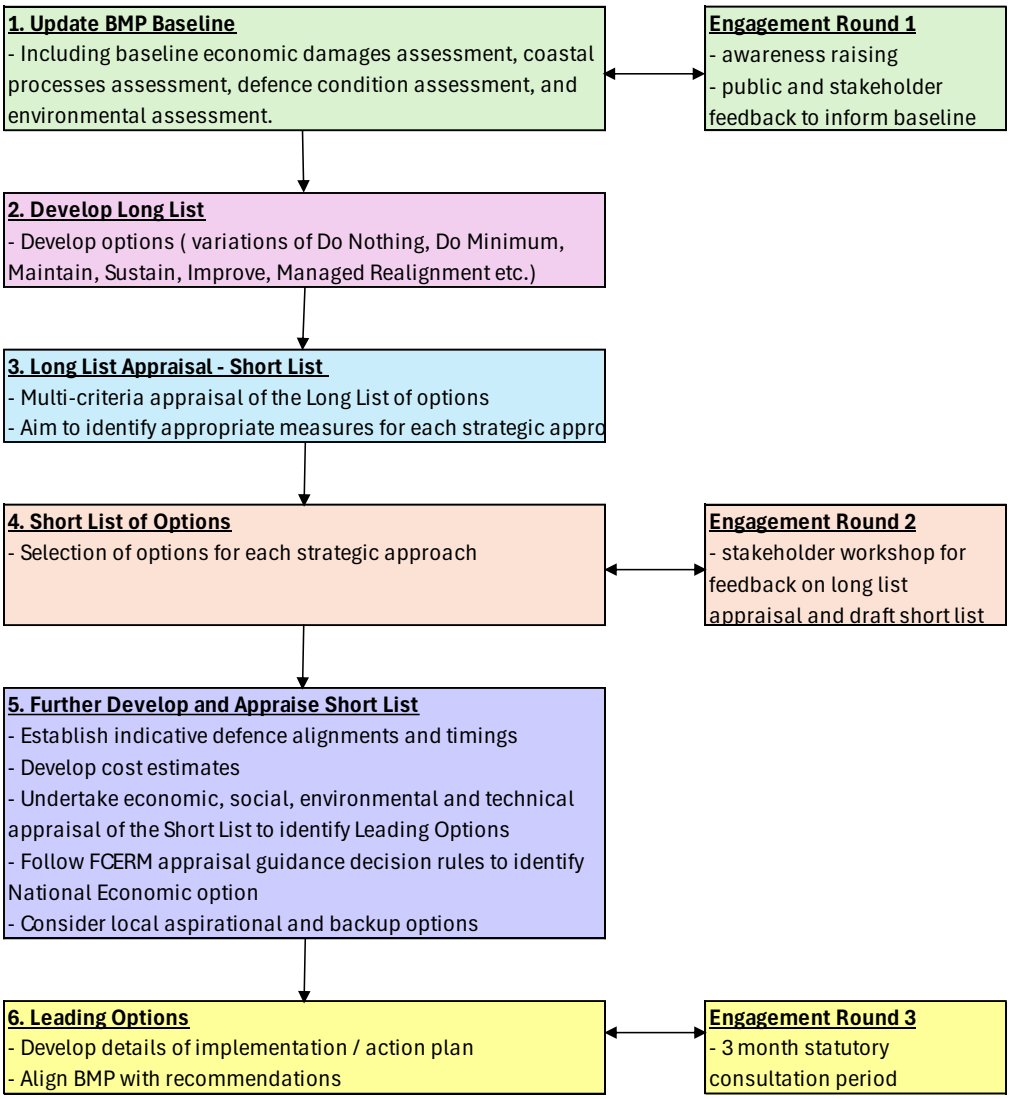

Figure 2-1: Flowchart showing the Option Development and Appraisal Process.

2.2 Further Development of Short List Options

To facilitate the appraisal, further work has been undertaken to develop the short list options in more detail.

Details for each of the options have been developed so that each option has an outline of which type of defences would be used, approximately where the defences would be required and the approximate timing of the interventions.

Given the condition of the existing defences along the frontage, most of the options recommend intervening and improving defences over the next 5-10 years (i.e. by 2035). However, subsequent interventions in the future are also included in the options. Timings of measures and interventions were developed based on three time epochs:

- Epoch 1: between 2024-2044 (0-20 years)
- Epoch 2: between 2044-2074 (20-50 years)
- Epoch 3: between 2074-2124 (50-100 years).

The key factors that were considered in developing the options further were:

- Intent of the option – the intent of the options vary between:
  - Holding the Line with Hard Defences
  - Holding the Line with Beach Management
  - Managed Realignment / Adaptation.
- Type and location of risk – risks vary by location along the frontage, influencing which of the Short List measures are appropriate in each location. For example, flood risk is higher in some locations along the frontage than others.
- Onset of risk – the timing of the risk to properties and other assets from flooding and erosion varies by location and new defence measures may not be required immediately in every location.
- Residual life of existing defences – the residual life of the existing defences may influence the timing of the initial intervention.

2.3 Selecting the National Economic Leading Option

This Section provides an overview of the process for identifying the National Economic Leading Option (stage 5 of the appraisal). The approach has followed the steps outlined in the FCERM-AG (Environment Agency, 2022) and is based on a Cost Benefit Analysis (CBA).

CBA balances the range of costs and benefits allowing the appraiser to identify the Nationally Economic Leading Option. It is an effective approach where multiple FCERM problems across a large, interconnected area are being considered.

There are multiple risks along the frontage that the short list options seek to manage, including flood risk and erosion risk. Therefore, as per FCERM-AG, in the first instance the National Economic Leading Option has been selected based on the Net Present Value (NPV) metric, which is the difference between the economic benefits and costs of an option (economic benefits minus the economic costs).

The key steps for identifying the National Economic Leading Option are:

1. **Establish the whole life costs and benefits of the options:** Remove any options with an average benefit cost ratio (ABCR) <1. Take forward the options with an ABCR >1.

2. **Organise the options and select the leading economic option:** Organise the options with an ABCR >1 into a list based on NPV. The provisional National Economic Leading Option is the option with the highest NPV.

3. **Test for uncertainty:** Using results from a sensitivity analysis, consider whether the choice of the provisional National Economic Leading Option needs to change to account for the uncertainties. If the provisional option choice stays the same in the sensitivity tests, do not change the option choice. However, if the sensitivity tests are showing that the choice of the provisional option changes under the test, consider a range of next steps, including whether to change the choice of option or to adapt the option to minimise the impact of uncertainties.

4. **Determine National Economic Leading Option:** The leading option at the end of step 3 is identified as the National Economic Leading Option.

For step 2, FCERM-AG typically recommends that options are organised according to the standard of protection from flood risk and then incremental benefit cost ratios used to identify the provisional National Economic Leading Option. However, if the standard of protection from flooding is not the sole driving factor (for example if erosion risk is a key risk or there are other driving factors), then the guidance recommends using the NPV, as outlined above.

2.4 Selecting the Local Aspirational Leading Option

The National Economic Leading Option may not be preferable for local decision makers or the communities, and there may be compelling local reasons to choose an alternative option from the short list.

Therefore, the next step of the appraisal (in stage 5) was to consider whether a ‘local choice' option was also required.

FCERM-AG outlines how a local choice option can be selected as the overarching leading option to replace the National Economic Leading Option if the additional expenditure for the local option is fully funded. Given that the BMP Update represents the initial part of the overall appraisal process and funding for subsequent projects has yet to be secured, the local choice option has been termed the ‘Local Aspirational Leading Option.’ This reflects the intent of EDDC to secure funding if possible, but acknowledges that at this stage the Local Aspirational Leading Option does not fully replace the National Economic Leading Option.

With respect to FCERM-GiA availability for the Local Aspirational Leading Options, this will be no more than the amount of FCERM-GiA available for the National Economic Leading Option. Any Local Aspirational Leading Options will need to secure funding for all other costs.

2.5 Selecting the Backup Option

The final step of the appraisal process was to consider whether a Backup Option was required.

This decision was informed primarily by the results of the indicative Partnership Funding assessment that was undertaken on the National / Local Options. If a significant funding shortfall was expected then a Backup Option was identified because the funding shortfall introduced uncertainty as to whether the National / Local Options may be deliverable.

2.6 Partnership Funding

An indicative Partnership Funding assessment has been undertaken to understand potential affordability challenges for the National Economic Leading Option and Local Aspirational Leading Option. The results of the funding assessment are presented in Section 6.3.

2.6.1 Partnership Funding

FCERM schemes in England are typically jointly funded from central government funding via FCERM-GiA and other funding sources, such as private contributions, local levy, council funds and others. This arrangement is known as Partnership Funding.

The amount of FCERM-GiA that a scheme is eligible for is based on a series of Outcome Measure (OM) targets defined by the UK Government. There are four OMs under which projects can currently attract FCERM-GiA:

- **OM1**: All benefits arising as a result of the investment, less than those valued under the other outcome measures;
- **OM2**: Households moved from one category of flood risk to a lower category;
- **OM3**: Households better protected against coastal erosion; and,
- **OM4**: Statutory environmental obligations met through flood and erosion risk management.

The Environment Agency has prepared a standard spreadsheet Partnership Funding calculator (2020 version) to calculate the level of FCERM-GiA available to a scheme based on a series of input parameters. These include whole life option costs, benefits (OM1) and the number of properties moving from one flood or erosion risk band to another (OM2s and OM3s). The Partnership Funding calculator provides a GiA contribution (£) and an initial 'Raw' OM score which can be used to assess the likelihood of a scheme attracting Partnership Funding. The GiA contribution represents a theoretical maximum funding value that could be available based upon the outcomes delivered by the scheme.

A key output of the Partnership Funding calculator is the Partnership Funding score (%). Broadly this percentage shows the amount of the option cost that is eligible to be covered by GiA. The remaining % of the cost would need to be covered by non-GiA sources, such as private or other public sector contributions. In order to be eligible for the GiA contribution, any shortfall in funding needs to be secured, so that the adjusted Partnership Funding score reaches 100%.

For more details and definitions of each term used in the Partnership Funding calculator, please refer to the Partnership Funding guidance documents[1] (2021).

2.6.2 Timing of Initial Scheme

For the National Economic and Local Aspirational Leading Options, to provide sufficient time for further appraisal, design and construction, in the option cost build-ups the major capital scheme has been assumed to occur between years 5-10 (i.e. 2029 to 2034) and therefore would not occur in year 0 (i.e. present day, 2024).

For the funding assessment, in order to establish an indicative Partnership Funding score for a scheme in the future, it has been necessary to 'jump forward' in time in the appraisal period and re-baseline the option costs and benefits to the time of the scheme implementation (i.e. years 5-10). This results in using a higher scheme cost and benefits for the scheme in the funding calculator because the discounting over the first 5-10 years has been removed.

2.6.3 Limitations

There are limitations with the Partnership Funding calculations undertaken as part of the assessment:

[1] https://www.gov.uk/government/publications/partnership-funding-calculator-2020-for-fcerm-grant-in-aid-gia

- The calculations assume that the funding rules between now and the time of the scheme intervention would remain unchanged.
- The calculations also assume the current baseline and climate change scenarios recommended by the Environment Agency for use in FCERM projects which may be subject to change in the future.
- The estimated option and scheme costs and benefits will be subject to change with further appraisal and design work and macro-economic factors such as inflation. This will impact the amount of funding that may be available.

2.7 Summary of Appraisal Process

Figure 2-2 overleaf provides a flowchart that summarises the key steps in the Option Appraisal Process that are described in the previous Sections.

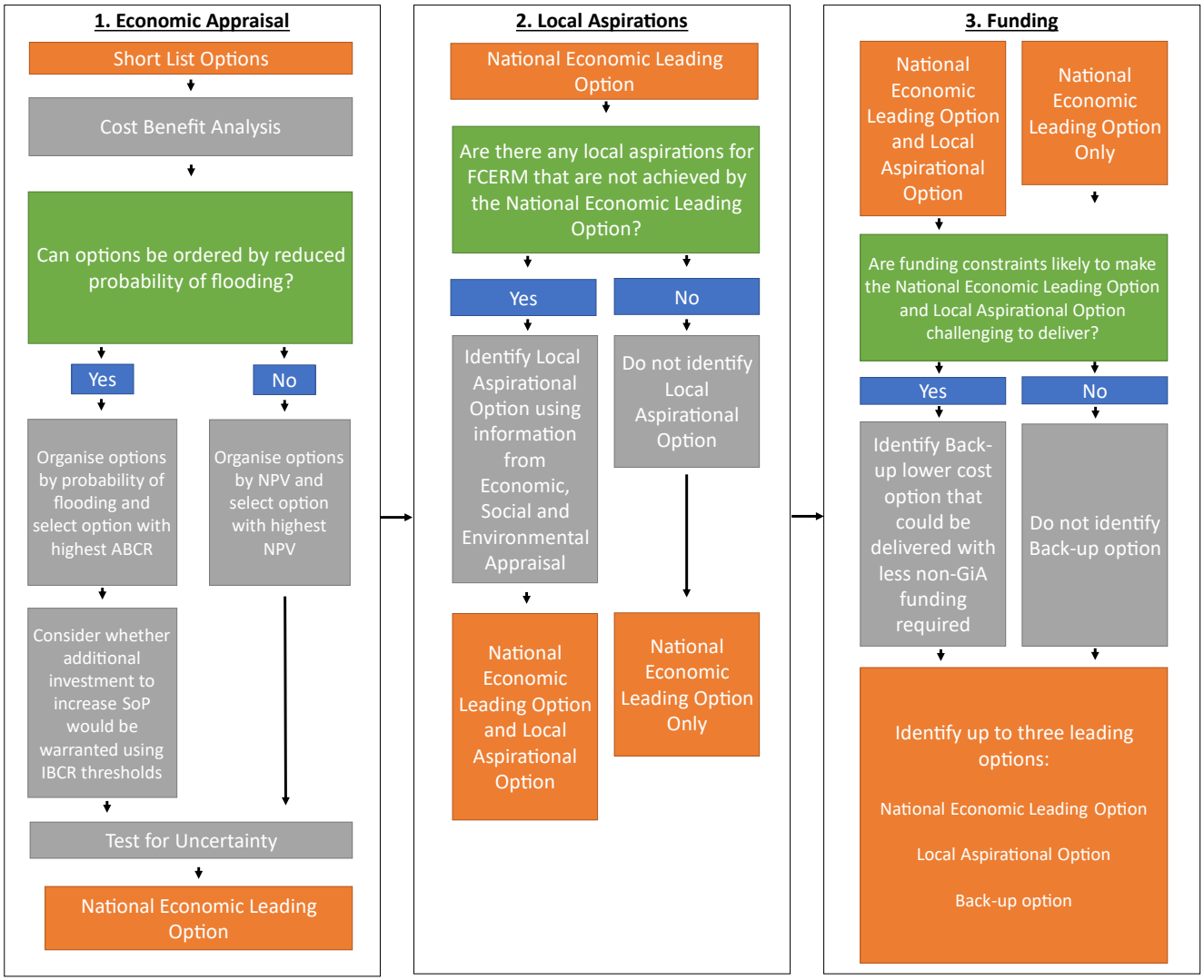

Figure 2-2: Option Appraisal Summary Flowchart

3. Short List Options

The Short List Options are presented in the Sections below. The options are grouped into three overarching Strategic Approaches:

- **Hold the Line with Hard Defences:** aim to prevent flood and erosion risk to the frontage by utilising the existing seawall as the primary (and only) defence. With this approach there would be no FCERM interventions undertaken or any aspiration to control the beach level. It would be accepted that the beach would remain highly dynamic and that it would not be relied upon to provide toe protection to the seawall. Instead, new toe protection would be required to the seawall to prevent undermining.
- **Hold the Line with Beach Management:** aim to use the beach as the primary means of toe protection to the seawall. If delivered successfully this approach would reduce the risk of undermining of the seawall, reduce the risk of failure and the possibility of erosion occurring. It also has the potential to reduce flood risk. In order to provide confidence that this approach could be implemented successfully in the long term, it is likely that beach control structures (such as groynes or nearshore breakwaters) would be required to help stabilise beach levels. These control structures could be implemented alongside beach management techniques such as beach recycling and beach nourishment.
- **Managed Realignment:** This approach would involve realigning the existing seawall defence alignment further inland along parts of the frontage (such as at the Maer). The intent of this option would be to create a wider space for the beach to occupy and to encourage the development of natural defence features such as sand dunes, which could help reduce flood risk. This option is likely to be a sustainable approach in the long term to mitigate rising sea levels and would be focussed on working alongside natural processes. However, it would cause disruption, and the coastal zone would undergo significant change requiring wider adaptation of the Exmouth seafront area.

A summary of the advantages and disadvantages of the Strategic Approaches is provided in Table 3-1 below.

Table 3-1: Strategic Approaches

Approach	Advantages	Disadvantages
Hold the Line with Hard Defences	- With new toe defences this approach would not need to rely on a dynamic beach to provide toe protection. This would provide long term certainty in defence performance and stability. - Lower monitoring and maintenance requirements relative to alternative beach management approach	- The beach would not be actively managed and therefore there is uncertainty around the evolution of the beach in the future, particularly with regards to sea level rise and coastal squeeze. Whilst the beach would not be relied upon to provide an FCERM function, lowering or loss of the beach could still negatively impact tourism / recreation in the area. - Maintaining / improving the hard defence line could lead to additional scour / lower beach levels in the future due to the role of sea level rise - Potential to be a costly approach, subject to the defences utilised - Potential for negative environmental impacts associated with defence encroachment and hard engineering works

Approach	Advantages	Disadvantages
Hold the Line with Beach Management	- The beach would continue to support tourism and recreation in the future, in addition to providing an FCERM function and protecting the toe of the seawalls - Could be more supportive of future development aspirations along the frontage (e.g. the Exmouth Placemaker project) which are likely to benefit from a wide / healthy beach	- Less certainty in defence performance / stability relative to hard defence approach. For example, successive storms could remove beach material without sufficient time for the beach to recover naturally or with active management - Significant monitoring and beach maintenance would be required to ensure the beach is providing the intended FCERM function - Potential to be a costly approach, subject to the Defence Measures utilised (i.e. beach nourishment, beach control structures) - Potential for negative environmental impacts associated with defence encroachment (i.e. beach control structures) and also changing sediment make-up of the beach subject to source of beach material.
Managed Realignment / Adaptation	- Sustainable approach working alongside natural processes - Could lead to habitat creation and biodiversity net gain, and help prevent coastal squeeze - Significant change to the coastal zone that has potential to impact tourism / recreation (either positively or negatively) - Uncertain environmental impacts (likely both positive and negative)	- A range of uncertainties, such as whether sand dunes would naturally form and what the standard of protection of the dunes would be - Significant monitoring and beach maintenance would be required during the transition period and once new sand dunes had formed - Significant change to the coastal zone that has potential to impact tourism / recreation (either positively or negatively) - Uncertain environmental impacts (likely both positive and negative)

3.1 Hold the Line with Hard Defences

In total four different short list options have been identified for holding the line of the seawall to reduce coastal erosion risk (Do Minimum, Seawall Toe Protection, Rock Revetment, Seawall Encasement), with a further two options identified for reducing flood risk (Setback Floodwall, Property Level Resilience).

The options that reduce flood risk would need to be delivered in parallel with either of the four core options that focus on the seawall. A summary of the option combinations for Holding the Line with Hard Defences is provided in Table 3-2 below.

Table 3-2: Short List Option Combinations for Hold the Line with Hard Defences

Approach	Option
Hold the Line with Hard Defences	Do Minimum
	Seawall Toe Protection
	Rock Revetment
	Seawall Encasement
	Seawall Toe Protection with Setback Floodwall
	Rock Revetment with Setback Floodwall
	Seawall Encasement with Setback Floodwall
	Seawall Toe Protection with Property Level Resilience (PLR)
	Rock Revetment with PLR
	Seawall Encasement with PLR

3.1.1 Do Minimum / Minimum Intervention

This option would involve undertaking reactive patch-repairs to the existing seawall and groynes as required. This approach is similar to the existing management approach for the frontage and therefore represents a continuation of the 'status quo'.

With this approach, despite further maintenance, due to the ageing seawall and vulnerability of the structure to undermining, the risk of seawall failure would increase in the future. It is unlikely that the defences could continue to be patch-repaired indefinitely and therefore this approach is unlikely to provide a long term solution.

This approach would not involve a large scale capital scheme and therefore funding for the patch-repair maintenance of the defence structures would likely need to come from EDDC maintenance budgets or applications for emergency funding from central government. The amount of funding that can be found will determine how much maintenance could be undertaken.

The residual risk of flooding and erosion would increase over time with this approach and a defence failure could happen in the future as there may not be sufficient funds to keep defences in a reasonable condition. This should be recognised and communicated to key stakeholders and the local community if this approach were to be taken forward.

Key costing and benefit assumptions for this option

The seawall repair work that would be needed with this option would need to be determined based on monitoring of the seawall condition and the beach levels (risk of undermining). This would be influenced by the frequency and severity of storms in the future. It is therefore challenging to accurately estimate a cost for this option ahead of time.

Approximately 60% of the seawall (by length) is currently in either a fair or poor condition and therefore with this option it has been assumed that the existing wall would only be able to last another 20 years maximum. It is possible that the wall may not be able to last this long and additional emergency repair work could be needed that is not accounted for in the option costing.

For the purposes of the appraisal, a number of assumptions have been made for the cost and benefits of this option. These are summarised in in Table 3-3 below.

Table 3-3: Key costing and benefit assumptions for Do Minimum option (HTL with Hard Defences)

Key costing assumptions	Key benefit assumptions
Patch-repair maintenance costs for the seawall applied for a period of 20 years.	Delay failure of defences by 10 years, which delays erosion damages in the economic appraisal by 10 years (to year 20). See Table 4-2 for more details.
Over this 20 year period, assumed 5% of the wall (by length) requires patch-repair work every 5 years, until the majority of the structure reaches the end of its service life in year 20 and the wall cannot be further maintained.	Reduced damages (and therefore an economic benefit) as erosion damages are discounted more heavily as they occur further into the future.
Assume no timber groyne maintenance or beach management.	Full flooding damages still occur.
The amount of maintenance required is uncertain and it is possible that emergency repairs not accounted for in the option costs could be required, subject to damages caused by storms.	

3.1.2 Sheet Piling Toe Protection

This option would involve installing buried sheet pile toe protection and a concrete apron to the seawall to reduce the risk of undermining and collapse. A concept cross section sketch of this option is provided below in Figure 3-1.

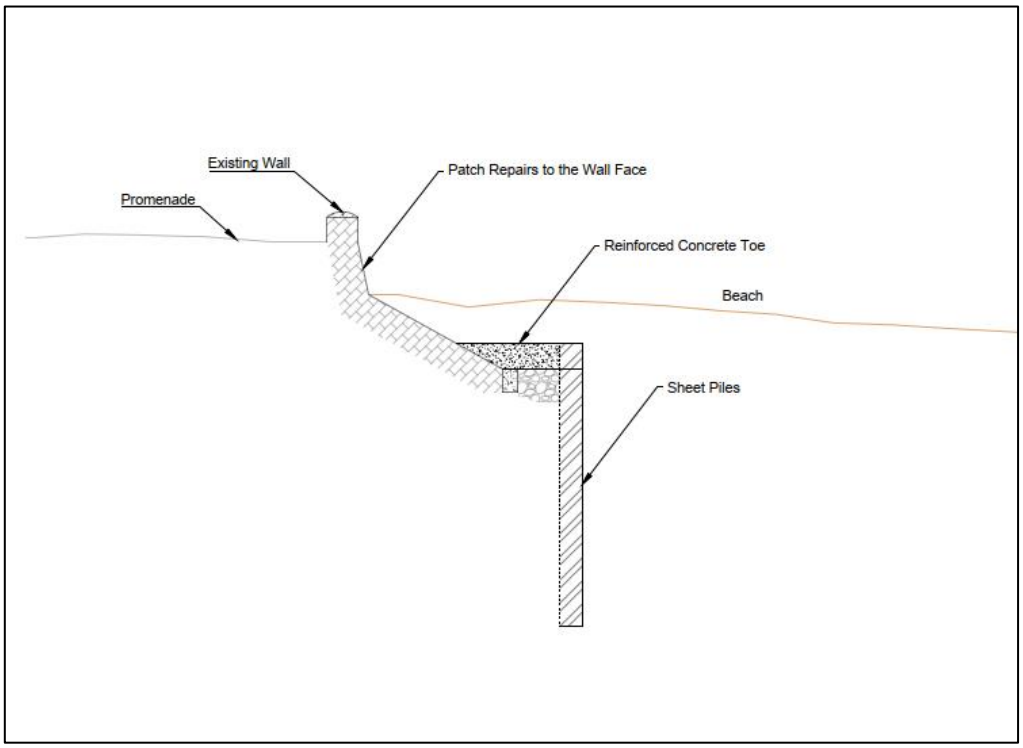

Figure 3-1: Concept sketch of Sheet Piling Toe Protection option

Initially the sheet piling toe protection would be targeted along the areas of seawall which are most vulnerable to undermining (medium / high risk or unknown risk), as informed by the defence condition undermining assessment (AECOM, 2024 (a)). Provisionally, this is approximately 1,625m of the seawall, however this is uncertain and is based on the limited information available when undertaking the undermining assessment. With further investigation during scheme design the length may need to increase.

In the future approximately 235m of the frontage may also require sheet piling toe protection to be installed (currently low risk of undermining) and an allowance has been made for this in the option costing.

It has been assumed that sheet pile toe protection would not be needed for approximately 600m of the frontage in two locations where repairs have been recently undertaken within the last 10 years (namely a section near Sideshore, and another section from Smeaton's Wall to The Octagon), or the approximately 300m of wall at the western end of the frontage where a rock revetment has been placed in front of the seawall. These assumptions are for costing purposes and should be revisited during subsequent business case / design work.

This option would reduce the risk of defence undermining, but there would remain other potential failure mechanisms of the seawall, such as structural failure (STR), washout of fines or failure caused by hydrostatic water pressures behind the wall following flooding events. Therefore, whilst this option would significantly reduce the risk of the wall collapsing, there would still be some residual risk which would need to be accounted for.

Alongside the sheet piling toe protection, it would be necessary to continue with the patch-repairs of the existing seawall to help to manage the risk of other structural failure mechanisms.

Key costing and benefit assumptions for this option

The key assumptions made for the costing and benefits for this option are summarised in Table 3-4 below.

Table 3-4: Key costing and benefit assumptions for Sheet Piling Toe Protection option (HTL with Hard Defences)

Key costing assumptions	Key benefit assumptions
Capital scheme in year 10 to install seawall toe protection (sheet pile and concrete apron) along approx. 1625m of seawall.	Assumed partial erosion benefits, accounting for residual risk of seawall still failing due to other structural failure mechanisms. See Table 4-2 for more details.
Assumed to occur in year 10 to provide time for appraisal, design and funding.	No flood risk benefits as seawall would not be raised and therefore standard of protection would reduce over time due to sea level rise.
Capital scheme in year 30 to install remaining length of seawall toe protection to approx. 235m of seawall.	
Ongoing patch-repair maintenance to existing seawall, assuming on average 7.5% of the length every 5 years.	
Assumed no timber groyne maintenance or beach management.	
Assumed no toe protection needed for approximately 900m of the frontage (areas of recent repairs and rock revetment).	

A map showing the Sheet Piling Toe Protection alignment assumed in the costing is provided in Figure 3-2.

Figure 3-2: Sheet Piling Toe Protection Alignment (as used in costing)

3.1.3 Rock Revetment

This option would involve constructing a rock revetment adjacent to the existing seawall to reduce the risk of undermining and collapse. The revetment would serve a dual purpose of breaking wave energy to reduce the risk of wave overtopping along the frontage. A concept cross section sketch of this option is provided below in Figure 3-3.

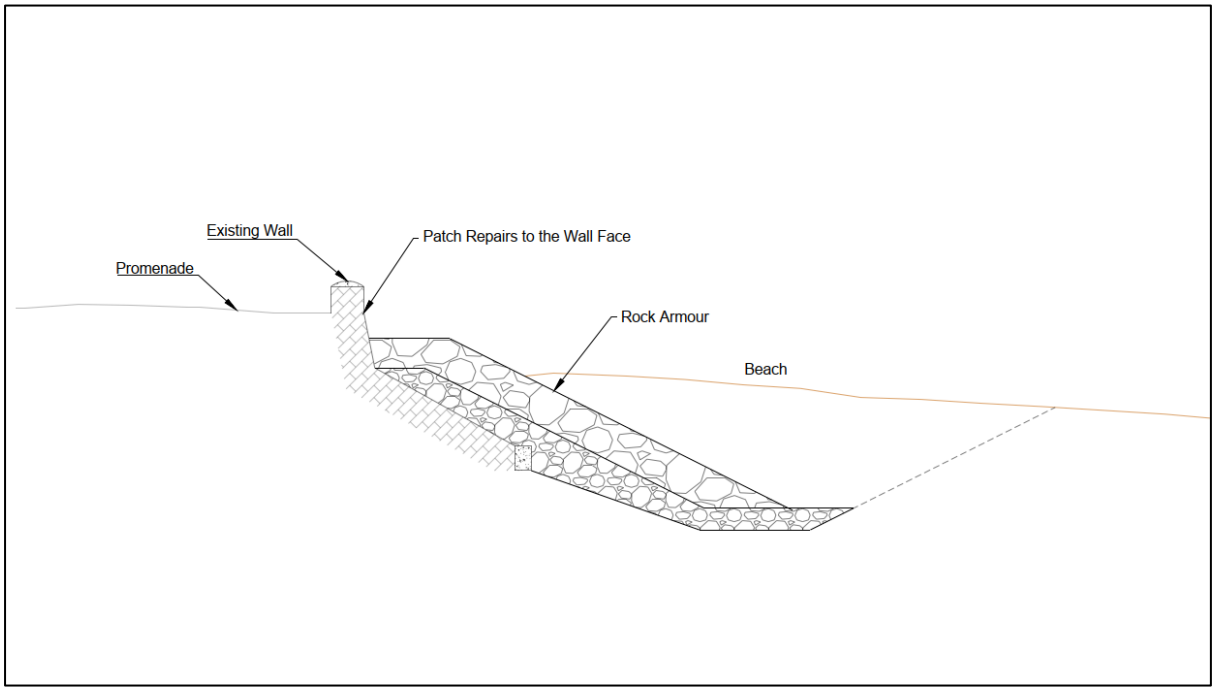

Figure 3-3: Concept sketch of Rock Revetment option

At this stage of the assessment, to avoid the risk of outflanking of the new defence it has been assumed that the rock revetment would be constructed along almost the full length of the BMP frontage (approximately 2,350m) in one intervention / scheme. There is currently approximately 300m of rock revetment at the western end of the frontage and therefore it has been assumed that a new revetment would not be needed here.

Key costing and benefit assumptions for this option

The key assumptions made for the costing and benefits for this option are summarised in Table 3-5 below.

Table 3-5: Key costing and benefit assumptions for Rock Revetment option (HTL with Hard Defences)

Key costing assumptions	Key benefit assumptions
Capital scheme in year 10 to construct rock revetment along approx. 2,350-2,400m of frontage (300m at western end already has rock revetment).	Assume rock revetment would stop all erosion risk to the land over the next 100 years.
Assumed to occur in year 10 to provide time for appraisal, design and funding.	Conservatively assumed flood damages would still occur as it is uncertain as to how much the revetment would reduce overtopping risk without undertaking further design work.
Rock revetment maintenance after construction, assuming 2% rock replacement / reprofiling every 5 years.	
Assumed no timber groyne maintenance or beach management.	

A map showing the rock revetment alignment assumed in the costing is provided in Figure 3-4.

Figure 3-4: Rock Revetment Alignment (as used in costing)

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3.1.4 Seawall Encasement

This option would involve constructing a new retaining seawall with sheet pile toe protection directly in front of and encasing the existing seawall. The structure would be designed to retain the existing seawall and land behind and there would be no reliance on the existing structure for defence performance. A concept cross section sketch of this option is provided below in Figure 3-5.

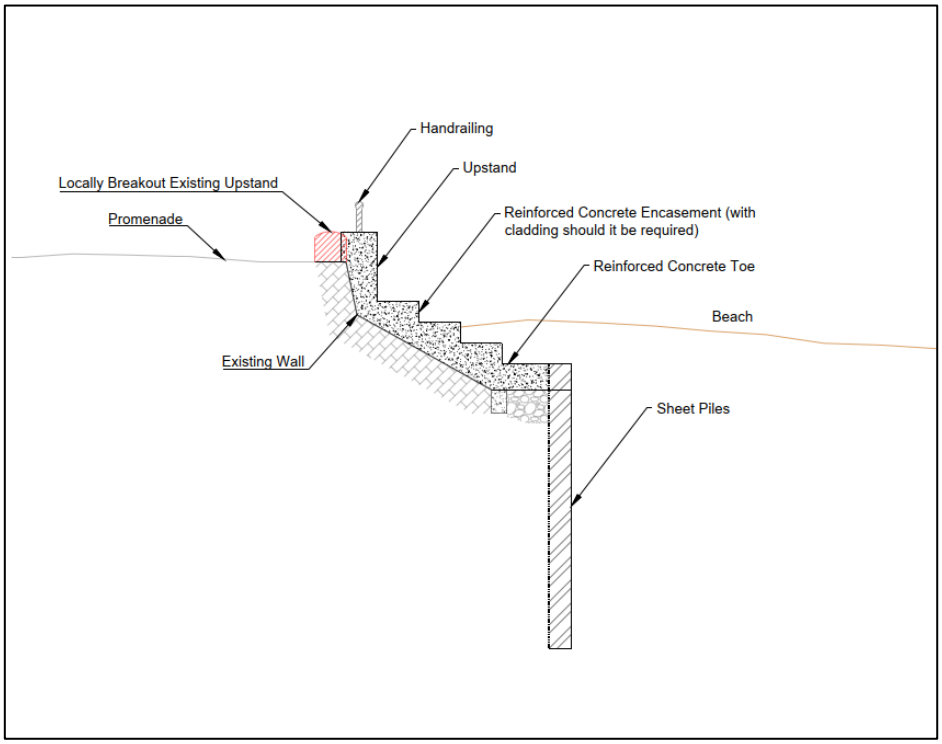

Figure 3-5: Concept sketch of Seawall Encasement Option (cross section will vary subject to existing wall geometry).

It has been assumed that the seawall encasement would be undertaken along approximately 1,860m of the seawall. It has been assumed that encasement wouldn't be needed along the 300m section of frontage at the western end where there is a rock revetment, and a further 600m in two locations where repairs have been undertaken in approximately the last 10 years (namely a section near Sideshore, and another section from Smeaton's Wall to The Octagon). These assumptions are for costing purposes and should be revisited during subsequent business case / design work.

It has also been assumed that the encasement would be undertaken in one scheme / intervention, but phasing of the option should also be explored during subsequent design and business case development. This could involve undertaking the encasement to the most vulnerable sections of the seawall first and returning to other areas at a later date.

Of the short list options considered, this option would provide the most long-term confidence in the stability and functioning of the seawall and would have the lowest level of residual risk of defence failure.

Careful consideration will be needed around the visual properties of the structure. There would be opportunities to explore cladding to the encasement to ensure the structure is in-keeping with the local environment.

Key costing and benefit assumptions for this option

The key assumptions made for the costing and benefits for this option are summarised in Table 3-6 below.

Table 3-6: Key costing and benefit assumptions for Seawall Encasement option (HTL with Hard Defences)

Key costing assumptions	Key benefit assumptions
Capital scheme in year 10 to construct seawall encasement along approx. 1,860m of frontage (300m at western end already has rock revetment and therefore encasement not required).	Assume seawall encasement would stop all erosion risk to the land over the next 100 years.
Assumed to occur in year 10 to provide time for appraisal, design and funding.	Conservatively assumed flood damages would still occur as it is uncertain as to how much the encasement would reduce overtopping risk without undertaking further design work.
Assumed vertical wall encasement in cost build up.	
Assumed seawall maintenance after construction, starting with repairs to 0.5% (by length) every 5 years, increasing to 2% over time as structure ages.	
Assumed no timber groyne maintenance or beach management.	
Assumed no encasement needed for approximately 900m of the frontage (areas of recent repairs and rock revetment).	

A map showing the seawall encasement alignment assumed in the costing is provided in Figure 3-6.

Figure 3-6: Seawall Encasement Alignment (as used in costing)

3.1.5 Setback Floodwall

This option would involve constructing a setback floodwall across the two key flood pathways to properties at risk. The option would need to be combined with either of the toe protection, rock revetment or seawall encasement options. A concept cross section sketch of this option is provided below in Figure 3-7.

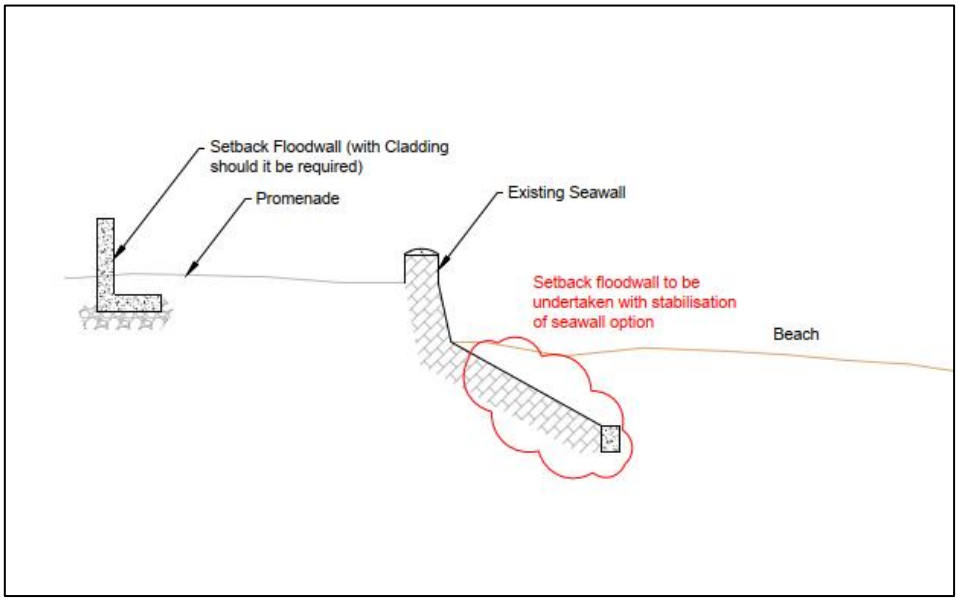

Figure 3-7: Concept sketch of Setback Floodwall Option.

The setback floodwall would not be required along the full length of the frontage but only in the areas where the flood cell propagates inland and where properties are concentrated, as shown in Figure 3-8 below. These alignments are based on the 200yr return periods available from the Exe Estuary Mapping and Modelling study (Mott MacDonald, 2012) and include the area in proximity to the Premier Inn and the area along the Esplanade to the east of Carlton Hill Road.

It has been assumed that the setback wall will be delivered in two phases, the first phase constructed in year 10 to deliver a 2074 200yr SoP (approx. 360m long) and the second phase constructed in year 50 to deliver a 2124 200yr SoP (approx. 260m long).

In the areas not defended by the setback floodwall, wave overtopping over the seawall would still lead to flooding of the promenade and roadway. Floodgates or passive road ramps may be required for the wall in proximity or across the promenade / road to ensure access is not impacted during normal conditions.

Key costing and benefit assumptions

The key assumptions made for the costing and benefits for this option are summarised in Table 3-7 below. Costs and benefit amounts will differ depending on which other option is included with the setback floodwall – i.e. sheet piling toe protection, rock revetment, or seawall encasement; however, the assumptions apply to all combinations.

Table 3-7: Key costing and benefit assumptions for Setback Floodwall Option (HTL with Hard Defences)

Key costing assumptions	Key benefit assumptions
Capital scheme in year 10 to construct setback floodwall along 360m of frontage to 2074 200yr SoP.	No residual damages – full flooding benefits assumed.
Assumed to occur in year 10 to provide time for appraisal, design and funding.	Residual erosion damages would occur if combined with toe protection. No residual erosion damages if combined with rock revetment or seawall encasement.

Key costing assumptions	Key benefit assumptions
Further scheme in year 50 to construct setback floodwall along 260m of frontage to 2124 200yr SoP.	
Assumed 1m height of wall in costing but will need to be confirmed during further appraisal / design.	

A map showing the setback floodwall alignments assumed in the costing is provided in Figure 3-8.

Figure 3-8: Setback Floodwall Alignment (as used in costing)

3.1.6 Property Level Resilience

This option would involve undertaking property level resilience (PLR) measures to the properties at risk from flooding along the frontage. The resilience measures could involve measures such as installing flood doors, flood gates, waterproofing walls, raising electrical sockets, non-return valves and pumps. The measures would not stop all flooding but would help to reduce the impacts to individual properties.

The option would need to be combined with either of the toe protection, rock revetment or seawall encasement options.

PLR is effective up to depths 600 mm above the property threshold, or 150 mm above the outside ground level[2]. This assumes a short flood duration, a slow flood water speed, and a shallow depth.

An upper end estimate of the number of properties that could utilise PLR measures are shown in Table 3-8. This shows the number of properties at risk from a 1 in 200 year return period for different time epochs. Some of these properties may not require PLR as they may not be at risk from more frequent return periods for which PLR is likely to be more cost effective. It is worth noting that only properties at very significant risk of flooding (i.e. 1 in 20 year return period) are eligible for GiA for PLR measures.

Table 3-8: Potential number of properties that could utilise PLR measures

Return period	Number of properties at risk
2024 200yr	13
2044 200yr	14
2074 200yr	21
2124 200yr	41

Key costing and benefit assumptions

The key assumptions made for the costing and benefits for this option are summarised in Table 3-9 below. Actual costs and benefit amounts will differ depending on which other option is included with the PLR – i.e. sheet piling toe protection, rock revetment, or seawall encasement; however, the assumptions apply to all combinations.

Table 3-9: Key costing and benefit assumptions for PLR (HTL with Hard Defences)

Key costing assumptions	Key benefit assumptions
Assume PLR required every 20 years, based on number of properties at risk and typical service life.	Assume no flooding damages for events <1 in 20 year return period.
	Residual flooding damages for return periods greater than this.

[2] Source: Property Flood Resilience | The Flood Hub, accessed 01.07.2024

3.2 Hold the Line with Beach Management

The short list options identified for the Hold the Line with Beach Management Strategic Approach are outlined below. In total three short list options have been identified for managing the beach levels to reduce coastal erosion risk (Timber groynes with Beach Nourishment, Breakwaters with Beach Nourishment, Rock Fishtail Groynes with Beach Nourishment) with a further two options identified for reducing flood risk (Setback Floodwall and PLR).

The options that reduce flood risk would need to be delivered in parallel with either of the three beach management options. A summary of the option combinations for Holding the Line with Beach Management is provided in Table 3-10 below.

Table 3-10: Short List Option Combinations for Hold the Line with Beach Management

Approach	Option
Hold the Line with Beach Management	Do Minimum
	Timber Groynes with Beach Nourishment
	Breakwaters with Beach Nourishment
	Rock Fishtail Groynes with Beach Nourishment
	Timber Groynes with Beach Nourishment and Setback Floodwall
	Breakwaters with Beach Nourishment and Setback Floodwall
	Rock Fishtail Groynes with Beach Nourishment and Setback Floodwall
	Timber Groynes with Beach Nourishment and Property Level Resilience (PLR)
	Breakwaters with Beach Nourishment and PLR
	Rock Fishtail Groynes with Beach Nourishment and PLR

3.2.1 Do Minimum / Minimum Intervention

This option would involve undertaking beach recycling on a frequent basis to move material from areas of accretion to areas of erosion.

This option is a comparatively low cost approach but there is no guarantee with this option that there will be sufficient material on the beach at all times to provide the required level of toe protection to the defences. The beach will remain vulnerable to loss of material during storms which could lead to undermining and failure of the seawall.

In addition to the beach recycling, this option would also involve undertaking patch repair maintenance works to the existing groynes and seawall on a regular basis.

This approach would not involve a large scale capital scheme and therefore funding for beach management and patch-repair works would likely need to come from EDDC maintenance budgets or applications for emergency funding from central government. The amount of funding that can be secured will determine how much beach management and maintenance could be undertaken.

The residual risk of flooding and erosion would increase over time with this approach and a defence failure could happen in the future as there may not be sufficient funding to keep defences in a reasonable condition and to stop defences from failing.

Key costing and benefit assumptions for this option

The key assumptions made for the costing and benefits for this option are summarised in Table 3-11 below. The amount and position of beach material to be moved would be determined by ongoing beach monitoring and analysis which is difficult to estimate at this stage. However, for the purpose of costing it has been assumed that approximately 8,500m^3 of material would need to be moved on an annual basis, based on the total volume of beach erosion in the central part of the study frontage (Maer area in Management Unit 2) over the period 2007-2023 (approximately 135,000m^3 beach volume loss over 16 years). This is a slightly higher estimate than the previous BMP which estimated annual recycling volumes of approximately 6,000m^3.

The seawall and groyne repair work that would be needed alongside the beach management activities would need to be determined based on monitoring of the defence condition and the beach levels (risk of undermining). For costing purposes, it has been assumed that less wall maintenance would be undertaken compared to the Do Minimum; Hold the Line with hard defences approach because the small scale beach management may help to reduce damage to the wall (compared to a scenario with no beach management). It has been assumed that on average 2% of the wall would be repaired every 5 years (compared to 5% for the Do Minimum Hold the Line with Hard Defences approach).

For the purposes of the appraisal a number of assumptions have been made for the cost and benefits of this option. These are summarised in Table 3-11 below.

Table 3-11: Key costing and benefit assumptions for Do Minimum (HTL with Beach Management)

Key costing assumptions	Key benefit assumptions
Annual beach recycling of 8,500m^3 applied for a period of 20 years.	Delay failure of defences by 10 years, which delays erosion damages in the economic appraisal by 10 years. See Table 4-2 for more details.
Patch-repair maintenance costs for the seawall and timber groynes applied for a period of 20 years.	Reduced damages (and therefore an economic benefit) as erosion damages are discounted more heavily as they occur further into the future.
Over this 20 year period, assumed 2% of the wall (by length) requires patch-repair work every 5 years, until the majority of the structure reaches the end of its service life in year 20 and cannot be further maintained. Over this period also assumed repair of 10 structural elements on each timber groyne every 5 years.	Full flooding damages still occur.

3.2.2 Groynes and Beach Nourishment

This option would involve undertaking a beach nourishment scheme and constructing groynes with the aim of retaining the beach material. The beach would then form the primary defence for the toe of the seawall. Annual beach recycling would also be required to ensure beach levels remain as intended along the frontage.

Beach nourishment with groynes was the general approach that was recommended as the long term option during the previous BMP (2015), however, there are some differences between the options.

In the previous BMP (2015) the beach nourishment and groyne approach recommended upgrading two of the groynes at Queen's Drive East, placing 80,000m^3 of material at Queens Drive and constructing up to two new groynes at the Maer.

However, new beach monitoring data has been collected since the previous BMP (2015) was developed and this indicates high levels of accretion at Queens Drive East and significant erosion at the Maer between 2007-2023 (see Figure 3-9). Placement of beach material should therefore be prioritised for the Maer section of the beach alongside new groynes in this location. Should the trend of accretion at Queens Drive East continue then the need to improve the groynes here is less (above and beyond normal maintenance works). This interpretation aligns with the level of undermining risk for the seawall in these locations in the defence condition assessment (AECOM, 2024(a)). In the assessment the seawall at Queens Drive East was estimated to have a 'low to medium' risk of undermining whereas much of the seawall at the Maer was estimated to have a 'Medium' or 'Medium to high' risk of undermining.

The beach at Exmouth remains dynamic and therefore the trends should continue to be monitored over the next several years to inform the design of a beach nourishment or groyne scheme. Should the trends change then the option provides sufficient flexibility to place groynes in other locations (such as improving the groynes at Queens Drive East if the accretion here reverts back to erosion).

Figure 3-9: Elevation difference plot between October 2007 LiDAR survey and 2023 survey

As part of the updated groynes and beach nourishment option, based on current trends it is therefore recommended that this option involves:

- Beach nourishment at the Maer to improve beach levels in this location and provide better protection to the toe of the defences.
- Construction of groynes along the Maer frontage to help retain material placed in this location.

A well-designed groyne system would be expected to reduce the amount of longshore transport of beach material. However, there are some uncertainties as to how effective groynes may be in this location:

- Groynes can be used on both shingle and sand beaches but the way the groynes work varies. With coarse materials (e.g. gravel), groynes act directly by trapping a fraction of the material as it moves alongshore. However, on sand beaches such as Exmouth, groynes typically act more indirectly by affecting the longshore currents containing the sand. Groynes on sand beaches typically perform better in micro-tidal conditions than meso-tidal or macro-tidal conditions where the spatial distribution of transport due to waves is more limited. The tidal range at Exmouth is macro-tidal (greater than 4m) and therefore, the ability of the groyne to restrict sediment transport may be more limited. Groynes at the Maer may therefore need to be designed to control a sufficient part of the beach profile but accept that not all movement of sand will be managed (i.e. some bypassing / movement of material from the groyne bays would need to be accounted for).
- There is also uncertainty as to how effective groynes may be in stabilising the beach during storms. This is because groynes will not prevent offshore losses during severe storm events because they do not act on cross shore processes.

To explore these uncertainties in more detail, further appraisal and numerical sediment transport modelling would be required to inform the design of this option. This will need to determine the amount of beach material that is required as well as the number, type, spacing and length of the groynes at the Maer frontage.

For the purposes of this appraisal, two groyne approaches have been considered and included on the short list; timber groynes and rock fishtail groynes. Both approaches have relative advantages / disadvantages. The timber groynes would be less visually intrusive and have smaller defence footprints (preferable from an environmental perspective) but would not be expected to provide much control on cross shore transport. The rock fishtail groynes would be larger structures but would be expected to provide greater control on cross shore transport and may therefore provide more stability to the beach during storms, reducing the risk of beach drawdown and the seawall undermining.

For the timber groyne approach, for costing purposes it has been assumed that 11 new groynes would be constructed along the Maer frontage, each approximately 80m long with 90m spacing. This is a similar structure size to the existing groynes at Queens Drive East. This is significantly more groynes than outlined in the previous BMP (2015) which only recommended 2 groynes at the Maer. The reason for this increase is that the beach at the Maer has eroded significantly since that previous assessment and it is anticipated that more than 2 groynes would be needed to stabilise the beach in this location. Subject to the results of further numerical modelling / scheme design, it is possible that fewer than 11 groynes would actually be required but it is preferable to be conservative at this stage with the assumptions and to over-estimate the requirements of the option rather than under-estimate. Should the number of groynes be reduced then it is likely that the cost of option would reduce and it would become more feasible.

For the rock fishtail groyne approach, for costing purposes it has been assumed that 8 new groynes would be constructed along the Maer frontage, each approximately 80m long plus 2x20m fishtails at the seaward end. It has been assumed that the groynes would be spaced 120m apart (more than the timber groynes) as the structures would be expected to have a greater influence on cross shore transport so wider spacing may be achievable.

The volume of beach nourishment for both groyne approaches has been assumed to be approximately 200,000m^3. This volume has been derived by calculating the additional volume needed at the Maer frontage to create the same beach cross sectional profile as is currently observed at Queens Drive East. Further refinement and more detailed beach design calculations would be required should this option be taken forward.

Key costing and benefit assumptions

The key assumptions made for the costing and benefits for this option are summarised in Table 3-12 (timber groynes) and Table 3-13 (fishtail groynes) below.

Table 3-12: Key costing and benefit assumptions for Timber Groynes with Beach Nourishment option (HTL with Beach Management)

Key costing assumptions	Key benefit assumptions
Capital scheme in year 10 to construct 11 new groynes and undertake beach nourishment.	Assume defences would stop all erosion risk to the land over the next 100 years.
Assumed 11 new timber groynes, each 80m long with 90m spacing. Assumed 200,000m^3 of beach material placed.	Conservatively assumed flood damages would still occur as it is uncertain as to how much the groynes / beach nourishment would reduce overtopping risk without undertaking further design work.
At the same time, also replace 7 existing timber groynes along the frontage which would be expected to be at or close to the end of their service life (e.g. at Queens Drive East).	
Ongoing patch repair work to existing seawall, assuming on average 3% of the length every 5 years.	
Beach recycling approx. 8,500 m^3 per year.	
Repeat timber groyne capital scheme in year 60	

Table 3-13: Key costing and benefit assumptions for Fishtail Groynes with Beach Nourishment option (HTL with Beach Management)

Key costing assumptions	Key benefit assumptions
Capital scheme in year 10 to construct 8 new groynes and undertake beach nourishment.	Assume defences would stop all erosion risk to the land over the next 100 years.
Assumed 8 new rock fishtail groynes, each 80m long plus 2x20m fishtail sections, 120m spacing. Assumed 200,000m^3 of beach material placed.	Conservatively assumed flood damages would still occur as it is uncertain as to how much the groynes / beach nourishment would reduce overtopping risk without undertaking further design work.
At the same time, also replace 7 existing timber groynes along the frontage which would be expected to be at or close to the end of their service life (e.g. at Queens Drive East). This would also be repeated in year 60 at end of service life.	
Ongoing patch repair work to existing seawall, assuming on average 3% of the length every 5 years.	
Beach recycling approx. 8,500 m^3 per year.	

Maps showing the area proposed for new groynes and potential locations, as used in the costing, are provided in Figure 3-10 and Figure 3-11.

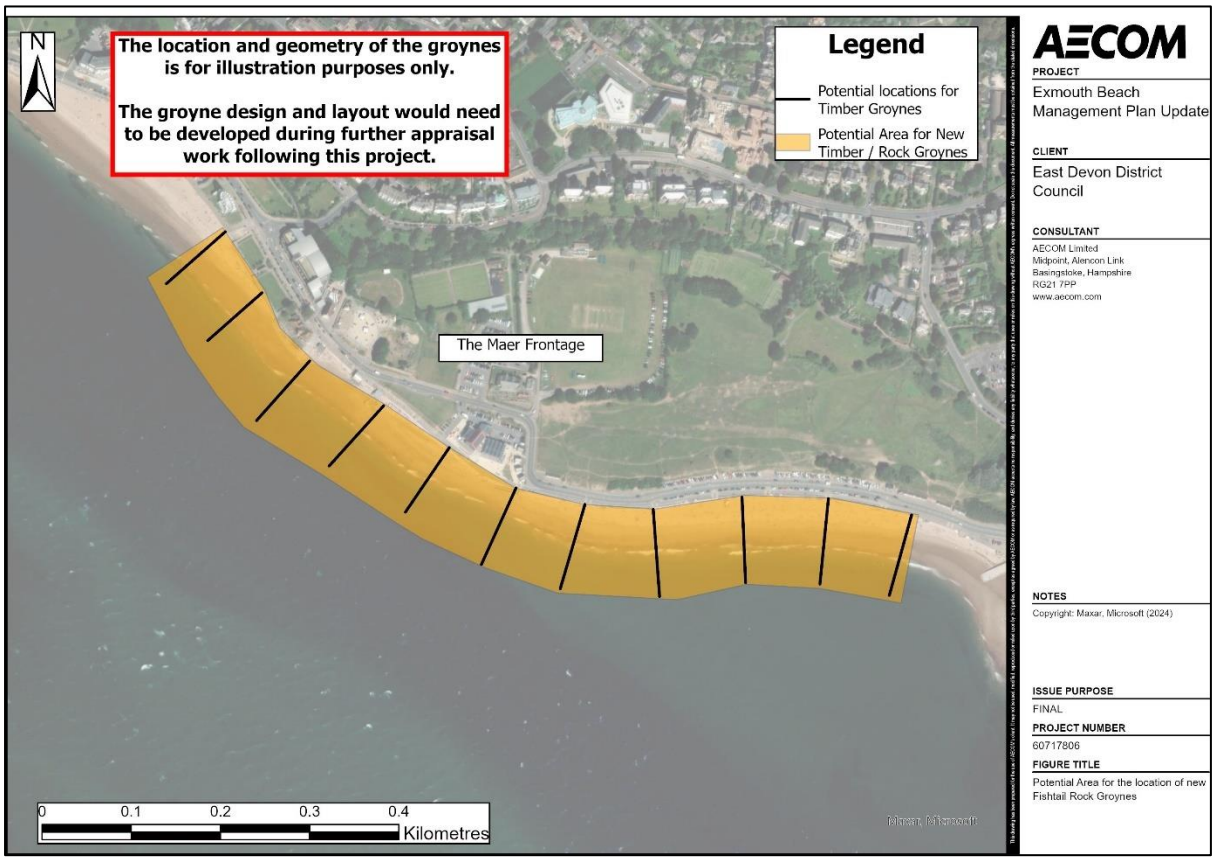

Figure 3-10: Potential Timber Groyne Area and Locations (as used in costing)

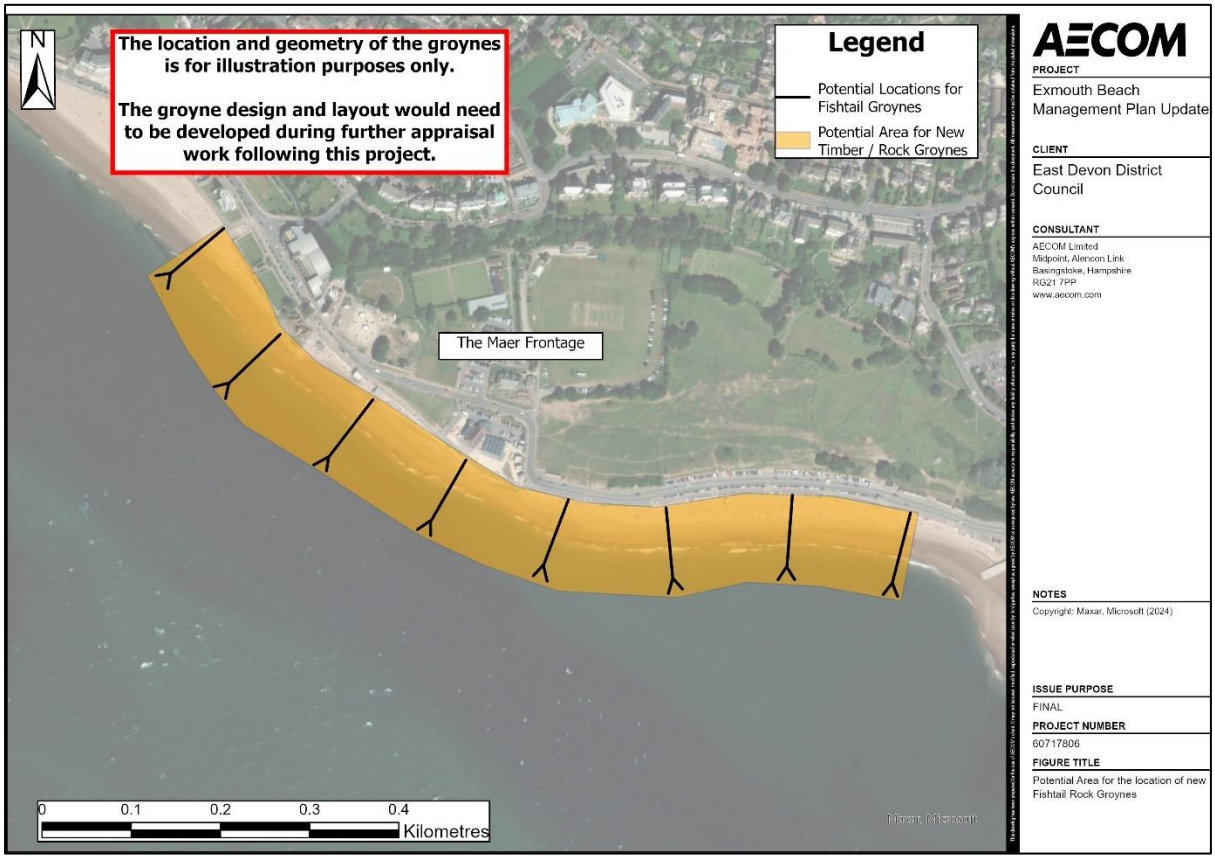

Figure 3-11: Potential Fishtail Rock Groyne Area and Locations (as used in costing)

3.2.3 Breakwaters and Beach Nourishment

This option would involve constructing multiple breakwaters adjacent to the beach to create a series of beach 'salient' or 'tombolo' features. The breakwaters would significantly alter the wave conditions at the beach allowing the cross shore and long-shore transport of material to be effectively controlled. This would ensure that the beach adjacent to the seawall could be stabilised and would be less susceptible to drawdown during storm events.

Breakwaters are likely to be a more effective beach control measure than groynes, but there are some negative impacts associated with this option such as significant cost, encroachment into the environmental designations and changes to the landscape of the beach. In addition, there is potential for fast currents to develop in proximity to the breakwaters which could be a hazard to beach goers, swimmers and vessel navigation.

Further design work would be required if this option were to be taken forward to determine breakwater size, distance offshore, spacing and length. However, for the purposes of costing it has been assumed that the breakwater option would involve the construction of 4 breakwaters along the Maer frontage, each 100-110m long, approximately 7.5m high above bed level, with 100-110m spacing and distance from the top of the beach.

The breakwaters would be accompanied by beach nourishment at the Maer section of the beach where beach levels have been eroding. The same assumptions for beach nourishment as the groyne options have been included in the option costing (200,000m^3).

Key costing and benefit assumptions

The key assumptions made for the costing and benefits for this option are summarised in Table 3-14 below.

Table 3-14: Key costing and benefit assumptions for Breakwaters with Beach Nourishment option (HTL with Beach Management)

Key costing assumptions	Key benefit assumptions
Capital scheme in year 10 to construct 4 new rock breakwaters and undertake beach nourishment.	Assume defences would stop all erosion risk to the land over the next 100 years.
Assumed 4 new rock breakwaters, each 100-110m long, 100-110m spacing and distance from top of beach. Assumed 200,000m^3 of beach material placed.	Conservatively assumed flood damages would still occur as it is uncertain as to how much the breakwaters and beach nourishment would reduce overtopping risk without undertaking further design work.
Ongoing patch repair work to existing seawall, assuming on average 3% of the length every 5 years.	
Beach recycling approx. 8,500 m^3 per year.	

A map showing the area proposed for breakwaters and potential locations, as used in the costing, is provided in Figure 3-12.

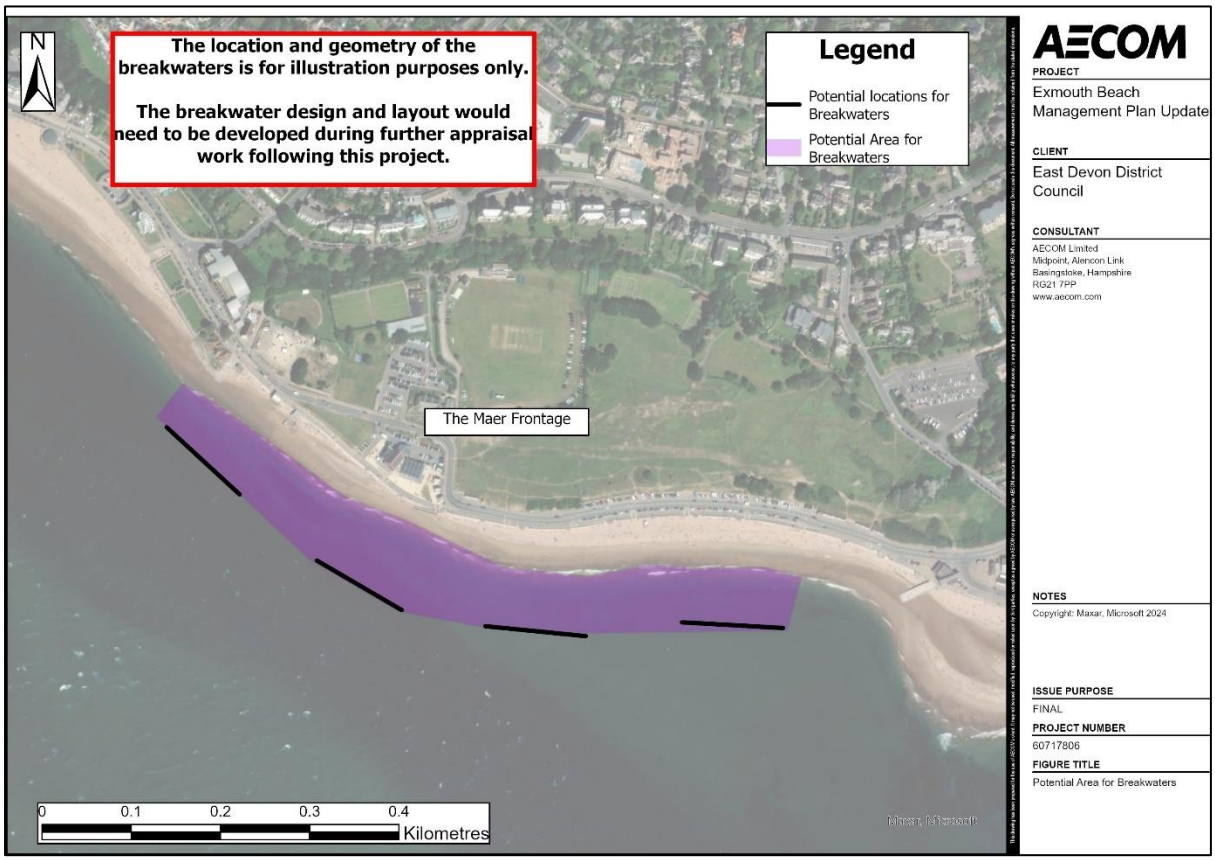

Figure 3-12: Breakwater Area and Potential Locations (as used in costing)

3.2.4 Setback Floodwall

As described in Section 3.1.5, a setback floodwall could be constructed to reduce flood risk along the frontage. This would need to be combined and delivered in parallel with either of the three beach management options outlined in the Section above. There would be no differences to the key assumptions that are outlined in Section 3.1.5 when combined with the beach management options.

3.2.5 Property Level Resilience

As described in Section 3.1.6, property level resilience measures could be implemented to reduce the impact of flooding to properties along the frontage. This would need to be combined and delivered in parallel with either of the three beach management options outlined in the Section above. There would be no differences to the key assumptions that are outlined in Section 3.1.6 when combined with the beach management options.

3.3 Managed Realignment / Adaptation

The short list options identified for the Managed Realignment / Adaptation Strategic Approach are outlined below. In total, three short list options have been identified for realigning the position of the shoreline. These options could be combined with other options to manage the risk of flooding in adjacent areas. It has been assumed that the main realignment area would be at the Maer, although exact alignments would need to be decided with further appraisal if this option were to be taken forward.

A map showing the area assumed for Managed Realignment in the costing is provided in Figure 3-13.

Figure 3-13: Potential Managed Realignment Area (as used in costing)

A summary of the option combinations for Managed Realignment / Adaptation is provided in Table 3-15 below.

Table 3-15: Short List Option Combinations for Managed Realignment

Approach	Option
Managed Realignment	Do Minimum
	Beach Nourishment
	Sand Dune Establishment
	Beach Nourishment and Setback Floodwall
	Sand Dune Establishment and Setback Floodwall
	Beach Nourishment and Property Level Resilience (PLR)
	Sand Dune Establishment and PLR

With any Managed Realignment option, a series of other interventions may be required to prepare the local community and to help adapt to the change that would occur. This could involve (subject to the area being realigned):

- Community awareness raising, engagement and support
- Consider redirecting transport infrastructure such as coastal roads, footpaths and cycleways inland in areas where shoreline realignment is to occur
- Relocation of any buried services / utilities
- Council support to local businesses in relocating
- Development of a new master plan to identify new land-use areas.

3.3.1 Minimum Intervention

With this approach, maintenance of the seawall at The Maer would be ceased. This would lead to the managed failure of the seawall over time. It is likely that the seawall would fail in sections, most likely in response to storm events. Following failure of the wall the debris from the seawall should be cleared and any remaining unstable sections be demolished to ensure health and safety compliance.

Once the seawall fails, the land behind would be at increased risk of erosion and therefore beach recycling should be used to help control rates of erosion following the failure of the seawall. It is anticipated that this would need to be undertaken on a frequent basis and should move material from areas of beach accretion to areas of erosion.

The amount and position of material to be moved is highly uncertain with this approach, particularly with the potential for 'catch-up' erosion following the failure of the seawall. The recycling would need to be informed by monitoring the beach and levels of shoreline erosion. The ethos for the beach recycling would not be to prevent erosion of the land behind, but rather slow / control the rate of erosion to ensure the shoreline is evolving into a desired position. There is potential that beach recycling by itself would not be sufficient to control the shoreline evolution and more costly interventions may be required (such as beach nourishment).

With a setback shoreline position, there would be greater potential for sand dunes to form naturally along the frontage as space will be created for this to occur. However, the minimum intervention option would not involve any specific measures to actively promote sand dune creation and there is no guarantee that dunes would form.

To the west and east of The Maer frontage, there would be continued patch-repair maintenance to the existing seawall as per the Do Minimum approach outlined for the Hold the Line option with Hard Defences (see Section 3.1.1).

Key costing and benefit assumptions

The key assumptions made for the costing and benefits for this option are summarised in Table 3-16 below.

Table 3-16: Key costing and benefit assumptions for Do Minimum option (Managed Realignment / Adaptation)

Key costing assumptions	Key benefit assumptions
Assumed managed realignment area is 550m frontage of The Maer.	No properties at risk in managed realignment area at The Maer therefore assumed the same benefits as Do Minimum (HTL with Hard Defences). See Table 4-2 for more details.
No patch repair work to seawall at Maer but seawall repairs included elsewhere along the frontage.	
Beach recycling to help control rates of erosion: approx. 8,500m^3 per year (same as for HTL options).	
Assumed Maer seawall would collapse over first 15 years. Applied debris clearance costs in 3 increments (once every 5 years over this period).	

3.3.2 Beach Nourishment

This approach is similar to the Minimum Intervention approach described above in the sense that no maintenance would be undertaken on the seawall at The Maer and it would fail over time, likely in response to damage during storm events.

However, this approach would be more proactive in terms of beach management and would involve undertaking a beach nourishment scheme (or schemes) to add material to the beach in areas where the shoreline erosion needed to be stabilised / controlled following failure of the seawall. The nourishment could be combined with beach recycling to ensure the beach provides the desired control on the shoreline evolution in the correct places along the frontage.

As with the Minimum Intervention approach, beach monitoring would be essential to the successful implementation of this option. It is uncertain how much beach nourishment would be required to successfully control rates of erosion at The Maer. However, for costing purposes it has been assumed that on average 20,000m^3 of beach material would be required every 10 years. The addition of beach material may also promote the creation of sand dunes as more material would be available. However, this would require an appropriate grading of material to be used.

To the west and east of The Maer frontage, it has been assumed that the existing seawall position would be retained through a seawall encasement scheme in year 10. This would have the same assumptions as the seawall encasement outlined for the Hold the Line option with Hard Defences (see Section 3.1.4).

Key costing and benefit assumptions

The key assumptions made for the costing and benefits for this option are summarised in Table 3-17 below.

Table 3-17: Key costing and benefit assumptions for Beach Nourishment option (Managed Realignment / Adaptation)

Key costing assumptions	Key benefit assumptions
Assumed managed realignment area is 550m frontage of the Maer.	No properties at risk in managed realignment area at The Maer therefore no damages associated with this area. See Table 4-2 for more details.
No patch repair work to seawall at The Maer but seawall repairs included elsewhere along the frontage.	Assume seawall encasement either side of the Maer would stop all erosion risk to the land here over the next 100 years.
Smaller scale targeted beach nourishment to help control rates of erosion at the Maer. Assumed 20,000m^3 every 10 years.	Conservatively assumed flood damages would still occur as it is uncertain as to how much the encasement would reduce overtopping risk without undertaking further design work.
Capital scheme in year 10 to construct seawall encasement along rest of frontage either side of The Maer (approx. 1800m of frontage (300m at western end already has rock revetment and therefore encasement not required).	
Assumed to occur in year 10 to provide time for appraisal, design and funding.	
Assumed vertical wall encasement in cost build up.	

3.3.3 Sand Dune Establishment and Reinforcement

This option would be undertaken in addition to the Beach Nourishment option outlined in the Section above. This option would involve undertaking measures to promote the establishment of sand dunes and then provide reinforcement if required once the dunes have established.

The measures available to promote the growth of sand dunes include:

- Access management to control footfall (e.g. fencing, boardwalks)
- Public awareness (signs and information boards to help with public co-operation)
- Fencing to trap sand and promote dune growth
- Thatching (placing branches / brushwood on surface to increase roughness), mulching (embedding hay / bracken / straw into the dune surface) and vegetation planting (e.g. Marram Grass).

The measures to reinforce the sand dunes include:

- Buried gabion mattresses / addition of hardcore material
- Geotextile mesh
- Further vegetation planting.

Key costing and benefit assumptions

The key assumptions made for the costing and benefits for this option are summarised in Table 3-18 below.

Table 3-18: Key costing and benefit assumptions for Sand Dune Establishment option (Managed Realignment / Adaptation)

Key costing assumptions	Key benefit assumptions
As per Beach Nourishment Option, with Sand Dune Enhancement additions.	No properties at risk in managed realignment area at the Maer therefore no damages associated with this area. See Table 4-2 for more details.
Dune planting and fencing installed every 5 years as dunes evolve.	Assume seawall encasement either side of the Maer would stop all erosion risk to the land here over the next 100 years.
	Conservatively assumed flood damages would still occur along frontage as it is uncertain as to how much the seawall encasement (either side of the Maer) would reduce overtopping risk without undertaking further design work.

4. Economic Appraisal

The process of identifying the National Economic option is described in Section 2.3 above. To enable the economic comparison to be undertaken the whole life option costs and benefits have been estimated.

4.1 Option Costs

The whole life cost estimates of the short list options are comprised of the following aspects:

- Capital construction costs
- Maintenance / operation costs
- Optimism bias / risk.

4.1.1 Capital and Maintenance Unit Costs

The costs for capital construction and maintenance works were estimated using a variety of sources and information, including:

- Typical cost build-ups from engineering price books such as SPONS (2024)
- Actual construction costs from relevant and previous projects
- Contractor price estimates from relevant and previous projects
- Environment Agency guidance (2015) on the cost of coastal and fluvial defences.

The majority of cost estimates were developed from SPONS (2024) and the base date for unit rates is May / June 2023. At the time of writing, this date is over 1 year old and therefore the Construction Price Index from the Office for National Statistics was checked to determine whether there had been any inflation in the index for new infrastructure construction. At the time of writing, the latest Construction Price Index release from the Office for National Statistics was March 2024 and between May / June 2023 and March 2024 the index fell by 1%. Given the small magnitude of change downwards no adjustment to the SPONS unit rates were provided. The base date for the costs in the Strategy is therefore accurate to March 2024.

The details provided in Section 3 outline the defence measures / interventions for each option. Option costs were developed for each of the defence measures / interventions on a per unit basis and then scaled up accordingly for each option based on the estimated defence lengths or maintenance required.

Table 4-1 provides a summary of the unit costs used in the assessment for each of the defence types. Information is included on the key assumptions, as well as the primary source used to estimate the costs.

The costs in Table 4-1 include an allowance for preliminaries (assumed to be 35%), appraisal costs (assumed to be 10%) and optimism bias and risk (90%). More details on the optimism bias and risk build-up are provided in the next Section.

As can be seen, the unit cost rates that have been used are broadly in line with the Environment Agency guidance (2015) when adjusted for inflation.

Table 4-1: Summary of unit cost estimates

Defence type / measure	Cost range used in assessment (including OB, risk, prelims etc.)	Primary source of cost estimate	Cost range in Environment Agency guidance (2015)	Cost range in Environment Agency guidance (2015), adjusted for inflation*	Notes / assumptions
Seawall patch-repair maintenance	£1,500 per m^2	Contractor cost estimates for coastal projects	Not available	Not available	- Assumptions made as to the area of wall that need repairing and frequency
Timber groyne patch-repair maintenance	£2,000 for 10 structural elements	Contractor cost estimates for coastal projects	Not available	Not available	- Assumptions made as to the number of structural elements that need repairing and frequency
Rock defence maintenance	£110 for 2% of typical cross sectional area	Cost build-up from SPONS (2024), including: - imported rock armour stone - placement of rock armour stone	Not available	Not available	- Assumptions made as to the area of defences that need repairing and frequency
Seawall toe protection	£5,500 for 1m length of seawall	Cost build-up from SPONS (2024), including: - site clearance - sheet pile toe protection installation - concrete apron	Seawall toe protection not specified. However, cost of sheet pile wall states as: - Urban reach <100m in length: average rate of £9.1k per m length - Urban reach >100m in length: average rate of £2.5k per m length - Rural reach: average rate of £1.8k per m length	- Urban reach <100m in length: average rate of £14.7k per m length - Urban reach >100m in length: average rate of £4.1k per m length - Rural reach: average rate of £2.9k per m length **Note that the urban reach > 100m length (£4.1k) is most applicable to the Strategy options**	- Assumed 6m pile depth - Assumed 2m wide concrete apron at base of wall - Assumed no structural modifications to existing wall

Defence type / measure	Cost range used in assessment (including OB, risk, prelims etc.)	Primary source of cost estimate	Cost range in Environment Agency guidance (2015)	Cost range in Environment Agency guidance (2015), adjusted for inflation*	Notes / assumptions
			(Note that the urban reach > 100m length is most applicable to the BMP options)		
Seawall encasement	£9,000 for 1m length of seawall	Cost build-up from SPONS (2024), including: - site clearance - sheet pile toe protection installation - concrete apron - concrete wall encasement / facing with dowel connections into existing wall	Seawall encasement cost not available. However, cost of new seawall stated as: - £0.7 to £5.4k per m length	- £1.1 to £8.7k per m length	- Assumed typical height of 3m seawall - Assumed 6m pile depth - Assumed vertical seawall face - Assumed 2m wide concrete apron at base of wall - Assumed no structural modifications to existing wall which would remain in situ
Rock revetment	£10,100 for 1m length of revetment	Cost build-up from SPONS (2024), including: - site clearance - excavation and geotextile - rock import and placement - rock cost uplift for non-local source	- £1.3k to 6k per m length of defence (rock armour)	- £2.1k to 9.7k per m length of defence (rock armour)	- Assumed typical height of revetment of 3m - Assumed 1:2 slope - Applied uplift to account for potential non-local source of rock - Sourcing of rock likely to be key driver of cost
Setback floodwall	£4,700 per 1m length of wall	Cost build-up from SPONS (2024), including: - site clearance - excavation for foundations - concrete, reinforcement and placement - masonry cladding	- £1.4k per m length for height less than 1.2m - £2.9k per m length for height between 1.2m and 2.1m	- £2.3k per m length for height less than 1.2m - £4.7k per m length for height between 1.2m and 2.1m	- Assumed 1m high L-shaped floodwall - Assumed 2m sheet pile cut-off depth - Assumed structure would not be a retaining wall

Defence type / measure	Cost range used in assessment (including OB, risk, prelims etc.)	Primary source of cost estimate	Cost range in Environment Agency guidance (2015)	Cost range in Environment Agency guidance (2015), adjusted for inflation*	Notes / assumptions
		- sheet pile cut-off	- £3.6k per m length for height between 2.1m and 5.3m	- £5.8k per m length for height between 2.1m and 5.3m	
Property level protection / resilience	£10,000 per property	Environment Agency guidance	- £4k to £8k per property for protection measures - £8k to £12k per residential property for resilience measures	- £6.4k to £12.9k per property for protection measures - £12.9k to £19.3k per residential property for resilience measures	- Assumed mid-point of EA property level protection cost, adjusted for inflation - For scheme delivery, each property would require bespoke solution and therefore costs will vary on property by property basis
Beach recycling	£10.50 per m^3 of material moved	Actual costs from similar beach recycling schemes on the south coast (Hayling Island between 2017-2021) adjusted for inflation and including optimism bias	- £1 per m^3	- £2 per m3	- Assumed volume of 8,500m3 per year for beach recycling based on erosion / accretion volumes on the beach
Beach nourishment	£58 per m^3 of material moved	Average of actual costs from beach nourishment schemes on the south coast (Hayling Island) as well as Environment Agency guidance. Cost adjusted for inflation and including optimism bias	- £9 to £32 per m^3	- £15 to £52 per m3	- Assumed 200m^3 of material needed per 1m length of beach at Maer - Existing beach profile at Queens Drive East assumed to be the target profile for beach nourishment works for the Maer (given wider beach here). - Beach profile / LiDAR used to determine volume of material needed in each location to deliver target profile. - Beach design required as any scheme appraisal
Timber groynes	£5,800 per 1m length of timber groyne	Cost build-up from SPONS (2024), including: - Excavation	- £100,000 to £320,000 per groyne	- £162,000 to £520,000 per groyne	- Assumed 80m long - Assumed to extend 3m below to 1m above beach level

Defence type / measure	Cost range used in assessment (including OB, risk, prelims etc.)	Primary source of cost estimate	Cost range in Environment Agency guidance (2015)	Cost range in Environment Agency guidance (2015), adjusted for inflation*	Notes / assumptions
	£460,000 per groyne (80m long)	- Timber piles and driving - Timber sheeters - Bolted connections	(typically 70-100m in length)		- Assumed spacing of 90m between groynes (similar layout to Queens Drive East) - Further groyne design required as part of any scheme appraisal
Rock groynes	£7,600 per 1m length of rock groyne £610,000 per groyne (80m long)	Cost build-up from SPONS (2024), including: - site clearance - excavation and geotextile - rock import and placement - rock cost uplift for non-local source	- £0.2k to £2.5k per m length of groyne	- £0.3k to £4.1k per m length of groyne	- Assumed 80m long - Further groyne design required as part of any scheme appraisal - Applied uplift to account for potential non-local source of rock - Sourcing of rock likely to be key driver of cost
Fishtail rock groynes	£7,600 per 1m length of rock groyne £915,000 per groyne (80m long with 2x20m tails)	Cost build-up from SPONS (2024), including: - site clearance - excavation and geotextile - rock import and placement - rock cost uplift for non-local source	- £0.2k to £2.5k per m length of groyne	- £0.3k to £4.1k per m length of groyne	- Assumed 80m long plus 2x20m fishtails - Assumed 120m spacing - Further groyne design required as part of any scheme appraisal - Applied uplift to account for potential non-local source of rock - Sourcing of rock likely to be key driver of cost
Rock breakwater	£40,600 per 1m length of breakwater £4,470,000 per breakwater (110m long)	Cost build-up from SPONS (2024), including: - site clearance - excavation and geotextile - rock import and placement - rock cost uplift for non-local source	- £1.7k to £4.3k per m length	- £2.8k to £7.0k per m length	- Assumed 110m long breakwater, 7.5m high above bed level - Assumed approx. 100m offshore and 100m spacing - Further breakwater design required as part of any scheme appraisal - EA guidance outlined complexity in cost estimate for these structures and also didn't have a large

Defence type / measure	Cost range used in assessment (including OB, risk, prelims etc.)	Primary source of cost estimate	Cost range in Environment Agency guidance (2015)	Cost range in Environment Agency guidance (2015), adjusted for inflation*	Notes / assumptions
					sample size for the cost database. Therefore, the rate provided in EA guidance is particularly uncertain.
Dune enhancements	£110 per m length of dunes	Cost build-up using costs from Dune Management Guide (Scottish Natural Heritage, 2000), adjusted for inflation: - dune vegetation and planting - dune fencing	Not available	Not available	

* Cost base for EA guidance is 2007 and inflation between 2007-2024 is estimated to be approximately 62%. This is based on:
- Consumer Price Index (CPI) inflation is approximately 62% between 2007-2024.
- The Construction Output Price Index (OPIs) are available from 2014-March 2024. However, these do not extend back to 2007 therefore an inflation calculation for the period 2007-2024 using this index is not possible.
- Using rates of inflation from the Consumer Price Index for the period 2007-2014, and then Construction Price Index (new infrastructure type) for the period 2014-March 2024, the overall rate of inflation is approximately 58% between 2007-2024. This is less than the inflation from just the CPI (62%) between 2007-2024 and therefore the CPI 62% has been used.

4.1.2 Optimism Bias and Risk

Optimism bias is the demonstrated systematic tendency for appraisers to be over-optimistic about key project parameters, including capital costs, operating costs, project duration and benefits delivery. The Green Book recommends applying specific adjustments for this at the outset of an appraisal. The aim of adjusting for optimism bias is to provide a more realistic assessment of the initial estimate of costs (HM Treasury Green Book, 2022).

The FCERM appraisal guidance recommends that different amounts of optimism bias are applied to option costs at different stages of appraisal. For strategic studies such as this, the guidance recommends applying 60% optimism bias and therefore this amount has been applied to the option costs.

In addition to the 60% optimism bias adjustment, a further risk adjustment of 30% has also been applied to take into account known risk factors, such as potential for tidal working, the potential need for temporary works and potential buried services.

Note that the unit cost values presented in Table 4-1 include optimism bias and risk allowances.

4.1.3 Whole Life Costs

The capital construction costs, and maintenance costs associated with each short list option were combined and sequenced through the appraisal period (100 years) to develop the whole life cost estimates of the options.

Future costs in the appraisal period were discounted using the discount factors recommended by the HM Treasury Green Book (2022); 3.5% for the years 0 to 30, 3% for the years 31 to 75, and 2.5% for the years 76 to 99 resulting in a PV factor over 100 years at 29.9. Discounting converts the whole life cash cost of the option into a present value, ensuring that the whole life costs can be directly compared to the whole life damages / benefits of options in present value terms.

4.1.4 Uncertainties and Limitations

There are several uncertainties and limitations in the short list option cost estimates that should be considered. These uncertainties and limitations are typical for an appraisal project at this stage and could result in changes to the option costs over time. The uncertainties should be considered during subsequent scheme development and appraisal and work undertaken to improve cost certainty as schemes get closer to construction.

- **Defence alignments and geometry:** for the purposes of costing, indicative defence alignments and geometry (e.g. length, height etc.) have been identified for the options. It is likely that there will be modifications to these alignments when they are appraised in more detail during subsequent scheme development. This has the potential to alter the overall cost of the options.
- **Inflation / deflation:** the base year for the cost estimates is 2024 to align with the project appraisal period and time the costing work was undertaken. Macro-economic factors over time such as inflation / deflation will change the cost of the options. For example, the material and labour costs associated with coastal defence construction and maintenance change over time in response to supply / demand and broader macro-economic factors.
- **Site specific conditions including unknown ground conditions, UXO, buried utilities etc:** the option costs are suitably high level for the project and it was beyond scope to consider the site specific conditions of each area along the frontage. The optimism bias and risk uplifts applied to the option costs help to cover this uncertainty. However, it is likely that when schemes are designed and developed in more detail the costs will need to change to reflect site specific design decisions and construction approaches. In addition, specific legal / consenting / compensation costs are also not included in the cost estimates at this stage as these will be site specific and would need to be assessed during more detailed business case development.
- **Maintenance requirements:** costs for small scale defence maintenance have been included in the option costs. However, there is uncertainty around the future maintenance requirements as defence deterioration is not linear. For example, large amounts of damage can occur during stormy

periods and the frequency of this occurring is not predictable. Therefore, there is potential for maintenance costs in any given year to be more or less than the costs included in the costing.

- **Service life of existing / new defences:** in the whole life costing of options, it has been necessary to assume when defences may come to the end of their service life. For existing defences this has been based on information from the defence condition assessment, and for new defences design lives appropriate to the defence measure type have been assumed. However, the residual service life of existing defences or the design life of new defences will be impacted by the existing condition, frequency of storms, the amount of maintenance undertaken, and design decisions taken during scheme design. Each of these factors will impact when new defences are required and the timings for interventions assumed in the option costing is likely to change.

4.2 Option Benefits

The monetary benefits of each short list option have been calculated to facilitate the appraisal of the options in line with the FCERM-AG.

The monetary benefits have been calculated against the Do Nothing damages (on a national basis) presented in the Economic Baseline Report (AECOM, 2024 (c)) as these are the benefits that are eligible for inclusion as per FCERM-AG and the FCERM Partnership Funding criteria.

The first step to calculating the option benefits was to estimate the residual damages associated with flooding and erosion for each of the options. Once the residual damages were calculated, they were subtracted from the baseline Do Nothing damages to determine the economic benefits of the options.

Table 4-2 below outlines the approach to estimating the residual damages for the options.

Some of the options deliver the same outcomes and therefore have the same residual damages / benefits. These options have been grouped in the same benefit calculation / scenario.

During the subsequent development of an outline business case for FCERM options that are recommended from this project, there will be an opportunity to refine and improve the economic appraisal and potentially increase the benefits that the options are estimated to be delivering. It is recommended that the following aspects are considered:

- Update the erosion zones used in the economic assessment to consider local geology and the potential for catch-up erosion following defence failure. This could significantly increase the erosion zones and therefore increase the number of receptors at risk / potential benefits of the options.
- Collect traffic data for the coastal roads along the frontage to inform an updated calculated of road traffic damages.

Table 4-2: Summary of residual damage calculations

Benefit scenario	Short List Option(s) applied	Residual damage assumptions
Do Minimum	Hold the Line with Hard Defences: - Do Minimum Hold the Line with Beach Management: - Do Minimum Managed Realignment: - Do Minimum	- Small scale interventions to extend service life of defences. - Assume erosion damages would be delayed by 10 years compared to the baseline Do Nothing scenario, leading to the erosion damages occurring in year 20. - The erosion damages still occur but have more discounting applied, leading to an economic benefit. - The 10 year timing is based on the Environment Agency defence deterioration curves and expected increase in residual life when moving to a 'medium' maintenance regime rather than a 'low' maintenance regime.
Erosion Benefits	Hold the Line with Hard Defences: - Rock Revetment - Seawall Encasement Hold the Line with Beach Management: - Timber groynes with Beach Nourishment - Rock Fishtail Groynes with Beach Nourishment Managed Realignment: - Beach Nourishment - Sand Dune Establishment	- Assume defences would stop all erosion risk over the next 100 years - All erosion damages removed from the residual damages. - No flood risk benefit so full flood risk damages included in the residual damages.
Erosion and Flood Defence Benefits	Hold the Line with Hard Defences: - Rock Revetment with Setback Floodwall - Seawall Encasement with Setback Floodwall Hold the Line with Beach Management: - Breakwaters and Beach Nourishment - Timber groynes with Beach Nourishment and Setback Floodwall	- Assume defences would stop all erosion risk and flood risk up to high Standard of Protection (e.g. 1 in 200 year SoP) over the next 100 years. - All flooding and erosion damages removed from residual damages.

Benefit scenario	Short List Option(s) applied	Residual damage assumptions
	- Rock Fishtail Groynes with Beach Nourishment and Setback Floodwall Managed Realignment: - Beach Nourishment with Setback Floodwall - Sand Dune Establishment with Setback Floodwall	
Erosion and Property Level Resilience Benefits	Hold the Line with Hard Defences: - Rock Revetment with PLR - Seawall Encasement with PLR Hold the Line with Beach Management: - Breakwaters and Beach Nourishment and PLR - Timber groynes with Beach Nourishment and PLR - Rock Fishtail Groynes with Beach Nourishment and PLR Managed Realignment: - Beach Nourishment with PLR - Sand Dune Establishment with PLR	- Assume defences would stop all erosion risk over the next 100 years - All erosion damages removed from the residual damages. - PLR would not provide as high SoP as a new floodwall, therefore some flood damages would still occur. - Assumed PLR would provide an SoP < 1 in 20 years. Therefore all damages caused by flooding from 1 in 20 years return period or greater retained as an residual damage.
Partial Erosion Benefits	Hold the Line with Hard Defences: - Seawall Toe Protection	- With the toe protection option there is still a reliance on the existing seawall and a risk that it could fail in the future, leading to erosion. - The risk of failure is less than a situation without the toe protection but likelihood and timing uncertain. - To account for this risk, the full baseline Do Nothing erosion damages have not been removed and a residual erosion damage has been retained. - The residual erosion damage is based on baseline erosion damages in epoch 1, which have been applied as a residual damage by distributing evenly them between the years 20-99. - No flood risk benefit so full flood risk damages included in the residual damages.

Benefit scenario	Short List Option(s) applied	Residual damage assumptions
Partial Erosion Benefits and Flood Defence Benefits	Hold the Line with Hard Defences: - Seawall Toe Protection with Setback Floodwall	- As per the Partial Erosion Benefits approach outlined above, except setback floodwall would provide a high standard of flood protection (e.g. 1 in 200 year SoP) over the next 100 years. - All flooding damages therefore removed from residual damages.
Partial Erosion Benefits and Property Level Resilience Benefits	Hold the Line with Hard Defences: - Seawall Toe Protection with PLR	- As per the Partial Erosion Benefits approach outlined above, except PLR would provide some flood risk benefit. - PLR would not provide as high SoP as a new floodwall, therefore some flood damages would still occur. - Assumed PLR would provide an SoP < 1 in 20 years. Therefore all damages caused by flooding from 1 in 20 years return period or greater retained as an residual damage.

4.3 Cost-Benefit Comparison

Table 4-3 below presents the whole life option costs and benefits for the short list options. The average benefit cost ratio (ABCR) and net present value (NPV) are shown. The benefits used in the comparison are the nationally eligible benefits which do not include the local economic benefits such as tourism, Gross Value Added, council revenue from car parks etc.

As can be seen, on a national economic basis, many of the options have an ABCR less than unity and a negative NPV. However, if local economic benefits were to be included in the comparison, the economic case of the options improves significantly.

The options with an ABCR > 1 and a positive NPV are shaded in blue in the table. These options are taken forward for further appraisal for selecting the National Economic Leading Option. Options with an ABCR <1 are not viable from a National Economic perspective and have therefore been discounted from being selected as the National Economic Leading Option.

Table 4-3: Cost-Benefit Comparison of Options

Approach	Option	PV cost (£k)	PV damages (£k)	PV benefits (£k)	ABCR	NPV
Baseline	Do Nothing	0	19,958	0	-	-
Hold the Line Hard Defences	Do Minimum	1,946	17,689	2,269	1.17	323
	Seawall Toe Protection	12,721	12,426	7,532	0.59	-5,189
	Rock Revetment	19,421	10,169	9,789	0.50	-9,632
	Seawall Encasement	13,271	10,169	9,789	0.74	-3,482
	Seawall Toe Protection with Setback Floodwall	14,135	2,258	17,700	1.25	3,565
	Rock Revetment with Setback Floodwall	20,835	0	19,958	0.96	-877
	Seawall Encasement with Setback Floodwall	14,685	0	19,958	1.36	5,273
	Seawall Toe Protection with PLR	13,064	4,285	15,673	1.20	2,609
	Rock Revetment with PLR	19,765	2,028	17,930	0.91	-1,835
	Seawall Encasement with PLR	13,615	2,028	17,930	1.32	4,315
Hold the Line Beach Management	Do Minimum	2,131	17,689	2,269	1.06	138
	Timber Groynes with Beach Nourishment	20,570	10,169	9,789	0.48	-10,781
	Breakwaters with Beach Nourishment	26,159	0	19,958	0.76	-6,201
	Rock Fishtail Groynes with Beach Nourishment	21,647	10,169	9,789	0.45	-11,858
	Timber Groynes with Beach Nourishment and Setback Floodwall	21,984	0	19,958	0.91	-2,026
	Breakwaters with beach Nourishment and Setback Floodwall	26,826	0	19,958	0.74	-6,868
	Rock Fishtail Groynes with Beach Nourishment and Setback Floodwall	23,061	0	19,958	0.87	-3,103
	Timber Groynes with Beach Nourishment and PLR	20,914	2,028	17,930	0.86	-2,984

Approach	Option	PV cost (£k)	PV damages (£k)	PV benefits (£k)	ABCR	NPV
	Breakwaters with beach Nourishment and PLR	26,502	2,028	17,930	0.68	-8,572
	Rock Fishtail Groynes with Beach Nourishment and PLR	21,991	2,028	17,930	0.82	-4,061
Managed Realignment	Do Minimum	4,517	17,689	2,269	0.50	-2,248
	Beach Nourishment	18,867	10,169	9,789	0.52	-9,078
	Sand Dune Establishment	19,258	10,169	9,789	0.51	-9,469
	Beach Nourishment with Setback Floodwall	20,295	0	19,958	0.98	-337
	Sand Dune Establishment with Setback Floodwall	20,685	0	19,958	0.96	-727
	Beach Nourishment with PLR	19,217	2,028	17,930	0.93	-1,287
	Sand Dune Establishment with PLR	19,608	2,028	17,930	0.91	-1,678

Options arranged by NPV

Table 4-4 below presents a comparison of the options with an ABCR > 1 and a positive NPV. As per FCERM-AG, the options have been ordered according to the NPV and the option with the largest NPV has been identified as the provisional National Economic Leading Option. This option is the Seawall Encasement with Setback Floodwall option.

Table 4-4: Economic appraisal of options with ABCR > 1, arranged by NPV

Approach	Option	PV cost (£k)	PV benefits (£k)	ABCR	NPV	Provisional National Economic Leading Option
HTL Hard Defences	Seawall Encasement with Setback Floodwall	14,685	19,958	1.36	5,273	X
	Seawall Encasement with PLR	13,615	17,930	1.32	4,315	
	Seawall Toe Protection with Setback Floodwall	14,135	17,700	1.25	3,565	
	Seawall Toe Protection with PLR	13,064	15,673	1.20	2,609	
	Do Minimum	1,946	2,269	1.17	323	
HTL Beach Management	Do Minimum	2,131	2,269	1.06	138	

Table 4-5 and

Table 4-6 below provide two alternative ways of comparing the economic case of the options with an ABCR > 1. Both of the approaches identify the Seawall Encasement with Setback Floodwall option as

the Provisional National Economic Leading option which aligns with the comparison using the NPV in Table 4-4.

Options arranged by ABCR

Table 4-5 arranges the options by ABCR (highest to lowest). When ordered in this way, the incremental benefit cost ratio (IBCR) can often be used to assess whether there is an economic case to move to an option with a lower ABCR if it delivers more benefits but at a higher cost.

The IBCR is the difference in benefits between two options divided by the difference in cost between the two options. If an IBCR between two options is greater than 1 it indicates that the additional benefits created by the higher cost option are larger than the additional investment that would be required to deliver the option. An IBCR greater than 1 indicates that it would be economically favourable to deliver the higher cost option.

However, in this case, the IBCR cannot be calculated between the options as you move down the list because the benefits of the options reduce sequentially. The option with the highest ABCR (Seawall Encasement with Setback Floodwall) is therefore identified as the most economically favourable option.

Table 4-5: Economic appraisal of options with ABCR > 1, arranged by ABCR (highest to lowest)

Approach	Option	PV cost (£k)	PV benefits (£k)	ABCR	IBCR	Provisional National Economic Leading Option
HTL Hard Defences	Seawall Encasement with Setback Floodwall	14,685	19,958	1.36	-	X
	Seawall Encasement with PLR	13,615	17,930	1.32	NA	
	Seawall Toe Protection with Setback Floodwall	14,135	17,700	1.25	NA	
	Seawall Toe Protection with PLR	13,064	15,673	1.20	NA	
	Do Minimum	1,946	2,269	1.17	NA	
HTL Beach Management	Do Minimum	2,131	2,269	1.06	NA	

Options arranged by cost

In

Table 4-6 the options are arranged by increasing cost. As can be seen in this table, some of the options on adjacent rows have the same level of benefits and therefore the IBCR cannot be calculated between the options.

However, in Table 4-7 the options with equal benefits have been removed from the comparison. This enables the IBCR to be calculated sequentially between all options in the table. As can be seen, the IBCR between all options is greater than 1 indicating that in each case the additional benefits delivered by a higher cost option outweigh the increase in option cost. On this basis the Seawall Encasement

with Setback Floodwall option at the bottom of the list has the strongest economic case. The IBCR between this option and the Seawall Encasement with PLR option is 1.9.

Table 4-6: Economic appraisal of options with ABCR > 1, arranged by cost (lowest to highest)

Approach	Option	PV cost (£k)	PV benefits (£k)	ABCR	IBCR	Provisional National Economic Leading Option
HTL Hard Defences	Do Minimum	1,946	2,269	1.17	-	
HTL Beach Management	Do Minimum	2,131	2,269	1.06	NA	
HTL Hard Defences	Seawall Toe Protection with PLR	13,064	15,673	1.20	1.22	
	Seawall Encasement with PLR	13,615	17,930	1.32	4.10	
	Seawall Toe Protection Setback Floodwall	14,135	17,700	1.25	-	
	Seawall Encasement with Setback Floodwall	14,685	19,958	1.36	4.11	

Table 4-7: Economic appraisal of options with ABCR >1, omitting Seawall Toe Protection with PLR and Do Minimum (Hard Defences). Arranged by cost (lowest to highest)

Approach	Option	PV cost (£k)	PV benefits (£k)	ABCR	IBCR	Provisional National Economic Leading Option
HTL Beach Management	Do Minimum	2,131	2,269	1.06	-	
HTL Hard Defences	Seawall Toe Protection with PLR	13,064	15,673	1.20	1.23	
	Seawall Encasement with PLR	13,615	17,930	1.32	4.10	
	Seawall Encasement with Setback Floodwall	14,685	19,958	1.36	1.90	X

4.4 Considering Uncertainty

The main uncertainty with the economic appraisal is a potential increase in cost of an option arising from changes to costing assumptions, unforeseen site constraints or macro-economic factors. The option costs have suitable optimism bias / risk included for this stage of appraisal but there is still a possibility that costs could increase as more detail is developed during further appraisal and design.

To sensitivity test the impact of a cost increase, a generic 10% and 25% cost uplift has been applied to the Seawall Encasement options. The Seawall Encasement with Setback Floodwall option was identified as the provisional National Economic Leading Option in the analysis in Section 4.3.

Table 4-8 and Table 4-9 below show the updated NPV comparison for these sensitivity tests. With a 10% and 25% increase in cost, the ABCR for the Seawall Encasement with Setback Floodwall option remains above unity with ABCRs of 1.24 and 1.09 respectively.

A 10% increase in cost for the Seawall Encasement options does not change the choice of the provisional National Economic Leading Option with the Seawall Encasement with Setback Floodwall option still having the highest NPV and remaining the most economically advantageous option.

However, a 25% increase in cost of the Seawall Encasement options results in the Seawall Toe Protection with Setback Floodwall option having the strongest economic case. However, many of the construction elements of the Seawall Encasement options are similar to the Seawall Toe Protection options (i.e. sheet piling toe, concrete apron etc.) and in a scenario whereby the costs of the Encasement option were to rise, similar cost increases would also be expected to occur with the Seawall Toe Protection options.

On this basis, it is not recommended to change the choice of the National Economic Leading Option and therefore the Seawall Encasement with Setback Floodwall option is confirmed as the National Economic Leading Option.

Table 4-8: Sensitivity test of a 10% increase in cost of seawall encasement options. Options arranged by NPV

Approach		Option	PV cost (£k)	PV benefits (£k)	ABCR	NPV
HTL Hard Defences	Seawall Encasement with Setback Floodwall (+10% cost)	16,154		19,958	1.24	3,804
	Seawall Toe Protection with Setback Floodwall		14,135	17,700	1.25	3,565
	Seawall Encasement with PLR (+10% cost)	14,977	17,930		1.20	2,954
		Seawall Toe Protection with PLR	13,064	15,673	1.20	2,609
		Do Minimum	1,946	2,269	1.17	323
HTL Beach Management		Do Minimum	2,131	2,269	1.06	138

Table 4-9: Sensitivity test of a 25% increase in cost of seawall encasement options. Options arranged by NPV

Approach	Option	PV cost (£k)	PV benefits (£k)	ABCR	NPV
HTL Hard Defences	Seawall Toe Protection with Setback Floodwall	14,135	17,700	1.25	3,565
	Seawall Toe Protection with PLR	13,064	15,673	1.20	2,609
	Seawall Encasement with Setback Floodwall (+25% cost)	18,356	19,958	1.09	1,602
	Seawall Encasement with PLR (+25% cost)	17,019	17,930	1.05	911
	Do Minimum	1,946	2,269	1.17	323
HTL Beach Management	Do Minimum	2,131	2,269	1.06	138

4.5 National Economic Leading Option

The economic appraisal undertaken in the Sections above has identified the Seawall Encasement with Setback Floodwall option as the National Economic Leading Option.

Whilst this option is expected to significantly reduce the erosion risk and risk of flooding in the future, it is clear that this option will not achieve all of the aspirations and wider objectives for the frontage. For example, the option will do little to control the beach levels in the future and therefore the beach could be vulnerable to further erosion, particularly with sea level rise. This could lead to an impact to the amenity value of the beach and threaten tourism in the area.

On this basis a Local Aspirational Option has also been identified, as described in the next Section.

5. Wider Appraisal

It is recognised that the National Economic Leading Option (Seawall Toe Protection with Setback Floodwall) may not achieve all of the social and environmental aspirations for the frontage and therefore a wider appraisal of the options has been undertaken with the view to identifying a Local Aspirational Option.

As part of this wider appraisal, a social and environmental appraisal have been undertaken and covered in the Sections below.

5.1 Social Appraisal

5.1.1 Stakeholder Engagement Workshop

To inform the social appraisal, a stakeholder engagement workshop was held on 18th July 2024 to discuss the short list options with key stakeholders.

During the workshop the options were grouped into the following headings and roundtable conversations were held on each to gather feedback:

Minimum Intervention	Patch and repair
	Beach recycling
Seawall	Sheet piling toe protection
	Encasement
Beach Management	Groynes and beach nourishment
	Breakwaters and beach nourishment
Alternatives	Rock revetment
	Managed realignment
Combination Options	Setback floodwall
	Property Level Resilience (PLR)

The overall feedback was that the beach is a vital amenity for locals as well as tourists, and without the beach, there could be a loss of income and attractions within the town. The beach is currently accessible to all, and activities include walking along the promenade, dog walking on the beach, kite surfing, paddle boarding, family games and many social activities in groups of all sizes.

Several discussions were held on the ways in which Exmouth, Dawlish Warren and the Exe Estuary (including Pole Sands) interact, and it was suggested that the area should be studied as a whole in order to try and prevent any negative impacts from individual schemes.

Key feedback was that it would be potentially challenging to develop support from the local community for big changes to the coastal defences along the frontage.

Table 5-1 presents the key feedback collected from stakeholders during the engagement workshop.

Table 5-1. Key Stakeholder Feedback from Workshop.

Option	Feedback
Patch and Repair	This option represents a minimum intervention approach and would cause the least amount of inconvenience to the community. It is likely this option would be supported, although there may be a perception by stakeholders that it is insufficient on its own. There is concern that this approach would only provide a temporary solution rather than a long term fix. Concerns were raised about the viability of this option in terms of the cost of ongoing repairs. The listed section, Smeaton's Wall, may require this approach.
Beach Recycling	The general perception is that the community would like to keep the beach "as is" and would likely be receptive to this option. The beach is predominantly seen as an amenity, rather than a way to protect the seawall. Safety concerns were raised with regard to having plant on the beach, and there were mixed views as to the effectiveness of such an approach. It was acknowledged that, for this approach to be effective, there would need to be ongoing monitoring and studies in order to understand how the beach responds. It was noted that interaction with Dawlish Warren should also be considered. There were concerns over the quality and source of material for nourishment.
Seawall – sheet piling toe protection Seawall – encasement	This approach was viewed by some as Advance The Line rather than Hold The Line (the approach recommended by the Shoreline Management Plan). The main concerns were regarding cost and the uncertainty around foundation depths, making toe protection design difficult. Encasement was considered a "drastic" option. Applying these options to the entire length of the frontage was viewed as possible but unrealistic and costly. However, there would be opportunities for broader public realm enhancement to create a multi-use structure which is not just a wall.
Groynes and Beach Nourishment	Timber and rock groynes were discussed. Issues around access to the beach were raised, currently it is possible to walk the length of the beach, on the sand, with no barrier. Access for the RNLI lifeguard buggy would be impeded by new groynes. Access for the RNLI lifeboat would also need to be considered in design. Rock groynes could create capacity for wave run-up, which could lead to a need to raise the crest level of the seawall. Rocks could also create a potential health and safety concerns regarding people climbing on the rocks. Timber groynes are viewed as "typical British beach furniture" and would be an easier "sell" to the community than rock groynes. It was suggested that new groynes could provide markers for the area of beach designated for dogs during the months of restriction. Successful groynes would increase the sand held on the beach, but questions were asked around the impacts of increased levels of sand - whether this would lead to a requirement for dredging in the navigation channel, and whether this could lead to more sand being blown on to the road and subsequent additional costs for sand removal. Comments on beach nourishment were broadly similar to those noted above for beach recycling.

Option	Feedback
Breakwaters and Beach Nourishment	Many health and safety concerns were raised with this option, mainly around changes to the wave conditions and safety of swimmers and sailors. The Maer section of the frontage is seen as the safest place for young families to swim, and a breakwater of this design in that area would not be acceptable. Concerns include potential rip tides taking swimmers directly into the river currents – there is a complex pattern of strong currents off Exmouth. Such structures do not always perform as per models – an example was cited where sea level rise appears to have impacted the effectiveness of a similar structure. As with the rock groynes above, this could become a target for climbing. This option is costly, and it was noted that Natural England would be unlikely to approve this as a preferred option.
Rock Revetment	This option was seen by some as Advance The Line, and not Hold The Line (the approach recommended by the Shoreline Management Plan). It was considered that this would have a negative impact on the views and could impact tourist numbers. The footprint of this option would cause a loss of beach area, and this would be exacerbated by sea level rise. If a rock revetment was used in MU1 and the MU1 extension, it could deter swimmers from entering an area that is unsafe for bathing. Climbing on the rocks was considered a health and safety issue, as per other options above. Access to the beach was also a concern.
Managed Realignment	This option would involve moving not just the road, but many community amenities such as tennis courts and a cricket pitch. It is thought that there is nowhere within Exmouth for these to be relocated. Therefore, this is seen as hard to “sell” to the local community. The option is viewed as very costly and may not be accepted by a “very passionate community that care a lot about the seafront”. While the restoration of the dunes could be an attraction for visitors, there could be the loss of the solid promenade for visitors and locals to walk along the entire frontage. However, the sustainability of the dunes against sea level rise was questioned. Access to the RNLI station would need to be maintained. Sand dune restoration could involve the community (e.g. use of old Christmas trees). However, there is a local residents group that would like to remove the dunes, due to the amount of sand blown onto the road.
Setback floodwall	The key concern for this option is the height of the wall. Up to 0.5 m is seen as acceptable; any higher would be difficult to justify.

Option	Feedback
	Questions were raised on the effectiveness of the option, and whether it would stop flood waters draining back to the beach; whether it would help retain the sand / prevent windblown sand reaching the road; and whether the road will be at larger flood risk if drainage is insufficient. Both positive and negative views were shared on public safety. The wall would provide a barrier between cars and pedestrians but, depending on the height, it could provide something for children to climb on / walk along, potentially bringing them closer to danger from passing vehicles. Concerns were raised with regard to funding, in that this option may not be protecting sufficient numbers of properties / businesses in order to gain funding. This option would bring further hardening of the seafront, making future management more challenging.
Property Level Resilience (PLR)	While this option would be compatible with placemaking aspirations, the responsibility is on homeowners / business owners. An effective warning system would need to be in place, and tourists staying in properties (other than hotels) would need to know how and when to use these measures. PLR usually works best for low level flooding and is usually designed for non-saline environments. Seawater is a corrosive environment and assets would have a shorter life due to this, making it a more expensive option. It is potentially expensive for the homeowner / business owner as the maintenance costs could lie with them rather than the Council. This option does not cover erosion risk.

5.1.2 Social Appraisal

Based on the feedback received during the workshop a social appraisal of the short list options has been undertaken in Table 5-2. The options have been assigned a red, amber or green rating based on how well the option appears to align with the feedback and stakeholder aspirations:

- Red – option does not appear to align with stakeholder aspirations and feedback
- Amber – option partially aligns with stakeholder aspirations and feedback
- Green – option aligns with stakeholder aspirations and feedback.

Table 5-2: Social Appraisal

Approach	Option Rating	Comments
Baseline	Do Nothing	Option would lead to significant flood and erosion damages
Hold the Line Hard Defences	Do Minimum	Option would cause the least amount of inconvenience to the community in the short term but in the long term could lead to widespread erosion and damages if defences fail and increased risk of flooding.
	Seawall Toe Protection	Option would help reduce erosion risk to the promenade and properties. However, option would not manage beach levels and there is uncertainty, particularly in the future with sea level rise, as to the whether the amenity / tourism function of the beach could be retained.
	Rock Revetment	This option would have a large footprint on the beach and therefore a negative impact on both the amount of beach available for use and the visual aesthetics of the beach. There are safety concerns with regard to people climbing on the rocks.
	Seawall Encasement	Option would safeguard the promenade and properties against erosion risk. However, option would not manage beach levels and there is uncertainty, particularly in the future with sea level rise, as to the whether the amenity / tourism function of the beach could be retained. Opportunities to incorporate public realm enhancements into the design.
	Seawall Toe Protection with Setback Floodwall	In addition to the comments above on the seawall toe protection, rock revetment and seawall encasement, there are likely to be mixed views on a setback floodwall. Whilst the defence would reduce flood risk to properties there are likely to be concerns about the height and impact on the visual landscape.
	Rock Revetment with Setback Floodwall	
	Seawall Encasement with Setback Floodwall	
	Seawall Toe Protection with PLR	In addition to the comments above on the seawall toe protection, rock revetment and seawall encasement, PLR could have mixed views from stakeholders and the local community. PLR is likely to have less of a visual impact than a setback floodwall and therefore may be more supported by the general public. However, the PLR will not provide the same standard of protection and therefore may not be favoured by the owners of the properties at risk of flooding.
	Rock Revetment with PLR	
	Seawall Encasement with PLR	
Hold the Line Beach Nourishment	Do Minimum	Option would likely lead to little disruption to the community in the short term but in the long term could lead to widespread erosion and damages if defences fail and increased risk of flooding.
	Timber Groynes with Beach Nourishment	Timber groynes and beach nourishment would aim to manage beach levels and help to ensure the beach can continue to provide both a flood and erosion defence function but also an amenity / tourism function for the area. Of the beach control

Approach	Option Rating	Comments
		structures considered, timber groynes are likely to be most supported by the community and key stakeholders due to having a typically smaller defence footprint and being a typical feature of the area already (Queens Drive East has timber groynes on the beach). However, there is some uncertainty as to how effective timber groynes would be at Exmouth in retaining beach material.
	Breakwaters with Beach Nourishment	It is unlikely that breakwaters would be supported by the local community or key stakeholders for a variety of reasons. A key concern with this option is a safety concern around the potential for strong currents and the impact this could have on swimming. In addition, there would be risks associated with climbing on the structure. The breakwaters would also be very large structures which would change the character of the beach and could impact on the amenity function / tourism value of the area.
	Rock Fishtail Groynes with Beach Nourishment	Rock fishtail groynes would aim to manage beach levels and help to ensure the beach can continue to provide both a flood and erosion defence function but also an amenity / tourism function for the area. In comparison to timber groynes, fishtail groynes are more likely to be effective in the management of cross shore transport but would have a larger defence footprint and there may be concerns around safety risks of climbing on the rocks.
	Timber Groynes with Beach Nourishment and Setback Floodwall	In addition to the comments above on the timber groynes, breakwaters and rock groynes, there are likely to be mixed views on a setback floodwall. Whilst the defence would reduce flood risk to properties there are likely to be concerns about the height and impact on the visual landscape.
	Breakwaters with beach Nourishment and Setback Floodwall	
	Rock Fishtail Groynes with Beach Nourishment and Setback Floodwall	
	Timber Groynes with Beach Nourishment and PLR	In addition to the comments above on the timber groynes, breakwaters and rock groynes, PLR could have mixed views from stakeholders and the local community. PLR is likely to have less of a visual impact than a setback floodwall and therefore may be more supported by the general public. However, the PLR will not provide the same standard of protection and therefore may not be favoured by the owners of the properties at risk of flooding.
	Breakwaters with beach Nourishment and PLR	
	Rock Fishtail Groynes with Beach Nourishment and PLR	
Managed Realignment	Do Minimum	Based on the feedback received to date, it is unlikely that any of the Managed Realignment options would be supported by the local community or the majority of key stakeholders. Managed Realignment is considered to be too disruptive to the local community and businesses.
	Beach Nourishment	
	Sand Dune Establishment	
	Beach Nourishment with Setback Floodwall	
	Sand Dune Establishment with Setback Floodwall	
	Beach Nourishment with PLR	

Approach	Option Rating	Comments
	Sand Dune Establishment with PLR	

In summary:

- The rock revetment options are unlikely to be supported by key stakeholders and the community due to safety concerns (i.e. climbing on rocks), visual impact, loss of beach space and potential negative impact on tourism.
- The breakwater options are unlikely to be supported by key stakeholders and the community due to safety concerns (i.e. potential for strong currents and risk of climbing) and the significant change to the character of the beach / frontage that it would bring.
- Each of the Managed Realignment options are also unlikely to be supported by key stakeholders and the community, regardless of the defence measures that would be used to implement this approach. Managed Realignment is considered to be too disruptive as it may involve moving key features of the area such as the road and other facilities and there is generally a lack of space to do this.
- The seawall toe protection / seawall encasement options are likely to have partial support as they would defend the area from erosion and there would also be opportunities to incorporate public realm enhancements (particularly with the encasement option). However, the options would not help control the beach material in the future with sea level rise and therefore the long term viability of the beach as an amenity / tourism area is uncertain.
- The setback floodwall and PLR options are likely to have some support, depending on which of the other options they are paired with.
- The groyne options (timber groyne / fishtail rock groynes) with beach nourishment would be expected to help control beach levels so that the beach can continue to provide an amenity function and attract tourism to the area. However, there is some uncertainty as to how effective groynes would be in this location (see Section 3.2.2). Timber groynes are likely to be better supported from a health and safety and visual perspective from the local community.

5.2 Environmental Appraisal

A high-level environmental appraisal of the short list options has been undertaken and is presented in Table 5-3. The options have been assigned a red, amber or green rating across three environmental categories; landscape / built environment, natural environment and carbon.

- Red – option is likely to lead to significant negative impacts
- Amber – option likely to have neutral impact (some negative impacts / some positive impacts)
- Green – option is unlikely to have significant negative impacts / could have positive impacts.

The appraisal has been informed by the project team's understanding of the environmental features at the site and preliminary input from Habitats Regulation Assessment (HRA) specialists.

A detailed HRA, Marine Conservation Zone (MCZ) Assessment and Water Framework Directive (WFD) Assessment are currently being undertaken and the environmental appraisal can be updated following the findings of these assessments (notably once the Stage 2 HRA is complete).

Table 5-3: Environmental Appraisal

Approach	Option	Landscape / Built Environment	Natural Environment	Carbon
Baseline	Do Nothing			
Hold the Line Hard Defences	Do Minimum			
	Seawall Toe Protection			
	Rock Revetment			
	Seawall Encasement			
	Seawall Toe Protection with Setback Floodwall			
	Rock Revetment with Setback Floodwall			
	Seawall Encasement with Setback Floodwall			
	Seawall Toe Protection with PLR			
	Rock Revetment with PLR			
	Seawall Encasement with PLR			
Hold the Line Beach Nourishment	Do Minimum			
	Timber Groynes with Beach Nourishment			
	Breakwaters with Beach Nourishment			
	Rock Fishtail Groynes with Beach Nourishment			
	Timber Groynes with Beach Nourishment and Setback Floodwall			
	Breakwaters with beach Nourishment and Setback Floodwall			
	Rock Fishtail Groynes with Beach Nourishment and Setback Floodwall			
	Timber Groynes with Beach Nourishment and PLR			
	Breakwaters with beach Nourishment and PLR			
	Rock Fishtail Groynes with Beach Nourishment and PLR			
Managed Realignment	Do Minimum			
	Beach Nourishment			
	Sand Dune Establishment			

Approach	Option	Landscape / Built Environment	Natural Environment	Carbon
	Beach Nourishment with Setback Floodwall			
	Sand Dune Establishment with Setback Floodwall			
	Beach Nourishment with PLR			
	Sand Dune Establishment with PLR			

In summary:

- The rock revetment options are likely to lead to significant negative impacts across the three categories considered. The revetment would be a large structure with a considerable defence footprint which would change the character / beach setting and visual landscape. From a natural environment perspective, the large defence footprint would lead to a significant loss of designated site but this may not be of major concern as being at the top of the beach this area is unlikely to be a key part of the designation and may not contain the designated habitat. Subject to the source location, importing rock to Exmouth could be carbon intensive and lead to a high carbon footprint of the option.
- The breakwater options are also likely to lead to significant negative impacts across the three categories considered. Breakwaters would be large structures with considerable defence footprint which would take up beach space and change the character / beach setting and visual landscape. The breakwaters would also be expected to significantly alter the coastal processes of the beach and also likely to the surrounding area, including the navigation channel.
- The seawall toe protection / encasement options would have a much smaller defence footprint than the rock revetment and therefore would likely be more favourable from both a landscape / built environment and natural environmental perspective. The seawall toe protection and encasement would lead to minimal encroachment and would not be expected to alter the coastal processes of the beach and therefore would not be expected to have an impact on the natural environment. The seawall encasement option also has opportunities to incorporate public realm improvements into the design such as tiered seating.
- The groyne options (timber groynes / fishtail rock groynes) with beach nourishment are likely to have an impact on the natural environment and would also likely have a significant carbon footprint (subject to the sourcing of beach material and sourcing of timber / rock). There could be potential to reuse timber or rock from elsewhere in the UK which would improve the sustainability of these options (a recent example of reuse of timber is at Ventnor, Isle of Wight which has reused used timber from Bournemouth). For the natural environment, the construction of groynes is likely to result in general changes to the coastal processes which could impact the SAC habitat. Timber groynes are likely to be more in-keeping with the landscape / built environment given there are already timber groynes located along the frontage at Queens Drive East.
- A new setback floodwall is likely to lead to landscape / built environment impacts, the degree to which will be dependent on the height and alignment of the wall in relation to the receptors. PLR is unlikely to lead to significant impacts across the environmental categories considered.
- The Managed Realignment options are likely to have variable impacts depending on the approach. The creation of sand dunes has the potential to improve biodiversity and create new habitats and also soften the landscape which could be favourable.

  All options are likely to lead to some disturbance during construction, but this can likely be mitigated with appropriate construction timings.

6. Leading Option Selection and Funding

6.1 National Economic Leading Option

As outlined in Section 4, the economic appraisal of options has identified the Seawall Encasement with Setback Floodwall option as the National Economic Leading Option.

Whilst this option is expected to significantly reduce the erosion risk and risk of flooding in the future, it is clear that this option will not achieve all of the aspirations and wider objectives for the frontage. Primarily the option would not help to manage beach levels in the future. The beach is very dynamic and with sea level rise there is a risk that significant erosion of the beach could occur, reducing the attraction of the beach for amenity and tourism purposes.

It has therefore been appropriate to identify a Local Aspirational Option which would deliver broader benefits should it be delivered (subject to funding).

6.2 Local Aspirational Leading Option

The results of the wider appraisal in Section 5 can be used to identify a Local Aspirational Option for the frontage.

Tourism is a key driver of the local economy and therefore a key objective of the frontage is to maintain a beach that can be used for amenity and recreation purposes and help to attract visitors and tourism to the area. An Exmouth visitor survey was undertaken for East Devon District Council in 2016 by The South West Research Company Ltd. The research indicated that in 2015 Exmouth attracted approximately 421,000 staying visits from the UK and overseas visitors combined with approximately 2.9million day visits. This was estimated to generate £183million worth of visitor spend in the local economy.

This was emphasised in the Stakeholder Engagement Workshop in which the key feedback was that the beach is a vital amenity for locals as well as tourists, and without the beach, there could be a loss of income and attractions within the town. The beach is currently accessible to all, and activities include walking along the promenade, dog walking on the beach, kite surfing, paddle boarding, family games and many social activities in groups of all sizes.

The short list options that would help to manage the beach and improve its resilience to sea level rise are:

- Timber groynes with Beach Nourishment
- Rock fishtail groynes with Beach Nourishment
- Breakwaters with Beach Nourishment.

Of these options, the Breakwaters with Beach Nourishment option is likely to provide the most control on cross shore beach sediment transport and provide the greatest stability to the beach. However, this option is the most costly and it is not likely to be supported by the local community or key stakeholders due to safety concerns (e.g. changes to currents in swimming areas, climbing risks, navigation impacts, etc.) and the significant change in beach character and visual impact that it could lead to.

From an environmental perspective, with the Breakwaters option there is potential for significant encroachment into environmental designation areas and changes to the coastal processes which could impact the Exe Estuary Ramsar / SPA / SSSI sites as well as the Dawlish Warren SAC / SSSI habitat. The option may also be technically challenging to deliver due to the close proximity of the navigation channel to the beach at the western end of the Maer which could restrict the distance offshore the breakwaters could be placed or result in the navigation channel changing position. For these reasons it is not recommended that the Breakwaters with Beach Nourishment option is taken forward as a Local Aspirational Option at this stage.

The Timber Groynes with Beach Nourishment option and the Rock Fishtail Groynes with Beach Nourishment option are likely to be more deliverable and would likely have more support from key stakeholders and the local community. It is therefore recommended that these options are taken forward as Local Aspirational Leading Options.

Of these options, the Timber Groynes with Beach Nourishment option is likely to have most support, with stakeholder feedback from the workshop indicating that timber groynes were considered a typical British beach feature. Consideration for continued access for the RNLI lifeboat and buggy would be needed as part of the design.

From an environmental perspective, both the groyne options would likely be more favourable for the environmental designations than breakwaters but would still have an impact on coastal processes that would need to be considered. Design of the groynes should aim to minimise habitat loss in the intertidal zone and the timber groyne option is likely to have a smaller footprint to enable this.

As noted in Section 3.2.2, there is uncertainty as to how effective groynes would be in stabilising the beach at Exmouth due to the limited control they provide to cross shore sediment transport. The rock fishtail groynes would likely provide more control on cross shore transport but it is recommended that detailed sediment transport modelling is undertaken during design to confirm groyne type, layout and size, alongside further stakeholder engagement to more-fully understand concerns / acceptability of the two groyne-type options. Both of the timber and rock groyne approaches have therefore been recommended as a Local Aspirational Option with the exact approach to be decided during subsequent design work.

It is recommended that a setback floodwall is included with either of the groyne options as part of the Local Aspirational Options to ensure the options deliver flood risk benefits. As discussed in Section 3.1.5, further thought as to the timing, height and finish of such a structure would be required during a more detailed appraisal and design.

Table 6-1 summarises the key details of the breakwater and groyne short list options.

Table 6-1: Details of Breakwater and Groyne with Beach Nourishment options

Breakwaters with Beach Nourishment	Timber Groynes with Beach Nourishment	Rock Fishtail Groynes with Beach Nourishment
- Unlikely to achieve key stakeholder and community support due to safety concerns associated with strong currents and could also significantly change the character of the beach frontage.	- Timber groynes likely to lead to the least significant change to the landscape and character of the beach frontage of the three options.	- Rock structures on the beach likely to lead to significant changes to the character of the beach but less so than nearshore breakwaters.
- Likely to lead to significant encroachment in intertidal habitat designations and potential to alter coastal processes, impacting the designations.	- Timber groynes likely to have the smallest defence footprint of the three options and therefore encroach into intertidal habitat areas the least. However, still potential for coastal processes impacts that will need to be considered fully in HRA.	- Rock fishtail groynes will have a larger defence footprint than timber groynes and lead to more encroachment. There will also be potential for coastal processes impacts that will need to be fully considered in the HRA.
- Most costly of the short list options considered.	- Uncertainty as to the effectiveness of timber groynes in stabilising the beach because timber groynes unlikely to provide much control of cross shore transport processes.	- Uncertainty as to the effectiveness of rock fishtail groynes in stabilising the beach. However, the fishtail part of the structures will provide some control on cross shore sediment transport so likely to be more effective than timber groynes in stabilising the beach.
- Not recommended as a Local Aspirational Leading Option	**- Recommended as a Local Aspirational Leading Option,** with further refinement and numerical modelling to be undertaken during design development to confirm effectiveness and inform choice of timber or rock groynes.	**- Recommended as a Local Aspirational Leading Option,** with further refinement and numerical modelling to be undertaken during design development to confirm effectiveness and inform choice of timber or rock groynes.

As outlined in Section 4, on a national basis the economic case of the Local Aspirational Leading Options (Timber Groyne with Beach Nourishment and Rock Fishtail Groyne with Beach Nourishment) are poor, with both options having an ABCR less than unity. However, both of these options would be expected to provide more stability and better control of the beach in the future, helping to preserve and enhance the amenity function of the beach and continue to attract tourism to the area. Therefore, both of these options are likely to deliver a range of benefits to the local economy which, when considered, would significantly improve the economic case of the options on a local basis.

Table 6-2 below presents the national and local economic case of the Local Aspirational Options. As can be seen, the local economic benefits far outweigh the cost of the options with estimated benefit-cost ratios for the local economy greater than 9. It should be noted that not all of the local economic benefits are directly related to the beach (for example, GVA impacts and car park income are related to erosion of the land rather than the beach) so will also be applicable to the National Economic Option.

Table 6-2: Economic case of Local Aspirational Options

Option	PV Cost (£k)	National Economic Benefits (£k)	National Economic ABCR	Local Economic Benefits (£k)*	Local Economic ABCR
Timber Groynes with	21,984	19,958	0.91	210,724 – 618,713	9.58 – 28.14

Option	PV Cost (£k)	National Economic Benefits (£k)	National Economic ABCR	Local Economic Benefits (£k)*	Local Economic ABCR
Beach Nourishment and Setback Floodwall					
Rock Fishtail groynes with Beach Nourishment and Setback Floodwall	23,061	19,958	0.87	210,724 – 618,713	9.14 – 26.83

**Low range of local economic benefits estimated by combining: GVA, welfare value of coastal recreation, physical health, car park income and beach hut income categories.*

**Upper range of local economic benefits estimated by combining: Visitor economy / tourism, welfare value of coastal recreation and physical health categories.*

6.3 Funding

A Partnership Funding Assessment has been undertaken to estimate the amount of government FCERM GiA funding that could be available for the National Economic Leading Option (Seawall Encasement with Setback Floodwall).

The funding assessment is based on the major capital scheme for the option which would involve encasing the seawall and constructing phase 1 of the setback floodwall. In the option appraisal this scheme was assumed to occur in year 10 to allow sufficient time for appraisal, design and to obtain funding. However, for the purpose of the funding assessment the scheme is assumed to occur in year 0 (i.e. the baseline year has been reset to the time of delivering the scheme). This removes the discounting of the initial scheme cost and gives a better representation of the amount of funding that would be needed to deliver the schemes in 10 years' time. Discounting is still applied to maintenance costs after scheme construction, albeit at a reduced rate as all interventions have effectively been brought forward by 10 years relative to the baseline.

Table 6-3 shows the Partnership Funding score for the scheme, the indicative amount of FCERM GiA that could be available for the upfront costs, and the funding amount that would need to be secured from non-GiA sources to deliver the scheme.

As can be seen, the amount of FCERM GiA that is expected to be available for the initial scheme costs is £849k. However, over £17.5million of funding would be required from non-GiA sources to cover the remainder of the upfront scheme cost. Non-GiA funding would also be required for maintenance after construction. This leads to a raw Partnership Funding score of 5%. It is noted that this is very similar to the Partnership Funding score which was generated in the Strategy Appraisal Report for the Exe Estuary Flood and Coastal Erosion Risk Management Strategy (2013) for the Maer frontage (which broadly covers the same areas as the BMP). In this strategy, this area had a partnership funding score of 5%, with GIA contributions of approximately £300k.

Table 6-3: Indicative Partnership Funding Assessment

Option	Initial scheme cost (£k)	PV Maintenance cost (£k)	PV Total cost (£k)	National Economic Benefits (£k)	Duration of Benefits	PF score	Indicative GiA available (up front costs) (£k)	Indicative shortfall / funding required for upfront scheme to obtain GiA (£k)
Seawall Encasement with	18,416	659	19,075	23,768	90	5%	849	17,567

Option	Initial scheme cost (£k)	PV Maintenance cost (£k)	PV Total cost (£k)	National Economic Benefits (£k)	Duration of Benefits	PF score	Indicative GiA available (up front costs) (£k)	Indicative shortfall / funding required for upfront scheme to obtain GiA (£k)
Setback Floodwall								

The amount of FCERM-GiA funding that would be available for either of the Local Aspirational Options would be no more than the amount available for the National Economic Leading Options. The additional cost required to deliver the Local Aspirational Options would therefore need to be funded by non-GiA sources. Table 6-4 below outlines the funding amounts required for the major initial schemes as part of the Local Aspirational Options.

Similar to the National Economic Leading Option, in the option appraisal the initial schemes for the Local Aspirational Options were assumed to occur in year 10 to allow sufficient time for appraisal, design and to obtain funding. However, for the purpose of the funding assessment the schemes are assumed to occur in year 0 (i.e. the baseline year has been reset to the time of delivering the scheme). This removes the discounting of the initial scheme cost and gives a better representation of the amount of funding that would be needed to deliver the schemes in 10 years' time. Discounting is still applied to maintenance costs after scheme construction, albeit at a reduced rate as all interventions have effectively been brought forward by 10 years relative to the baseline.

Table 6-4: Outline of funding for Local Aspirational Options

Option	Scheme cost (£k)	Maintenance cost (£k)	PV Total cost (£k)	Indicative GiA available (up front costs) (£k)	Indicative shortfall / funding required for upfront scheme to obtain GiA (£k)
Timber Groynes with Beach Nourishment and Setback Floodwall	21,714	7,005	28,719	849	20,865
Rock Fishtail groynes with Beach Nourishment and Setback Floodwall	23,913	6,364	30,227	849	23,064

As shown in Table 6-3 and Table 6-4, FCERM GiA funding is only expected to cover a very small proportion of the overall scheme costs for either of the National Economic or Local Aspirational Options. The non-GiA funding requirements for the upfront scheme costs are significant (in excess of £20m) and further funding would also be required for ongoing maintenance costs. It is uncertain if this amount of funding could be secured and therefore a Backup Option has been identified as an alternative approach should funding not be available.

6.4 Backup Option

Of the options that have an ABCR greater than unity (on a national basis), the Do Minimum options (Hold The Line with hard defences or Hold the Line with Beach Management) have the lowest cost and funding gap and are likely to be the most deliverable options in the short term. Both options have similar costs and the same benefits delivered (on a national basis).

The Do Minimum option (Hold the Line with hard defences) would be a continuation of the existing management approach for the frontage and therefore this option has been identified as the Backup Option. This option would involve undertaking reactive patch-repairs to the existing seawall and groynes as required.

It should be recognised that with this approach, despite further maintenance, due to the ageing seawall and vulnerability of the structure to undermining, the risk of seawall failure would increase in the future. The residual risk of flooding and erosion would also increase over time with this approach and the defences cannot be patch-repaired indefinitely. A defence failure could happen in the future as there may not be sufficient funding to keep defences in a reasonable condition and to stop defences from failing. The costs of the option could exceed the estimates if a substantial defence failure were to occur that led to emergency repair works being needed.

The Do Minimum option should not be thought of as a long term solution to managing the risks along the frontage as it is not feasible to continue to rely on the existing defences indefinitely. However, whilst not a long term solution, implementing the Do Minimum option in the short term would provide additional time for the project team to seek non-GiA funding to deliver either the National Economic or Local Aspirational Options.

The Do Minimum approach would not involve a large scale capital scheme and therefore funding for the patch-repair maintenance of the defence structures would likely need to come from EDDC maintenance budgets or applications for emergency funding from central government. The amount of funding that can be found will determine how much maintenance could be undertaken.

7. Summary and Next Steps

This report details the appraisal process to identify the draft proposed Leading Options for the Exmouth BMP frontage. The appraisal has considered economic, funding, environmental and social factors and recommends the following draft proposed Leading Options:

- National Economic Leading Option: Seawall Encasement with Setback Floodwall option
- Local Aspirational Leading Option(s): Timber Groynes with Beach Nourishment or Rock Fishtail Groynes with Beach Nourishment
- Backup Option: Do Minimum (Hold the Line with hard defences).

There remains a range of uncertainties in delivering the proposed Leading Options, such as:

- Funding availability: (significant non-GiA funding is required to deliver either the National Economic or Local Aspirational options)
- Effectiveness of groynes in stabilising the beach: given the dynamic nature of the beach and the role of cross shore transport in moving beach material during storms it is not certain how effective groynes will be in stabilising the beach. However, the alternatives, such as breakwaters are not considered to be feasible in this location. In order for the Local Aspirational Options to be progressed, there will need to be more detailed work, including numerical modelling, to improve confidence and input to the groyne and beach design process.
- Environmental compliance: a Habitats Regulations Assessment (HRA), Water Framework Directive Assessment (WFD) and Marine Conservation Zone (MCZ) Assessment are currently being undertaken on the draft Leading Options. These assessments will outline the potential impacts of the options and will determine whether any changes to the options or mitigation measures are required. The draft findings of the assessments are summarised below:
  - The MCZ screening assessment concluded that there is no significant risk to the designated features or conservation objectives of Otter Estuary and Torbay MCZ because of the project. As such, a MCZ Stage 1 assessment is not considered to be required.
  - The WFD assessment concluded that there are potential impacts on waterbodies within the study area, however, they are anticipated to be minimal and temporary for the most part. Where potential impacts have been identified, mitigation has been proposed to negate these impacts and can be further reduced with sensitive construction techniques and reference to the Environment Agency's Pollution prevention for business guidance. Impacts resulting from construction are unlikely to cause permanent change in the ecological potential of the waterbody.
  - The HRA screening assessment indicates that all three leading options have potential to result in likely significant effects and it is recommended that a Stage 2 Appropriate Assessment is completed.

The next step of the appraisal will be to undergo a period of consultation on the draft proposed Leading Options, including with members of the public. Following the consultation period, the feedback will be collated, and the Leading Options updated accordingly. Once the HRA Stage 2 Assessment is completed then the environmental appraisal in section 5.2 of this report can also be updated, as appropriate.

Following this project, when delivering the options in the future, further design and consultation work would be undertaken with key stakeholders and the community to agree on alignments and details such as visual finish of structures (likely to be important for both the National and Local Aspirational Options) and access requirements (for example for the RNLI etc.).

8. References

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