Sandown Bay Initial Appraisal and Scheme Identification Study

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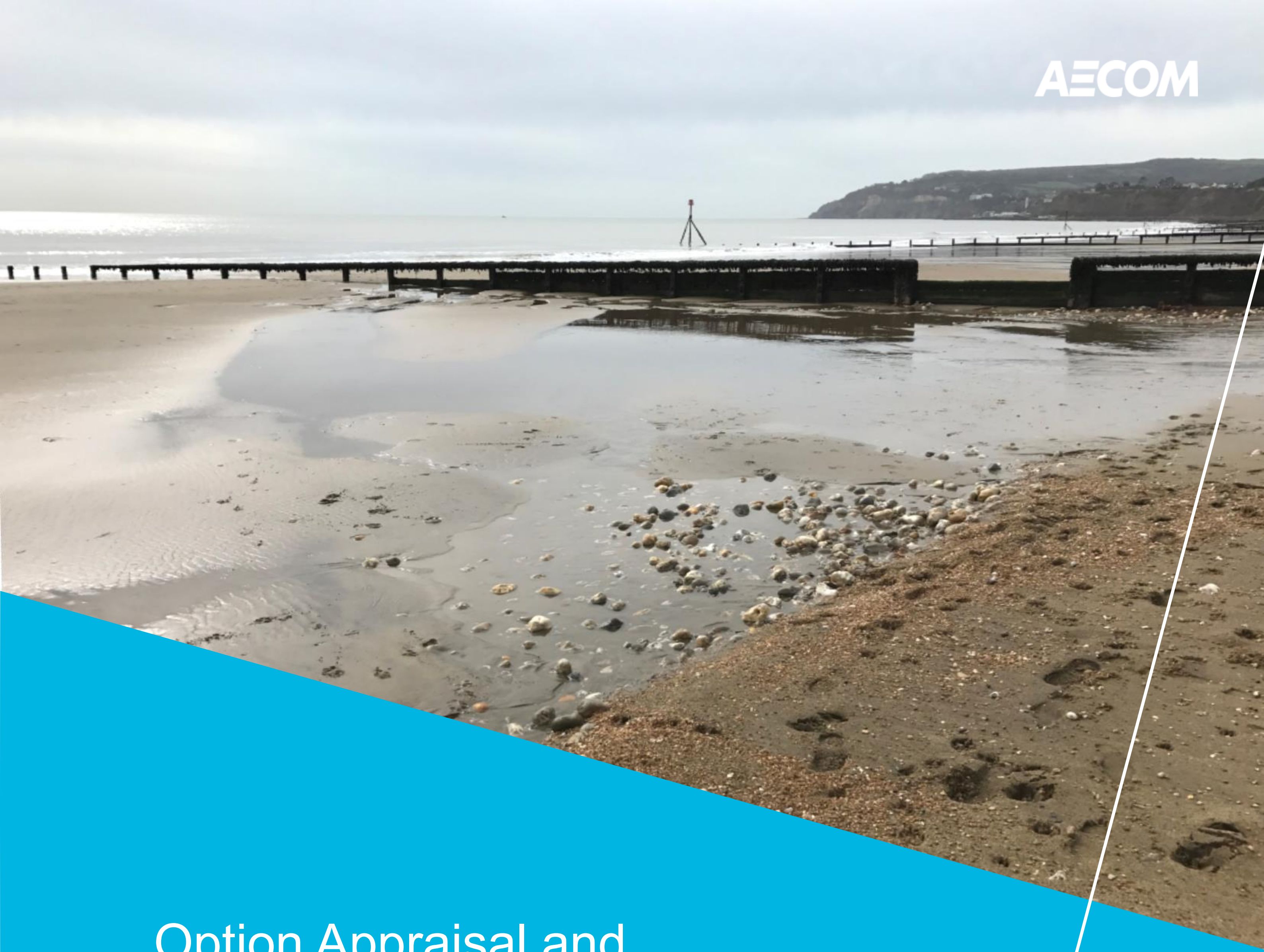

Option Appraisal and Scheme Identification Report

Sandown Bay Initial Appraisal and Scheme Identification Study

Isle of Wight Council

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2019

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Quality information

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1. Introduction

1.1 Background

AECOM Infrastructure and Environment UK Limited was appointed by Isle of Wight Council to undertake an initial appraisal and scheme identification study for Sandown Bay and Embankment Road.

This study appraises management options to identify and recommend future schemes for the frontage which faces significant risks. Along this eroding coastline the existing defences are deteriorating and properties and assets along the frontage are at risk from erosion and flooding.

The existing defences are a combination of seawalls and groynes, originally designed to provide back stop protection and beach control. The defences are deteriorating and in some locations the groynes are in a very poor condition. There is a prominent erosion risk and the flood risk is expected to develop in the future so without timely renewal, significant asset losses can be expected in the future.

1.2 Purpose of this report

This technical report describes the process of identifying the preferred options and priority schemes for managing the flood and erosion risk along the study frontage. This includes proposals to reduce flood risk to over 600 properties and reduce erosion risk to over 600 properties.

This report has been developed and informed by an option appraisal workshop that was undertaken in June 2017 which was attended by members of the project team. In addition, the evidence collected in the Coastal Processes Report, the Defence Condition Report and further work undertaken during this phase of the study, including additional flood modelling and an economic assessment, has informed this stage of the project. The Isle of Wight Shoreline Management Plan (2010), which recommends a hold the line policy for the majority of the frontage, was also reviewed and this study builds on this plan and appraises the management options available to implement the SMP. Early public consultation fed into the development of this report and the preferred approaches, and consultation with key stakeholders on the draft outcomes has also fed into this final report.

1.3 Overview of the study area

The study area comprises a 5.8km frontage at Sandown Bay and also includes the Eastern Yar Valley and a 1.5km section at Embankment Road at Bembridge, Isle of Wight (Figure 3-1). Sandown Bay is located on the east coast of the island whilst Embankment Road is located behind Bembridge Harbour on the north-east coast of the island. It is necessary to consider both areas within the study because the sites are linked, from a flood risk perspective, by the Eastern Yar Valley which forms a coherent tidal flood cell. The economic benefits of reducing the flood risk can therefore only be obtained by protecting the flood cell from both ends; at both Sandown and Embankment Road.

The Sandown Bay frontage extends from Yaverland to Shanklin, comprising study units IW21-IW28 (Figure 3-1). The Shoreline Management Plan (SMP) policy for this area is to 'Hold the Line' as the entire length of the Sandown frontage is vulnerable to erosion. The defences along the frontage comprise a combination of seawalls and groynes which help trap littoral sediment and maintain beach levels. These defences currently mitigate the erosion risk but are ageing and in variable condition. In some locations, such as within IW26 & parts of IW27 (Lake to Shanklin) there are some areas where beach levels have fallen over the past decade, although there is variation in the beach level trends within the Bay including localised areas of erosion, no significant change and accretion in different groyne bays. Further information is provided in the Coastal Processes Baseline Report. Without timely renewal of the deteriorating defences, significant asset losses are anticipated in the future.

The Sandown to Shanklin frontage is also a popular tourist and amenity area with the long sandy beach, esplanade, and key assets a key attraction for visitors. In the north of the area between Yaverland and Sandown the hinterland behind the frontage is low lying. In the south of the area at Lake and Shanklin where the promenade is backed by steep ferruginous sandstone cliffs, up to 35m high. Cliff falls occur regularly in this area with the potential to endanger life below, damage beach huts/cafes, restrict property access, and occasionally damage more substantial property and regularly cut off footpath access along the cliff top and cliff foot.

There are significant numbers of properties and assets at risk from tidal flooding within the Eastern Yar floodplain, especially on the outskirts of Sandown.

The present deteriorating defences of seawalls and groynes are linked; the seawalls benefit from functioning of the groynes through retaining beach material to help protect the wall foundations. Work reported in the Coastal Processes Report for the study shows a net north-eastward longshore drift within the bay, and the undefended cliffs at Luccombe to the south of the Shanklin frontage provide a source and continual supply of beach feeding materials to the down drift frontages to their north.

The Embankment Road frontage extends 1.5km along Embankment Road, between Bembridge and St. Helens, comprising study unit IW15. The embankment was originally constructed for a railway route, reclaiming the land behind it to create Brading Marshes. The marshes are now a designated SSSI and form part of the Solent and Southampton Water Ramsar and SPA. The embankment is approximately 10m wide at its narrowest point. The seaward face of the embankment includes some localised protection works such as sandbags, stone and concrete blockwork.

1.4 Structure of this report

The option appraisal process has followed the Environment Agency's Flood and Coastal Erosion Risk Management Appraisal guidelines (FCERM-AG, 2010).

This report is split into the following chapters:

2. Option Development Approach; the approach to developing and appraising the options is explained;
3. Study units - an overview of the study units and their location;
4. Local Measures (long list); a long list of measures to implement the management options considered in the appraisal, for example seawalls, revetment, groynes, crest raising etc.
5. Management options (short list); the high level management options considered in the appraisal and in different study units;
6. Option Development; development of options on a unit basis. Composition of a short list and identification of the different measures which could be used to implement the different management options;
7. Appraisal of shortlist options; economic costs and benefits, environmental and social impacts;
8. Selecting the preferred options; and
9. Priority schemes and funding

<u>Appendices</u>

A. Economic Damage Assessment; description of the economic assessment methodology. Presentation of Do Nothing and Do Minimum damages for each management unit.

B. Environmental appraisal – detailed Red, Amber, Green (RAG) tables

<u>Supporting Technical Reports</u>

- Coastal Processes Report (Stage 1 and 2)
- Defence Condition Report
- Baseline Environmental Report

2. Option development and appraisal - approach

This chapter gives an overview of the approach used to develop the options for managing the flood and erosion risk across the study site. A breakdown of the option development procedure is provided below:

1. Develop and characterise the baseline (including flood and erosion risk, economic, environmental, asset condition, coastal processes) and identification of different study units and groupings across the study site, to underpin and facilitate the option development process.
2. Identify a long list of measures which could be used to implement various high level options for the different units.
3. Screen out unfeasible and ‘non-starter’ long list measures that do not warrant more detailed appraisal.
4. Identify the short list of high level management options for each unit (or unit groups). These can include (one or a combination of):
    i. Do Nothing - let nature take its course. No work will be carried out to maintain or repair defences allowing them to deteriorate over time
    ii. Do Minimum - maintain existing defences until they fail and then do nothing as above
    iii. Maintain - defences are maintained as they are, but as sea levels rise flood and erosion risk increases over time
    iv. Sustain - defences are raised and strengthened keeping the levels of flood and erosion risk the same as now
    v. Improve - defences are improved to increase the standard of protection (SoP) over time, beyond the requirements of rising sea levels
    vi. Environmental mitigation – mitigation to environmental receptors
5. Identify how the long list measures can be used, or combined, to implement the high level management options (the short list options). There a potentially thousands of different ways in which the measures could be combined / timed and therefore to facilitate and rationalise this process discussions were held by the project team during the option appraisal workshop and in subsequent meetings.
6. Appraise the short list options, with input from environmental and economic assessments and stakeholder feedback, to determine the preferred option(s).
7. Carry out sensitivity tests of the preferred option to check that it is robust against a range of uncertainties.
8. Carry out partnership funding assessments for initial schemes identified to ascertain potential Grant in Aid eligibility and likely shortfalls.

3. Study units

The study site frontage has been broken down into eight different units (named IW 22 to 28 in Sandown Bay, and also IW 15 in Bembridge) which form the basis of the assessment. Options were developed at the unit level which has ensured that options are specific to the local conditions, risks and opportunities.

This study covers three Policy Units of the Isle of Wight Shoreline Management Plan (2011). These are Policy Units 3C.2 and 3C.3 in Sandown Bay, and also Policy Unit 3A.4 at Embankment Road, Bembridge, all with a 'Hold the Line' policy. This Study investigates and appraises options to implement the 'hold the line' policy.

For the purpose of developing the initial long list of options the management units were grouped according to the risk and geographic extent; units IW22 to IW25 were grouped as these units are subject to both flood and erosion risk and units IW26 to IW28 were grouped as these are subject to erosion risk only. Unit IW15, at Embankment Road, was not grouped with any other units as it is in a different geographical area. However, in order to effectively and strategically manage flood risk at Sandown it is necessary to consider flood risk and management interventions at both ends of the Eastern Yar Valley simultaneously.

The location of the study units is shown in Figure 3-1 and a summary of the unit characteristics is provided in Table 3-1.

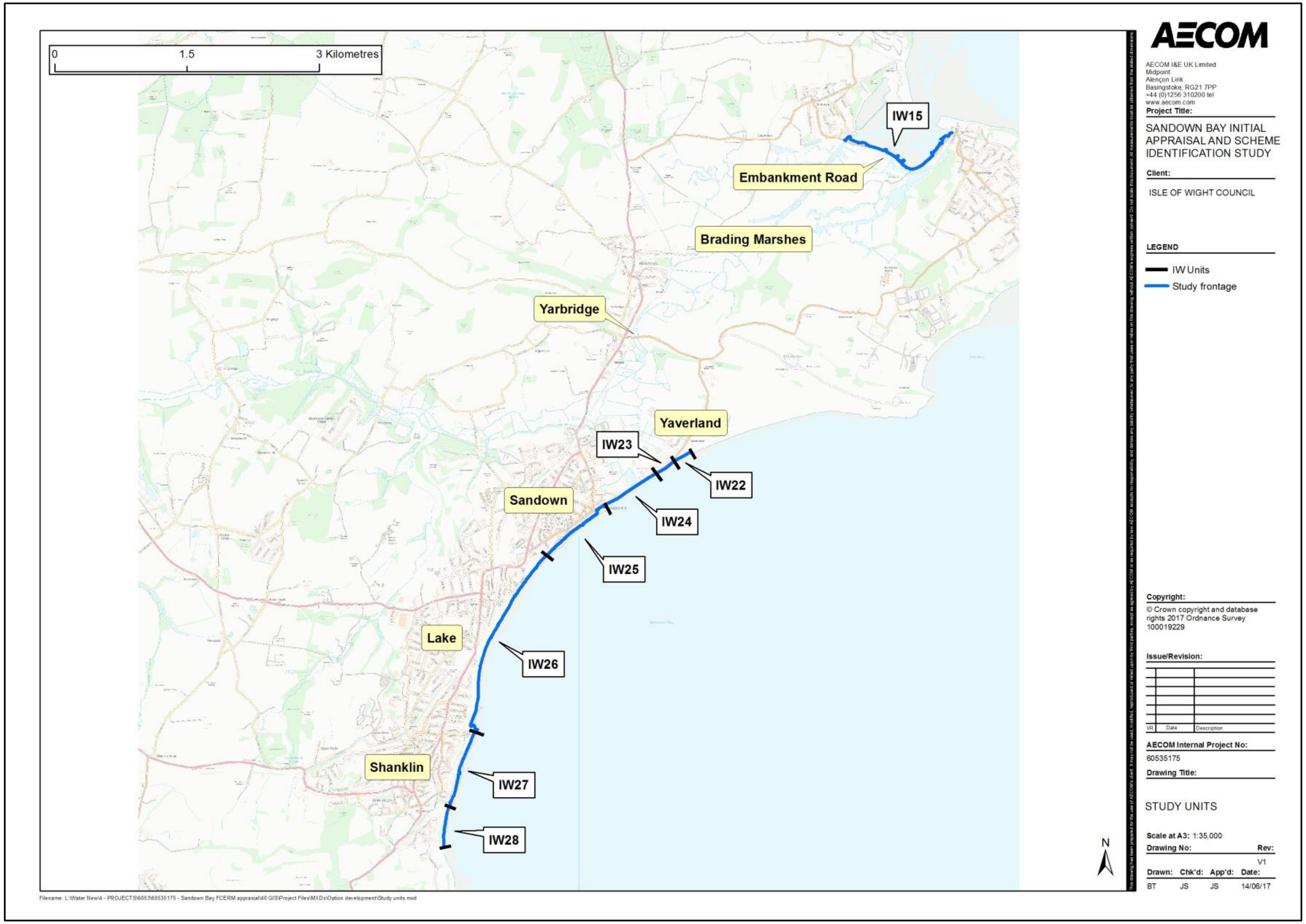

Figure 3-1. Location of study units

Table 3-1. Study unit summary

Units	IW15	IW22 to IW25	IW26 to IW28
Location	Embankment Road	Yaverland & Sandown	Lake & Shanklin
Geographic extent	Environment Agency control structure on Embankment Road to intersection with Beach Road	Yaverland beach car park to western end of Pier Street	Pier Street to Luccombe Road
SMP Policy Unit	3A.4	3C.2 (IW 22,23,24) 3C.3 -part (IW 25)	3C.3
SMP Policy	Hold the Line	Hold the Line	Hold the Line
Characteristics	- Earth embankment with highway - Coastal access - Residential and commercial land use - Flood risk becoming more significant over time. - Sheltered environment. Short section of embankment exposed to storm waves from the north and therefore an erosion risk. - Environmentally designated area of Brading Marshes located behind the defence	- Concrete seawall / revetment with concrete / timber groynes, generally in fair condition with areas of good condition. - Exposed open coastline - Coastal promenade and highway - Wide sandy beach in-front of the defences - Low lying land behind - Residential and commercial land use. - Regeneration opportunities - Flood risk becoming more prominent over time - Erosion risk	- Concrete seawall / revetment with concrete / timber groynes, generally in fair to good condition although some large areas in poor and very poor condition (sections of seawall and timber groynes). - Exposed open coastline - Coastal promenade - Wide sandy beach in-front of the defences - Backed by steep cliffs (which are unstable). Little or no flood risk. - Erosion risk is prominent if the defences fail with many properties located along the cliff top.

4. Potential management measures (long list)

In order to deliver a range of potential management options (i.e. maintain, sustain, improve etc.) a number of measures and interventions may be required, either separately or in conjunction with one another. These may also need to be phased or sequenced in time to deliver the different management options.

To ensure all of the potential 'tools' were available for the development and appraisal of options it was important to cast the net as wide as possible at this initial stage to capture all potential measures which could have been considered.

4.1 Potential Measures

This section provides an overview of local measures comprising the long list. Typical cost ranges for the measures have been included, although where quoted these ranges are suitably high-level and do not include an allowance for optimism bias. 'SoP' refers to 'Standard of Protection' provided by the defence structure.

Reactive patch and repair / small scale maintenance for health and safety compliance

This measure allows for the reactive repair or small scale maintenance of the existing defence and to ensure health and safety compliance. This measure does not allow for capital interventions such as large scale refurbishment or replacement of the existing defences.

Costs for the ongoing patch and repair maintenance works at the study site have been based on those provided by the IoW Council (2017). Excluding costs associated with cliff stabilisation works, the current average maintenance expenditure for the frontage between Yaverland and Shanklin (IW22 to IW28) is estimated to be approximately £32k per year. The frontage in these units is approximately 5.8km long so annual expenditure equates to approximately £5.5 per metre of shoreline (the total defence length exceeds 5.8km due to presence of groynes perpendicular to the frontage). It is recognised that this is not necessarily the required or desired level of investment to maintain all the coastal defence assets but it is reflective of the current economic climate and budgetary constraints. It is therefore a realistic cost to use for this measure which will help 'sweat the assets' to prolong their life but it is recognised that this would not be a sustainable or robust maintenance solution in the longer term.

Advantages	Disadvantages
• Relatively inexpensive	• Reactive
• Focus resources on at risk areas	• Does not minimise probability of failures from occurring
	• Does not reduce flood risk
	• Health and safety risks

Capital refurbishment to *existing* defence structures (and groynes)

This measure allows for a proactive repair or large scale refurbishment of the existing defences to ensure that it retains its erosion / flood defence function. In the case of groynes, this measure does not allow for extension or raising of the structures. Methods of refurbishment vary and depend on the structure type. For hard defences such as seawalls or revetments typical approaches are concrete spraying or encasement / strengthening. On previous occasions the concrete spraying technique has been used effectively within the study site (e.g. along the Environment Agency seawall at Culver Parade, Yaverland). For timber groynes refurbishment may involve replacing timber planks and joints.

Typical costs for refurbishment depend on the structure type and approach. For hard defences at the back of the beach the most costly approach is a full encasement with toe protection (upwards of £2k per metre) whilst cheaper alternatives include concrete resurfacing / spraying (up to £1.0k per metre). For timber groynes refurbishment costs depend on the amount of materials which need to be replaced. Indicative costs for 10-30% material replacement range from £10-40k per groyne.

Advantages	Disadvantages
• Proactive	• Unlikely to have as long a service life as a new structure
• Inexpensive compared to construction of new structures	• Does not include crest raising
• Focus resources on at risk areas	
• Typically no significant environmental impacts	

Concrete spraying

As noted above, this method of refurbishing existing seawalls (to extend their life) has already been used in the Study Area, along Culver Parade in 2006.

Photographs from examples around the UK showing the concrete spraying and encasement approaches are provided in Figure 4-1 and Figure 4-2 below.


Figure 4-1. Photographs showing examples of concrete spraying of a seawall at Minehead (left) and at Yaverland on the study frontage (right) used to prolong the service life of the asset.

Encasement:

Figure 4-2. Photograph of Cromer seawall encasement

Beach nourishment

This measure involves increasing the level of sediment along the frontage, which will improve the beach's ability to protect the cliffs / defences from wave energy. Beach nourishment could be carried out in a number of ways but is most likely to involve sediment being deposited onto the beach by heavy machinery or an offshore dredging vessel.

Typical costs for beach nourishment in the UK range between £9-32 per metre^3 of beach material (Environment Agency, 2015). For example, the recent £6.8m Lincshore replenishment scheme (20km of beach frontage between Skegness and Mablethorpe) involved nourishment of approximately 350,000m^3 of sand, with an average cost of £19 per m^3 of material.

Advantages	Disadvantages
• 'Soft' management approach	• Expensive
• Potential benefit for recreation / tourism in the area	• Continuous monitoring and maintenance
	• Likely to require repetitive interventions
	• It is likely that it will need to be combined with other beach management measures to prolong effectiveness
	• Potential environmental impacts – at both the dredge and deposit sites. The Sandown frontage designations include SAC, SINC, SSSI and a proposed SPA and a recommended MCZ which could be impacted by nourishment in this area (i.e. sediment movement patterns, local ecosystem impacts, etc.)

Beach recycling

This measure involves moving some of the existing beach sediment to areas of the beach that are prone to erosion. The sediment would be moved from areas of accretion where there is typically a high build-up of beach material. This will help to improve the beach's ability to protect the cliffs / defences from wave energy in the areas where beach levels are typically low. Beach recycling would be carried out by heavy machinery and would likely be required on a recurring basis, with repetitive interventions creating ongoing costs. Beach recycling can be used to create a sacrificial beach which is regularly lost and replaced. In both the source and destination areas, potential impacts on designated features and on beach levels (during and after the works) would need careful consideration to determine if there are locations which could supply and receive appropriate types of sediment.

Typical costs for beach recycling in the UK are less widely available, but information from a shingle recycling scheme at Seaford (Bulk recycling scheme , 2002-03) suggests a cost of £1 per metre^3 of beach material moved (maximum haul distance <2km).

Advantages	Disadvantages
• 'Soft' management approach	• By moving sediment from one area to another, potential for the source area to have reduced beach levels
• Potential benefit for recreation / tourism in the area	• Continuous monitoring and maintenance
• Relatively inexpensive per cycle, although regular repetition needs to be allowed for.	• Likely to require repetitive interventions
	• It is likely that it will need to be combined with other beach management measures to prolong effectiveness
	• Potential environmental impacts – at both the removal and deposit sites. The Sandown frontage designations include SAC, SINC, SSSI and a proposed SPA and a recommended MCZ which could be impacted by nourishment in this area (i.e. sediment movement patterns, local ecosystem impacts, etc.)

Extension / raising of the existing groynes (groyne improvement)

This measure involves extending the length and/or raising the height of the existing groyne structures. This could help to hold more sediment on the beach and improve the beach's ability to protect the cliffs / defences from wave energy. This measure does not allow for construction of new groynes.

Costs for groyne extension and raising will vary depending on the type of groyne being modified (e.g. timber or concrete) and the amount of material required. Typical costs for the extension of timber groynes and concrete groynes (per metre of groyne length) are likely to be in the ranges set out below for the construction of new groynes.

Advantages	Disadvantages
• Potential to trap more sediment to increase beach levels	• Further disturb natural movement of the beach sediment and lead to downdrift erosion
• Potentially improve amenity of the beach area	• Potential health and safety issues with large changes in beach levels over the groynes
• Reduced cost compared to construction of new groynes	• Further modelling studies required to determine effectiveness
	• Potential environmental impacts associated with extending groynes further into the intertidal zone

Construct new groynes

This measure involves the construction of new groynes to potentially improve the retention of sediment on the beach. To optimise the construction of new groynes a detailed numerical modelling study would be required to determine the preferred groyne configuration. A variety of construction types are available (i.e. timber, concrete, rock armour etc.) and this measure would be significantly more costly than working with the existing groyne structures.

The groynes could be constructed using the same layout / setup as the existing groyne field, or could follow an entirely new approach. Evidence collected in the coastal processes report suggests that at the study site the larger concrete groynes are better at retaining sediment on the beach than the smaller timber groynes. The new groyne field design may therefore involve construction of new concrete groynes within the bay at a larger spacing (compared to the existing timber groynes). The timber groynes would then be allowed to deteriorate (in a controlled manner, to preserve H&S requirements) and would not be replaced at the end of their service life. This approach would essentially change the existing groyne layout / setup and a detailed numerical modelling exercise would be required prior to the scheme to check whether this approach is likely to be optimal.

Typical costs for new timber groynes range from £100k to £320k per groyne or between £1k-3k per metre length of groyne (Environment Agency, 2015). Concrete groynes are less common structures than timber construction and therefore example cost ranges for concrete groynes are not readily available. It has therefore been necessary to estimate the cost of concrete groynes by scaling up the costs of timber groynes; concrete groynes assumed to cost approximately £4.5k per metre length

Advantages	Disadvantages
• Optimal sediment retention on the beach	• Likely to be very costly
• Potential to improve amenity of the beach area	• Further disturb the natural movement of the beach sediment and lead to downdrift erosion
• Increased service life	• Potential health and safety issues with large changes in beach levels over the groynes
• Construction could be staggered	• Further modelling studies required
	• Potential environmental impacts associated with new or larger groynes extending further into the intertidal zone

Offshore breakwater(s)

This measure involves reducing wave action along the frontage by constructing a (or multiple) offshore breakwaters. The presence of breakwater(s) could potentially benefit the beach levels behind the structure, helping to further protect the cliffs / defences from wave attack. An offshore breakwater(s) is an extremely costly measure and could disrupt the natural sediment movement and hydrodynamics both locally and in adjacent areas, especially downdrift. The measure would also bring about fundamental environmental impacts given the range of offshore designations.

There are a number of factors which contribute to the cost of offshore breakwaters (geometry, material type and source, construction methods, timing of construction etc.) and therefore the cost of an offshore breakwater can be extremely variable. The Environment Agency unit cost database includes two examples of offshore breakwater projects with unit costs ranging between £1.7k to £3.3k per metre of breakwater.

Advantages	Disadvantages
• Help to absorb wave energy and reduce erosion	• Likely to be very costly
• Potential to increase beach levels	• Will impact offshore environment and coastal processes
• Potentially creates an offshore habitat	• Environmentally intrusive
• Potential benefit for recreation/tourism in the area	• Will not eliminate potential for flooding
	• Detailed modelling study would be required to determine breakwater dimensions and positioning
	• Potential environmental impact associated with construction of offshore structure(s) in areas designated for environmental importance (i.e. SAC, SINC, SSSI, proposed SPA and a recommended MCZ)
	• It is likely that it will need to be combined with other beach management measures to prolong effectiveness, for example beach recycling, adding additional costs.

Gabion revetment / wall

This measure involves protecting the cliff toe from wave action by constructing a gabion revetment / wall at the toe of the cliff. Gabions could also be used as a measure to prevent outflanking of frontline defences.

Typical costs for gabion revetment / walls range from £50-500 per metre of defence length (Environment Agency, 2015) depending on the height and depth of the gabion wall required.

Advantages	Disadvantages
• Help to absorb wave action at the cliff toe	• Service life is typically short, and dependant on wave climate of the area
• Relatively inexpensive	• Potentially large maintenance costs
• Less intrusive than other hard defences, can be removed and relocated if required	• No beach management benefits
• Simple to construct	• Failure of gabions can lead to health and safety risks – i.e. split wire meshing
• Gabions placed behind the existing defences could have improved service life and be more effective than if left exposed to wave climate	• Obtrusive/visually prominent structures may have a negative visual impact.

Concrete revetment

Construction of a new concrete revetment along the frontage would protect the cliffs from erosion and also reduce the flood risk in the low lying areas. A new revetment is a sloped hard defence measure and is likely to be very costly per metre relative to the other measures. Except where technically unfeasible, a revetment would be constructed within the existing defence footprint. If this is unfeasible, there would be potential environmental impacts of the increased defence footprint of the new sloping defence.

The typical costs of concrete revetments vary between £700-5,400 per metre length of defence (Environment Agency, 2015).

Advantages	Disadvantages
• Will protect the cliff toe from erosion	• Likely to be have a high capital cost
• Will provide flood risk benefits by increasing the SoP	• Will limit entry of cliff material to the beach
• Requires little maintenance	• Would impact visual aesthetics of the area

Rock armour revetment

Construction of a new rock revetment along the frontage would protect the cliffs from erosion. A rock revetment is a sloped structure and is likely to be very costly per metre relative to other measures but could be less expensive than a concrete revetment. There could be a range of issues associated with construction of a rock revetment, including an advanced defence footprint (5-10m per m length potentially) and access issues. It could also go against aspirations to maintain a sandy beach along the frontage which is popular for tourists and therefore may not be supported by stakeholders / the public. The typical costs of rock revetments vary, and are also sensitive to the availability of suitable rock and the volumes of material that are imported (greater efficiencies with larger schemes). A cost estimate for a similar scale revetment (to that which may be required at Sandown) is approximately £3k per metre, although depending on the size of revetment required and the rock import arrangements this could feasibly be between £2-5k per metre length of defence.

Advantages	Disadvantages
• Will protect the cliff toe and/or defences from erosion and reduce wave attack	• Likely to be have a high capital cost
• If placed in front of existing defences these would require maintenance	• Will limit entry of cliff material to the beach
	• Would impact visual aesthetics of the area
	• Potential access / safety issues (in tourist area)
	• Potential to advance the line / increase defence footprint

Seawall

Construction of a new seawall along the frontage would protect the cliffs from erosion and also reduce the flood risk in the low lying areas. A new seawall is a vertical hard defence measure and is likely to be very costly per metre relative to the other measures. Except where technically unfeasible, a seawall would be constructed within the existing defence footprint.

The typical costs of concrete seawalls vary between £700-5,400 per metre length of defence, with costs from specific examples in the UK ranging from £1.3k-6.3k per metre (Environment Agency, 2015).

Advantages	Disadvantages
• Will protect the cliff toe from erosion	• Likely to be have a high capital cost
• Will provide flood risk benefits by increasing the SoP	• Will limit entry of cliff material to the beach
• Requires little maintenance	• Would impact visual aesthetics of the area
• Multifunctionality of such a facility, if combined with a typical esplanade providing access/amenity space.	

Crest raising of existing defences

This measure involves raising the crest level of the existing defences by raising the height of the capping beam or constructing a new vertical capping beam at the top of the defence (e.g. Figure 4-3). This measure will lead to a higher SoP against flooding but it is likely that in some areas a refurbishment of the existing defences will be needed to support the increased defence height and to reduce the risk of erosion.

Typical costs of raising / modifying existing hard defences range from £600-1,500 per metre of raised defence (Environment Agency, 2015).

Advantages	Disadvantages
• Will increase the SoP against flooding	• Does not increase condition of existing defences and likely that a refurbishment will also be needed in some locations to prevent erosion
• Lower cost relative to construction of a new structure	• Could impact landscape and views in the area
• Requires little maintenance	

Wave return

This measure involves construction of a wave return on the crest of the existing defences. A wave return wall is curved structure at the top of a defence which will help to reduce the wave overtopping risk and reduce the quantity of flood water passing over the defences during overtopping events. This measure will not improve the SoP against tidal inundation. A wave return will not improve the condition of the existing defences and it may also be necessary to refurb the defences in areas where the condition is poor (to prevent erosion risk).

Typical costs of installing a wave return wall on existing hard defences range from £900-1,500 per metre of return wall (Environment Agency, 2015).

Advantages	Disadvantages
• Will increase the SoP against flooding from wave overtopping	• Does not increase the SoP against flooding from tidal inundation
• Lower cost relative to construction of a new structure	• Does not increase condition of existing defences and likely that a refurbishment will also be needed in some locations to prevent erosion
• Requires little maintenance	• Could impact landscape and views in the area

Figure 4-3. Example of crest raising at the top of the defence (left, Sandown) and a wave return wall (right, Pevensey)

Setback floodwall

Construction of a new setback floodwall has the potential to improve the SoP against flooding along the frontage. However, being set back from the frontline it will not improve the condition of the existing defences and these will still need to be maintained or refurbished to improve their service life and ensure that the setback floodwall is not undermined.

A setback floodwall can be placed anywhere behind the existing defences, however, given the characteristics and built-up nature of much of the frontage a setback wall is likely to be located between 1-10m behind the existing defence line (often on the top of the defence to reduce height requirements).

Indicative costs for setback floodwalls between 0.5-1.5m in height, on top on an existing defence (adopting a T shape design) are estimated to range from £1.1k-3k per metre length of defence.

Advantages	Disadvantages
• Will increase the SoP against wave overtopping flooding	• Does not increase condition of existing defences and likely that a refurbishment will also be needed in some locations to prevent undermining. No erosion prevention benefits.
• Long service life	• Could impact landscape and views in the area
	• Could impact access and services
	• Potentially high cost
	• Environmental impact if the floodwall is setback on designated land.

Setback embankment

Construction of a new setback embankment could be used to improve the SoP along the frontage. However, being setback from the frontline it will not reduce erosion risk or improve the condition of the existing defences and these will still need to be maintained or a refurbished to improve their service life and ensure that the setback embankment is not undermined. A setback embankment would take up considerably more space than a setback floodwall and opportunities to implement this defence in the study site are limited.

Costs for embankments vary and are largely dependent on the volume (height x width) of the embankment per metre length. The mean cost per metre length of embankment ranges from £600-3,400 (Environment Agency, 2015) although for large embankments (e.g. in excess of 2m high) costs would be expected to increase up to £4-6k per metre, mainly due to the large amount of fill material required in structures this large. Due to the low land levels in the Eastern Yar Valley it is likely that costs would be in the upper end of the range if an embankment was to be used in this location.

Advantages	Disadvantages
• Will increase the SoP against flooding	• Does not increase condition of existing defences and likely that a refurbishment will also be needed in some locations to prevent undermining. No erosion prevention benefits.
• Lower cost measure than setback floodwall, although not if a complete or high new structure is required.	• Could impact landscape and views in the area
• Opportunity for a landmark architectural feature	• Could impact access and services
	• Can only be implemented where there is sufficient space behind the frontline defences which may not be available
	• Environmental impact if the embankment is setback on to designated land (potentially involving a large footprint if a high embankment is required).

Cliff stabilisation / drainage

This measure involves using cliff drainage and stabilisation techniques to help reduce the rate of cliff top erosion. With this measure there is no guarantee that a cliff erosion event would not occur, but the drainage and stabilisation would help reduce weathering and slope processes related erosion. It would not prevent marine induced erosion (i.e. wave attack at the toe of the cliff).

Currently this measure is already carried out between Lake and Shanklin (IW26-28) and the costs associated with continuing with this measure will be included as a maintenance cost for the various Do Something options. In order to be successful, it is likely that this measure would need to be combined with another measure which controls the rate of erosion at the cliff toe (such as a hard defence).

The average annual costs between 2009-2016 in the study area for Cliff stabilisation / drainage works are approximately £16k, an average of £4 per m of cliff stabilisation works.

Advantages	Disadvantages
• Will help reduce quantity of material lost from cliff due to weathering	• Will need to be combined with other measures to protect the cliff toe from wave action
• Limited footprint on the beach	• Impact on the cliff face, which could be of geological interest and environmentally important
• Potentially low cost (as a measure on its own)	• Could impact visual aesthetics of area

Cliff regrading

This measure involves re-profiling the cliff face to reduce its slope and help prevent further cliff erosion in the future. In order to be a successful long term solution, this approach would need to be combined with another measure which controls the rate of erosion at the cliff toe (such as a hard defence).

Advantages	Disadvantages
• Will help reduce quantity of material lost from cliff due to weathering	• Will need to be combined with other measures to protect the cliff toe from wave action
• Limited footprint on the beach	• Impact on the cliff face, which could be of geological interest and environmentally important
• Potentially low cost (as a measure on its own)	• Could impact visual aesthetics of area
	• Initial re-profiling could lead to loss of properties at the cliff top

Road raising

This measure involves raising the road level in areas where the road is located immediately behind the existing defences. This can be used to improve the SoP against flooding to the area behind the road / defence but it is likely that in some areas a refurbishment of the existing defences will be needed to ensure that the defences do not fail and undermine the roadway.

Typical costs for road raising vary depending on the existing road surface and height of raising required. Costs for a 0.8m raise have been priced at an estimated £5-7k per metre length of road.

Road raising has been discussed at a high level as a potential option for unit IW24 (Culver Parade). The existing road levels in this unit vary but for large parts of the frontage it would be necessary to raise levels 1.5-2m to just match the height of the existing defences. The cost of raising to this height and beyond (to account for higher standards of protection) is likely to significantly exceed the cost range stated above.

Advantages	Disadvantages
• Will increase the SoP against flooding	• Does not increase condition of existing defences and likely that a refurbishment will also be needed in some locations to prevent erosion
• Requires little maintenance	• Could lead to significant disruption during construction

Temporary defences and PLP

This measure involves utilising temporary flood defences and property level protection (PLP) measures to reduce the flood risk to properties behind the existing defences. This measure can typically provide only a low standard of flood protection but is generally low cost relative to other measures.

Costs for PLP are estimated to be in the region of £5k per property. Costs for temporary defences (e.g. 0.9m in height) are estimated to be between £300-400 per metre. This cost is for purchase only and does not include costs associated with deployment and operation.

Advantages	Disadvantages
• Improved SoP against flooding	• Does not reduce erosion risk
• Low cost	• Cannot protect to a high SoP
	• Residual risk of defences failing
	• A flood event could overtop the Temporary defences

Yarbridge tidal gates

This measure is specific to Yarbridge where there is a potential opportunity to construct tidal flood gates on the River Yar beneath the Marshcombe Shute Road at Yarbridge. The tidal flood gates would be used to prevent tidal flood waters propagating from the Embankment Road side of the frontage to the outskirts of Sandown and

Yaverland (i.e. to prevent tidal flooding through the backdoor). The main benefit of this measure is that it would be considerably less expensive than raising the defences at Embankment Road to provide an equal standard of protection to the Sandown frontage, although it would be dependent on consideration of the interaction with fluvial flood risk and tide locking.

Costs for tidal flood gates vary considerably and depend on the size and complexity of the structures / control infrastructure. A high level indicative cost estimate for a set of gates at Yarbridge is approximately £500k-1million but this will need to be revisited during further appraisal work and design.

Advantages	Disadvantages
• Improved SoP against flooding for Sandown frontage	• Does not mitigate tidal flood risk to properties between Embankment Road and Yarbridge.
• Low cost compared to alternatives	• Potential for environmental issues associated with tidal gates on the Eastern Yar
	• Residual risk of gate operation failures
	• Potential for increased fluvial flood risk during times of gate closure • Impact of salt water flooding on the designated freshwater environmental habitats downstream of Yarbridge.

Figure 4-4. Example of flood gates which could be used to mitigate high tidal levels.

Localised erosion protection - Armourlock, rock armour, gabions

There are a variety of methods which can be used to protect against localised erosion, such as Armourlock, rock armour and gabions. Costs for these methods typically range between £0.5-2.5k per metre of defence. The advantages and disadvantages of the methods are shown below.

Advantages	Disadvantages
• Small defence footprint (armourlock)	• Potentially large defence footprint (gabions, rock armour)
• Low cost compared to alternative hard structures (i.e. seawall, revetment)	• Safety and access concerns (rock armour)
	• Do not mitigate against flood risk

4.2 High level cost summary of measures

Table 4-1 below presents typical cost ranges for the different measures described in section 4.1. The sources of the costs vary and these are also noted in the table.

Table 4-1. High level summary of costs (excluding optimism bias) for different measures considered

Measure	Typical cost range	Source
Reactive patch repair maintenance	£32k per year for Sandown frontage	Based on actual costs 2009-2016 (IWC)
Capital refurbishment – seawall spraying	Up to 1k per m of structure	Contractor price estimate from WW Coastal Strategy (2016)
Capital refurbishment – masonry seawall refurbishment	£400 – 2k per m of structure	SPONS unit costing
Capital refurbishment – seawall encasement	> £2k per metre	Cromer sea defence scheme (2015)
Capital refurbishment – groynes	£10-40k per groyne	Mundesley contractor estimate (2015), for 30-40% material replacement
Beach nourishment	£9-32 per m^3 of beach material	Environment Agency (2015)
Beach recycling	£1-8 per m^3 of beach material dependent on frequency required)	Environment Agency (2015) & ESCP example.
New Groynes (or extension) – timber	£1k - £3k per metre	Environment Agency (2015) SPONS unit costing
New Groynes (or extension) – concrete	Examples not available. Estimated £4.5k per metre	SPONS unit costing / scaling
Offshore breakwater	£1.7k - £3.3k per metre	Environment Agency (2015)
Gabions	£50 - £500 per metre	Environment Agency (2015)
Concrete revetment	£700 - £5.4k per metre	Environment Agency (2015)
Rock revetment	Approx. £2-5k per metre but varies depending on size / import arrangement	SPONS unit costing
Seawall	£700 - £5.4k per metre	Environment Agency (2015)
Crest raising	£600 - £1.5k per metre	Environment Agency (2015)
Wave return	£900 - £1.5k per metre	Environment Agency (2015)
Setback floodwall	£1.1k - £3k per metre	SPONS unit costing, for 0.5 to 1.5m height.
Setback embankment	£600 – £6k per metre	Environment Agency (2015 SPONS unit costing
Cliff stabilisation	£16k per year for Sandown frontage	Actual costs 2009-2016 (IWC)
Road raising	£5k - £7k per metre	SPONS unit costing
Temporary defences	£300 - £400 per metre	Contractor price estimate (2015)
PLP	£5k per property	GiA eligibility
Yarbridge tide gates	£500-1000k	Build-up based on Environment Agency (2015)

4.3 Initial screening of potential measures

4.3.1 Approach

A high level multivariate appraisal of the long list measures was undertaken to screen out any unfeasible measures (on technical, environmental, health and safety, legal grounds etc.) and to justify removal of any impractical or 'non-starter' measures. This was carried out to ensure that unviable measures were not taken forward any further in the development or more detailed appraisal of the options.

Depending on the location along the study frontage the measures need to mitigate different sources of risk. In units IW15 and IW22-25 the measures are required to mitigate both flood and erosion risk. However, between IW26-28 the measures are only required to provide erosion protection (as this area is backed by steep cliffs and no properties are at risk of flooding). Therefore the screening exercise was undertaken on two levels; one screening exercise for the measures that mitigate just erosion risk, and another screening exercise for the measures which mitigate both flood and erosion risk.

Each long list measure was appraised against the following criteria;

- Risk Management (flood and erosion risk)
- Indicative capital cost
- Indicative ongoing / maintenance costs
- Service life
- Technical feasibility
- Environmental impacts
- Coastal processes impact
- Stakeholder aspiration / broader outcomes

In the appraisal each measure was tested against a set of scoring rules for each category to ensure a consistent decision making process.

The appraisal was informed by the following:

1. Supporting data and assessments – a review of a wide range of relevant data and completion of the baseline studies provided the understanding of the frontage and issues, constraints and opportunities. This information provided the facts from which to screen out non-viable measures.
2. Visual site inspections – several site walkovers were carried out along the study frontage. The walkovers aided the teams' understanding and helped inform the decisions on viability of different measures along the frontage.
3. Stakeholder engagement – consideration of engagement feedback and aspirations of stakeholders was incorporated into the appraisal.
4. Knowledge of IoW Council asset managers – an options workshop was held to utilise local and detailed knowledge of officers responsible for upkeep of the coastal management assets.

Table 4-2 presents the results from the screening process, where non-starter long list options were screened out. Further details of the long list appraisal are provided in Appendix C.

Figure 4-5 and Figure 4-6 present the long list measures for each area that were taken forward in the appraisal.

Table 4-2. Long list potential measures for each area. Summary of screening appraisal

	IW 15 Embankment Road Flood & Erosion risk	IW 22 – IW 25 Yaverland and Sandown Flood & Erosion risk	IW 26 – IW28 Lake and Shanklin Erosion risk only
Screened in measures	- Reactive patch and repair - Capital refurbishment - Gabions - Setback floodwall - Revetment - Seawall - Road raising - Tide gates (Yarbridge) - Temporary defences and PLP	- Reactive patch and repair - Capital refurbishment (e.g. concrete spraying, encasement, groyne repairs) - Beach recycling - Beach nourishment - Gabions - Groyne improvements - Groyne construction - Revetment - Seawall - Crest raising / wave return - Setback floodwall - Road raising	- Reactive patch and repair - Capital refurbishment (e.g. concrete spraying, encasement, groyne repairs) - Beach recycling - Beach nourishment - Gabions - Groyne improvements - Groyne construction - Revetment - Seawall - Crest raising / wave return - Setback floodwall* - Cliff stabilisation
Screened out measures	- Offshore breakwater - Setback embankment - Beach nourishment	- Offshore breakwater - Setback embankment - Temporary defences and PLP	- Offshore breakwater - Setback embankment - Temporary defences and PLP - Cliff regrading

*where wave attack could undermine the cliff toe.

4.3.2 Screened out measures

Offshore breakwater

An offshore breakwater(s) has been screened out of the option appraisal for all the units within the study area. The main reasons for this are:

- Cost – an offshore breakwater(s) is a high cost approach and alternative methods of reducing erosion / flood risk are available at much lower costs.
- Residual risk - Offshore breakwaters could reduce erosion risk but would not reduce the significant tidal flood risk to the frontage.
- Sediment regime –Offshore breakwaters would have significant impacts on the sediment regime in surrounding areas, especially in reducing sediment supply downdrift, and may require ongoing beach recycling/moving sediments near each feature(s), based on experience elsewhere e.g. Monks Bay.
- Environmental concerns – the offshore zone in the study area is designated as a SAC, proposed SPA and a recommended MCZ also with areas of SSSI, SPA, Ramsar and SINC. Offshore breakwaters would have potential impacts upon their potential footprint, their local area, and areas downdrift. . Therefore, construction of an offshore breakwater(s) within these zones is unlikely to consented. The potential environmental impacts associated with an offshore breakwater(s) include habitat displacement, changes to sediment movement patterns and visual impact. Further considerations are set out in section 4.1 above.

For Embankment Road in Bembridge Harbour, St Helen's Duver spit already plays a sheltering role at the mouth of the harbour.

Harbour

The same considerations as listed above for offshore breakwaters also apply to potential construction of a harbour structure in Sandown Bay, which could bring additional tourism benefits, but which due to its size (potentially larger than offshore breakwaters) would likely have a significant impact in permanently starving sediment on the beaches on the immediate downdrift side of the harbour and in the north of the Bay. It would require ongoing costs if this impact was attempted to be ameliorated by moving sediment across the harbour by mechanical means (e.g. using machinery/vehicle). Longshore drift would continually bring new sediments into the area from the south which could potentially affect the accessibility of the harbour mouth and channels, which may therefore require dredging to keep clear. The footprint of the harbour and its knock-on impacts in adjacent areas would have significant impacts on the highly designated natural environment and habitats in the Bay and adjacent coastline.

Setback embankment

A setback embankment has been screened out of the option appraisal for all the units within the study area. The main reasons for this are:

- Cost and residual risk – If a breach in the seawall and a setback embankment is considered at Culver Parade, Yaverland, to protect the surrounding settlements a new floodwall or embankment would be required on an potential semi-circular arc behind/within any setback site, to a height equal to (and higher than) the current floodwall embankment along the Yaverland seafront. This would be a substantial and costly structure, considering the low land levels throughout the Eastern Yar Valley (which is approximately only 1m above sea level). The mean cost per metre length of embankment ranges from £600-3,400 (Environment Agency, 2015) although for large embankments (e.g. in excess of 2m high) costs would be expected to increase up to £4-6k per metre, mainly due to the large amount of fill material required in structures this large. Due to the low land levels in the Eastern Yar Valley it is likely that costs would be in the upper end of the range if an embankment was to be used in this location. This could equate as much as £6 million per km for a setback embankment, and costs for a new flood wall (rather than an embankment) along a new alignment would likely be even higher.

  Any land use in front of the setback embankment would be at increasing risk of regular tidal inundation. The remainder of the frontline seawall would require ongoing maintenance/improvement to prevent erosion (and flood risk from adjacent areas). The new setback flood embankment would also require maintenance, as would the seawall surrounding any breach.

- Technical feasibility – an embankment is a structure which requires a significant amount of space and large defence footprint. For example, an embankment of 2m+ in height with steep 1:2 slopes and a 2m wide crest would require a 10m wide defence footprint (and the height required could be significantly higher than this in places). Space is generally constrained along the frontage, with rows of buildings, roadways, utilities, amenity uses, cliff faces, heritage assets and other features located immediately behind the existing defences within the different units of the Study area and therefore there is unlikely to be sufficient space for this type of large structure.
- Sediment regime – If a breach occurs in the frontline defences (either by design, or due to deterioration of the existing structures), linked to provision of a setback option, the breach would be likely affected by sand accumulating within it and affecting it , from the longshore drift sediment being continually transported northwards along the Sandown Bay shoreline.
- Infrastructure and utilities – The seafront road at Yaverland or Embankment Road at Bembridge (if located in front of a setback flood embankment or wall) would be increasingly inundated and lost, with the road and any utility infrastructure in the area needing to be rerouted away from the seafront around the back of the new flood embankment, and no longer having a continuous seafront road route. Alternatively the road would need to be rerouted across any breach in the existing structures via a bridge at additional cost,
- Environmental concerns – in IW15 (Embankment Road) a setback embankment has also been ruled out for environmental reasons. The land levels behind the existing structure in IW15 fall away sharply in places which means that a very large embankment (2m+ high) would be required in places to achieve the desired design level. The space behind the existing structure is also part of the highly designated Brading Marshes, and therefore proposals to situate a new large defence structure in this area, are unlikely to be consented. Adjacent to Sandown Bay and Culver Parade (IW 24), there are also areas of SINC, as well as a lake and other developments located in the low-lying valley floor behind the existing seawall.
- Further considerations are outlined in section 4.1 above.

Therefore, a setback flood embankment has been scoped out of further assessment. Alternative approaches such as land raising and road raising could potentially have more feasible applications to the local characteristics of these areas, with opportunities to maintain or improve access in the area, alongside the consideration of the range of frontline defence improvements.

Beach Nourishment (screened out of IW15 only)

In IW15 (Embankment Road, Bembridge) beach nourishment has been screened out because this measure is not suitable or technically feasible in this location. The frontage in IW15 is situated in a sheltered harbour and, with the exception of a small section of the frontage, a beach is not currently present. Nourishment to create a beach along this frontage would likely to lead to a number of impacts, such as habitat/ecological impacts on these highly designated habitats and sedimentation of the harbour and impacts on vessel navigation. For these reasons this measure was screened out for this unit.

Temporary defences and Property level protection (IW22-28)

For the Yaverland to Sandown frontage (IW22-IW25) the flood risk to rows of properties immediately behind the defences is primarily from wave overtopping, with the risk increasing over time in this. Property level protection and temporary barriers are effective at preventing flooding from still water levels but not as effective against wave driven flooding in exposed locations where waves have the effect of pulsing water against the defences. There is also flood risk to the properties in the Eastern Yar valley from breach of the existing defences. If the existing defences were to fail, the depth and frequency of flooding would mean temporary defences and PLP were not sufficient to address the scale of the flood risk in these areas. For this reason this measure has been ruled out for these units.

Between Lake and Shanklin (IW26-28) the risk is primarily from erosion, rather than flooding and therefore temporary defences and property level protection has also been ruled out for these units, as well as due to the impacts of waves on temporary structures outlined above.

Cliff regrading

Cliff regrading has been screened out from further consideration because it would likely lead to a loss of properties at the cliff top. In addition, as a short term solution regrading the cliff slope could slow the rate of erosion but as the cliff toe becomes more exposed to wave action in the future it is possible that the cliff slope could re-activate leading to further recession.

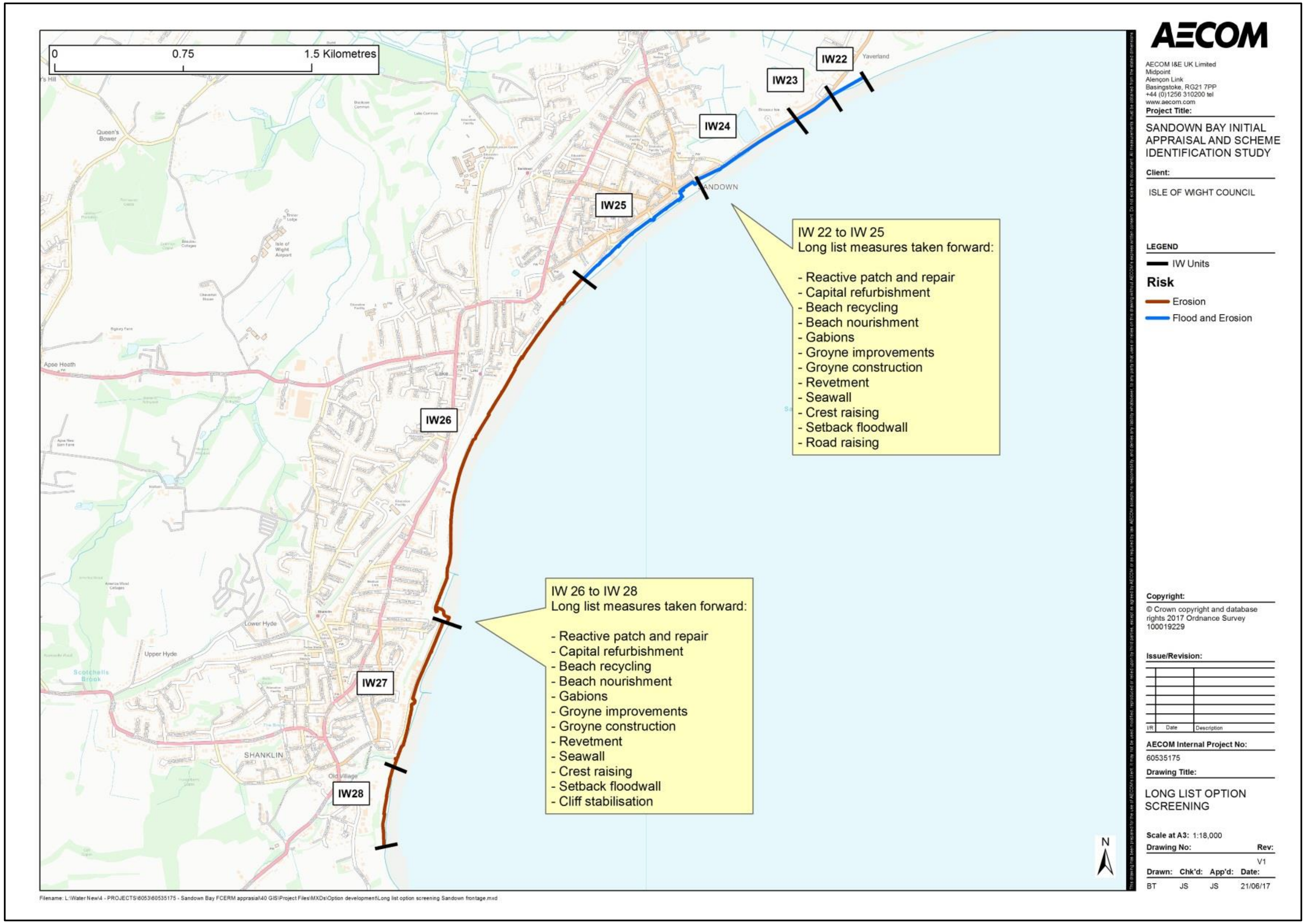

Figure 4-5. Long list measures taken forward for the Sandown frontage.

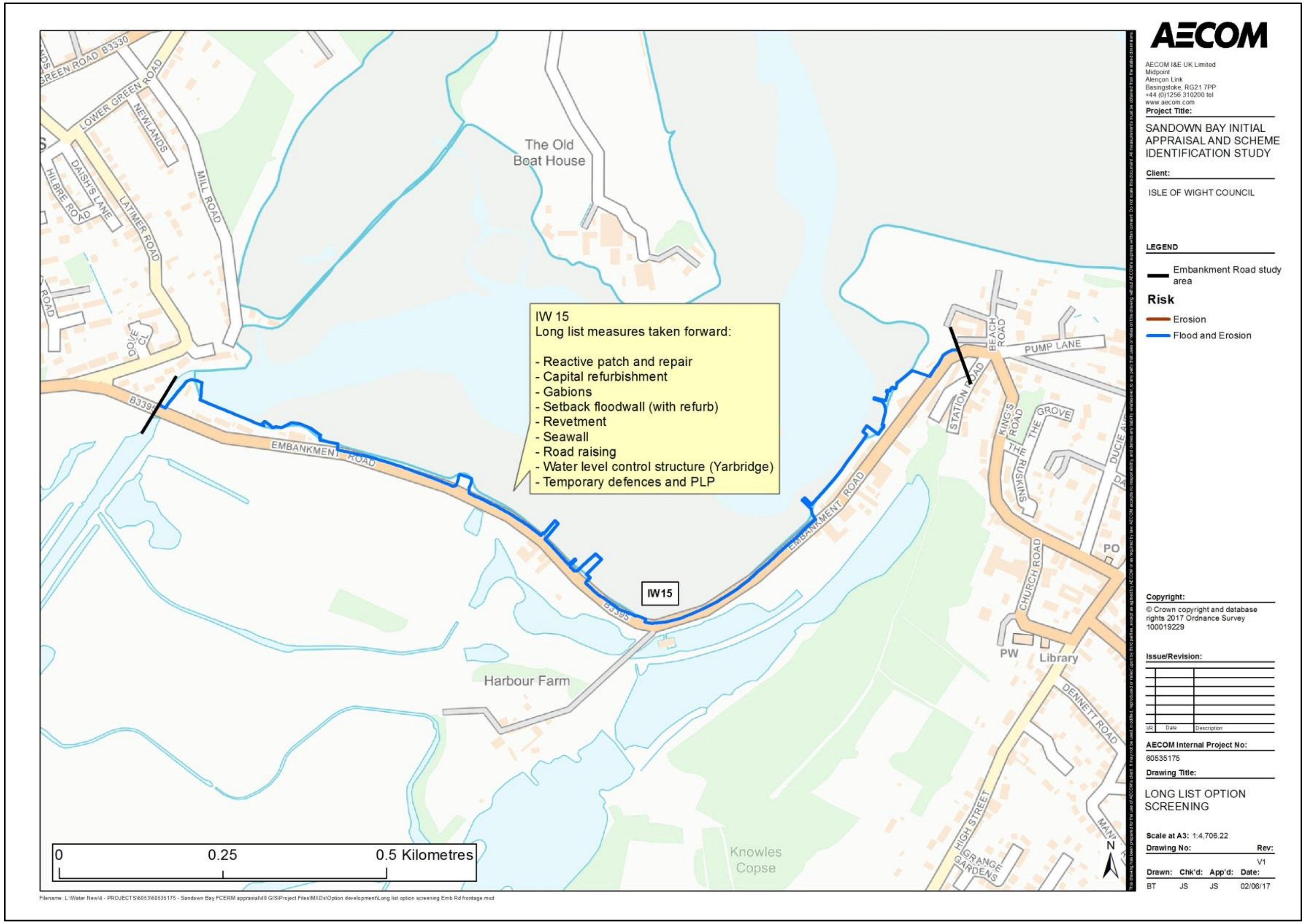

Figure 4-6. Long list measures taken forward for the Embankment Road frontage.

5. Management options (short list)

The strategic management options (i.e. Do Nothing, Do Minimum, Maintain, Sustain, Improve, Environmental mitigation) formed the basis of the short list. These options can then be implemented by applying combinations of the measures identified in chapter 6.

For some of the units, variations or combinations of the high level management options have been used to create a hybrid approach. For example, where there may be a financial case to delay improving defences (e.g. IW22 to IW25), a 'Maintain-Sustain' option has been created. This involves implementing the maintain option until it makes financial sense to improve the defences at a later stage.

Section 5.1 of this chapter outlines the principles of the standard high level management options. The short list for each unit is presented in section 5.2.

5.1 Description of options

5.1.1 Do Nothing

The Do Nothing scenario is a hypothetical 'walk away' scenario which is used as a baseline against which to appraise various 'Do Something' management options.

Under the Do Nothing scenario the existing defences are abandoned in terms of maintenance or repair, and no remedial or additional protection works are carried out. In addition, adaptation to sea level rise or other climate change responses are not addressed.

Under this scenario the existing defences along the frontage will fail at the end of their service life and the land behind will be subject to erosion. The erosion risk under the Do Nothing scenario is far reaching and this has already been established and is represented by the No Active Intervention (NAI) erosion lines. These are presented in the Coastal Processes Stage 1 & 2 Report. Accelerated 'catch up' erosion is likely when hard defences fail along the frontage which would impact properties, infrastructure and assets behind.

Flood risk would increase significantly over time affecting properties and assets in the flood cell behind the defences in units IW15 (Embankment Road), IW22, IW23 and IW24 (Sandown to Yaverland). In these locations there is the potential for wave overtopping and tidal inundation over the defences; this water then spills into the low lying land behind. Under the Do Nothing scenario it is anticipated that the defences in this location will fail and breach in the future. If this occurs the low lying area behind the defences would be inundated frequently through the breached defences (even during normal astronomical high tides).

Figure 5-1 shows the flood extent in the Sandown area following a breach for the following tides; mean high water (MHW) in 2057, mean high water springs (MHWS) in 2057, MHW in 2117 and MHWS in 2117. Mean high water typically occurs twice per day and therefore following a breach at some point the future a large area would be flooded on a daily basis, including the strategic A-road and railway line, properties at risk would be uninhabitable, utilities would be affected, including the wastewater treatment works for the Isle of Wight, and the seafront B-road would be severed. The depth of flooding following a breach varies with the land level behind the existing defences. For MHW in 2057 it ranges up to approximately 1m for the eastern edge of Sandown (just to the east of Avenue Road).

The Do Nothing scenario could also present a number of risks such as increasing risks of public liability injury claims due to unsafe defences, degrading promenades and associated structures, a loss of rental income and business claims as a result of potential promenade or beach closures. There are also likely to be indirect impacts on tourism, recreation and regeneration opportunities in the study area.

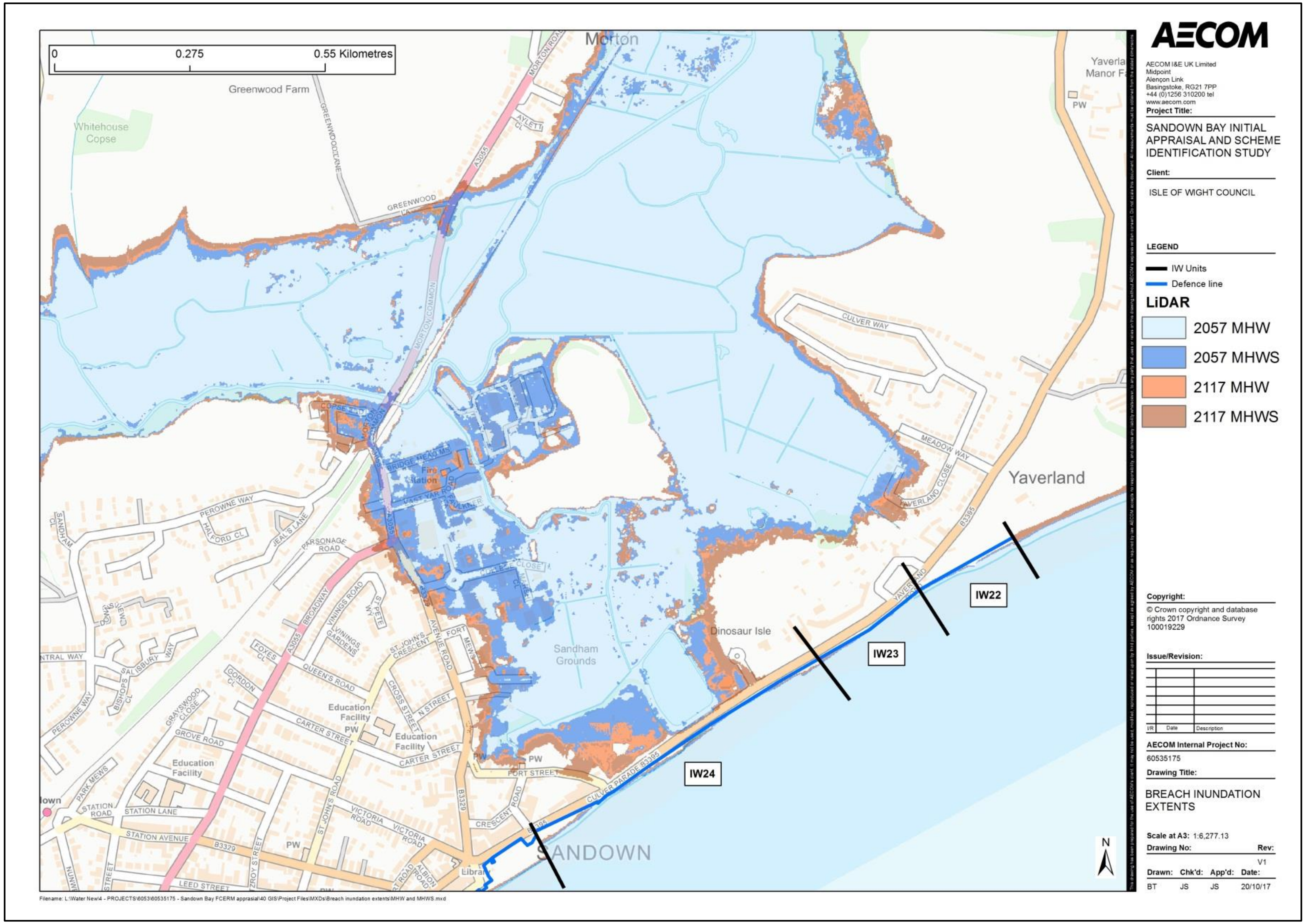

Figure 5-1. Extent of inundation for daily / monthly tides in 2057 and 2117 following a breach (MHW and MHWS tides shown for 2057 and 2117).

5.1.2 Do Minimum

The Do Minimum management option essentially represents the existing ‘status quo’. Under this approach, small scale reactive maintenance and ‘patch repair’ work, as well as activities to maintain Health and Safety compliance will be undertaken. This will help increase the residual life of assets and delay the point at which they are expected to fail. Do Minimum does not allow for any adaptation to sea level rise or other climate change responses (i.e. by crest raising) and therefore the flood risk will increase in the future as a function of sea level rise.

This approach does not allow for scheduled or capital maintenance or refurbishment, rebuild, or any replacement of assets. It has been assumed through ‘Do Minimum’ activities, the service life of assets compared to a ‘Do Nothing’ Scenario can be extended by a modest amount (typically 5-10 years depending on the structure). This scenario therefore includes a low / basic allowance for maintenance, that is suitable for the Do Minimum scenario. The benefit of this scenario stems from the delayed onset of erosion behind defences, and the delayed breach risk at Yaverland compared to the ‘Do nothing Scenario, with the extent of delay depending on the defence type in question.

5.1.3 Maintain

The maintain option typically involves scheduled maintenance of the existing defences and would likely follow an asset maintenance plan; this is likely to require and include capital refurbishment works. A maintain option represents a proactive approach to maintenance and refurbishment, typically working with existing defence assets rather than building new. It will require increased investment compared to the existing ‘status quo’ as climate change and sea level increases pressure on the aging assets. The maintain option includes an allowance for the cost of ongoing modest maintenance to the current structures until such times when capital refurbishments are required during the 100 year appraisal period.

The maintain option will ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years) and therefore it will provide erosion benefits. However, the maintain scenario does not allow for any adaptation to sea level rise or other climate change responses (i.e. by crest raising) and therefore the flood risk will increase in the future as a function of sea level rise.

5.1.4 Sustain

The sustain option typically applies to flood defences where it involves raising the crest level (or width) of the defences over time to keep pace with sea level rise. For example the crest level may be raised to ensure that a required standard of protection (SoP) is sustained for the duration of the appraisal period.

The sustain option could be implemented by constructing new defences or by refurbishing and raising the existing defences. The sustain option involves an increased investment compared to the maintain option.

By maintaining the position of the defences and sustaining standard of protection this option provides both erosion and flood risk benefits in the future.

5.1.5 Improve

The improve option involves actively improving the standard of protection against flooding and erosion. For example, this could be carried out through implementation of new defences or through raising the crest level of the existing defences to improve the standard of protection, accommodating future sea level rise.

It is likely that new defences would be required to implement the improve option and the improve option will usually require the greatest investment of the management options; however, this option will deliver greatest benefits.

By maintaining the position of the defences and improving the standard of protection this option provides both erosion and flood risk benefits, immediately and also in the future.

5.1.6 Environmental protection

Environmental protection is often carried out alongside another of the management options (i.e. maintain, sustain or improve) to provide additional environmental benefit. The scope for environmental mitigation varies depending on the environmental receptors in the area.

For this study the main environmental mitigation is for the protected habitats of Brading Marshes, situated behind Embankment Road. By continuing to protect the habitats in this area it would provide mitigation because these habitats would otherwise be lost to coastal erosion / flooding if the existing defences were to breach.

5.2 Short list

The short list of management options is presented in Table 5-1. In areas where there are strong environmental drivers for future management (IW15), bespoke options were developed to capture the local issues and opportunities. In addition, for some areas variations or combinations of the high level management options have been used to create a hybrid approach.

Table 5-1. Short list management options.

Area	Units	Option	Description
Embankment Road	IW15	Do Nothing	No active intervention. Baseline scenario
		Do Minimum	Reactive maintenance and repairs
		Maintain	Maximise the service life of existing defences. Fall in SoP over time
		Maintain then Improve	Initially maintain the existing defences then Improve the defences
		Sustain / Improve SoP + environmental protection	Improve the SoP of the defences at Embankment Road, providing additional mitigation to Brading Marshes.
		Improve SoP (Yarbridge)	Improve the SoP at Sandown via tidal gates at Yarbridge and maintain defences at Embankment Road. Undertake the improvements now or delay until later and maintain in the interim.
		Improve SoP (Yarbridge) and saline habitat creation	Improve the SoP at Sandown via tidal gates at Yarbridge and maintain defences at Embankment Road. Operation of EA sluices to create saline habitat. Undertake the improvements now or delay until later and maintain in the interim.
Yaverland and Sandown	IW22 to IW25	Do Nothing	No active intervention. Baseline scenario
		Do Minimum	Reactive maintenance and repairs
		Maintain	Maximise the service life of existing defences. Fall in SoP over time
		Sustain SoP	Sustain a minimum SoP of the defences
		Maintain then Sustain SoP	Initially maintain the existing defences with a gradual fall in SoP, then sustain a minimum SoP of the defences
		Improve SoP	Improve the existing SoP of the defences
Lake and Shanklin	IW26 to IW28	Do Nothing	No active intervention. Baseline scenario
		Do Minimum	Reactive maintenance and repairs
		Maintain	Maximise the service life of existing defences. Fall in SoP over time
		Sustain / Improve performance (erosion)	Improve the performance of the existing or new defences to reduce wave action on the cliffs

SoP = Standard of Protection

6. Option development - developing shortlist options at the local level

Each short list option (Table 5-1) will be implemented by using one, or a selection, of the long list measures taken forward from Chapter 4 (Table 4-2).

There are potentially thousands of different measure combinations and timings which could be used to implement each management option. Therefore a pragmatic rationalisation was required to facilitate the development of option combinations. It was agreed between the project team that in the first instance the technically feasible lowest cost or 'lower investment' combination of measures would be identified. These measure combinations provide the risk management authorities with a baseline from which to assess FCERM GiA funding availability. However, in addition to this, alternative more costly measure combinations have also been explored in some instances as these could potentially provide further benefits to the area. For example, higher investment options which may include works to refurbish the groynes which would help to sustain beach levels and encourage tourism in the area.

This chapter presents details of the measure combinations considered for each option in each study unit.

Present value costs of the measure combinations are presented. For more information on how these costs were developed, refer to Appendix A: Economic Damage Assessment and Costing. At this stage of the option development the option costs are estimates and include a 60% optimism bias allowance, in accordance with the appraisal guidance. The costs have also been rounded to the nearest £5k to reflect the strategic level and uncertainty in the costing exercise. As schemes are progressed further in future studies there will be opportunities to refine the cost estimates and provide a greater degree of certainty in cost estimations.

In the following option descriptions the years of implementing specific measures are specified e.g. in year 2045. Note that these years should only be used as a guideline / estimate and are specified for costing purposes. In reality, if a defence is still in a good condition when the works are specified then they could be delayed. Furthermore, sea level rise projections are inherently uncertain, and therefore crest raising or structures to protect against flooding may be required before, or after the years specified in this report. Continual monitoring of sea levels should be carried out in the future to determine when exactly interventions are required.

6.1 Unit IW22 (Yaverland Car Park)

This unit is located at the northern end of the Sandown frontage and is currently defended by a sloped revetment, constructed in 1960 and three timber groynes (see Figure 6-1). The unit is 225m long and is bounded by a concrete slipway. There is a large stretch of undefended coast to the north. The number of properties at risk in IW22 over the next 100 years is presented in Table 6-1 below.

Table 6-1 Properties at risk in unit IW22

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion (cumulative)
2017	8	6	14	0
2027	8	8	16	0
2057	71	9	80	2
2117	99	12	111	3

There is both a flood and erosion risk in this unit, although the immediate flood risk is principally from wave overtopping. By 2117, to achieve a 1:75yr SoP (Standard of Protection) approximately 30m of the existing defence length would need to be raised, or to achieve a 1 in 200 year SoP approximately 50m of the existing defence length would need to be raised.

Figure 6-1. Yaverland revetment

6.1.1 Do Nothing

Doing Nothing involves no active intervention. The present value cost of this option is £0.

6.1.2 Do Minimum

Do Minimum involves small scale reactive maintenance and 'patch repair' work to the existing revetment and groynes. Based on the current IoW Council expenditure on patch and repair maintenance along the Sandown frontage it is estimated that a continuation of this activity for the next 100 years would cost approximately PV £35k for this unit. This equates to £125k in cash terms. The limitations of this method are outlined in section 5.1.2 above.

6.1.3 Maintain

The maintain option involves scheduled maintenance of the existing defences to ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years).

The mean crest level of the defences in this unit is approximately 5.1m AOD, with low points near Yaverland Café (4.5m AOD) and at the eastern end of the defence near the slipway (although land levels rise behind this point). .

A visual inspection of the flood modelling suggests that the indicative standard of protection provided by the defences in this unit is between a present day 1:100 – 1:200yr SoP. Despite this relatively high standard, there is still a large area of flooding in this unit for return periods as low as present day 1:5yr. This is because there are low points in the defences in the adjoining units (IW23 and 24) which allow flood water to propagate behind the defences in unit IW22 and flood the land behind.

The residual life of the existing defences is shown in Table 6-2 below. When the defences come towards the end of their service life it will be necessary to undertake capital repair / refurbishments to extend the service life of the defences.

Two approaches have been considered to implement the maintain option in this unit.

Table 6-2. Defence type and residual life estimates

Defence unit	Defence structure	Existing condition	Estimated residual life (with patch and repair)	Proposed timing of initial capital refurbishment
IW22	Revetment	Fair	10-15 years	2027
IW22	Timber groynes	Fair to Good	10-20 years	2027

The estimated residual life of the existing defences is between 10-15 years. The proposed timing of the initial capital refurbishment is from 2027 which is 10 years from now and therefore is at lower end of the residual life estimate. This timing has conservatively been proposed because refurbishment works will need to be undertaken before the existing asset has actually failed (otherwise a full replacement may be required at higher cost) and for the purpose of costing it provides a precautionary estimate of costs once discounting has been considered (by bringing the initial scheme forward). In addition, failure of the defences in units IW22-24 could lead to significant damages associated with the breach risk in these units and therefore a precautionary approach to managing this frontage is advised (i.e. minimising the breach risk by aiming to undertake refurbishments before the risk of the defences failing becomes too high, especially considering that the estimate residual life is based on a visual assessment only).

<u>Approach 1 – no groyne refurbishments (lower overall investment approach)</u>

Undertake a capital refurbishment of the existing revetment at the end of its current service life (estimated year 2027). This refurbishment will involve resurfacing the face of the structure (e.g. concrete spraying – assumed 4m high for costing). This is expected to extend the service life of the structure by up to 20 years. Between the years 2045-50 the resurfacing works will need repeating, extending the service life to year 2065-70. Between years 2065-70 it is anticipated that further resurfacing will no longer be a suitable or plausible option and therefore a full encasement of the existing defence will be required. The encasement will include new toe protection (i.e. sheet piling) and will reduce the defence's vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore this refurbishment will carry the defence through to the end of the appraisal period.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £515k. This equates to £1,515k in cash terms (approx. £1.5m).

<u>Approach 2 – alternative (higher investment) approach including groyne refurbishments</u>

This approach also includes refurbishments of the timber groynes in this unit, which may help to sustain the beach levels in-front of the revetment defence, extending its service life and reducing the frequency of refurbishments required.

The initial refurbishments would be required towards the end of the structure service life (estimated year 2027). This will involve resurfacing the face of the revetment (e.g. concrete spraying) and a 20% material replacement on the three timber groynes (20% material replacement assumed for costing informed from a visual site inspection. Actual requirements will need to be investigated during scheme design). The groynes are currently in a good condition, however, for cost savings and efficiencies it has been assumed that the groyne refurbishments will be undertaken at a similar time to the revetment refurbishment.

It has been assumed that by sustaining the performance of the timber groynes in the unit the beach levels will remain sufficiently high meaning the next refurbishment of the revetment and groynes will not be required for another 30 years, between years 2055-60.

From years 2085-90, the revetment will be encased alongside a further refurbishment to the groynes. It will not be essential to refurbish the groynes alongside the encasement, because the encased revetment will have new toe protection and will not rely on a beach to protect it. However, for amenity and tourism purposes a further groyne refurbishment has been included although the eligibility for GiA for this refurbishment will need to be explored nearer the time.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £580k. This equates to £2,025k in cash terms (approx. £2.0m).

6.1.4 Sustain SoP

The sustain option will involve raising the crest level of the defences over time to keep pace with sea level rise and to sustain a minimum standard of flood protection. In this unit the properties are generally set back from the coast behind the car park and road, and the existing defence line prevents erosion. However, increasing wave overtopping in the future has the potential to supply flood water into this unit and also from adjacent units in IW23 and IW24. Crest raising therefore needs to be considered alongside raising in the adjacent units in order to provide a common standard of protection to the assets behind the defences.

The preferred standard of protection which will be provided is discussed in later chapters. The indicative route alignment for the crest raising will be established at a later stage should this option be selected as the preferred option during the appraisal. For costing purposes it has been assumed that the crest raising will be undertaken by installing or raising a capping beam on top of the existing defence.

The lengths of crest raising required to achieve a range of standards of protection are presented in Table 6-3. The lengths specified are based on still water levels and a high level assumption of wave heights that could be found at the toe of the structure (in the absence of more detailed assessment / information). Based on this a consideration of where additional defence length may be required to reduce wave overtopping has been made. It has been necessary to make this high level assumption at this stage because a detailed overtopping study is beyond the scope of this assessment.

Due to this the lengths of defence that are specified should be treated as indicative for costing purposes (with the limitation above in mind) and it is recommended that an overtopping study is undertaken to better inform future design stages after this study.

Table 6-3. Length of crest raising required; IW22

Standard of protection	Year	Length of crest raising (approx.)	Average height of raising (approx.)*
1:75 SoP	2057	5m	Between 0.1m to 0.5m
1:75 SoP	2117	30m	Between 0.1m to 0.5m
1:200 SoP	2057	5m	Between 0.1m to 0.5m
1:200 SoP	2117	50m	Between 0.1m to 0.5m

*actual height of raising would be dependent on variations in existing defence heights along the lengths identified in column 3 of this table.

The sustain option will be implemented by raising defence levels in phases. This represents an adaptive approach to manage the increased risk posed by sea level rise and helps account for the uncertainty in future sea level rise projections.

Two approaches have been considered to implement the sustain option in this unit. Both approaches make best use of the existing defences and build upon the maintain approaches discussed in section 6.1.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach involves crest raising of the existing defence in two intervals; in year 2027 the crest will be raised to the 2057 desired SoP and then between years 2055-60 the crest will be raised to the desired 2117 standard. To achieve the 2117 1:75 year SoP, approximately 30m of crest raising will be required (mainly by Yaverland Café), whereas to achieve the 1:200 year standard approximately 50m will be required (same locations as 1:75 SoP but over longer length).

In addition to the crest raising, it will also be necessary to undertake maintenance and refurbishment works to the existing defences. For this approach the ‘lower investment’ maintenance regime set out in section 6.1.3 will be adopted (i.e. does not include groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £525k to sustain a 1:75yr SoP and £535k to sustain a 1:200yr SoP. These equate to cash costs of £1,555k and £1,580k respectively (approx. £1.6m).

Approach 2 - alternative (higher investment) approach including groyne refurbishments

The alternative approach that has been considered is different to the lower investment approach in the way the existing defences are maintained and refurbished. There are no differences to the timing or extent of crest raising. This approach adopts the ‘alternative approach’ to maintenance as set out in section 6.1.3 (i.e. includes groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £590k to sustain a 1:75yr SoP and £595k to sustain a 1:200yr SoP. These equate to cash costs of £2,065k and £2,085k respectively (approx. £2.1m)

6.1.5 Maintain then Sustain

The Maintain- Sustain option involves undertaking crest raising later on during the appraisal period and accepting a gradual fall in the standard of protection in the interim (indicative existing SoP between 1:100 – 1:200yr SoP, expected to fall to between 1:5 – 1:20yr by 2057). This could be an acceptable solution for the area given that the flood risk is minimal until the third epoch.

A lower investment and an alternative higher investment approach to implementing this option have been developed. Akin to the sustain options, both approaches make best use of the existing defences and build upon the maintain options outlined in section 6.1.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.1.4) but only one round of crest raising will be implemented. This will be done between 2055-60 to achieve the 2117 SoP (i.e. no crest raising in 2027).

The estimated PV cost of this combination of measures is approximately £525k to implement Maintain then Sustain to a 1:75yr SoP and £530k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £1,550k and £1,575k respectively (approx. £1.6m)

Approach 2 – alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.1.4) but only one round of crest raising will be implemented. This will be done between 2055-60 to achieve the 2117 SoP (i.e. no raising in 2027).

The estimated PV cost of this combination of measures is approximately £590k to implement Maintain then Sustain to a 1:75yr SoP and £595k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £2,060k and £2,080k respectively (approx. £2.1m).

The overall costs of the 'Maintain then Sustain' approaches are similar to 'Sustain', but timing of the crest raising is different, as it has been rationalised into one phase of raising.

6.1.6 Improve

The improve option involves improving the standard of protection against flooding following a precautionary approach. This will involve just one crest raise to the desired SoP for 2117 rather than multiple incremental raises as set out in the Sustain options above.

A lower investment and an alternative higher investment approach to implementing this option have been developed. Akin to the sustain options, both approaches make best use of the existing defences and build upon the maintain options outlined in section 6.1.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.1.4) but only one round of crest raising will be implemented. This will be done in 2027 to achieve the 2117 SoP (i.e. no crest raise between 2055-60 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £570k. This equates to cash costs of £1,575k (approx. £1.6m).

Approach 2 - alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.1.4) but only one round of crest raising will be implemented. This will be done in 2027 to achieve the 2117 SoP (i.e. no raise between 2055-60 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £635k. This equates to cash costs of £2,080k (approx. £2.1m).

The overall costs of the 'Improve' approaches are similar to the previous options, but timing of the crest raising is different, as earlier investment will be required.

6.1.7 Summary

The measure combinations considered in the development of options for unit IW22 are summarised in Table 6-4 below.

Table 6-4. Summary of measure combinations developed for IW22

Option	Measures and timing*	PV cost	Cash cost	Notes
Do Minimum	- Patch and repair	£35k	£125k	Ongoing. Cost estimate based on recent expenditure
Maintain – approach 1	- Resurface revetment (2027 & 2045-50) - Encase revetment (2065-70)	£515k	£1,515k	Resurface to extend service life by approx. 20yrs (along an approx. 4m height). Encasement required from 2065-70 as resurfacing alone is unlikely to be sufficient.
Maintain – approach 2	- Resurface revetment (2027 & 2055-60) - Encase revetment (2085-90) - Refurb timber groynes (2027, 2055-60 & 2085-90)	£580k	£2,025k	Refurb of timber groynes may hold beach in place which will better protect revetment. Therefore longer service life of existing structure.
Sustain – approach 1	- As per maintain approach 1 - Crest raising in 2027 and 2055-60	£525 – 535k	£1,555 – 1,580k	Crest raising in 2027 to 2057 SoP. Crest raising in 2057 to 2117 SoP. Cost range for 75yr to 200yr SoP.
Sustain – approach 2	- As per maintain approach 2 - Crest raising in 2027 and 2055-60	£590 – 595k	£2,065 – 2,085k	
Maintain then Sustain approach 1	- As per maintain approach 1 - Crest raising in 2055-60	£525 – 530k	£1,550 – 1,575k	Crest raising in 2055-60 to 2117 SoP. Cost range for 75yr to 200yr SoP.
Maintain then Sustain approach 2	- As per maintain approach 2 - Crest raising in 2055-60	£590 – 595k	£2,060 – 2,080k	
Improve – approach 1	- As per maintain approach 1 - Crest raising in 2027 (to 2117 SoP)	£570k	£1,575k	Crest raising in 2027 to 2117 SoP. Cost for 200yr SoP.
Improve – approach 2	- As per maintain approach 2 - Crest raising in 2027 (to 2117 SoP)	£635k	£2,080k	

**Note – measures and timings are only estimates, refer to paragraph at the start of section 6 for more details.*

With the implementation of the Maintain, Sustain or Improve options it may be necessary to prevent outflanking to the north-east of unit IW22 which is currently undefended. At the time of writing this report outflanking is largely prevented by the concrete slipway and car park which are located at the northern margin of IW22 (see Figure 6-2).

Future outflanking could be prevented by a number of measures, including gabions and rock armour. Costs for flank protection have not specifically been included in the cost estimates for the options because the amount of protection required is very uncertain, mainly due to characteristically unpredictable rates of outflanking that can occur adjacent to defences. However, for reference, the costs for both gabions and rock armour have been presented in Table 6-5 below. These costs are based on estimated outflanking distances which could occur if the coastline is left undefended. The distances have been approximated from the Do Nothing erosion lines and are a high level estimate only. The Do Nothing erosion lines do not take into account the impact of holding the line immediately adjacent to the undefended area and the potential impact that this could have on sediment drift and wave energy in the area (and consequently on the rate of erosion).

Table 6-5 Estimated costs for outflanking measures

Protection approach	Potential outflanking distance (approx.)	Cost (cash)
Gabions – 1m high	Present day to 2027 = 5m 2027 to 2057 = 20m 2057 to 2117 = 50m	5m = £3k, 20m = £12k, 50m = £30k
Rock armour (3t rocks) with geotextile layer		5m = £12k, 20m = £48k, 50m = £120k

Figure 6-2 Photograph of potential outflanking area to the north of IW22

As an overview of unit 22, the cash cost for the range of options in this whole unit is approximately £1.5 to £2.1 million, to provide continued or improved protection from erosion and flood risks over the next 100 years, dependent on the standard of protection chosen and on whether or not the groynes are maintained. The timing/phasing of the works and the timing of investment required also varies in the different options, as outlined in this chapter.

Methods of maintaining or improving the defences

Cost-effective and appropriate methods to reduce risks have been sought and costed in this chapter. These include using a sprayed coating of concrete to extend the life of the current defences, as this method has already been used in Sandown Bay, at neighbouring Culver Parade seawall in 2006 (in unit IW24). Other methods proposed include more substantial encasement of the defences in concrete (when technically required), plus crest-raising of the defences (when required). Options including refurbishment of the groynes in the area have also been included in the costings.

Alternative methods have also been considered, such as beach nourishment or a new sloping revetment. Each method has different costs, advantages and disadvantages, and would last for a different number of years before needing to be repeated. When packaged into combinations of methods over 100 years these alternative measures are anticipated to add up to more expensive solutions than those proposed in the chapter above. Therefore if extra funding is available, alternative methods could also be considered. The alternative options considered for all the defence units are summarised in section 0.

6.2 Unit IW23 (Sandown Zoo)

This 254m long unit is located in front of Sandown Zoo and is currently defended by a seawall, constructed in 1930 and four masonry groynes (Figure 6-3). The number of properties at risk in IW23 over the next 100 years is presented in Table 6-6 below. Whilst there are no properties at risk immediately within this unit, the unit provides a flow pathway for flood water into adjacent units (IW22 and 24) and places properties at risk (see numbers of properties at risk in section 6.1 and 6.3). It is therefore imperative to consider the different options and their costs within this unit in order for options across the full IW22-24 frontage to be developed.

Table 6-6 Properties at risk in unit IW23

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion (cumulative)
2017	0	0	0	0
2027	0	0	0	0
2057	0	0	0	0
2117	0	0	0	4

As outlined above the table, there is therefore both flood and erosion risk in this unit. The immediate flood risk is principally from wave overtopping at localised low spots in the defence levels; a short 5m section in front of the zoo carpark and 15m of defence immediately in front of The Grand Hotel. By 2117, to achieve a 1:75yr SoP (Standard of Protection) approximately 165m of the existing defence length would need to be raised, and to achieve a 1:200yr SoP approximately 180m of the defences would need to be raised.

Figure 6-3. Members of the project team inspect the defences in Unit IW23

6.2.1 Do Nothing

Doing Nothing involves no active intervention. The present value cost of this option is £0.

6.2.2 Do Minimum

Do Minimum involves small scale reactive maintenance and 'patch repair' work to the existing seawall and groynes. Based on the current IoW Council expenditure on patch and repair maintenance along the Sandown frontage it is estimated that a continuation of this activity for the next 100 years would cost approximately PV £40k for this unit. This equates to £140k in cash terms. The limitations of this method are outlined in section 5.1.2 above.

6.2.3 Maintain

The maintain option involves scheduled maintenance of the existing defences to ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years).

Typical crest levels of the defences in this unit fall between 4.3-5.8m AOD, although there are local low points in front of Sandown Zoo car park and the Grand hotel (both approximately 3.5m AOD).

A visual inspection of the flood modelling suggests that the indicative standard of protection provided by the defences in this unit is less than a present day 1:5yr SoP. Whilst there are no properties at risk from flooding within this unit the floodwater which spills over the defences propagates into the adjacent units (IW22 and 24) which puts properties at risk.

The residual life of the existing defences is shown in Table 6-7 below. When the defences come towards the end of their service life it will be necessary to undertake capital repair / refurbishments to extend the service life of the defences.

Two approaches have been considered to implement the maintain option in this unit.

Table 6-7. Defence type and residual life of unit IW23

Defence unit	Defence structure	Existing condition	Estimated residual life (with patch and repair)	Proposed timing of initial capital refurbishment
IW23/01	Seawall	Fair	10-15 years	2027
IW23/02	Seawall	Good	15-25 years	2027
IW23	Masonry groynes	Good	10-20 years	2027

The estimated residual life of the existing defences is between 10-20 years, and the condition of the defences varies along the unit with section 23/02 having an estimated residual life of 15-25 years. The proposed timing of the initial capital refurbishment is from 2027 which is 10 years from now and therefore is at lower end of the residual life estimate and actually before unit 23/02 is expected to fail. This timing has conservatively been proposed because refurbishment works will need to be undertaken before the existing asset has actually failed (otherwise a full replacement may be required at higher cost) and for the purpose of costing it provides a precautionary estimate of costs once discounting has been considered (by bringing the initial scheme forward). In addition, failure of the defences in units IW22-24 could lead to significant damages associated with the breach risk in these units and therefore a precautionary approach to managing this frontage is advised (i.e. minimising the breach risk by aiming to undertake refurbishments before the risk of the defences failing becomes too high, especially considering that the estimated residual life is based on a visual assessment only). Furthermore, grouping the works into one implementation across the unit could provide a number of efficiencies which should be explored during future appraisals.

Approach 1 - no groyne refurbishments (lower overall investment approach)

Undertake a capital refurbishment of the existing seawall towards the end of its current service life in year 2027. This refurbishment will involve resurfacing the face of the structure (e.g. concrete spraying – assumed 4m high in for costing). This is expected to extend the service life of the structure by up to 20 years. Between the years 2045-50 the resurfacing works will need repeating, extending the service life to year 2070-75 (est.).

Between the years 2065-70 it is anticipated that further resurfacing will no longer be suitable and therefore a full encasement of the existing defence will be required. The encasement will include new toe protection (i.e. sheet piling) and will reduce the defence's vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore this refurbishment will carry the defence through to the end of the 100 year appraisal period.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £500k. This equates to £1,710k in cash terms (approx. £1.7m).

Approach 2 – alternative (higher investment) approach including groyne refurbishments

This approach also includes refurbishments of the masonry groynes in this unit, which may help to sustain the beach levels in-front of the seawall defence, extending its service life and reducing the frequency of refurbishments required.

The initial refurbishments would be required towards the end of the structure service life in year 2027. This will involve resurfacing the face of the seawall (e.g. concrete spraying) and a concrete refurbishment of the four masonry groynes. For cost savings and efficiencies it has been assumed that the groyne refurbishments will be undertaken at a similar time to the seawall refurbishment.

It has been assumed that by sustaining the performance of the groynes in the unit the beach levels be sustained and therefore the next refurbishment of the seawall and groynes will not be required for another 30 years, between years 2055-60.

Between years 2085-90, the seawall will be encased alongside a further refurbishment to the groynes. It will not be essential to refurbish the groynes alongside the encasement, because the encased seawall will have new toe protection and will not rely on a beach to protect it. However, for amenity and tourism purposes a further groyne refurbishment has been included although the amount of GiA available for this refurbishment will need to be determined nearer the time.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £1,020k. This equates to £3,315k in cash terms (approx. £3.3m).

6.2.4 Sustain SoP

The sustain option will involve raising the crest level of the defences over time to keep pace with sea level rise and sustain a minimum standard of flood protection. The preferred standard of protection which will be provided is discussed in later chapters. The indicative route alignment for the crest raising will be established at a later stage should this option be selected as the preferred option during the appraisal. For costing purposes it has been assumed that the crest raising will be undertaken by installing or raising a capping beam on top of the existing defence.

The lengths of crest raising required to achieve a range of standards of protection are presented in Table 6-8. The lengths specified are based on still water levels and a high level assumption of wave heights that could be found at the toe of the structure. Based on this a consideration of where additional defence length may be required to reduce wave overtopping has been made. It has been necessary to make this high level assumption at this stage because a detailed overtopping study is beyond the scope of this assessment. Due to this the lengths of defence that are specified should be treated as indicative for costing purposes and it is recommended that an overtopping study is undertaken to better inform future design stages after this study.

Table 6-8. Length of crest raising required; IW23

Standard of protection	Year	Length of crest raising (approx.)	Average height of raising (approx.)*
1:75 SoP	2057	15m	Between 0.1m to 0.5m
1:75 SoP	2117	165m	Between 0.1m to 0.5m
1:200 SoP	2057	25m	Between 0.1m to 0.5m
1:200 SoP	2117	180m	Between 0.1m to 0.5m

*actual height of raising would be dependent on variations in existing defence heights along the lengths identified in column 3 of this table.

The sustain option will be implemented by raising defence levels in phases. This represents an adaptive approach to manage the increased risk posed by sea level rise and helps account for the uncertainty in future sea level rise projections.

Two approaches have been considered to implement the sustain option in this unit. Both approaches make best use of the existing defences and build upon the maintain approaches discussed in section 6.2.3.

<u>Approach 1 - no groyne refurbishments (lower investment approach)</u>

This approach involves crest raising of the existing defence in two intervals; from year 2027 the crest will be raised to the 2057 desired SoP and then between years 2055-60 the crest will be raised to the desired 2117 standard. To achieve the 2117 1:75 year SoP, approximately 165m of crest raising will be required, whereas to achieve the 1:200 year standard approximately 180m will be required.

In addition to the crest raising, it will also be necessary to undertake maintenance and refurbishment works to the existing defences. For this approach the ‘lower investment’ maintenance regime set out in section 6.2.3 will be adopted (i.e. does not include groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £585k to sustain a 1:75yr SoP and £595k to sustain a 1:200yr SoP. These equate to cash costs of £1,980k and £2,020k respectively (approx. £2.0m).

Approach 2 – alternative (higher investment) approach including groyne refurbishments

The alternative approach that has been considered is different to the lower investment approach in the way the existing defences are maintained and refurbished. There are no differences to the timing or extent of crest raising. This approach adopts the 'alternative approach' to maintenance as set out in section 6.2.3 (i.e. includes groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £1,095k to sustain a 1:75yr SoP and £1,115k to sustain a 1:200yr SoP. These equate to cash costs of £3,565k and £3,625 respectively (approx. £3.6m).

6.2.5 Maintain then Sustain

The Maintain then Sustain option involves undertaking crest raising later on during the appraisal period and accepting a gradual fall in the standard of protection in the interim (indicative existing SoP less than 1:5yr falling to <1yr in 2057).

A lower investment and an alternative higher investment approach to implementing this option have been developed. Akin to the sustain options, both approaches make best use of the existing defences and build upon the maintain options outlined in section 6.1.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.2.4) but only one round of crest raising will be implemented. This will be done between the years 2055-60 to achieve the 2117 SoP (i.e. no crest raise in 2027).

The estimated PV cost of this combination of measures is approximately £565k to implement Maintain then Sustain to a 1:75yr SoP and £575k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £1,950k and £1,995k respectively (approx. £2.0m).

Approach 2 – alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.2.4) but only one round of crest raising will be implemented. This will be done between 2055-60 to achieve the 2117 SoP (i.e. no raise in 2027).

The estimated PV cost of this combination of measures is approximately £1,085k to implement Maintain then Sustain to a 1:75yr SoP and £1,095k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £3,550k and £3,590k respectively (approx. £3.6m).

The overall costs of the 'Maintain then Sustain' approaches are similar to, but slightly cheaper than the 'Sustain' option, as timing of the crest raising is different as it has been rationalised into one phase of raising.

6.2.6 Improve

The improve option involves improving the standard of protection against flooding following a precautionary approach. This will involve just one crest raise to the desired SoP for 2117 rather than multiple incremental raises as set out in the Sustain options above.

A lower investment and an alternative higher investment approach to implementing this option have been developed. Akin to the sustain options, both approaches make best use of the existing defences and build upon the maintain options outlined in section 6.2.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.2.4) but only one round of crest raising will be implemented. This will be done from 2027 to achieve the 2117 SoP (i.e. no crest raise between 2055-60 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £785k. This equates to cash costs of £1,995k (approx. £2.0m).

Approach 2 – alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.2.4) but only one round of crest raising will be implemented. This will be done from 2027 to achieve the 2117 SoP (i.e. no raise between 2055-60 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £1,305k. This equates to cash costs of £3,595k (approx. £3.6m).

The overall costs of the 'Improve' approaches are similar to the previous options, but timing of the crest raising is different, as earlier investment will be required.

6.2.7 Summary

The measure combinations considered in the development of options for unit IW23 are summarised in Table 6-9 below.

Table 6-9. Summary of measure combinations developed for IW23

Option	Measures and timing*	PV cost	Cash cost	Notes
Do Minimum	- Patch and repair	£40k	£140k	Ongoing. Cost estimate based on recent expenditure
Maintain – approach 1	- Resurface seawall (2027 & 2045-50) - Encase seawall (2065-70)	£500k	£1,710k	Resurface to extend service life by approx. 20yrs. Encasement required from 2070-75 as resurfacing alone is unlikely to be sufficient.
Maintain – approach 2	- Resurface seawall (2027 & 2055-60) - Encase seawall (2085-90) - Refurb masonry groynes (2027, 2055-60 & 2085-90)	£1,020k	£3,215k	Refurb of groynes may hold beach in place which will better protect seawall. Therefore longer service life of existing structure.
Sustain – approach 1	- As per maintain approach 1 - Crest raising from 2027 and 2055-60	£585 – 595k	£1,980 – 2,020k	Crest raising from 2027 to 2057 SoP. Crest raising in 2055-60 to 2117 SoP. Cost range for 75yr to 200yr SoP.
Sustain – approach 2	- As per maintain approach 2 - Crest raising from 2027 and 2055-60	£1,095 – 1,115k	£3,565 – 3,625k	
Maintain then Sustain approach 1	- As per maintain approach 1 - Crest raising in 2055-60	£565 – 575k	£1,950 – 1,995k	Crest raising in 2055-60 to 2117 SoP. Cost range for 75yr to 200yr SoP.
Maintain then Sustain approach 2	- As per maintain approach 2 - Crest raising in 2055-60	£1,085 – 1,095k	£3,550 – 3,595k	
Improve – approach 1	- As per maintain approach 1 - Crest raising from 2027 (to 2117 SoP)	£785k	£1,995k	Crest raising from 2027 to 2117 SoP. Cost for 200yr SoP.
Improve – approach 2	- As per maintain approach 2 - Crest raising from 2027 (to 2117 SoP)	£1,305k	£3,595k	

**Note – measures and timings are only estimates, refer to paragraph at the start of section 6 for more details.*

The cash cost for the range of options in this unit is approximately £1.7 to £3.6 million, to provide continued or improved protection from erosion and flood risks over the next 100 years, dependent on the standard of protection chosen and on whether or not the groynes are maintained. The timing/phasing of the works and timing of investment required also varies in the different options, as outlined in this chapter.

Methods of maintaining or improving the defences

Cost-effective and appropriate methods to reduce risks have been sought and costed in this chapter. These include using a sprayed coating of concrete to extend the life of the current defences, as this method has already been used in Sandown Bay, at neighbouring Culver Parade seawall in 2006 (in unit IW24). Other methods proposed include more substantial encasement of the defences in concrete (when technically required), plus crest-raising of the defences (when required). Options including refurbishment of the groynes in the area have also been included in the costings.

Alternative methods have also been considered, such as beach nourishment. Each method has different costs, advantages and disadvantages, and would last for a different number of years before needing to be repeated. When packaged into combinations of methods over 100 years these alternative measures are anticipated to add up to more expensive solutions than those proposed in the chapter above. Therefore if extra funding is available, alternative methods could also be considered. The alternative options considered for all the defence units are summarised in section 0.

6.3 Unit IW24 (Culver Parade)

This 681m long unit at Culver Parade is currently defended by sections of seawall, originally constructed between 1911 and 1930. The Environment Agency owned section of the seawall was rendered in 2006 (Figure 6-4). There are a total of nine groynes in this unit; seven timber groynes and two masonry groynes. Environmental enhancement techniques for coastal protection structures are being tested on groynes within this unit near Browns mini golf course.

There is both a flood and erosion risk in this unit. Whilst the immediate flood risk is principally from wave overtopping there are some localised low spots in the defence levels; in front of the Pluto pump house, between the Dinosaur Isle museum and the Lake and the intersection of Fort St. and Culver Parade. The flooding originating from this unit propagates behind adjacent units and also along the east and north sides of Sandown during larger return period events. There are therefore a large number of properties at risk from flooding in this unit.

The number of properties at risk in IW24 over the next 100 years is presented in Table 6-10 below. The significant step change in properties at risk of flooding between 2027 and 2057 is related to the assumed breach of the defences at some point over this period (assumed under the Do Nothing scenario).

Table 6-10 Properties at risk in unit IW24

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion (cumulative)
2017	1	11	12	0
2027	1	11	12	0
2057	256	170	426	25
2117	332	174	506	43

In order to achieve a present day 1:75yr SoP (Standard of Protection), approximately 215m of the defence requires raising (mainly near Sandown recreation facilities; skatepark, playground etc.). To achieve the same SoP in 2117 the entire length of the existing defence would require raising.

Figure 6-4. IW24 seawall

6.3.1 Do Nothing

Doing Nothing involves no active intervention. The present value cost of this option is £0.

6.3.2 Do Minimum

Do Minimum involves small scale reactive maintenance and 'patch repair' work to the existing seawall and groynes. Based on the current IoW Council expenditure on patch and repair maintenance along the Sandown frontage it is estimated that a continuation of this activity for the next 100 years would cost approximately PV £110k for this unit. This equates to £375k in cash terms. The limitations of this method are outlined in section 5.1.2 above.

6.3.3 Maintain

The maintain option involves scheduled maintenance of the existing defences to ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years).

Typical crest levels of the defences in this unit fall between 3.6-3.8m AOD, although there are local low points along a 25m length in front of the operation Pluto pump house, a low point (+2.4m) between the Dinosaur Isle museum and the lake and another near the intersection of Fort Street and Culver Parade.

A visual inspection of the flood modelling suggests that the indicative standard of protection provided by the defences in this unit is less than a present day 1:5yr SoP.

The residual life of the existing defences is shown in Table 6-11 below. When the defences come towards the end of their service life it will be necessary to undertake capital repair / refurbishments to extend the service life of the defences.

Table 6-11. Defence type and residual life of unit IW24

Defence unit	Defence structure	Existing condition	Estimated minimum residual life (with patch and repair)	Proposed timing of initial capital refurbishment
IW24/01	Seawall	Fair	10-15 years	2027
IW24/02	Seawall	Very good	25-35 years	2027
IW24/03	Seawall	Good	15-20 years	2027
IW24	Timber and masonry groynes	Good	10-20 years	2027

The estimated residual life of the existing defences is between 10-25 years, and the condition of the defences varies along the unit with section 24/02 having an estimated residual life of 25-35 years (although this is a typical estimate based on the condition from a visual assessment only, and the condition of the defences below the beach level is uncertain; It is also noted that this is a section resprayed with concrete in 2006, a method with a likely shorter residual life than other methods, and dependent on underlying structural stability of the embankment). The proposed timing of the initial capital refurbishment is from 2027 which is 10 years from now and therefore is at lower end of the residual life estimate and actually before units 24/02 and 24/03 are expected to fail. However, this timing has conservatively been proposed because refurbishment works will need to be undertaken before the existing asset has actually failed (otherwise a full replacement may be required at higher cost) and for the purpose of costing it provides a precautionary estimate of costs once discounting has been considered (by bringing the initial scheme forward). In addition, the preferred approach in this unit needs to be considered in conjunction with units 22 and 23 where residual lives of defences are lower. The failure of the defences in units IW22-24 could lead to significant damages associated with the breach risk and therefore a precautionary approach to managing this frontage is advised (i.e. minimising the breach risk by aiming to undertake refurbishments before the risk of the defences failing becomes too high). Furthermore, grouping the works into one implementation across the unit(s) could provide a number of efficiencies which should be explored during future appraisals.

Two approaches have been considered to implement the maintain option in this unit.

<u>Approach 1 - no groyne refurbishments (lower overall investment approach)</u>

Undertake a capital refurbishment of the existing seawall sections towards the end of the current service life (proposed year 2027). This refurbishment will involve resurfacing the face of the structure (e.g. concrete spraying – assumed 4m height for costing purposes). This is expected to extend the service life of the structure by 20 years. Between years 2045-50 the resurfacing works will need repeating, extending the service life to year 2065-70. Between years 2065-2070 it is anticipated that further resurfacing will no longer be suitable (limit to effectiveness after multiple resurfacing) and therefore a full encasement of the existing defence will be required. The encasement will include new toe protection (i.e. sheet piling) and will reduce the defence's vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore this refurbishment will carry the defence through to the end of the appraisal period.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £1,345k. This equates to £4,585k in cash terms (approx. £4.6m).

<u>Approach 2 – alternative (higher investment) approach including groyne refurbishments</u>

This approach also includes refurbishments of the masonry and timber groynes in this unit, which may help to sustain the beach levels in-front of the seawall defence, extending its service life and reducing the frequency of refurbishments required.

The initial refurbishments would be required towards the end of the seawall and groynes service life in year 2027. This will involve resurfacing the face of the seawall (e.g. concrete spraying), a concrete refurbishment of the two masonry groynes and a 20% material refurbishment of the seven timber groynes (20% material replacement assumed for costing informed from a visual site inspection. Actual requirements will need to be investigated during scheme design). For cost savings and efficiencies it has been assumed that the groyne refurbishments will be undertaken at a similar time to the seawall refurbishment.

It has been assumed that by sustaining the performance of the groynes in the unit the beach levels will remain and therefore the next refurbishment of the seawall will not be required for another 30 years, between the years 2055-60. However, the timber groynes are likely to require a second refurbishment prior to this between the years 2045-50.

Between 2085-90, the seawall will be encased alongside a further refurbishment to the groynes. It will not be essential to refurbish the groynes alongside the encasement, because the encased seawall will have new toe protection and will not rely on a beach to protect it. However, for amenity and tourism purposes a further groyne refurbishment has been included although the potential GiA available towards this refurbishment will need to be determined nearer the time.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £2,250k. This equates to £7,890k in cash terms (approx. £7.9m).

6.3.4 Sustain SoP

The sustain option will involve raising the crest level of the defences over time to keep pace with sea level rise and sustain a minimum standard of flood protection. The preferred standard of protection which will be provided is discussed in later chapters. The indicative route alignment for the crest raising will be established at a later stage should this option be selected as the preferred option during the appraisal. For costing purposes it has been assumed that the crest raising will be undertaken by installing or raising a capping beam on top of the existing defence.

The lengths of crest raising required to achieve a range of standards of protection are presented in Table 6-12. The lengths specified are based on still water levels and a high level assumption of wave heights that could be found at the toe of the structure. Based on this a consideration of where additional defence length may be required to reduce wave overtopping has been made. It has been necessary to make this high level assumption at this stage because a detailed overtopping study is beyond the scope of this assessment. Due to this the lengths of defence that are specified should be treated as indicative for costing purposes and it is recommended that an overtopping study is undertaken to better inform future design stages after this study.

Table 6-12. Length of crest raising required; IW24

Standard of protection	Year	Length of crest raising	Average height of raising (approx.)*
1:75 SoP	2057	385m	Between 0.5-1m
1:75 SoP	2117	680m	Between 0.5-1m
1:200 SoP	2057	445m	Between 0.5-1m
1:200 SoP	2117	680m	Between 1-1.5m

*actual height of raising would be dependent on variations in existing defence heights along the lengths identified in column 3 of this table.

The sustain option will be implemented by raising defence levels in phases. This represents an adaptive approach to manage the increased risk posed by sea level rise and helps account for the uncertainty in future sea level rise projections.

Two approaches have been considered to implement the sustain option in this unit. Both approaches make best use of the existing defences and build upon the maintain approaches discussed in section 6.3.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach involves crest raising of the existing defence in two intervals; in year 2027 the crest will be raised to the 2057 desired SoP and then between 2055-60 the crest will be raised to the desired 2117 standard. To achieve both the 2117 1:75 year and 1:200 year SoP raising along the full length of defence will be required.

In addition to the crest raising, it will also be necessary to undertake maintenance and refurbishment works to the existing defences. For this approach the 'lower investment' maintenance regime set out in section 6.3.3 will be adopted (i.e. does not include groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £2,185k to sustain a 1:75yr SoP and £2,335k to sustain a 1:200yr SoP. These equate to cash costs of £6,730k and £7,005k respectively (approx. £6.7 or £7.0m).

Approach 2 – alternative (higher investment) approach including groyne refurbishments

The alternative approach that has been considered is different to the lower investment approach in the way the existing defences are maintained and refurbished. There are no differences to the timing or extent of crest raising. This approach adopts the 'alternative approach' to maintenance as set out in section 6.3.3 (i.e. includes groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £3,090k to sustain a 1:75yr SoP and £3,240k to sustain a 1:200yr SoP. These equate to cash costs of £10,030k and £10,310k respectively (approx. £10.0 to £10.3m).

6.3.5 Maintain then Sustain

The Maintain then Sustain option involves undertaking crest raising later on during the appraisal period and accepting a gradual fall in the standard of protection in the interim (indicative existing SoP less than 1:5yr falling to <1yr in 2057).

A lower investment and an alternative higher investment approach to implementing this option have been developed. Akin to the sustain options, both approaches make best use of the existing defences and build upon the maintain options outlined in section 6.1.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.3.4) but only one round of crest raising will be implemented. This will be done between 2055-60 to achieve the 2117 SoP (i.e. no crest raise in 2027).

The estimated PV cost of this combination of measures is approximately £1,750k to implement Maintain then Sustain to a 1:75yr SoP and £1,780k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £6,115k and £6,220k respectively (approx. £6.1 or £6.2m).

Approach 2 - alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.3.4) but only one round of crest raising will be implemented. This will be done between 2055-60 to achieve the 2117 SoP (i.e. no raise in 2027).

The estimated PV cost of this combination of measures is approximately £2,655k to implement Maintain then Sustain to a 1:75yr SoP and £2,685k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £9,415k and £9,525k respectively (approx. £9.4 or £9.5m).

6.3.6 Improve

The improve option involves improving the standard of protection against flooding following a precautionary approach. This will involve just one crest raise to the desired SoP for 2117 rather than multiple incremental raises as set out in the Sustain options above.

A lower investment and an alternative (higher investment) approach to implementing this option have been developed. Akin to the sustain options, both approaches make best use of the existing defences and build upon the maintain options outlined in section 6.3.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.3.4) but only one round of crest raising will be implemented. This will be done from 2027 to achieve the 2117 SoP (i.e. no crest raise between 2055-60 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £2,980k. This equates to cash costs of £6,220k (approx. £6.2m).

Approach 2 - alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.3.4) but only one round of crest raising will be implemented. This will be done in 2027 to achieve the 2117 SoP (i.e. no raise between 2055-60 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £3,885k. This equates to cash costs of £9,525k (approx. £9.5m).

The overall costs of the 'Improve' approaches are similar to the previous options, but timing of the crest raising is different, as earlier investment will be required.

6.3.7 Summary

The measure combinations considered in the development of options for unit IW24 are summarised in Table 6-13 below.

Table 6-13. Summary of measure combinations developed for IW24

<table>
<tr><th>Option</th><th>Measures and timing*</th><th>PV cost</th><th>Cash cost</th><th>Notes</th></tr>
<tr><td>Do Minimum</td><td>- Patch and repair</td><td>£110k</td><td>£375k</td><td>Ongoing. Cost estimate based on recent expenditure</td></tr>
<tr><td>Maintain – approach 1</td><td>- Resurface seawall (2027 & 2045-50)
- Encase seawall (2065-70)</td><td>£1,345k</td><td>£4,585k</td><td>Resurface to extend service life by approx. 20yrs. Encasement required from 2065-70 as resurfacing alone is unlikely to be sufficient.</td></tr>
<tr><td>Maintain – approach 2</td><td>- Resurface seawall (2027 & 2055-60)
- Encase seawall (2085-90)
- Refurb timber groynes (2027, 2045-50, 2065-70 & 2085-90)
- Refurb masonry groynes (2027 & 2065-70)</td><td>£2,250k</td><td>£7,890k</td><td>Refurb of groynes may hold beach in place which will better protect seawall. Therefore longer service life of existing structure.</td></tr>
<tr><td>Sustain – approach 1</td><td>- As per maintain approach 1
- Crest raising in 2027 and 2055-60</td><td>£2,185 – 2,335k</td><td>£6,730 – 7,005k</td><td rowspan="2">Crest raising in 2027 to 2057 SoP. Crest raising in 2055-60 to 2117 SoP. Cost range for 75yr to 200yr SoP.</td></tr>
<tr><td>Sustain – approach 2</td><td>- As per maintain approach 2
- Crest raising in 2027 and 2055-60</td><td>£3,090 – 3,240k</td><td>£10,030 – 10,310k</td></tr>
<tr><td>Maintain then Sustain approach 1</td><td>- As per maintain approach 1
- Crest raising in 2055-60</td><td>£1,750 – 1,780k</td><td>£6,115 – 6,220k</td><td rowspan="2">Crest raising in 2055-60 to 2117 SoP. Cost range for 75yr to 200yr SoP.</td></tr>
<tr><td>Maintain then Sustain approach 2</td><td>- As per maintain approach 2
- Crest raising in 2055-60</td><td>£2,655 – 2,685k</td><td>£9,415 – 9,525k</td></tr>
<tr><td>Improve – approach 1</td><td>- As per maintain approach 1
- Crest raising in 2027 (to 2117 SoP)</td><td>£2,980k</td><td>£6,220k</td><td rowspan="2">Crest raising in 2027 to 2117 SoP. Cost for 200yr SoP.</td></tr>
<tr><td>Improve – approach 2</td><td>- As per maintain approach 2
- Crest raising in 2027 (to 2117 SoP)</td><td>£3,885k</td><td>£9,525k</td></tr>
</table>

**Note – measures and timings are only estimates, refer to paragraph at the start of section 6 for more details.*

The cash cost for the range of options in this unit is approximately £4.6 to £10.3 million, to provide continued or improved protection from erosion and flood risks over the next 100 years, dependent on the standard of protection chosen and on whether or not the groynes are maintained. The timing/phasing of the works and the timing of the investment required also varies for the different options, as outlined in this chapter.

Methods of maintaining or improving the defences

Cost-effective and appropriate methods to reduce risks have been sought and costed in this chapter. These include using a sprayed coating of concrete to extend the life of the current defences, as this method has already been used this unit in 2006. Other methods proposed include more substantial encasement of the defences in concrete (when technically required), plus crest-raising of the defences (when required). Options including refurbishment of the groynes in the area have also been included in the costings.

Alternative methods have also been considered, such as beach nourishment and road raising. Each method has different costs, advantages and disadvantages, and would last for a different number of years before needing to be repeated. When packaged into combinations of methods over 100 years these alternative measures are anticipated to add up to more expensive solutions than those proposed in the chapter above. Therefore if extra funding is available, alternative methods could also be considered. The alternative options considered for all the defence units are summarised in section 0.

6.4 Unit IW25 (Sandown Esplanade)

Unit IW25 is just over 1km long (1026m) and forms the main frontage of the town of Sandown (Figure 6-5). There is an esplanade and roadway running along the majority of the frontage immediately behind the defence line. Sandown Pier is located approximately half way along this unit. The unit is defended by various sections of seawall and one timber groyne located at its southern end.

The number of properties at risk in IW25 over the next 100 years is presented in Table 6-14 below.

Table 6-14 Properties at risk in unit IW25

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion (cumulative)
2017	1	5	6	0
2027	1	5	6	0
2057	1	5	6	79
2117	1	5	6	203

There is both a flood and erosion risk in this unit. Whilst the immediate flood risk is principally from wave overtopping there are some localised low spots in the defence levels; at the waterfront monument between Albert Road and Esplanade Road, immediately to the west of the monument in front of the Ocean Hotel, and in front of the Trouville Hotel. By 2117, to achieve a 1:75yr SoP (Standard of Protection) approximately 800m of the existing defence length would need to be raised, and to achieve a 1:200yr SoP approximately 820m of the defences would need to be raised. The flood risk in this unit potentially affects properties lining the seafront, behind which the land rises. There is not the extensive low-lying floodplain inland of this unit such as is present in the neighbouring units to the north.

Figure 6-5. Sandown frontage

6.4.1 Do Nothing

Doing Nothing involves no active intervention. The present value cost of this option is £0.

6.4.2 Do Minimum

Do Minimum involves small scale reactive maintenance and ‘patch repair’ work to the existing seawall and groynes. Based on the current IoW Council expenditure on patch and repair maintenance along the Sandown frontage it is estimated that a continuation of this activity for the next 100 years would cost approximately PV £170k for this unit. This equates to £565k in cash terms. The limitations of this method are outlined in section 5.1.2 above.

6.4.3 Maintain

The maintain option involves scheduled maintenance of the existing defences to ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years).

Typical crest levels of the defences in this unit fall between 4.3-4.4m AOD, although there are local low points (lower than the typical range) at waterfront monument between Albert Road and Esplanade Road, immediately to the west of the monument in front of the Ocean Hotel, and in front of the Trouville Hotel.

A visual inspection of the flood modelling suggests that the indicative standard of protection provided by the defences in this unit is less than a present day 1:5yr SoP.

The residual life of the existing defences is shown in Table 6-15 below. When the defences come towards the end of their service life it will be necessary to undertake capital repair / refurbishments to extend the service life of the defences.

Table 6-15. Defence type and residual life of unit IW25

Defence unit	Defence structure	Existing condition	Estimated residual life (with patch and repair)	Proposed timing of initial capital refurbishment
IW 25/01 to 25/03	Seawall	Good	15-20 years	2027-32
IW25/04	Seawall	Very good	25-35 years	2027-32
IW25/05	Seawall	Good	10-20 years	2027-32
IW25/05	Timber groyne	Fair	10-15 years	2027

The estimated residual life of the existing defences is between 10-35 years, and the condition of the defences varies along the unit with section 25/04 having an estimated residual life of 25-35 years. The proposed timing of the initial capital refurbishment is from 2027-32 which is 10-15 years from now and therefore is at the lower end of the residual life estimate and actually before unit 25/04 is expected to fail. This timing has conservatively been proposed because refurbishment works will need to be undertaken before the existing asset has actually failed (otherwise a full replacement may be required at higher cost) and for the purpose of costing it provides a precautionary estimate of costs once discounting has been considered (by bringing the initial scheme forward). In addition, grouping the works into one implementation across the unit could provide a number of efficiencies which should be explored during future appraisals (e.g. reduced costs associated with repeat mobilisation, potential for initial scheme to only refurbish localised sections of the defences in better condition to extend its overall service life further). The beach provides a degree of protection to the seawall in this unit along Sandown Esplanade, and beach levels have remained relatively stable overall in this unit from a baseline recorded in 2004 to 2016, so the timing of future intervention in this unit will also depend on the future changes in the beach levels affecting the exposure of the seawall.

A number of approaches have been considered to implement the maintain option in this unit.

Approach 1 - no groyne refurbishments (lower overall investment approach)

Undertake a capital refurbishment of the existing seawall towards the end of its current service life between years 2027-32. This refurbishment will involve resurfacing the face of the structure (e.g. concrete spraying – assumed 4m height for costing). This is expected to extend the service life of the structure and for costing purposes it has been assumed that between 2045-50 the resurfacing works will need repeating, extending the service life to between years 2065-70. Between 2065-70 it is anticipated that further resurfacing will no longer be suitable and therefore a full encasement of the existing defence will be required. The encasement will include new toe protection (i.e. sheet piling) and will reduce the defence's vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore this refurbishment will carry the defence through to the end of the appraisal period.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £2,025k. This equates to £6,910k in cash terms (approx. £6.9m).

Approach 2 - alternative (higher investment) approach including groyne refurbishments

This approach also includes refurbishments to the single timber groyne in this unit. This will help avoid the groyne going into disrepair which may not be favourable to the public or stakeholders in the area. However, given that there is just the one groyne in this unit located updrift of most of the seawall, upkeep of the groyne is unlikely to lead to significant changes in beach levels in front of the seawall defence. Given that this is the case, it is unlikely that works to the groyne will be eligible for GiA funding and this will need to be explored in further appraisal work should this approach be taken forward.

The timings of the seawall refurbishments and encasement are the same with this approach as with the 'lower investment' approach outlined above. The initial refurbishments would be required towards the end of the structure service life in year 2027-32. This will involve resurfacing the face of the seawall (e.g. concrete spraying) and a 20% material refurbishment of the single timber groyne (20% material replacement assumed for costing have been informed from a visual site inspection. Actual requirements will need to be investigated during scheme design). For cost savings and efficiencies it has been assumed that the groyne refurbishments will be undertaken at a similar time to the seawall refurbishment.

The seawall and groyne refurbishment will be repeated between 2045-50 before the seawall is encased in 2065-70. The timber groyne will continue to be refurbished approximately every 20 years in 2065-70 and 2085-90 although the GiA eligibility for these refurbishments will need to be explored nearer the time.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £2,080k. This equates to £7,120k in cash terms (approx. £7.1m).

Approach 3 – early encasement with no groyne refurbishments

Undertake a capital refurbishment of the existing seawall towards the end of its current service life between the years 2027-32. This refurbishment will involve encasing the structure and providing new toe protection (i.e. sheet piling) and will reduce the defences vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore a repeat intervention will be likely be required between 2075-80.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £2,945k. This equates to £7,790k in cash terms (approx. £7.8m).

It is likely that with an encased refurbishment that crest raising could be incorporated into the new defence. This approach is therefore also suitable for the Sustain / Improve options and has similar costs to approach 1 in section 6.4.4.

Approach 4 – seawall resurfacing with masonry wall replacement where required, no groyne refurbishments

Undertake a capital refurbishment of the existing seawall towards the end of its current service life between years 2027-32. This refurbishment will involve resurfacing the face of the structure (e.g. concrete spraying) but in areas where the existing defence is a masonry wall this will involve like-for-like replacement of this masonry structure (i.e. approx.. 991m of the 1026m unit).

This is expected to extend the service life of the structure and for costing purposes it has been assumed that between 2045-50 the resurfacing works and masonry replacement works will need repeating, extending the service life to between years 2065-70. Between 2065-70 it is anticipated that further resurfacing will no longer be suitable and therefore a full encasement of the existing defence will be required. The encasement will include new toe protection (i.e. sheet piling) and will reduce the defence's vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore this refurbishment will carry the defence through to the end of the appraisal period.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £2,350k. This equates to £7,630k in cash terms (approx. £7.6m).

6.4.4 Sustain SoP

The sustain option will involve raising the crest level of the defences over time to keep pace with sea level rise and sustain a minimum standard of flood protection. The preferred standard of protection which will be provided is discussed in later chapters. The indicative route alignment for the crest raising will be established at a later stage should this option be selected as the preferred option during the appraisal. For costing purposes it has been assumed that the crest raising will be undertaken by installing or raising a capping beam on top of the existing defence.

The lengths of crest raising required to achieve a range of standards of protection are presented in Table 6-16. The lengths specified are based on still water levels and a high level assumption of wave heights that could be found at the toe of the structure. Based on this a consideration of where additional defence length may be required to reduce wave overtopping has been made. It has been necessary to make this high level assumption at this stage because a detailed overtopping study is beyond the scope of this assessment. Due to this the lengths of defence that are specified should be treated as indicative for costing purposes and it is recommended that an overtopping study is undertaken to better inform future design stages after this study.

Table 6-16. Length of crest raising required; IW25

Standard of protection	Year	Length of crest raising	Average height of raising (approx.)*
1:75 SoP	2057	505m	Between 0.1-0.5m
1:75 SoP	2117	800m	Between 0.5-1m
1:200 SoP	2057	565m	Between 0.1-0.5m
1:200 SoP	2117	820m	Between 0.5-1m

*actual height of raising would be dependent on variations in existing defence heights along the lengths identified in column 3 of this table.

The sustain option will be implemented by raising defence levels in phases. This represents an adaptive approach to manage the increased risk posed by sea level rise and helps account for the uncertainty in future sea level rise projections.

Two approaches have been considered to implement the sustain option in this unit. Both approaches make best use of the existing defences and build upon the maintain approaches discussed in section 6.4.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach involves crest raising of the existing defence in two intervals; in year 2027 the crest will be raised to the 2057 desired SoP and then between 2055-60 the crest will be raised to the desired 2117 standard. To achieve the 2117 1:75 year SoP, approximately 800m of crest raising will be required, whereas to achieve the 1:200 year standard approximately 820m will be required.

In addition to the crest raising, it will also be necessary to undertake maintenance and refurbishment works to the existing defences. For this approach the ‘lower investment’ maintenance regime set out in section 6.4.3 will be adopted (i.e. does not include groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £2,925k to sustain a 1:75yr SoP and £3,090k to sustain a 1:200yr SoP. These equate to cash costs of £9,220k and £9,555k respectively (approx. £9.2m or £9.6m).

As presented in section 6.4.3 an alternative approach to maintaining the existing defences would be to encase the structures early (which could also involve crest raising as part of the new structure). This is estimated to have similar costs to resurfacing and crest raising and therefore should a scheme be pursued in this area then an early encasement remains a potentially viable approach.

Approach 2 - alternative (higher investment) approach including groyne refurbishments

The alternative approach that has been considered is different to the lower investment approach in the way the existing defences are maintained and refurbished. There are no differences to the timing or extent of crest raising. This approach adopts the ‘alternative approach’ to maintenance as set out in section 6.4.3 (i.e. includes groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £2,970k to sustain a 1:75yr SoP and £3,140k to sustain a 1:200yr SoP. These equate to cash costs of £9,035k and £9,775k respectively (approx. £9.3m or £9.8m).

6.4.5 Maintain then Sustain

The Maintain then Sustain option involves undertaking crest raising later on during the appraisal period and accepting a gradual fall in the standard of protection in the interim (indicative existing SoP less than 1:5yr falling to <1yr in 2057).

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.4.4) but only one round of crest raising will be implemented. This will be done between 2055-60 to achieve the 2117 SoP (i.e. no crest raise in 2027).

The estimated PV cost of this combination of measures is approximately £2,470k to implement Maintain then Sustain to a 1:75yr SoP and £2,515k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £8,575k and £8,750k respectively (approx. £8.6m or £8.8m).

Approach 2 - alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.4.4) but only one round of crest raising will be implemented. This will be done between 2055-60 to achieve the 2117 SoP (i.e. no raise in 2027).

The estimated PV cost of this combination of measures is approximately £2,520k to implement Maintain then Sustain to a 1:75yr SoP and £2,565k to implement Maintain then Sustain to a 1:200yr SoP. These equate to cash costs of £8,785k and £8,960k respectively (approx. £8.8m or £8.9m).

6.4.6 Improve

The improve option involves improving the standard of protection against flooding following a precautionary approach. This will involve just one crest raise to the desired SoP for 2117 rather than multiple incremental raises as set out in the Sustain options above.

A lower investment and an alternative approach to implementing this option have been developed. Akin to the sustain options, both approaches make best use of the existing defences and build upon the maintain options outlined in section 6.4.3.

Approach 1 - no groyne refurbishments (lower investment approach)

This approach is the same as the lower investment approach set out for the sustain option (section 6.4.4) but only one round of crest raising will be implemented. This will be done in 2027 to achieve the 2117 SoP (i.e. no crest raise in 2057 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £3,865k. This equates to cash costs of £8,750k (approx. £8.8m).

Approach 2 – alternative (higher investment) approach including groyne refurbishments

This approach is the same as the alternative approach set out for the sustain option (section 6.4.4) but only one round of crest raising will be implemented. This will be done in 2027 to achieve the 2117 SoP (i.e. no raise in 2057 will be required).

The estimated PV cost of this combination of measures to achieve a 2117 1:200yr SoP throughout the appraisal period is approximately £3,920k. This equates to cash costs of £8,965k (approx.. £9.0m).

6.4.7 Summary

The measure combinations considered in the development of options for unit IW25 are summarised in Table 6-17 below.

Table 6-17. Summary of measure combinations developed for IW25

Option	Measures and timing*	PV cost	Cash cost	Notes
Do Minimum	- Patch and repair	£170k	£565k	Ongoing. Cost estimate based on recent expenditure
Maintain – approach 1	- Resurface seawall (2027-32 & 2045-50) - Encase seawall (2065-70)	£2,025k	£6,910k	Resurface to extend service life by approx. 20yrs. Encasement required from 2065-70 as resurfacing alone is unlikely to be sufficient.
Maintain – approach 2	- Resurface seawall (2027-32 & 2045-50) - Encase seawall (2065-70) - Refurb timber groyne (2027, 2045-50, 2065-70 & 2085-90)	£2,080k	£7,120k	Only a single timber groyne located in this unit. It is unlikely to have a significant impact on beach levels throughout the entire unit therefore same frequency required for seawall refurbishments as approach 1.
Maintain – approach 3	- Encase seawall in 2027-32 and 2075-80	£2,945k	£7,790k	Early encasement of seawall. Repeat encasement later on in appraisal period
Maintain – approach 4	- Resurface seawall and masonry wall replacement where required (2027-32 & 2045-50) - Encase seawall in 2065-70	£2,350k	£7,630k	As per maintain approach 1 but masonry wall replacement in existing masonry areas
Sustain – approach 1	- As per maintain approach 1 - Crest raising in 2027 and 2055-60	£2,925 – 3,090k	£9,220 – 9,555k	Crest raising in 2027 to 2057 SoP. Crest raising in 2055-60 to 2117 SoP. Cost range for 75yr to 200yr SoP.
Sustain – approach 2	- As per maintain approach 2 - Crest raising in 2027 and 2055-60	£2,970 – 3,140k	£9,035 – 9,775k	
Maintain then Sustain approach 1	- As per maintain approach 1 - Crest raising in 2055-60	£2,470 – 2,515k	£8,575 – 8,750k	Crest raising in 2055-60 to 2117 SoP. Cost range for 75yr to 200yr SoP.
Maintain then Sustain approach 2	- As per maintain approach 2 - Crest raising in 2055-60	£2,520 - £2,565k	£8,785 – 8,960k	
Improve – approach 1	- As per maintain approach 1 - Crest raising in 2027 (to 2117 SoP)	£3,865k	£8,750k	Crest raising in 2027 to 2117 SoP. Cost for 200yr SoP.
Improve – approach 2	- As per maintain approach 2 - Crest raising in 2027 (to 2117 SoP)	£3,920k	£8,965k	

**Note – measures and timings are only estimates, refer to paragraph at the start of section 6 for more details.*

The cash cost for the range of options in this unit is approximately £6.9 to £9.8 million, to provide continued or improved protection from erosion and flood risks over the next 100 years, dependent on the standard of protection chosen and on whether or not the groynes are maintained. The timing/phasing of the works and the timing of investment required also varies in the different options, as outlined in this chapter.

Methods of maintaining or improving the defences

Cost-effective and appropriate methods to reduce risks have been sought and costed in this chapter. These include using a sprayed coating of concrete to extend the life of the current defences, as this method has already been used in Sandown Bay, at neighbouring Culver Parade seawall in 2006 (in unit IW24). Other methods proposed include more substantial encasement of the defences in concrete (when technically required), plus crest-raising of the defences (when required). Options including refurbishment of the groynes in the area have also been included in the costings.

Alternative methods have also been considered, such as beach nourishment or new terminal groynes (as there is only one groyne present in this unit currently). Each method has different costs, advantages and disadvantages, and would last for a different number of years before needing to be repeated. When packaged into combinations of methods over 100 years these alternative measures are anticipated to add up to more expensive solutions than those proposed in the chapter above. Therefore if extra funding is available, alternative methods could also be considered. The alternative options considered for all the defence units are summarised in section 0.

6.5 Unit IW26 (Lake Cliffs)

Unit IW26 is the longest unit along the frontage at over 2km (2,348m) and is located between the western end of Pier Street and Hope Groyne. The frontage is backed by steep cliffs, defended by a stepped revetment and wall that were constructed in the 1970's (one section of the seawall was refurbished in 2002) (see Figure 6-6). There are 20 timber groynes located along the frontage and 1 masonry groyne (Small Hope Groyne) which was originally constructed prior to 1901.

The number of properties at risk in IW26 over the next 100 years is presented in Table 6-18 below.

Table 6-18 Properties at risk in unit IW26

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion (cumulative)
2017	0	0	0	0
2027	0	0	0	0
2057	0	0	0	78
2117	0	0	0	229

The risk in this unit is from erosion. There is no flood risk to properties owing to the steep topography of the cliff line immediately behind the defences. The existing defences reduce the exposure of the cliff toe and therefore play an important role in reducing the erosion risk to the properties at the top of the cliff. However, it is important to note that in the future, sea level rise is likely to increase the frequency and severity to which the existing defences are overtopped or inundated which could increase the rate of cliff erosion.

Figure 6-6. IW26 frontage and Lake Cliffs

6.5.1 Do Nothing

Doing Nothing involves no active intervention. The present value cost of this option is £0.

6.5.2 Do Minimum

Do Minimum involves small scale reactive maintenance and ‘patch repair’ work to the existing seawall and groynes alongside the continued small scale cliff stabilisation measures which are currently undertaken. Based on the current IoW Council expenditure on patch and repair maintenance and cliff stabilisation along the Sandown frontage it is estimated that a continuation of these activities for the next 100 years would cost approximately PV £695k for this unit (£311k for cliff stabilisation works and £384k for patch and repair). This equates to £2,335k in cash terms. The limitations of this method are outlined in section 5.1.2 above.

6.5.3 Maintain

This Maintain option involves scheduled maintenance of the defences and groynes to ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years). This will help to reduce the exposure of the cliff toe to wave action and reduce the rate of cliff top erosion. However, the retreat of the cliff top will not be stopped completely under this option because other factors such as weathering and sea level rise will also be influential (due to the risk of wave overtopping of the existing defence height). There is also a risk that by working with the existing defences which are ageing there may be an increased chance of defence failure (compared to constructing completely new defences) which could lead to a local increase in erosion rates. This residual risk has been accounted for probabilistically in the maintain option benefits (as part of the economic assessment).

The average defence crest levels in this unit are typically between 3.0-4.1m AOD but there are localised low spots (lowest points at 1.7m AOD) mainly near the slipways at the Pioneer Café, Tradewinds Café and Small Hope groyne. The residual life of the existing defences in units IW26 is shown in Table 6-19 below. When the defences come towards the end of their service life it will be necessary to undertake capital repair / refurbishments to extend the service life of some of or all of the defences.

One approach has been developed to implement the maintain option in this unit.

Table 6-19. Defence type and residual life of unit IW26

Defence unit	Defence structure	Existing condition	Estimated residual life (with patch and repair)	Proposed timing of initial capital refurbishment
IW 26/01 to 26/02	Revetment	Fair	10-20 years	2027-32
IW 26/01 to 26/02	Timber groynes	Poor	2-7 years	ASAP
IW26/03	Revetment	Good	15 - 25 years	2027-32
IW26/03	Timber groynes	Poor	2-7 years	ASAP
IW26/04	Revetment	Good	15 - 25 years	2027-32
IW26/04	Timber groynes	Very poor	0 years	ASAP
IW26/05	Concrete groyne	Good	15-20 years	2027
IW26/06	Seawall	Good	15 - 25 years	2027-32
IW26/07	Revetment	Fair	10-15 years	2027-32

The estimated residual life of the existing defences is between 10-25 years, and the condition of the defences varies along the unit with sections 26/03, 26/04 and 26/06 having an estimated residual life of 15-25 years. The proposed timing of the initial capital refurbishment of the seawall is from 2027-32 which is 10-15 years from now and therefore is at lower end of the residual life estimate. This timing has conservatively been proposed because refurbishment works will need to be undertaken before the existing asset has actually failed (otherwise a full replacement may be required at higher cost) and for the purpose of costing it provides a precautionary estimate of costs once discounting has been considered (by bringing the initial scheme forward). In addition, grouping the works into one implementation across the unit could provide a number of efficiencies which should be explored during future appraisals (e.g. reduced costs associated with repeat mobilisation, potential for initial scheme to only refurbish localised sections of the defences in better condition to extend its overall service life further).

Approach

Evidence obtained from the Channel Coastal Observatory beach monitoring programme demonstrates some areas of lowering beach levels in areas within this unit over the past decade (refer to the Coastal Processes Report for further information, or Annual Reports at https://www.channelcoast.org/). In addition, there is a lack of benefits in this area (compared to potential option costs) because the majority of properties along the cliff top are at risk in the long term, rather than the short term, and therefore lower cost options are favourable (e.g. spraying / resurfacing rather than a full encasement – assumed 4m high for costing). By adopting lower cost refurbishment techniques for the revetment it becomes important to also seek to sustain or improve the performance of the existing groynes to help maintain beach levels and protect the toe of the revetment. The groynes in the worst condition are located in IW26/04 (8 groynes) between Small Hope Groyne and the beach huts to the south of Tradewinds Café.

With this approach the timber groynes would be recommended to be refurbished initially with an approximate 20% material replacement (20% material replacement assumed for costing has been assumed and informed from a visual site inspection. Specific requirements will need to be further investigated during scheme design). This is expected to extend the service life of the groynes by approximately 15-20 years and should sustain or improve the performance of the groynes at retaining beach material. To maintain the groynes throughout the duration of the appraisal period it has been assumed that they will require a refurbishment on average every 20 years.

Between 2027-32, as the sections of the revetment / seawall come towards the end of their service life a capital refurbishment will be undertaken. This refurbishment will involve resurfacing the face of the structure (e.g. concrete spraying). This is expected to extend the service life of the structure by 20 years. Between the years 2045-50 the resurfacing works will need repeating for the full length of the defences in the unit, extending the service life to years 2065-70. Between 2065-70 it is anticipated that further resurfacing will no longer be suitable and therefore a full encasement of the existing defence will be required. The encasement will include new toe protection (i.e. sheet piling) and will reduce the defence's vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore this refurbishment will carry the defence through to the end of the appraisal period.

The masonry groyne (Small Hope Groyne) is currently in a good condition and this structure will not need to be refurbished immediately. Once it reaches the end of its service life a concrete refurbishment will be undertaken.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £5,345k. This equates to £20,450k in cash terms (approx. £20.4m).

If this approach were to be undertaken without groyne refurbishments (i.e. only maintenance and refurbishments to the revetment / seawall) the PV cost of the option would be approximately £3,220k. However, given the importance of the groynes in this location and the increased risk of toe exposure should the groynes not be maintained there is less confidence that this approach would be a feasible solution (i.e. to implement the maintain option) and instead a full encasement would likely be needed from an earlier stage (see approach 1 for sustain / improve performance below).

6.5.4 Sustain / Improve performance

Given that the risk in unit IW26 is from erosion, the sustain / improve option is focussed on sustaining or improving the performance of the defences in terms of reducing the action of waves and high water levels at the cliff toe. In order to achieve this option the crest of the defences will need to be raised to keep pace with sea level rise.

In order to reduce the frequency of inundation / wave overtopping over the defences to a present day 1:75yr return period, it will be necessary to raise approximately 2km of the defences in the unit. The lengths of defence required to raise the defences to differing standards of protection are provided in Table 6-20 below.

Along some sections of the frontage in this unit there is also a setback wall at the back of the esplanade / toe of the cliff. The wall is approximately 0.5m high at and to the south of the Tradewinds Café and approximately 0.2m high to the north of the café. The walls help to reduce the exposure of the cliff toe to wave overtopping (after overtopping the frontline defences) and have been considered in the costing of the sustain / improve performance options.

There is no flood modelling currently available in this area and therefore it is not possible to determine in detail at what time period that wave overtopping / defence inundation is likely to lead to cliff toe erosion and therefore the time period in which the defences may require raising is unclear. Should schemes be pursued in this area it is recommended that numerical modelling is undertaken to resolve this uncertainty.

The sustain and improve options are combined for this unit because both approaches involve raising the defences to keep pace with sea level rise. Based on the information available (e.g. Do Nothing erosion lines and no wave overtopping assessment available) it is not possible to accurately estimate how different defence heights would impact the rate of erosion and the economic benefits. It has therefore been assumed in the economic assessment that the sustain and improve options will prevent all cliff top erosion and therefore there is no discernible difference between these two approaches. This is also based on the premise that the existing cliff stabilisation works will be continued over the appraisal period (a cost has been included for this).

Table 6-20. Length of crest raising required; IW26

Standard of protection	Year	Length of crest raising	Average height of raising (approx.)
1:75 SoP	2057	2185m	Between 0.5-1m
1:75 SoP	2117	2350m	1.5m (but less if setback at back of footpath next to cliff)
1:200 SoP	2057	2255m	Between 0.5-1m
1:200 SoP	2117	2350m	1.5 (but less if setback at back of footpath next to cliff)

Four approaches to implementing the sustain / improve option have been developed for IW26.

Approach 1 – early encasement, no groyne refurbishments (lower overall investment approach)

This approach involves encasing the revetment / seawall from 2027 when the existing structures come towards the end of their expected service life. The encasement will include a capping beam to increase the existing defence height (to a desired SoP) and will also have new toe protection (i.e. sheet piling) which will reduce the defence's vulnerability to lowering beach levels in the future. Therefore, with this approach there is no allowance for groyne refurbishments. The encased defence is expected to have a service life of approximately 50 years and therefore the refurbishment will need to be repeated during the second half of the appraisal period.

Prior to the encasement of the revetment / seawall there will be no refurbishments to the existing groynes. Some of these structures are already in a poor / failed condition and therefore it has been assumed that beach levels will fall in the area as a result.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £7,560k. This equates to £18,685k in cash terms (approx. 18.7m).

Approach 2 – crest raising and refurbishments (including groyne refurbishments)

This approach involves crest raising of the existing defences. Due to a lack of modelling in this unit the timing of when defences may need to be raised is unclear and this will need to be investigated further should schemes in this area be pursued. For the purpose of costing only it has been assumed that raising will be required in two intervals; from year 2027 the crest will be raised to the 2057 desired SoP and then between 2055-60 the crest will be raised to the desired 2117 standard. To achieve both the 2117 1:75 year and 1:200 year SoP raising along the full length of defence will be required.

In addition to the crest raising, it will also be necessary to undertake maintenance and refurbishment works to the existing defences and the maintenance regime set out in section 6.5.3 will be adopted (which include groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £9,290k. This equates to cash costs of £29,890k (approx. £29.8m).

Approach 3 – crest raising, refurbishments and new concrete groynes

This approach adopts the same maintenance and crest raising implementations and timings as approach 2 but instead of refurbishing the timber groynes, three new concrete groynes will be constructed. The construction of the concrete groynes will take place between 2027-32, alongside the initial refurbishment and crest raising of the revetment / seawall.

Anecdotal evidence from numerous site inspections suggests that the existing terminal (concrete) groynes at the study site produce a larger accumulation of beach sediment updrift of the structure compared to the smaller timber groynes. As a result, this option may be preferable although it is recommended that sediment modelling is undertaken to explore whether this is likely to be the case, and to determine the optimal positioning, length, height and spacing of any new groyne structures.

The estimated PV cost of this approach is approximately £10,900k. This equates to cash costs of £30,500k (approx. £30.5m).

Approach 4 – crest raising, refurbishments and beach recycling

With this approach beach recycling will be undertaken at regular intervals to improve beach levels in the area. Material will be moved from an alternative location along the frontage, potentially from the northern side of the frontage where existing beach levels are generally higher, although this would require further consideration and assessment of the impacts on environmental designations and lower beach levels in this area. In order to progress this option further a sediment modelling study will need to be undertaken to inform the quantities of sediment required, its possible movement after depositing and the optimal sources of sediment.

For the purpose of costing this approach a beach recycling cost has been applied every 30 years during the appraisal period. The cost for each recycling intervention is based on resupplying half the total beach material required to raise beach levels to the maximum recorded beach cross sectional area within this zone (CCO profiles 5e00117 to 5e00157, 2016). Approximately 25% of the total costs of this approach are associated with the beach recycling interventions.

The existing timber groynes and revetment / seawall will also need to be refurbished as per the maintain option outlined in section 6.5.3, except refurbishments to the revetment will not be required as frequently (due to higher beach levels). It has been assumed that the revetment will need to be refurbished every 30 years; between 2027-32, 2055-60 and 2085-90 (encased). Crest raising will be undertaken in two intervals and as per approaches 2 and 3, the timing of this will need to be investigated during future appraisals depending on the onset of risk (modelling required to inform this). For the purpose of costing it has been assumed that raising will be undertaken in year 2027 to the 2057 desired SoP and then between 2055-60 the crest will be raised to the desired 2117 standard. To achieve both the 2117 1:75 year and 1:200 year SoP raising along the full length of defence will be required.

The estimated PV cost of this approach is approximately £12,110k. This equates to cash costs of £41,075k (approx. £41.1m).

If beach recycling sediment cannot be reasonably sourced in the local area (e.g. as it would likely need to come from the northern end of the Bay, which is within the SSSI, SAC, pSPA and rMCZ, a popular amenity beach, and with fluctuating beach levels) then beach nourishment would be required instead under this option, involving importing suitable sediment from outside the area which would have further significantly increased costs.

6.5.5 Summary

The measure combinations considered in the development of options for unit IW26 are summarised in Table 6-21 below.

Table 6-21. Summary of measure combinations developed for IW26

Option	Measures and timing*	PV cost	Cash cost	Notes
Do Minimum	- Patch and repair	£695k	£2,335k	Ongoing. Cost estimate based on recent expenditure
Maintain	- Refurbish timber groynes (immediately, 2030-35, 2050-55, 2070-75, 2090-95 and 2110-2117) - Refurbish revetment / seawall (2027-32, 2045-50 and encase in 2065-70) - Refurbish Small Hope groyne at end of service life	£5,345k	£20,450k	Resurface to extend service life by approx. 20yrs. Encasement required from 2070 as resurfacing alone is unlikely to be sufficient.
Sustain / improve performance – approach 1	- Encase & raise revetment / seawall (2027 and 2075 onwards)	£7,560k	£18,685k	Encasement to include raising. No groyne refurbishments required as encased structure includes toe protection.
Sustain / improve performance – approach 2	- As per maintain approach - Crest raising – timings subject to modelling and the onset of risk	£9,290k	£29,890k	Crest raising to decrease wave action against cliff toe
Sustain / improve performance – approach 3	- As per sustain / improve approach 2, except; - Construction of large concrete groynes to replace existing timber groynes (between 2027-32)	£10,900k	£30,500k	Assumed 3 new concrete groynes would be sufficient to hold beach material in place. However, sediment modelling would be required to refine this option if it was advanced during later studies.
Sustain / improve performance – approach 4	- Beach recycling to improve beach levels in the area - Refurbish revetment / seawall (2027-32, 2055-60 and encase in 2085-90) - Refurbish timber groynes - Crest raising – timings subject to modelling and the onset of risk	£12,110k	£41,075k	Assumed beach recycling will improve beach levels. Refurbishments to structures required less frequently due to higher beach levels.

**Note – measures and timings are only estimates, refer to paragraph at the start of section 6 for more details.*

The cash cost for the range of options in this unit is approximately £18.7 to £41.1 million, to provide continued or improved protection from erosion and flood risks over the next 100 years, dependent on the standard of protection and type of method chosen, and on whether or not the groynes are maintained. The timing/phasing of the works and the timing of investment required also varies in the different options, as outlined in this chapter.

Methods of maintaining or improving the defences

Cost-effective and appropriate methods to reduce risks have been sought and costed in this chapter. These include using a sprayed coating of concrete to extend the life of the current defences, as this method has already been used in Sandown Bay, at neighbouring Culver Parade seawall in 2006 (in unit IW24). Other methods proposed include more substantial encasement of the defences in concrete (when technically required), plus crest-raising of the defences (when required). Options including refurbishment of the groynes in the area have also been included in the costings.

Alternative methods have also been considered, such as beach nourishment or revetment. Each method has different costs, advantages and disadvantages, and would last for a different number of years before needing to be repeated. When packaged into combinations of methods over 100 years these alternative measures are anticipated to add up to more expensive solutions than those proposed in the chapter above. Therefore if extra funding is available, alternative methods could also be considered. The alternative options considered for all the defence units are summarised in section 0.

6.6 Unit IW27 (Shanklin Esplanade)

Unit IW27 is 901m long and is located between Hope Groyne and the western end of Shanklin Esplanade roadway. The esplanade has a number of properties located along it which are backed by steep cliffs. The properties are a mixture of residential and commercial.

The number of properties at risk in IW27 over the next 100 years is presented in Table 6-22 below. This includes 111 properties which would first lose their only road access if sections of the seawall fail and erosion commences undermining the seafront road. It was agreed with the Environment Agency that in the economic assessment it was appropriate to write off these properties early when road access was lost.

Note that the section of defence to the north of Shanklin Esplanade and immediately to the north of Hope Groyne (e.g. along the northern end of the car park and pumping station) are included in unit IW26. The assets in this localised area are not expected to be at risk from erosion until 2057 onwards.

Table 6-22 Properties at risk in unit IW27

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion (cumulative)
2017	0	0	0	0
2027	0	0	0	0
2057	0	0	0	114
2117	0	0	0	151

The frontage is defended by various sections of seawall, generally constructed prior to 1900. Sections of the seawall are in a poor condition with an estimated service life of <10 years (see Figure 6-7 and Figure 6-8). The frontage also includes the large terminal groynes of Hope Groyne and Osborne Groyne. Both groynes are concrete / masonry structures and are in a good condition. In addition to the concrete groynes there are seven timber groynes, generally in a fair condition. Environmental enhancement techniques for coastal protection structures are currently being tested on the north side of Hope Groyne.

The risk in this unit is primarily from erosion. The existing defences protect the properties immediately behind from erosion and reduce the exposure of the platform forming Shanklin Esplanade (built out in front of the former sea cliff) and the cliff toe to erosion, including protecting properties at the top of the cliff from erosion risk. However, in the future, sea level rise is likely to increase the frequency and severity to which the existing defences are overtopped or inundated, affecting the road and properties along the promenade and potentially influencing rates of retreat.

The EA coastal flood modelling currently available does not include this area and therefore the flood risk to properties behind the defences is not certain. However, the majority of properties are raised above ground level and therefore the risk is not expected to be significant. Further flood modelling would be required to accurately quantify the level of flood risk in this area immediately behind the defences.

Figure 6-7. IW27 seawall in poor condition (southern end of the esplanade)

Figure 6-8. IW27 seawall in poor condition (northern end of the esplanade)

6.6.1 Do Nothing

Doing Nothing involves no active intervention. The present value cost of this option is £0.

6.6.2 Do Minimum

Do Minimum involves small scale reactive maintenance and 'patch repair' work to the existing seawall and groynes alongside the continued small scale cliff stabilisation measures which are currently undertaken. Given the poor condition of the defences in this unit (notably the seawall in unit IW27/02), the estimated cost of patch and repair is high in this location. It is estimated that the Do Minimum PV cost would be approximately £800k (approximately £440k for patch and repair and £360k for cliff stabilisation). This equates to £2,690k in cash terms. The limitations of this method are outlined in section 5.1.2 above.

6.6.3 Maintain

This Maintain option involves scheduled maintenance of the defences and groynes to ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years). This will continue to prevent erosion of the land forming the esplanade and shelter the cliff toe from wave action, reducing the rate of cliff falls and cliff top erosion. However, the retreat of the cliff face and cliff top will not be stopped completely under this option because other factors such as weathering and climate change will also be influential. There is also a risk that by working with the existing defences which are ageing there may be an increased chance of defence failure (compared to constructing completely new defences) which could lead to a local increase in erosion rates. This residual risk has been accounted for probabilistically in the maintain option benefits (as part of the economic assessment).

The typical defence crest levels in this unit range between 2.8-4.9m AOD but there are localised low spots (e.g. next to Sail/Surf and 'Lazy Wave' establishments), (lowest points at 2.2m AOD), so there is risk of waves overtopping the defences. The residual life of the existing defences in units IW27 is shown in Table 6-23 below. When the defences come towards the end of their service life it will be necessary to undertake capital repair / refurbishments to extend the service life of some of or all of the defences.

One approaches have been developed to implement the maintain option in this unit.

Table 6-23. Defence type and residual life of unit IW27

Defence unit	Defence structure	Existing condition	Estimated residual life (with patch and repair)	Proposed timing of initial capital refurbishment
IW27/01	Hope groyne	Good	15-20 years	2032
IW27/02	Seawall	Poor	<10 years	Immediately
IW27/03	Osborne groyne	Good	15-25 years	2032
IW27/04	Wall	Good	15-25 years	2027-32
IW27/05	Wall	Fair (locally poor)	10-15 years	2027-32
IW27/06	Timber revetment	Fair	8-12 years	2027-32
IW27/06	Timber groynes	Fair	8-12 years	2027

The condition of the defences in unit IW27 varies considerably with some sections expected to be very close to failure (e.g. 27/02) and other sections having a residual life of up to 25 years. Generally, the seawall is in a poor condition, whilst it is the terminal concrete groynes and the small stub of the former pier that are in better condition. Given that section 26/02 and parts of 20/05 (together forming the majority of the seawall esplanade) are in a poor condition with potential to fail soon this section is a priority. For costing purposes (and when comparing options in this unit) the approach to the proposed timing of the initial capital refurbishment is different to other units as two intervals for the initial intervention are proposed for the defences at the back of the beach; some structures immediately and then others in approximately 10 years between 2027-32. This is considered reasonable for the appraisal of options but for funding it may be beneficial to group works for different sections of the defence and deliver a wider scheme and benefits in the short term (because you can only claim benefits for duration until the next intervention, and by doing separate schemes you would reduce the chance of obtaining GiA funding). This is discussed in more detail in the funding chapter, in section 9.1.

Approach

Evidence obtained from the Channel Coastal Observatory monitoring programme demonstrates some areas of lowered beach levels in areas within this unit over the past decade, although there is also a varied pattern of beach level changes across this frontage geographically and over time (refer to the Coastal Processes Report for further information or Annual Reports at https://www.channelcoast.org/). As such, sustaining or improving the performance of the existing groynes is considered important if the service life of the seawall is to be significantly extended. This is based on the premise that the aim is to initially use lower cost seawall refurbishment measures such as resurfacing rather than a more costly encasement (encasement will include toe protection and therefore the defence will not as heavily rely on a beach to provide protection to the foundations). Without undertaking a detailed survey of the existing defence foundations (which is not possible during a visual survey with the existing beach in place) it is not possible to determine their condition. Therefore it has been conservatively assumed that the beach is more crucial in protecting the defences if the refurbishment relies on the existing foundations (increasing the need for groynes).

With this approach the groynes will be refurbished with an approximate 20% material replacement when they come to the end of their service life (timber groynes from 2027 and concrete groynes from 2032) (20% material replacement assumed for costing has been assumed and informed from a visual site inspection. Specific requirements will need to be investigated further during scheme design). This is expected to extend the service life of the groynes and should sustain or improve the performance of the groynes at retaining beach material. To maintain the groynes throughout the duration of the appraisal period it has been assumed that the timber groynes will require a refurbishment on average every 20 years and the concrete groynes (Hope and Osborne) will require a refurbishment every 40 years.

In the northern part of IW27/02 (Shanklin Esplanade) the existing seawall is in a particularly poor condition. With the maintain approach this section of wall would be recommended to be refurbished immediately (i.e. an initial scheme) and the remaining walls and timber breastwork (north of the Chine) will be refurbished towards the end of their service life, from 2027-32. The refurbishments will involve resurfacing the face of the structure (e.g. concrete spraying, and material replacement (for the breastwork). Note spraying height assumed to be 4m for costing). This is expected to extend the service life of the structure by 20 years. Prior to spraying the existing seawall will need localised minor structural repairs to be undertaken to repair cracks and thin sections of wall (e.g. approx. £20k) and the wave return (e.g. approx. £30k), which has been included in the cost estimates.

In 2045-50 the defence resurfacing works will need repeating, extending the service life to 2065-70. In 2065-70 it is anticipated that further resurfacing will no longer be suitable and therefore a full encasement of the existing defence will be required. The encasement will include new toe protection (i.e. sheet piling) and will reduce the defence's vulnerability to lowering beach levels in the future. The encased defence is expected to have a service life of approximately 50 years and therefore this refurbishment will carry the defence through to the end of the appraisal period. At the time of encasing the seawall the short section of timber breastwork north of the Chine (87m) could be replaced with a concrete structure (e.g. a new seawall).

In addition to the capital refurbishments outlined above, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £3,100k. This equates to £8,560k in cash terms (approx. £8.6m).

If this approach were to be undertaken without groyne refurbishments (i.e. only maintenance and refurbishments to the seawall) the PV cost of the option would be approximately £2,290k. However, given the importance of the groynes in this location and the increased risk of toe exposure should the groynes not be maintained there is less confidence that this approach would be a feasible solution (i.e. to implement the maintain option) and instead a full encasement would likely be needed from an earlier stage (see approach 1 for sustain / improve performance below).

Alternative approaches to Maintain:

An alternative approach to deliver the Maintain option would be to encase the existing structures however this approach is discussed below in section 6.6.4 for the Sustain/Improve option because an encased refurbishment would realistically include crest raising as part of the scheme (and thus help to sustain/improve the performance of the defences).

Another alternative approach to deliver the Maintain option would be to resurface the face of the structure (e.g. concrete spraying) but in areas where the existing defence is a masonry wall (IW27/02) undertake a like-for-like replacement of this masonry structure. The interventions would be carried out at the same time periods as proposed in the Maintain approach above. The estimate PV cost of this combination of measures is approximately £3,310k. This equates to £8,865k in cash terms (approx. £8.9m). The section of masonry wall (IW27/02) is in a conservation area so this approach could be preferred by a selection of stakeholders (despite its higher cost than the standard spraying approach). Decisions on whether to follow this approach should be made during further appraisal work (e.g. OBC stage) but for the remainder of this study the most cost effective approach is discussed / recommended.

6.6.4 Sustain / improve performance

The sustain / improve option is focussed on sustaining or improving the performance of the defences in terms of reducing the erosion risk to the properties immediately behind the existing defences and also to reduce the action of waves and high water levels at the cliff toe behind the esplanade. To achieve this option the existing defence line will need to be kept in place and the crest of the defences will need to be raised to keep pace with sea level rise. There is no flood modelling currently available in this area and therefore it is not possible to determine in detail at what time period that wave overtopping / defence inundation is likely to increase and therefore the time period in which the defences may require raising is unclear. Should schemes be pursued in this area numerical modelling could be undertaken to resolve this uncertainty, and efficiencies would be sought in the approach.

As in unit IW26, the sustain and improve options are combined for this unit (see section 6.5.4 for explanation).

To reduce the frequency of inundation / wave overtopping over the defences to a present day 1:75yr return period, it will be necessary to raise approximately 279m of the defences in the unit (mainly in the southern half of the unit). Alternatively, the increased lengths of defence required to raise the defences to differing future standards of protection are provided in Table 6-24 below.

For the purpose of appraising the options it has been assumed that provision of a 75yr SoP will limit wave overtopping to a low enough frequency to prevent cliff toe erosion, cliff reactivation and cliff top recession of the former sea cliff (i.e. assumed that only events greater than 1:75 could lead to overtopping and potentially lead to cliff toe erosion and reactivation). This is a high level assumption and in future appraisal work it will be necessary to undertake a wave overtopping assessment and cliff processes assessment to investigate this and to determine the standard of protection required.

Table 6-24. Length of crest raising required; IW27

Standard of protection	Year	Length of crest raising	Average height of raising (approx.)*
1:75 SoP	2057	380m	Between 0.5-1m
1:75 SoP	2117	855m	Between 0.5-1m
1:200 SoP	2057	425m	Between 0.5-1m
1:200 SoP	2117	865m	Between 0.5-1m

*actual height of raising would be dependent on variations in existing defence heights along the lengths identified in column 3 of this table.

Four approaches to implementing the sustain / improve option have been developed for IW27.

Approach 1 – early encasement, no groyne refurbishments (lower overall investment approach)

This approach involves encasing the revetment / seawall based on when the existing structures come towards the end of their service life. For the section of defence in IW27/02 which is in a poor condition, this will be encased immediately (i.e. an initial scheme), whilst the remaining seawall sections in the unit will be encased in between 2027-32 towards the end of their existing service life. For the section of timber breastwork at the southern end of the unit (87m, north of the Chine), this would be replaced with a new seawall structure.

The encasement will include a capping beam to increase the existing defence height and will also have new toe protection (i.e. sheet piling) which will reduce the defence's vulnerability to lowering beach levels in the future. Therefore, with this approach there is no allowance for groyne refurbishments. The encased defence is expected to have a service life of approximately 50 years and therefore the refurbishment will need to be repeated during the second half of the appraisal period.

With this approach there would be no refurbishment of the existing groynes in this unit. However, continued patch and repair maintenance will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £3,390k. This equates to £7,070k in cash terms (approx. £7.1m).

Approach 2 – crest raising and refurbishments (including groyne refurbishments)

This approach involves crest raising of the existing defences. Due to a lack of modelling in this unit the timing of when defences may need to be raised is unclear. For the purpose of costing only it has been assumed that raising will be required in two intervals; in year 2027 the crest will be raised to the 2057 desired SoP and then between 2055-60 the crest will be raised to the desired 2117 standard. To achieve both the 2117 1:75 year and 1:200 year SoP raising along almost the full length of defence will be required.

In addition to the crest raising, it will also be necessary to undertake maintenance and refurbishment works to the existing defences and the maintenance regime set out in section 6.6.3 will be adopted (which includes groyne refurbishments).

The estimated PV cost of this combination of measures is approximately £4,170k. This equates to cash costs of £11,265k (approx. £11.3m).

Approach 3 – crest raising, refurbishments and new concrete groyne

This approach adopts the same maintenance and crest raising implementations and timings as approach 2 but instead of refurbishing the timber groynes, one new concrete groyne will be constructed. The construction of the concrete groyne will take place around 2030, alongside the refurbishment and crest raising of the revetment / seawall. A sediment transport / modelling study would be required to identify the optimal position of the new groyne.

Anecdotal evidence from numerous site inspections suggests that the existing terminal (concrete) groynes at the study site produce a larger accumulation of beach sediment updrift of the structure compared to the smaller timber groynes (e.g. at Hope Groyne). As a result, if this option was developed further it is recommended that sediment modelling is undertaken to explore whether this is likely to be the case, and to determine the optimal positioning, length, height and spacing of any new groyne structures which could cause costs to rise further than the initial estimate below.

The estimated PV cost of this approach is approximately £4,515k. This equates to cash costs of £11,340k (approx. £11.3m).

Approach 4 – crest raising, refurbishments and beach recycling

With this approach beach recycling will be undertaken at regular intervals to improve beach levels in the area. Material will be moved from an alternative location along the frontage, potentially from the northern side of the frontage where existing beach levels are generally higher, although this would require further consideration and assessment of the impacts on environmental designations and beach levels, including on potential rocky reef near Hope Beach (north of Hope Groyne). In order to progress this option further a sediment modelling study will need to be undertaken to inform the quantities of sediment required, its possible movement after depositing and the optimal sources of sediment.

The existing groynes and seawall/breastwork will be refurbished as per the maintain option outlined in section 6.6.3, except refurbishments will not be required as frequently (due to higher beach levels). It has been assumed that the seawall will need to be refurbished every 30 years; present day (and 2027-32) and 2055-60 and will then be encased during the second half of the appraisal period (anticipated to be from year 2085 onwards). The breastwork north of the Chine could also be replaced with a seawall at this time. Crest raising will be undertaken in two intervals which due to a lack of modelling the timing of is unclear at this stage. However for the purpose of costing these have been assumed to be; in year 2027 the crest will be raised to the 2057 desired SoP and then in 2055-60 the crest will be raised to the desired 2117 standard. To achieve both the 2117 1:75 year and 1:200 year SoP raising along almost the full length of defence will be required.

The estimated PV cost of this approach is approximately £5,030k. This equates to cash costs of £15,075k (approx. £15.1m).

If beach recycling sediment cannot be reasonably sourced in the local area (e.g. as it would likely need to come from the northern end of the Bay, which is within the SSSI, SAC, pSPA and rMCZ, a popular amenity beach, and with fluctuating beach levels) then beach nourishment would be required instead under this option, involving importing suitable sediment from outside the area which would have further significantly increased costs.

6.6.5 Summary

The measure combinations considered in the development of options for unit IW27 are summarised in Table 6-25 below.

Table 6-25. Summary of measure combinations developed for IW27

Option	Measures and timing*	PV cost	Cash cost	Notes
Do Minimum	- Patch and repair	£800k	£2,690k	Ongoing. Cost estimate based on recent expenditure
Maintain	- Refurbish IW27/02 seawall (immediately, 2045-50) and encase (2065-70) - Refurbish remaining seawall and breastwork in unit (2027-32, 2045-50) and encase (2065-70) - Refurbish timber groynes (2027, 2045-50, 2065-70, 2085-90 and 2105-2110) - Refurbish concrete groynes (2032 and 2070)	£3,100k	£8,560k	Resurface to extend service life by approx. 20yrs. Encasement required from 2065 as resurfacing alone is unlikely to be sufficient.
Sustain / improve performance – approach 1	- Encase and raise seawall, replace breastwork with seawall (immediately/2027-32 and 2075 onwards)	£3,390k	£7,070k	Encasement to include raising. No groyne refurbishments required as encased structure includes toe protection.
Sustain / improve performance – approach 2	- As per maintain approach - Crest raising – timings subject to modelling and the onset of risk	£4,170k	£11,265k	Crest raising to decrease wave action against cliff toe
Sustain / improve performance – approach 3	- As per sustain / improve approach 2, except; - Construction of large concrete groyne to replace existing timber groynes (around 2030)	£4,515k	£11,340k	Assumed 3 new concrete groynes would be sufficient to hold beach material in place. However, sediment modelling would be required to refine this option if it was advanced during later studies.
Sustain / improve performance – approach 4	- Beach recycling to improve beach levels in the area - Refurbish seawall and breastwork (present day & 2027, 2055-60 then encase later) - Refurbish timber groynes - Crest raising – timings subject to modelling and the onset of risk	£5,030k	£15,075k	Assumed beach recycling will improve beach levels. Refurbishments to structures required less frequently due to higher beach levels.

**Note – measures and timings are only estimates, refer to paragraph at the start of section 6 for more details.*

The cash cost for the range of options in this unit is approximately £7.1 to £15.1 million, to provide continued or improved protection from erosion and flood risks over the next 100 years, dependent on the standard of protection and type of method chosen, and on whether or not the groynes are maintained. The timing/phasing of the works and the timing of investment required also varies in the different options, as outlined in this chapter.

Methods of maintaining or improving the defences

Cost-effective and appropriate methods to reduce risks have been sought and costed in this chapter. These include using a sprayed coating of concrete to extend the life of the current defences, as this method has already been used in Sandown Bay, at neighbouring Culver Parade seawall in 2006 (in unit IW24). Other methods proposed include more substantial encasement of the defences in concrete (when technically required), plus crest-raising of the defences (when required). Options including refurbishment of the groynes in the area have also been included in the costings.

Alternative methods have also been considered, such as beach nourishment. Each method has different costs, advantages and disadvantages, and would last for a different number of years before needing to be repeated. When packaged into combinations of methods over 100 years these alternative measures are anticipated to add up to more expensive solutions than those proposed in the chapter above. Therefore if extra funding is available, alternative methods could also be considered. The alternative options considered for all the defence units are summarised in section 0.

6.7 Unit IW28 (Luccombe Road, Shanklin)

Unit IW28 is 457m long and is located to the south of Shanklin Esplanade, extending from Shanklin Chine southwards to approximately the position of Luccombe Hall (located on the cliff top). This unit currently is a transition between the hard concrete sea defences to the north and the undefended cliffs to the south. This unit is backed by near-vertical cliffs.

The number of properties at risk in IW28 over the next 100 years is presented in Table 6-26 below.

Table 6-26 Properties at risk in unit IW28

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion
2017	0	0	0	0
2027	0	0	0	0
2057	0	0	0	2
2117	0	0	0	28

The defences in the unit comprise a length of timber breastwork (constructed in 1970) and six timber groynes (constructed in 1980). To the south of the unit the cliffs are undefended and gradually eroding, providing an important supply of sediment to the area and the rest of the bay (see Figure 6.9).

The primary risk in this unit is from erosion. There are only a limited number of properties located behind the existing defences, but at Luccombe there are properties located at the cliff top which could be at risk of erosion should the cliff top retreat.

The coastal flood modelling made available for this study does not include this area and therefore the flood risk is not certain. Given the small number of buildings at the base of the cliff in this unit the overall risk is not significant (in terms of property numbers). Further flood modelling would be required to accurately quantify the level of flood risk in the area.

Figure 6-9. Unit IW28

6.7.1 Do Nothing

Doing Nothing involves no active intervention. The present value cost of this option is £0.

6.7.2 Do Minimum

Do Minimum involves small scale reactive maintenance and 'patch repair' work to the existing timber breastwork and groynes alongside the continued small scale cliff stabilisation measures which are currently undertaken. Based on the current IoW Council expenditure on patch and repair maintenance and cliff stabilisation along the Sandown frontage it is estimated that a continuation of these activities for the next 100 years would cost approximately PV £135k for this unit (approximately £75k for patch and repair and £60k for cliff stabilisation). This equates to £455k in cash terms. The limitations of this method are outlined in section 5.1.2 above.

6.7.3 Maintain

This Maintain option involves scheduled maintenance of the timber breastwork and groynes to ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years). This will help to reduce the exposure of the cliff toe to wave action and reduce the rate of cliff top erosion. However, the retreat of the cliff top will not be stopped completely under this option because other factors such as weathering and sea level rise will also be influential.

The average crest level of the existing timber defences is approximately 3.1m. The residual life of the existing defences in units IW28 is shown in Table 6-27 below. When the defences come towards the end of their service life it will be necessary to undertake capital repair / refurbishments to extend the service life of some of some or all of the defences.

Table 6-27. Defence type and residual life of unit IW28

Defence unit	Defence structure	Existing condition	Estimated residual life (with patch and repair)	Proposed timing of initial capital refurbishment
IW28/01	Timber breastwork	Fair	10 years	2027
IW28/01	Timber groynes	Fair	10 years	2027

One approach has been considered to implement the maintain option in this unit.

Approach

Maintaining the performance of the existing groynes is considered important if the service life of the timber breastwork is to be significantly extended. Should beach levels in this unit drop, it could expose the base of the breastwork which is likely to accelerate its deterioration.

With this approach the groynes will be refurbished with a 20% material replacement when they come to the end of their service life (timber groynes from 2027) (20% material replacement assumed for costing has been assumed and informed from a visual site inspection. Specific requirements will need to be investigated during scheme design). This is expected to extend the service life of the groynes and should sustain or improve the performance of the groynes at retaining beach material. To maintain the groynes throughout the duration of the appraisal period it has been assumed that the timber groynes will require a refurbishment on average every 20 years.

In 2027, as the timber breastwork comes towards the end of its service life a capital refurbishment will be undertaken. This refurbishment will involve a 30% material replacement which is assumed to extend the service life of the structure by 20 years. The intervention will need to be repeated throughout the appraisal period to maintain the structure.

In addition to the capital refurbishments outlined above, continued patch and repair maintenance and cliff stabilisation will be required at intervals throughout the appraisal period.

The estimated PV cost of this combination of measures is approximately £1,165k. This equates to £4,015k in cash terms (approx. £4.0m).

The same approach without the groyne refurbishments is approximately £741k in PV terms. However, given the importance of the groynes in this location and the increased risk of toe exposure should the groynes not be maintained there is less confidence that this approach would be as effective at delivering the Maintain option.

6.7.4 Sustain / improve performance

The sustain / improve option is focussed on sustaining or improving the performance of the defences in terms of reducing the erosion risk to the properties immediately behind the defences and also to reduce the action of waves and high water levels at the cliff toe. To achieve this option the existing defence line will need to be kept in place and the crest of the defences will need to be raised to keep pace with sea level rise. There is no flood modelling currently available in this area and therefore it is not possible to determine in detail at what time period that wave overtopping / defence inundation is likely to lead to cliff toe erosion and therefore the time period in which the defences may require raising is unclear. Should schemes be pursued in this area it is recommended that numerical modelling is undertaken to resolve this uncertainty.

As in units IW26 and IW27, the sustain and improve options are combined for this unit (see section 6.5.4 for explanation).

To reduce the frequency of inundation / wave overtopping over the defences to a present day 1:75yr return period, it will be necessary to raise approximately 300m of the defences in the unit. This would reduce the wave attack eroding the base of the cliffs. The longer lengths of defence required to raise the defences to differing standards of future protection are provided in Table 6-28 below.

Table 6-28. Length of crest raising required; IW28

Standard of protection	Year	Length of crest raising	Average height of raising (approx.)
1:75 SoP	2057	350m	Between 0.5-1m
1:75 SoP	2117	365m	1.5m (but less if setback)
1:200 SoP	2057	350m	Between 0.5-1m
1:200 SoP	2117	370m	1.5m (but less if setback)

Three approaches to implementing the sustain / improve option have been developed for IW28.

The alignment of any proposed new defence elements should be carefully considered and designed to take account of potential outflanking at the southern end of this unit, which marks the transition to the undefended coast.

Approach 1 – Construct higher timber revetment, and refurbish groynes (lower overall investment approach)

This approach involves replacing the existing timber breastwork with a new higher timber revetment / breastwork (to a desired SoP). The breastwork would be replaced in year 2027 when it comes towards the end of its estimated service life and the new structure would need refurbishment approximately every 30 years (2055-60 and 2085-90).

Alongside the new revetment, there would be refurbishments to the timber groynes on average every 20 years to sustain their performance.

The estimated PV cost of this combination of measures is approximately £1,205k. This equates to £3,450k in cash terms (approx. £3.5m).

Approach 2 – Construct higher timber revetment, and new timber groynes

This approach involves replacing the existing timber breastwork with a new higher timber revetment / breastwork (as outlined in approach 1). The breastwork would be replaced in year 2027 when it comes towards the end of its estimated service life.

In addition to this, the existing timber groynes would be fully replaced with new structures at the end of their existing service (2027) (instead of refurbishing the existing groynes). This may improve the performance of the groyne field. As a result, it has been assumed that beach levels will be higher with this approach and therefore refurbishments to the timber revetment will be required less frequently than in Approach 1 above. It has been assumed that the initial service life of the new structure will be extended to 40 years (as opposed to 30 in approach 1).

The estimated PV cost of this combination of measures is approximately £1,555k. This equates to £4,210k in cash terms (approx. £4.2m).

Approach 3 – new timber revetment and groynes, replaced with a concrete seawall at end of service life

Initially this approach involves replacing the existing timber breastwork with a new higher timber revetment / breastwork. The breastwork would be replaced in year 2027 when it comes towards the end of its estimated service life. In addition, the existing timber groynes would be fully replaced with new structures at the end of their existing service (2027).

From 2055-60, at the end of the structures service life the revetment will be replaced with a concrete seawall. This will include toe protection and therefore groynes will not be required to hold the beach in place (purely from a flood and erosion perspective). The seawall will be a robust structure with a long service life and is expected to last for the duration of the appraisal period.

The transition from a new concrete seawall to the undefended cliffs to the south would require careful design as a new structure would start to be outflanked.

The estimated PV cost of this approach is approximately £1,755k. This equates to cash costs of £4,805k (£4.8m).

6.7.5 Summary

The measure combinations considered in the development of options for unit IW28 are summarised in Table 6-29 below.

Table 6-29. Summary of measure combinations developed for IW28

Option	Measures and timing*	PV cost	Cash cost	Notes
Do Minimum	- Patch and repair	£135k	£455k	Ongoing. Cost estimate based on recent expenditure
Maintain	- Refurbish timber groynes (2027, 2045-50, 2065-70, 2085-90, 2105 onwards) - Refurbish timber breastwork (2027, 2045-50, 2065-70, 2085-90, 2105 onwards)	£1,165k	£4,015k	Refurbishments to extend service life by approx. 20yrs.
Sustain / improve performance – approach 1	- Construct timber revetment (2027). Refurbish revetment in years 2055-60 and 2085-90. - Refurb timber groynes (2027, 2045-50, 2065-70, 2085-90, 2105 onwards)	£1,205k	£3,450k	New timber revetment with longer service life than existing breastwork
Sustain / improve performance – approach 2	- Construct timber revetment (2027). Refurbish revetment in year 2065-70 - Construct new timber groynes (2027). Refurbish in 2065-70.	£1,555k	£4,210k	As Sustain / improve – approach 1 except longer service life due to new structures and potentially improved performance of new groynes
Sustain / improve performance – approach 3	- Construct timber revetment (2027). - Refurb timber groynes (2027). - Construct new seawall (2055-60)	£1,755k	£4,805k	New seawall at end of timber revetment service life.

**Note – measures and timings are only estimates, refer to paragraph at the start of section 6 for more details.*

The cash cost for the range of options in this unit is approximately £3.5 to £4.8 million, to provide continued or improved protection from erosion and flood risks over the next 100 years, dependent on the standard of protection and type of method chosen, and on whether or not the groynes are maintained. The timing/phasing of the works and the timing of investment required also varies in the different options, as outlined in this chapter. The alternative approach of Do Minimum, based on patch and repair of existing structures, is also highlighted, for this transitional unit between the hard defences to the north and the undefended coast to the south.

With the implementation of the Maintain, Sustain/Improve options it may be necessary to prevent outflanking to the south of unit IW28 which is currently undefended. Future outflanking could be prevented by a number of measures, including gabions and rock armour. Costs for flank protection have not specifically been included in the cost estimates for the options because the amount of protection required is very uncertain, mainly due to characteristically unpredictable rates of outflanking that can occur adjacent to defences. However, for reference, the costs for both gabions and rock armour have been presented in Table 6-30 below. These costs are based on estimated outflanking distances which could occur if the coastline is left undefended. The distances have been approximated from the Do Nothing erosion lines and are a high level estimate only. The Do Nothing erosion lines do not take into account the impact of holding the line immediately adjacent to the undefended area and the potential impact that this could have on sediment drift and wave energy in the area (and consequently on the rate of erosion).

Table 6-30 Estimated costs for outflanking measures

Protection approach	Potential outflanking distance (approx.)	Cost (cash)
Gabions – 1m high	Present day to 2027 = 5m 2027 to 2057 = 20m 2057 to 2117 = 50m	5m = £3k, 20m = £12k, 50m = £30k
Rock armour (3t rocks) with geotextile layer		5m = £12k, 20m = £48k, 50m = £120k

Methods of maintaining or improving the defences

Cost-effective and appropriate methods to reduce risks have been sought and costed in this chapter. These include using a sprayed coating of concrete to extend the life of the current defences, as this method has already been used in Sandown Bay, at neighbouring Culver Parade seawall in 2006 (in unit IW24). Other methods proposed include more substantial encasement of the defences in concrete (when technically required), plus crest-raising of the defences (when required). Options including refurbishment of the groynes in the area have also been included in the costings.

Alternative methods have also been considered, such as beach nourishment. Each method has different costs, advantages and disadvantages, and would last for a different number of years before needing to be repeated. When packaged into combinations of methods over 100 years these alternative measures are anticipated to add up to more expensive solutions than those proposed in the chapter above. Therefore if extra funding is available, alternative methods could also be considered. The alternative options considered for all the defence units are summarised in section 0.

6.8 Unit IW15 (Embankment Road - flood risk only)

The Embankment Road frontage extends 1.5km along the back of Bembridge Harbour, linking Bembridge and St. Helens, comprising study unit IW15. The embankment was originally constructed for a railway route, reclaiming the land behind it to create Brading Marshes. The marshes are now a designated SSSI and form part of the Solent and Southampton Water Ramsar and SPA. The embankment is approximately 10m wide at its narrowest point. The seaward face of the embankment includes some localised protection works such as sandbags, stone and concrete blockwork. A photograph of Embankment Road is shown in Figure 6-10.

The number of properties at risk in IW15 over the next 100 years is presented in Table 6-31 below.

Table 6-31 Properties at risk in unit IW15

Year	Residential properties at risk of flooding (1:200yr event)	Commercial properties at risk of flooding (1:200yr event)	Total properties at risk of flooding (1:200yr event)	Properties at risk of erosion
2017	0	1	1	0
2027	0	2	2	0
2057	30	48	78	0
2117	37	62	99	0

For further information on numbers of properties at risk elsewhere in the low-lying Eastern Yar valley and how these have been divided up between adjacent units, please see Chapter 6.3 and also Appendix A (Economic Appraisal) section 10.3.9.

Figure 6-10. Embankment Road (looking west)

The development of options in this unit has drawn on previous work undertaken in the Eastern Yar Strategy, specifically the StAR Options Appraisal Report (Appendix D) and StAR Economics report (Appendix E). The preferred option recommended in the Strategy was to construct a defence from the present day to provide a 1:25yr SoP for 2110 along the length of Embankment Road. However, as part of this study the Embankment Road frontage has been considered in combination with units IW22-24 (also in the Eastern Yar flood cell) where the standards of protection being considered are 1:75 and 1:200yr. Given that the standard of protection at Embankment Road will need to match that provided in units IW22-24 (in order to deliver the full scheme benefits), the improve option for this unit considers these standards of protection.

6.8.1 Do Nothing

No active intervention. The present value cost of this option is £0.

6.8.2 Do Minimum

Do Minimum involves small scale reactive maintenance and 'patch repair' work to the existing defences (embankment). Based on estimated maintenance costs from the Eastern Yar Strategy it is estimated that a continuation of similar levels of activity along Embankment Road for the next 100 years would cost approximately PV £255k for this unit. This equates to £865k in cash terms.

6.8.3 Maintain

The maintain option involves scheduled maintenance of the embankment at its current height to minimise the risk of failure or breaching for the duration of the appraisal period (i.e. the next 100 years).

The current Standard of Protection provided by the embankment in unit IW15 is approximately between 1:20 – 1:25 years and the average crest level is approximately 3.9m AOD. The embankment is in a good, but locally poor condition (although in the locally poor areas there is no sign of distress to the pavement or carriageway). It is generally sheltered from waves, except for a section towards its eastern end (to the south west of Bembridge sailing club) which could potentially be exposed during storms with a dominant wave direction from the north. The residual life of the embankment is estimated to be 25 years, although where it is exposed this could be as low as 5-10 years. The propagation from a failure to a breach would be dependent on the width of the embankment at the point of first failure.

It has also been noted that the seawall along the seaward face of St Helens Duver (the spit crossing the entrance of the harbour) was refurbished in 2012, so currently provides good shelter to the majority of Embankment Road. For the 50-100 year time horizon the St Helens Duver policy transfers to a policy of managed realignment.

Table 6-32. Defence type and residual life of unit IW15

Defence unit	Defence structure	Existing condition	Estimated residual life (with patch and repair)	Proposed timing of initial capital works
IW15	Embankment	Good, but locally poor (5-10m stretch)	25 years although locally 5-10 years	TBC by EA
IW15	Various short sections of other defence	Varied, generally good to fair	Typically 10-25 years	TBC by EA

One approach to the maintain option has been developed for this unit.

Approach

To maintain the embankment a long term asset maintenance plan will need to be implemented. Given the sheltered environment of the embankment, this is likely to mainly involve patch and repair works. However, for areas which are more exposed or in a poor condition, refurbishment will be required (soon) to strengthen the defence against wave attack. It is assumed the Environment Agency will continue to maintain and operate the water level control gates at the western end of Embankment Road as part of this option.

There are different potential ways of refurbishing the embankment, such as providing Armourlock , gabions, rock armour protection or by reinforcing the toe with steel sheet piles and using geo-textile bags and soil nails. The exact approach will need to be determined during future appraisal work (and minimising environmental impacts) but for the purpose of costing the approach believed to be the most cost effective has been identified, which involves placing Armourlock, rock armour or gabions at the exposed section of defence. For this approach it has been assumed that this will be undertaken at regular intervals every 20 years. For interventions in the near future (e.g. up to 2037) it has been estimated that approximately 20m (length) of protection would be required, but from 2057 onwards when the embankment may be more exposed, it has been assumed that 50m of protection may be needed.

In addition to Armourlock / rock armour / gabion protection to the exposed sections, costs for ongoing maintenance (inspections, patch and repair) associated with a long term asset maintenance plan will occur. These costs have been based on estimated maintenance costs developed in the Eastern Yar Strategy for the embankment.

The estimated PV cost of this combination of measures is approximately £580k. This equates to £1,955k in cash terms (approx. £2m).

6.8.4 Sustain / Improve SoP (with environmental protection)

The sustain / improve option (with environmental protection) provides a minimum standard of protection of the Embankment Road defences. In addition to the 1:25yr sustain SoP, costs for delivering an improved 1:75yr SoP and 1:200yr SoP have been developed and the choice of the preferred standard of protection is discussed in later chapters.

Raising Embankment Road defences will not only protect properties that would otherwise be at increased risk of flooding in the future, but it will also protect the environmental area of Brading Marshes (a SSSI, Ramsar, SPA, SAC) which produces additional indirect benefits for this option.

The lengths of defence required to raise the defences to differing standards of protection are provided in Table 6-33 below.

Table 6-33. Length of crest raising required; IW15

Standard of protection	Year	Length of crest raising	Average height of raising (approx.)
1:75 SoP	2057	1190m	Between 0.1-0.5m
1:75 SoP	2117	1415m	Between 0.5-1m
1:200 SoP	2057	1290m	Between 0.1-0.5m
1:200 SoP	2117	1415m	Between 0.5-1m

Approach

The Eastern Yar Strategy developed two different options for raising defences along this frontage (both with similar costs – within 1%). For costing purposes in this study the elements from the highest cost option have been adopted and re-costed using the latest rates to provide an updated, conservative cost estimate for raising the defence level in this unit. Three standards of protection have been costed, 2117 1:25, 1:75 and 1:200yr. The option involves a combination of raised reinforced concrete floodwalls, road raising, sheet piled sections and flood gates:

- Station Road (St Helens) to River Yar Bridge – south side Embankment Road – reinforce concrete wall (south side)
- River Yar Bridge – south side Embankment Road – replace open steel parapet with reinforced concrete (RC) wall
- River Yar to Brading Haven Yacht Club – south side Embankment Road – sheet pile wall, floodgate to sluice gates access and raising of access to track to south of Embankment Road
- Raising of Embankment Road
- Brading Haven Yacht Club to Sailing Club – north side Embankment Road – sheet pile wall, floodgates to access points
- Sailing Club – north side Embankment Road – RC wall, flood gate
- Sailing club to Pump Lane – north side Embankment Road – RC wall, raising of Beach Road and access road to flats
- Maintaining the functioning of Bembridge Tide-gate

The main defence line would be on the seaward side of Embankment Road. A constraint of the approach is that those properties located seaward of the embankment would not be protected. There may also be issues associated with access although flood gates have been proposed to account for this. Further appraisal and consideration of the route alignment will be required in subsequent studies and the alternative route alignment that was also developed in the Eastern Yar Strategy could be preferred. For more information and a high level map of the option route refer to the Eastern Yar Strategy document: StAR Appendix D Options Appraisal Report, pgs. 53-55.

Different heights of defence have been costed to provide a range of standards of protection. In order to provide a 2117 75yr SoP it is estimated that the raised defence heights would be between 1.1-1.6m high and to provide a 2117 200yr SoP between 1.2-1.7m high. The preferred standard of protection for this approach is discussed in later chapters, and is based on the FCERM decision rule and the incremental benefit cost ratio.

With regards to timing of the approach at Embankment Road, the Eastern Yar Strategy recommended that the existing standard of protection is sustained for the next 100 years. To conform with this approach the defence raising will need to take place from present day. Further discussion on the timing of the options at Embankment Road are provided in the preferred options chapter, section 8.1.2.

In addition to capital costs, costs for ongoing maintenance (inspections, patch and repair) associated with a long term asset maintenance plan will occur. These costs have been based on estimated maintenance costs developed in the Eastern Yar Strategy for the embankment

The estimated PV cost of this combination of measures is approximately £10,500k to sustain the existing 1:25yr SoP, £13,175k to improve to a 2117 1:75yr SoP and £13,470k to improve to a 2117 1:200yr SoP. In cash terms, these values equate to £11,765k (£11.8m), £14,440k (£14.4m) and £14,735k (14.7m) respectively.

6.8.5 Maintain then Improve (with environmental protection)

The maintain then sustain / improve option (with environmental protection) involves maintaining the existing defences at Embankment Road and then raising the defences in 2057. This will need to be coordinated with the timing for crest-raising proposed for units 22-24, so that a consistent SoP is achieved through raising of defences at both ends of the Eastern Yar floodplain the medium term. The defence raising from 2057 in this option is to be undertaken as outlined in the Sustain / Improve SoP option discussed in section 6.8.4.

The estimated PV cost of this combination of measures is approximately £3,955k to maintain and then construct to a 2117 1:75yr SoP in 2057 and £4,035k to maintain and then construct to a 2117 1:200yr SoP in 2057. In cash terms these values equate to £14,650k (£14.7m) and £14,940k (£14.9m) respectively.

6.8.6 Improve SoP (Yarbridge alternative, immediately or delayed)

This alternative Improve option involves delivering a standard of protection to some of the properties at risk by installing tidal flood gates at Yarbridge, whilst maintaining the existing defences at Embankment Road.

The vast majority of properties at risk from this frontage are actually located at Sandown (Unit 24), with flood water from the Embankment Road area flooding 'through the backdoor' to Sandown. A location for tide gates on the Eastern Yar channel and flood cell has been identified at Yarbridge near Brading. Tide gates at this location would prevent flooding at the Sandown area (to the properties shown in Table 6-10, from the Bembridge Harbour direction) and would likely be a cheaper approach than raising the defences at Embankment Road because a significantly shorter defence length would be required.

With this approach, whilst Embankment Road defences would not be raised, it would be important to continue the maintenance of the defences at Embankment Road to prevent the embankment from breaching which could lead to greater environmental issues and significant disruption to transport links.

The tide gates at Yarbridge would include flood gates (e.g. 3m high and 10m wide) which would be closed at times of increased risk from an extreme tidal event propagating upstream from Bembridge Harbour, but would remain open during normal conditions to allow water to flow downstream through the Eastern Yar channel undisturbed. Approximately 220m of raised defence (RC floodwall) would potentially be required along the adjacent road embankment of Marshcombe Shute to tie-in to the tide gates. This would prevent water from outflanking the structure and overflowing the existing raised embankment which Marshcombe Shute road is situated upon. Initial stakeholder feedback suggests that the Eastern Yar valley area may be of archaeological and palaeo-environmental importance and should the option be taken forward, any scheme designs will need to consider this.

Following the construction of the tide gates it will be necessary to maintain them by establishing and following a maintenance plan which sets out a long term maintenance schedule. An operations plan would also be required and implemented to ensure that the flood gates are closed during periods of increased flood risk.

With this approach the SoP provided by the maintained Embankment Road structure would fall over time (existing SoP between 1:20 to 1:25yr protection). This would result in an increasing flood risk of salt water into environmental area of Brading Marsh (a SSSI, Ramsar, SPA and SAC) with a large amount of designated habitat is located in the Eastern Yar valley between Embankment Road and Yarbridge. These habitats are currently freshwater or brackish habitats and increased tidal flooding could permanently alter the habitat composition and eventually could lead to the production of saline based habitat features. Habitat improvement and management activities have been, and currently are carried out by a range of organisations on the existing freshwater habitats throughout the Eastern Yar valley. However, assuming Embankment Road is not breached and based on current sea level rise projections and the expected frequencies on inundation, a transition to more saline based habitat is not expected to occur until the second half of the appraisal period (at the earliest). Further studies and input from Natural England and the Environment Agency are required to determine more precisely when a transition in the habitat may occur and whether this is favourable or not in terms of meeting Regional Habitat Creation Programme aims and objectives. It is understood that with this option, freshwater habitat compensation will not be required in the future given that the transition to intertidal habitat is unintentional and not deliberate (as this option includes maintaining Embankment Road at it's current height). However, this will require further discussion and confirmation with key stakeholders going forward.

It is also important to note that this approach would also lead to an unmitigated increasing flood risk to the properties located in the area between Embankment Road and Yarbridge (see property numbers at risk from different return period events in Table 6-31). Flood risk to these properties would be reduced by maintaining Embankment Road under this option (and therefore preventing a breach), but flood risk would increase as the height of Embankment Road would not be raised. In addition, Embankment Road serves as a key transport route between St. Helens and Bembridge and increased flood risk and travel disruption in the future would occur should the structure not be raised.

At this preliminary stage, this alternative approach of potential tide gates at Yarbridge mitigates the tidal flood risk which propagates from Embankment Road to the Sandown frontage. However, the operation of tide gates at Yarbridge has the potential to impact the fluvial flood risk of the River Yar Valley. This would not be the case during normal tide conditions when the tide gates remained open. However, when the structure was closed it could potentially have the effect of 'backing up' fluvial flows behind the structure leading to an increased fluvial flood risk elsewhere. The magnitude and extent of this impact is unknown at this time but it will be essential to undertake a joint probability analysis and modelling study to determine this impact, and also consider tide locking, prior to this option going ahead.

Initially the typical frequency that the tide gates would need to be closed would be low as the existing standard of protection provided by Embankment Road is between 1:20 – 1:25 years. However, as sea levels rise in the future and the standard of protection of Embankment Road falls, the gates would need to be closed on an ever more frequent basis.

Regarding the potential timing of this approach, the option benefits are unchanged if the Yarbridge tide gates and defences are constructed immediately or are delayed until the future. This is because the Yarbridge tide gates will provide benefits to other units (i.e. units IW22-24) and it is the maintenance of Embankment Road which leads to the benefits in this unit (IW15). Thus, provided Embankment Road is maintained throughout this option, the option benefits to IW15 remain unchanged.

The estimated PV cost of this option, assuming the Yarbridge tide gates and raised defences are constructed from present day is approximately £2,745k to improve to a 1:75yr SoP at Yarbridge and £2,805k to improve to a 1:200yr SoP (2117) . In cash terms this equates to £4,115 to 4,180k (approx. £4.1 or £4.2m).

The estimated PV cost, assuming the Yarbridge tide gates and raised defences are constructed from the year 2057, is approximately £1,160k to improve to a 1:75yr SoP at Yarbridge and £1,175k to improve to a 1:200yr SoP (2117). In cash terms these values equate to £4,130 to £4,190 (approx. £4.1 or £4.2m).

6.8.7 Improve SoP (Yarbridge alternative) and intentional creation of intertidal habitat

This approach follows the same implementations as the Improve SoP (Yarbridge alternative) option described in the previous section, section 6.8.6. However, the main difference with this option is that the EA controlled sluice gates which are currently operated at the western end of Embankment Road would be intentionally left open at all times. The purpose of this would be to allow the tide to regularly inundate the habitat behind Embankment Road which would lead to the primarily freshwater habitat changing to an intertidal habitat. A steer is required from Natural England and the Environment Agency (particularly from the Regional Habitat Creation Programme) to determine whether an intentional change in habitat type behind Embankment Road is favourable (from freshwater to intertidal).

This option will allow OM4 benefits to be claimed in the Partnership Funding assessment (which could help the funding case) although it will also be necessary to include costs associated with compensating the loss of freshwater habitat elsewhere (statutory requirement). There is also a substantial risk that it will not be possible to locate sufficient size area(s) within the region to compensate the up to 400ha of freshwater habitat that would be lost (currently no feasible sites of this size identified within the region). This would need to be further investigated within a Habitat Regulations Assessment after this project if this option were to be taken forward. Based on work undertaken in the Eastern Yar Strategy, a change to intertidal habitat would lead to loss of 291Ha of SPA (also designated as Ramsar and SSSI, and a small part of this area is also SAC), plus an additional 26.5ha of SSSI outside the boundary of the SPA (in their current form). In addition to this designated habitat, this Sandown Study has estimated an additional area of up to 75-85ha of non-designated potential freshwater habitat could also be impacted (based on theoretical consideration of the extent of the floodplain), leading to an overall estimated total (including both designated and non-designated freshwater habitats) of up to 400 hectares. However, regarding the designated areas, the environmental designations could potentially be re-designated based on the habitat that is produced.

The estimated PV cost, including habitat compensation costs, and that the Yarbridge tide gates and raised defences are constructed from the year 2057, is approximately £4,205k to improve to a 1:75yr SoP (2117) and £4,225k to improve to a 1:200yr SoP (2117). In cash terms these values equate to approx. £15,630k and £15,690k respectively (approx. £15.6 or £15.7m). Approximately £11.5m of these cash costs are associated with compensatory habitat costs.

6.8.8 Summary

The measure combinations considered in the development of options for unit IW15 are summarised in Table 6-34 below.

Table 6-34. Summary of measure combinations developed for IW15

Option	Measures and timing	PV cost	Cash cost	Notes
Do Minimum	- Patch and repair	£255k	£865k	Ongoing. Cost estimate based on recent expenditure
Maintain	- Ongoing maintenance plan - Armourlock / gabions (assumed every 20 years, from present day)	£580k	£1,955k	Armourlock / gabions to protect exposed sections of defences. Assumed increased length required in the future due to rising sea levels.
Sustain / Improve protection at Embankment Road	- Raising crest levels along Embankment Road, as per EYS design*	£10,500 – 13,470k	£11,765 – 14,735k	Additional benefit of protecting Environmental designations from increased flood risk from overtopping Cost range for present day 1:25yr SoP to 2117 1:200yr SoP
Maintain then Improve protection at Embankment Road	- Ongoing maintenance along Embankment Road as per maintain option, until 2057 - Raise crest levels along Embankment Road, as per EYS design from 2057	£3,955 – 4,035k	£14,650 – 14,940k	Cost range from 2117 1:75 to 1:200 SoP Delay in Embankment Road capital construction results in reduced PV costs
Improve protection at Yarbridge (immediately or delayed)	- Maintain Embankment Road defences - Tidal flood gates and RC floodwalls at Yarbridge to mitigate flood risk to Sandown frontage	Present day construction: £2,745 - 2,805k Construction in 2057: £1,160 – 1,175k	Present day construction: £4,115 – 4,180k Construction in 2057: £4,130 - £4,190k	Flood gates to be closed during times of increased risk, would remain open during normal operating conditions.
Improve protection at Yarbridge and intentional habitat creation	- As per Improve protection at Yarbridge option (above) - However, intentionally leave EA sluice gates at Embankment Road open to create intertidal habitat - Compensate freshwater habitat elsewhere	Construction in 2057: £4,205 – 4,225k	Construction in 2057: £15,630 – 15,690k	PV and cash costs increased compared to option above due to cost of compensating freshwater habitat elsewhere.

The cash cost for the range of options in this unit is approximately £0.8 to £14.9 million, ranging from Do Minimum to sustaining / improving the flood protection at Embankment Road at the back of Bembridge Harbour. An intermediate option (in terms of cost), which involves constructing Tidal flood gates at Yarbridge near Brading (as well as maintaining Embankment Road at its present height) has also been considered, which has an approximate cost of £4.1m. This cost rises to approx. £15.7m if additional elements are added to this Yarbridge alternative to create intertidal habitat and recreate freshwater habitat elsewhere. The main driver for the choice of the preferred option in this unit will be environmental, and also based on further assessment of combined flood risk, and steer from the Environment Agency and Natural England is required at a later stage.

6.9 Summary of alternative options costed

Table 6-35 below summarises the estimated capital (cash) costs of alternative measures which were not included in the options developed for each unit. These estimated costs (including an allowance for early-stage cost uncertainty, known as optimum bias, outlined in Appendix A) are provided for reference and were not considered further in this report as more cost effective and appropriate combinations of measures were identified when considering the full range of costs and impacts.

It should be noted that some of these measures would address erosion risks, others would address flood risks, and for variable lengths of time. They would require packaging up into combinations of measures with repeat interventions to address both erosion and flood risks in each unit over 100 years.

Table 6-35 Alternative measures and costs

Unit	Alternative measures and costs (capital costs in cash terms)
IW22	Beach nourishment (assuming half beach volume required) - £810k (and dependent on how long this would be retained). New concrete revetment (225m long) approx. £1.1 million (dependent on height/Standard of Protection) Beach recycling (assuming half beach volume required) - £320k per recycling (requiring regular repetition) New timber groynes (instead of refurbishing the existing groynes) - £640k (for 3 new groynes, based on existing lengths) Setback floodwall (on top of the existing defences) - £60k to 110k (dependent on height/Standard of Protection, and which would cost more than crest raising)
IW23	Beach nourishment (assuming half beach volume required) - £770k (and dependent on how long this would be retained). New seawall (254m long) - £1.2 million to £1.5 million (dependent on height/Standard of Protection) Beach recycling (assuming half beach volume required) - £300k per recycling (requiring regular repetition) New concrete groynes (instead of refurbishing the existing groynes) - £1.6 million (for 4 new concrete groynes, based on existing lengths) Setback floodwall (on top of the existing defences) - £340k to £370k (dependent on height/Standard of Protection, and which would cost more than crest raising)
IW24	Beach nourishment (assuming half beach volume required) - £1.8 million (and dependent on how long this would be retained).New seawall (681m long) - £3.3 million to £5 million (dependent on height/Standard of Protection) Road raising –see text below this table. Beach recycling (assuming half beach volume required) - £720k per recycling (requiring regular repetition) New groynes (instead of refurbishing the existing groynes) - £3.5 million for 2 concrete groynes and 7 timber groynes (based on existing lengths). Setback floodwall (on top of the existing defences) – approx. £2.3 million (dependent on height/Standard of Protection, and which would cost more than crest raising)
IW25	Beach nourishment (assuming half beach volume required) - £3.7 million (and dependent on how long this would be retained). New timber groyne (instead of refurbishing the existing timber groyne) - £250k (based on existing length) 2x new terminal concrete groynes - £1.7 million (approx. 120m in length) New seawall (1026m long) - £5 million to £6.8 million (dependent on height/Standard of Protection) Beach recycling (assuming half beach volume required) - £1.4 million per recycling (requiring regular repetition) Setback floodwall (on top of the existing defences) – approx. £2.7 million (dependent on height/Standard of Protection, and which would cost more than crest raising)
IW26	Beach nourishment (assuming half beach volume required) - £8 million (and dependent on how long this would be retained). New concrete revetment (2348m long) - £11.5 million to £17.2 million (dependent on height/Standard of Protection) Rock revetment (2348m long) – approx. £9 million (plus additional costs required for maintenance of accompanying structures e.g. esplanade, seawall, groynes and cliffs). Also see further text below this table. New timber groynes (instead of refurbishing the existing timber groynes) - £5.2 million for 20 groynes, (based on average existing length). New concrete groyne (instead of refurbishing the existing 1 longer concrete groyne) - £1 million (based on existing length) Beach recycling (assuming half beach volume required) - £3.2 million per recycling (requiring regular repetition) Setback floodwall to prevent toe erosion of the cliffs was also considered but was, as in other units, more expensive than crest raising.
IW27	Beach nourishment (assuming half beach volume required) - £3.1 million New seawall (901m long) - £4.4 million to £6.5 million (dependent on height/Standard of protection) New groynes (instead of refurbishing exiting groynes) - £3.9 million for 6 timber groynes and 2 concrete

	groynes, including Hope Groyne (based on existing average lengths).. Setback floodwall (on top of the existing defences) – approx. £2.9 million (dependent on height/Standard of Protection, and which would cost more than crest raising)
IW28	Beach nourishment (assuming half beach volume required) - £1.4 million (and dependent on how long this would be retained). Beach recycling (assuming half beach volume required) - £760k per recycling (requiring regular repetition) New timber revetment - £720k Rock revetment (457m) - £1.8 million New seawall (457m) - £2.2 million to £3.1 million (dependent on height/Standard of Protection)
IW15	Options approaches for Embankment Road established in Eastern Yar Strategy

Options for sloping concrete or rock revetments have not been added for most units where there is a currently a vertical seawall in place, as these would have a notably increased defence footprint (width) in an environmentally-designated area and also result in loss of amenity beach area, therefore costs for maintenance or replacement of the existing vertical seawalls are supplied. Also, there are cheaper alternatives available, rock revetments would not reduce tidal flood risk, they could have positive or negative effects on beach levels and can have safety considerations in popular areas. However, rock revetment costs have been included in principle in the list above in units 26 and 28 for comparison purposes. More cost effective and achievable alternatives were taken forward in the preferred options with all the relevant costs and impacts taken into account.

Road raising costs have been considered for unit 24, where the seafront road drops down below the seawall embankment. A typical height for locations where a road raising approach has been used is for an 0.8m raise; anything over this height the costs increase and it becomes a less favourable option compared to new defences. The cost for an 0.8m raise would be approximately £4,730 per metre, or £1.7 million for the approximately 360 metre length within unit where the road drops down below the embankment, or £3.2 million for the entire length of this 681 metre unit. In fact, a road raise much higher than 0.8 metres would be required for much of this area to raise the road up to the present defence level, and even more to raise it higher than the existing defences (to achieve the intention of improving the standard of flood protection). Therefore, it is anticipated that road raising is not a viable option due to the extremely high cost and the fact that it would also require frontline maintenance to the existing defences. In addition, although road raising could address wave overtopping risk in itself it does not address the more dominant risk of a potential breach in this unit. It would still need be supported by a frontline defence to prevent the erosion risk and therefore road raising as a standalone option has not been put forward. In terms of overtopping risk - there are less expensive options, such as modifying the frontline defence / raising it, which would mitigate this.

7. Appraisal of shortlist options

This chapter presents the appraisal of the shortlist options. The chapter is split into five sections;

- Overview of the appraisal process – FCERM decision process.
- Economic appraisal – comparison of option costs and benefits and the recommended preferred economic option and standard of protection.
- Environmental appraisal – environmental appraisal of measures. Does the environmental appraisal support the preferred economic option?
- Social appraisal – consideration of stakeholder aspirations and objectives. Does the preferred economic option support these?
- Summary and the recommended preferred options.

7.1 Overview of the appraisal process

7.1.1 Flood and Coastal Erosion Risk Management (FCERM) Decision Framework

The selection of the preferred options for each unit has followed the FCERM-AG decision rules. This process is necessarily iterative, taking into consideration technical feasibility and effectiveness, economic appraisal and environmental and social assessment. The decision rules are broken down into several key stages:

Stage 1 – Establish the whole life costs and benefits of the shortlist options. Ensure each option that was considered further had a benefit cost ratio >1.

Stage 2 – Organise the options. Following the FCERM decision making process the shortlist options were organised by reducing level probability of flooding. In instances where this could not be done (i.e. where two or more options provide protection to a similar level of flood risk, reduce or remove coastal erosion risk, provide different strategic methods or approaches and/or provide different ways of providing the same outcome), then the options were organised by Average-Benefit Cost Ratio (ABCR).

For units IW15 to IW25 the options could be ranked according to reducing flood risk. However, in units IW26 to IW28 the dominant risk is from erosion and therefore options were ranked based on their ABCR.

Stage 3 – Identify leading economic option. Once the options were organised the economic merits could be compared and the leading option identified.

For units IW26 to IW28 where the dominant risk is from erosion the option with the highest ABCR was identified as the leading economic option.

For units IW15 to IW25 where there is a flood risk, the decision process was started by selecting the option with the highest ABCR. Next, the Incremental Benefit Cost Ratio (IBCR) was used to determine whether the choice of the leading option should change.

The IBCR indicates the cost effectiveness of an option compared to other options. If the additional benefits of a more expensive option outweigh the additional cost then the IBCR will be greater than 1. The FCERM-AG has a set of IBCR thresholds which are used to indicate whether the additional investment of moving to a higher standard of flood protection is economically advantageous.

The FCERM-AG IBCR thresholds are presented in Table 7-1 below, in accordance with the appraisal guidance. When using the IBCR thresholds it is important to remember that you can only move from one option to the next if the IBCR exceeds the threshold relevant to the standard of protection offered by the next option. You cannot jump over options which have an IBCR which is lower than the thresholds.

Table 7-1. IBCR thresholds

Option type / risk level	Minimum requirement for option to be preferred
Options with existing AEP greater than 1.3% (or SoP <1:75yr)	IBCR > 1
Options with existing AEP less than 1.3% but greater than 0.5% (or SoP between 1:75yr and 1:200yr)	IBCR > 3
Options with existing AEP less than 0.5% (or SoP >1:200yr)	IBCR > 5

Stage 4 – Accounting for contributions. Considered any financial contributions which may have been secured and the impact this has on the average and incremental benefit cost ratios of options and the choice of the leading economic option.

Stage 5 – Testing uncertainty. Sensitivity tests to determine whether uncertainty would influence the choice of the leading option were undertaken. For example, would significant cost increases / decreases largely alter the average and incremental benefit cost ratios and how would this change the choice of the leading option?

Stage 6 – Consider other factors (environment and stakeholders). The choice of the leading option was then considered against other factors, such as stakeholder aspirations and environmental benefits / constraints. The choice of the leading option was reconsidered if an alternative option demonstrated a significantly stronger case in terms of meeting these aspirations and non-monetary benefits (e.g. through providing greater environmental benefits).

7.1.2 Basis for option comparison

In several units a number of different measure combinations have been identified and costed for each short list option. Amongst these combinations the approach which is likely to require the lowest investment (i.e. similar benefits achieved for lower investment) has been identified.

Grant in aid (GiA) funding is likely to be a key source of finance for implementing the preferred options in this study. Therefore, it is essential that the option comparison takes account of, but is not wholly guided by potential GiA funding. For example, two different measures could be used to deliver the same short list option (and therefore provide the same economic benefits), but the constraint that GiA will be limited to the lowest cost of these measures has been recognised. Any additional cost of implementing an alternative measure that does not deliver additional benefits would have to be funded from non GiA sources.

Based on this constraint, when undertaking the economic aspect of the short list option comparison, the measure combination for each option with potentially the lowest whole life cost has been adopted. This provides a fair basis to compare the shortlist options and prevents for example the IBCR of the ‘maintain option’ comprised of very expensive measures being compared directly to a ‘sustain SoP’ option comprised of the lowest cost measures. This approach also provides a more accurate assessment of potential GiA availability for the options because it is clearly demonstrated that the economic comparison of options is based on the options requiring the lowest investment, and it has not been skewed by cross comparison between lower cost and more expensive combinations.

Some of the more costly measure combinations that have been developed provide benefits to the area which are not monetised or provide only a low monetary value within the framework of the MCM benefits assessment. For example, option combinations which include groyne refurbishments / replacement are potentially costly, but would help sustain beach levels, preserve the character of the area and align with IoW Council and local aspirations to support and enhance the economy of the area. These more costly options have therefore been considered during Stage 6 of the option appraisal when the choice of the preferred option can be changed based on these aspects.

7.2 Economic appraisal

7.2.1 Introduction

The economic benefits of each short list option have been identified. For more information of how the economic damages and benefits were derived, refer to the Economics Appendix located at the end of this report. The 'Do Nothing' scenario for the Study Area is discussed in Section 3 of Appendix 1. Table 7-2 below presents the PV costs and benefits of each of the short list options. For comparison purposes, all measure combinations that have been considered (lower investment and more costly) are included in the table.

Note that in Table 7-2 the economic benefits have been split out for each individual unit including erosion/retreat of the shoreline being taken into consideration. However, in reality, for units IW22 to IW24 (Yaverland to Culver Parade, in Sandown Bay) there is one joined up flood cell which links across these units. Therefore, in order to achieve the full benefits for each unit it will be necessary to deliver the same strategic management option across units IW22 to IW24. If this approach is not followed, and for example, maintain is identified in one unit and sustain is identified in the other units, the lower standard of protection provided by maintain would allow flood water to enter the other units and decrease the perceived standard of protection. It is therefore necessary to appraise the high level shortlist options in units IW22 to IW24 by combining the total costs and benefits across these units and selecting a unified preferred option.

In addition to the above, IW15 (Embankment Road, at the back of Bembridge Harbour) provides a flood pathway to the Sandown frontage via the Eastern Yar valley. As a result, the preferred option in IW15 will need to deliver the same standard of protection that is identified for units IW22 to IW24 in order to achieve the full economic benefits and outcomes. The appraisal for the preferred option at IW15 is driven largely by environmental aspects and it has been agreed with the Environment Agency and the project team that without further steer on what the preferred environmental option is, this study will present the leading economic option and alternatives and provides a narrative on the environmental factors of each option. A decision on the preferred option will be made at a later stage, but as a necessary working assumption the option appraisal has been based on the premise that the option delivered at Embankment Road will ultimately provide the same standard of protection as the preferred option at the Sandown frontage. The Eastern Yar Strategy (Environment Agency, 2010) recommended that the standard of protection at Embankment Road was sustained for the duration of the Strategy appraisal period (2010-2110) and to deliver this it was recommended that a scheme protecting to the 1:25yr SoP in 2010 was constructed from present day.

Table 7-2. Summary of the short list options and the local level measures required to implement them along with Present Value (discounted) costs and benefits.

Nb. Alternative 'cash costs' for each of these options can be found in Chapter 6.

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
Yaverland Car Park	IW22	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	35	2,676	76.5
		Maintain 1	Refurbish Revetment	515	8,637	16.8
		Maintain 2	Refurbish Revetment & Refurbish Groynes	580	8,637	14.9
		Sustain 75yr 1	Refurbish Revetment & Crest Raising	525	10,444	19.9
		Sustain 75yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	590	10,444	17.7
		Maintain then Sustain 75yr 1	Refurbish Revetment & Crest Raising	525	8,806	16.8
		Maintain then Sustain 75yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	590	8,806	14.9
		Sustain 200yr 1	Refurbish Revetment & Crest Raising	535	10,489	19.6
		Sustain 200yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	595	10,489	17.6
		Maintain then Sustain 200yr 1	Refurbish Revetment & Crest Raising	530	8,806	16.6
		Maintain then Sustain 200yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	595	8,806	14.8
		Improve 2117 200yr 1	Refurbish Revetment & Crest Raising	570	10,656	18.7
		Improve 2117 200yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	635	10,656	16.8
Sandown Zoo	IW23	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	40	975	24.4
		Maintain 1	Refurbish Seawall	500	1,959	3.9
		Maintain 2	Refurbish Seawall & Refurbish Groynes	1,020	1,959	1.9
		Sustain 75yr 1	Refurbish Seawall & Crest Raising	585	1,967	3.4
		Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,095	1,967	1.8
		Maintain then Sustain 75yr 1	Refurbish Seawall & Crest Raising	565	1,967	3.5
		Maintain then Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,085	1,967	1.8
		Sustain 200yr 1	Refurbish Seawall & Crest Raising	595	1,967	3.3
		Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,115	1,967	1.8
		Maintain then Sustain 200yr 1	Refurbish Seawall & Crest Raising	575	1,967	3.4
		Maintain then Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,095	1,967	1.8
		Improve 2117 200yr 1	Refurbish Seawall & Crest Raising	785	1,967	2.5

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
		Improve 2117 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,305	1,967	1.5
Culver Parade	IW24	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	110	11,507	104.6
		Maintain 1	Refurbish Seawall	1,345	41,695	31.0
		Maintain 2	Refurbish Seawall & Refurbish Groynes	2,250	41,695	18.5
		Sustain 75yr 1	Refurbish Seawall & Crest Raising	2,185	43,384	19.9
		Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	3,090	43,384	14.0
		Maintain then Sustain 75yr 1	Refurbish Seawall & Crest Raising	1,750	41,867	23.9
		Maintain then Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	2,655	41,867	15.8
		Sustain 200yr 1	Refurbish Seawall & Crest Raising	2,335	43,464	18.6
		Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	3,240	43,464	13.4
		Maintain then Sustain 200yr 1	Refurbish Seawall & Crest Raising	1,780	41,867	23.5
		Maintain then Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	2,685	41,867	15.6
		Improve 2117 200yr 1	Refurbish Seawall & Crest Raising	2,980	43,913	14.7
		Improve 2117 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	3,885	43,913	11.3
Sandown Esplanade	IW25	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	170	2,155	12.8
		Maintain 1	Refurbish Seawall	2,025	7,005	3.5
		Maintain 2	Refurbish Seawall & Refurbish Groyne	2,080	7,005	3.4
		Sustain 75yr 1	Refurbish Seawall & Crest Raising	2,925	8,195	2.8
		Sustain 75yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	2,970	8,195	2.8
		Maintain then Sustain 75yr 1	Refurbish Seawall & Crest Raising	2,470	7,849	3.2
		Maintain then Sustain 75yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	2,520	7,849	3.1
		Sustain 200yr 1	Refurbish Seawall & Crest Raising	3,090	8,208	2.7
		Sustain 200yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	3,140	8,208	2.6
		Maintain then Sustain 200yr 1	Refurbish Seawall & Crest Raising	2,515	7,849	3.1
		Maintain then Sustain 200yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	2,565	7,849	3.1
		Improve 2117 200yr 1	Refurbish Seawall & Crest Raising	3,865	8,245	2.1

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
		Improve 2117 200yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	3,920	8,245	2.1
Lake Cliffs	IW26	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	695	2,042	2.9
		Maintain	Refurbish Revetment / Seawall & Refurbish Groynes	5,345	5,355	1.0
		Sustain / Improve 1	Refurbish & Raise Revetment / Seawall	7,560	5,606	0.7
		Sustain / Improve 2	Refurbish Revetment / Seawall, Refurbish Groynes & Crest Raising	9,290	5,606	0.6
		Sustain / Improve 3	Refurbish Revetment / Seawall, Construct Concrete Groynes & Crest Raising	10,900	5,606	0.5
		Sustain / Improve 4	Beach Recycling, Refurbish Revetment / Seawall, Refurbish Groynes & Crest Raising	12,110	5,606	0.5
Shanklin Esplanade	IW27	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	800	5,166	6.4
		Maintain	Refurbish Seawall & Refurbish Groynes	3,100	14,071	4.5
		Sustain / Improve 1	Refurbish & Raise Seawall	3,390	17,477	5.2
		Sustain / Improve 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	4,170	17,477	4.2
		Sustain / Improve 3	Refurbish Seawall, Construct Concrete Groyne & Crest Raising	4,515	17,477	3.9
		Sustain / Improve 4	Beach Recycling, Refurbish Seawall, Refurbish Groynes & Crest Raising	5,030	17,477	3.5
Luccombe Road	IW28	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	135	226	1.7
		Maintain	Refurbish Breastwork & Refurbish Groynes	1,165	521	0.4
		Sustain / Improve 1	Construct Timber Revetment & Refurbish Groynes	1,205	536	0.4
		Sustain / Improve 2	Construct Timber Revetment & Construct new Groynes	1,555	536	0.3
		Sustain / Improve 3	Construct Timber Revetment then Seawall. Refurbish Groynes	1,755	536	0.3
Embankment Road*	IW15	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	255	3,737	14.5
		Maintain	Maintenance plan & Armourlock / Gabions	580	14,482	24.9
		Sustain 75yr at Yarbridge	Maintenance plan, Armourlock / Gabions and tide gates	2,745	14,482	5.3
		Sustain 75yr at Emb. Rd	Maintenance Plan & EYS design (setback floodwall)	13,175	15,295	1.2
		Improve 200yr at Yarbridge	Maintenance plan, Armourlock / Gabions and tide gates	2,805	14,482	5.2
		Improve 200yr at Emb. Rd	Maintenance Plan & EYS design (setback floodwall).	13,470	15,542	1.2
		Maintain then Improve 75yr at Emb. Rd	Maintenance plan then EYS design (setback floodwall) later in appraisal period	3,955	15,248	3.9

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
		Maintain then Improve 200yr at Emb. Rd	Maintenance plan then EYS design (setback floodwall) later in appraisal period	4,035	15,248	3.8
		Maintain then Improve 75yr at Yarbridge	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period	1,160	14,482	12.5
		Maintain then Improve 200yr at Yarbridge	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period	1,175	14,482	12.3
		Maintain then Improve 75yr at Yarbridge with habitat creation	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period. Operation of EA sluices at Embankment road to create saline habitat.	4,205	13,678	3.3
		Maintain then improve 200yr at Yarbridge with habitat creation	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period. Operation of EA sluices at Embankment road to create saline habitat.	4,225	13,678	3.2

*Nb. A cost for a 1:25yr SoP option for Embankment Road is also discussed in Section 6.8.4 above. To build on the work of the Eastern Yar Strategy, now information is available for Culver Parade, the costs and benefits of 1:75yr and 1:200yr SoPs at both ends of the valley (Units 15 to 24) are discussed further in this appraisal.

7.2.2 Units IW22 to IW24 (flood and erosion risk)

As discussed in section 7.2.1, it is necessary to combine the option costs and benefits of these units to identify an integrated preferred option for this area. This is because the flood cell merges across all three units (22-24) and in order to deliver the full benefits of a given option, the standard of protection that is provided needs to be consistent.

Table 7-3 below shows the combined costs and benefits for the shortlist options in units IW22 to IW24 for the lower investment measure combinations.

Table 7-3. Combined PV costs and benefits of lowest cost shortlist options in units IW22-24.

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio
IW22 to IW24	Do Nothing	0	0	/
	Do Minimum	185	15,158	81.9
	Maintain (1)	2,360	52,291	22.2
	Sustain 75yr (1)	3,295	55,795	16.9
	Maintain then Sustain 75yr (1)	2,840	52,640	18.5
	Sustain 200yr (1)	3,465	55,920	16.1
	Maintain then Sustain 200yr (1)	2,885	52,640	18.2
	Improve 2117 200yr (1)	4,335	56,536	13.0

Note. The lowest cost options listed here are the range of options maintaining or improving the seawall only, not including groyne improvements too. Alternative options including groyne refurbishment are provided in Chapter 6.

To select the leading economic option for these units the options were organised according to their reducing probability of flooding. The IBCR between options has been calculated to determine the leading economic option. Table 7-4 below presents the IBCR analysis.

Table 7-4. IBCR assessment for shortlist options in units IW22-24

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	IBCR	IBCR threshold	Leading economic option
IW22 to IW24	Do Nothing	0	0	/	/	/	
	Do Minimum	185	15,158	81.9	/	/	
	Maintain (1)	2,360	52,291	22.2	17.1	1	
	Sustain 75yr (1)	3,295	55,795	16.9	3.7	1	✓
	Sustain 200yr (1)	3,465	55,920	16.1	0.8	3	
	Improve 2117 200yr (1)	4,335	56,536	13.0	0.7	5	

The initial leading economic option according to the IBCR assessment was Sustain (75yr SoP). This option has an IBCR of 3.7 compared to the Maintain Option. The IBCR of the Sustain (200yr SoP) option is only 0.8 which falls below the threshold required to justify the increased investment.

The 'Maintain then Sustain' options were not included in the IBCR comparison. This is because these options provide a varying standard of protection over time (a gradual fall in SoP initially) and cannot be ranked alongside the other options with respect to the standard of protection that they provide over the full appraisal period. Therefore, to assess the economic case for the Maintain then Sustain (75yr SoP) option, its ABCR was compared to the initial leading economic option (Sustain - 75yr SoP). By delaying the first flood risk intervention the ABCR of the option increases (rises from 16.9 to 18.5). In addition, for these units the vast majority of the economic benefits during the initial two epochs come from maintaining the defences and preventing a breach that would write-off a large number of properties. This, combined with the higher ABCR of maintaining initially and delaying the first flood risk intervention (mainly to limit overtopping) justifies changing the choice of the leading economic option from Sustain (75yr SoP) to Maintain then Sustain (75yr SoP).

It should be noted that whilst the Maintain then Sustain option does not initially reduce the SoP, it does include maintenance refurbishments which reduces erosion risk and the chance of the existing defences breaching. Table 7-5 below presents the comparison between Sustain and Maintain then Sustain (75yr SoP).

Table 7-5. Comparison to select revised leading economic option, units IW22-24

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	Revised leading economic option
IW22 to IW24	Sustain 75yr SoP	3,300	55,795	16.9	
	Maintain then Sustain 75yr SoP	2,840	52,640	18.5	✓

7.2.3 Unit IW25 (flood and erosion risk)

To select the preferred option in unit IW25 the ABCR and IBCRs have been compared. Table 7-6 below shows the costs and benefits for the shortlist options in unit IW25 for the lower investment measure combinations.

Table 7-6. PV costs and benefits of lowest cost shortlist options in unit IW25.

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio
IW25	Do Nothing	0	0	/
	Do Minimum	170	2,155	12.8
	Maintain (1)	2,025	7,005	3.5
	Sustain 75yr (1)	2,925	8,195	2.8
	Maintain then Sustain 75yr (1)	2,470	7,849	3.2
	Sustain 200yr (1)	3,090	8,208	2.7
	Maintain then Sustain 200yr (1)	2,515	7,849	3.1
	Improve 2117 200yr (1)	3,865	8,245	2.1

Nb. The lowest cost options listed here are the range of options maintaining or improving the seawall only, not including groyne improvements too. Alternative options including groyne refurbishment are provided in Chapter 6.

To select the leading economic option for these units the options were organised according to their reducing probability of flooding. The IBCR between options has been calculated to determine the leading economic option. Table 7-7 below presents the IBCR analysis.

Table 7-7. IBCR assessment for shortlist options in unit IW25

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	IBCR	IBCR threshold	Leading economic option
IW25	Do Nothing	0	0	/	/	/	
	Do Minimum	170	2,155	12.8	/	/	
	Maintain (1)	2,025	7,005	3.5	2.6	1	
	Sustain 75yr (1)	2,925	8,195	2.8	1.3	1	✓
	Sustain 200yr (1)	3,090	8,208	2.7	0.1	3	
	Improve 2117 200yr (1)	3,865	8,245	2.1	0	5	

The initial leading economic option according to the IBCR assessment was Sustain (75yr SoP). This option has an IBCR of 1.3 compared to the Maintain Option. The IBCR of the Sustain (200yr SoP) option is only 0.1 which falls below the threshold required to justify the increased investment.

The 'Maintain then Sustain' options were not included in the IBCR comparison. This is because these options provide a varying standard of protection over time (a gradual fall in SoP initially) and cannot be ranked alongside the other options with respect to the standard of protection that they provide over the full appraisal period. Therefore, to assess the economic case for the Maintain then Sustain (75yr SoP) option, its ABCR was compared to the initial leading economic option (Sustain - 75yr SoP). By delaying the first flood risk intervention the ABCR of the option increases (rises from 2.8 to 3.2) and this justifies changing the choice of the leading economic option from Sustain (75yr SoP) to Maintain then Sustain (75yr SoP).

It should be noted that whilst the Maintain then Sustain option does not initially reduce the SoP, it does include maintenance refurbishments which reduces erosion risk and the chance of the existing defences breaching. Table 7-8 below presents the comparison between Sustain and Maintain then Sustain (75yr SoP).

Table 7-8. Comparison to select revised leading economic option, unit IW25

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	Revised leading economic option
IW25	Sustain 75yr SoP	2,925	8,195	2.8	
	Maintain then Sustain 75yr SoP	2,470	7,849	3.2	✓

7.2.4 Unit IW26 (erosion risk)

To select the leading economic option for this unit the option's ABCR's have been compared. Table 7-9 below presents the comparison.

Table 7-9. ABCR assessment for shortlist options in unit IW26

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	Leading economic option
IW26	Do Nothing	0	0	/	
	Do Minimum	695	2,042	2.9	✓
	Maintain	5,345	5,355	1.0	
	Sustain / Improve (1)*	7,560	5,606	0.7	

*The lowest cost option listed here for Sustain/Improve is an option improving the seawall only, not including groyne improvements too. Alternative options including groyne refurbishment are provided in Chapter 6.

The leading economic option for IW26 is to Do Minimum. This option is justified as the leading economic option because it has the highest ABCR of the shortlist options. The Maintain option has an ABCR of 1.0 which shows that the additional benefits of implementing the option are similar to the extra cost. Whilst the economic case for the Maintain option is not particularly strong, there are additional factors which drive the choice of the preferred option in this unit. These are discussed later in the report.

The Sustain / Improve option has an ABCR less than 1. This is mainly because of the long length of this unit (approximately 2km) which leads to a relatively high cost to construct or raise the defences.

Overall the benefits for this frontage are low compared to costs of the Do Something options. This is largely because the properties at the cliff top are not at risk from erosion until 2057 onwards. This means that the property write-off values in the economics are discounted heavily which reduces the PV benefits of the options.

7.2.5 Unit IW27 (erosion risk)

To select the leading economic option for this unit the option's ABCR's have been compared. Table 7-10 below presents the comparison.

Table 7-10. ABCR assessment for shortlist options in unit IW27

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	Leading economic option(s)
IW27	Do Nothing	0	0	/	
	Do Minimum	800	5,166	6.4	✓
	Maintain	3,100	14,071	4.5	✓
	Sustain / Improve (1) to 75yr SoP	3,390	17,477	5.2	✓

As can be seen in the comparison above, the ABCR's of the shortlist options in unit IW27 are very similar (ranging from 4.5 to 6.4). When this is the case, FCERM-AG suggests that a number of leading economic options can be taken forward to the next stages of the appraisal. Other factors to determine the preferred option, such as the case for funding and meeting wider objectives, are considered later in this chapter.

For options mitigating erosion risk only, FCERM-AG does not require the use of IBCRs to inform the appraisal decision rules (typically used for flood risk mitigation options only). However, IBCR's are a useful tool for determining whether an additional investment is justified. The IBCR between Do Minimum and Maintain is 3.9 and the IBCR between Maintain and Sustain / Improve is 11.7. These ratios are both significantly greater than 1 which suggests that the increased investment required to deliver the Sustain / Improve option is justified (subject to funding).

7.2.6 Unit IW28 (erosion risk)

To select the leading economic option for this unit the option's ABCR's were compared. Table 7-11 below presents the comparison.

Table 7-11. ABCR assessment for shortlist options in unit IW28

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	Leading economic option
IW28	Do Nothing	0	0	/	
	Do Minimum	135	226	1.7	✓
	Maintain	1,165	521	0.4	
	Sustain / Improve (1)	1,205	536	0.4	

The leading economic option for IW28 is to Do Minimum. This option is justified as the leading economic option because it has the highest ABCR of the shortlist options. The Maintain and Sustain / Improve options actually have an ABCR less than 1. This is mainly due to the low FCERM countable benefits in this unit, with few properties at risk in the short term, although 26 properties are at risk from 2055 to 2117 years.

7.2.7 Unit IW15 (flood risk)

The choice of the preferred option in unit 15 is driven largely by environmental factors and a steer from the Environment Agency and Natural England is required to identify the preferred approach. With this input not currently received, this study has currently stopped short of recommending a preferred option but presents the leading economic option and later provides a commentary on the different options.

It is necessary for the IW15 preferred option to deliver the same SoP as the preferred option in units IW22-24. Providing an option with this SoP may not necessarily be the leading economic option for IW15, but it is essential in order to deliver the full benefits across units IW22-24. This is discussed further later on in this report.

For unit IW15 it is not possible to use the IBCR to select the leading economic option. This is because the comparison is largely between options which provide the same outcomes, but do so by different methods or approaches (i.e. measure at Yarbridge or at Embankment Road). The option with the highest ABCR is Maintain (see Table 7-12).

Whilst the Maintain option has the highest ABCR, the options to Maintain then Improve at Yarbridge also have a high ABCR and could equally be chosen as the leading option. These options also support the requirement to match the SoP provided by the preferred option at units IW22-24 to ensure that the Sandown frontage is protected from both ends of the Eastern Yar Valley.

Table 7-12. ABCR assessment for shortlist options in units IW15

Units	Option	PV cost (£k)	PV benefit (£k)	B:C ratio	Leading economic option(s)
IW15	Do Nothing	0	0	/	
	Do Minimum	255	3,737	14.5	
	Maintain	580	14,482	24.9	✓
	Improve 75yr at Yarbridge	2,745	14,482	5.3	
	Improve 75yr at Emb. Rd	13,175	15,295	1.2	
	Improve 200yr at Yarbridge	2,805	14,482	5.2	
	Improve 200yr at Emb. Rd	13,470	15,542	1.2	
	Maintain then Improve 75yr at Emb. Rd	3,955	15,248	3.9	
	Maintain then Improve 200yr at Emb. Rd	4,035	15,248	3.8	
	Maintain then Improve 75yr at Yarbridge	1,160	14,482	12.5	✓
	Maintain then Improve 200yr at Yarbridge	1,175	14,482	12.3	✓
	Maintain then Improve 75yr at Yarbridge with habitat creation	4,205	13,678	3.3	
	Maintain then improve 200yr at Yarbridge with habitat creation	4,225	13,678	3.2	

7.2.8 Contributions

According to FCERM-AG, the next stage of the appraisal involves reassessing the choice of the leading economic options by taking contributions into account. However at the time of writing this report there have been no financial contributions secured for prospective schemes in the study area and therefore the choice of the leading economic options for each unit remains unchanged. Contributions for the initial schemes recommended by the study will be sought at a later stage and will be informed by the likely shortfalls required for implementation.

7.2.9 Testing uncertainty

There are a number of uncertainties which could impact the choice of the leading economic options such as cost increases / decreases and rates of sea level rise and climate change. Sensitivity tests have been carried out to assess whether the choice of the leading economic options changes as a result of these uncertainties.

Cost uncertainty

When estimating costs for options there is a degree of uncertainty in the estimates that are made. Aspects such as unknown ground conditions, compulsory purchase, difficult construction conditions and fluctuations in raw material costs can alter the potential costs of a scheme. As a result, and as suggested by the HM Treasury Green Book, Optimism Bias was applied to all cost estimates in this study. A 60% Optimism Bias allowance has been adopted as this study is still at a relatively early stage of development (in terms of concept design through to construction).

As a sensitivity test, selection of the leading economic options has been tested with -30% and +30% decrease / increase in the estimated costs. This corresponds with 30% and 90% Optimism Bias allowances instead of the 60% currently adopted.

Table 7-13 to Table 7-18 below present the results and demonstrate that when the estimated cost of options is increased by 30%, the leading economic options continue to have a ABCR >1. When the costs are increased the only shortlist option whose ABCR falls from above to below the ABCR = 1 threshold is the Maintain option in IW26. This option is particularly sensitive to changes in cost given that the option benefits are very close to the original estimated cost (including 60% OB).

Table 7-13. Cost adjustment sensitivity for units IW22-24

Units	Option	PV benefit (£k)	PV cost (£k)				B:C ratio	
			-30%	0%	+30%	-30%	0%	+30%
IW22 to IW24	Do Nothing	0	0	0	0	/	/	/
	Do Minimum	15,158	150	185	220	101.1	81.9	68.9
	Maintain (1)	52,291	1,920	2,360	3,450	27.2	22.2	15.2
	Sustain 75yr (1)	55,795	2,680	3,295	3,910	20.8	16.9	14.3
	Maintain then Sustain 75yr (1)	52,640	2,305	2,840	3,375	22.8	18.5	15.6
	Sustain 200yr (1)	55,920	2,815	3,465	4,115	19.9	16.1	13.6
	Maintain then Sustain 200yr (1)	52,640	2,345	2,885	3,425	22.4	18.2	15.4
	Improve 2117 200yr (1)	56,536	3,525	4,335	5,150	16.0	13.0	10.8

Table 7-14. Cost adjustment sensitivity for units IW25

Units	Option	PV benefit (£k)	PV cost (£k)			B:C ratio		
			-30%	0%	+30%	-30%	0%	+30%
IW25	Do Nothing	0	0	0	0	/	/	/
	Do Minimum	2,155	140	170	200	15.1	12.8	10.6
	Maintain (1)	7,005	1,645	2,025	2,405	4.3	3.5	2.9
	Sustain 75yr (1)	8,195	2,375	2,925	3,475	3.5	2.8	2.4
	Maintain then Sustain 75yr (1)	7,849	2,005	2,470	2,935	3.9	3.2	2.7
	Sustain 200yr (1)	8,208	2,510	3,090	3,670	3.3	2.7	2.2
	Maintain then Sustain 200yr (1)	7,849	2,045	2,515	2,985	3.8	3.1	2.6
	Improve 2117 200yr (1)	8,245	3,140	3,865	4,590	2.6	2.1	1.8

Table 7-15. Cost adjustment sensitivity test for unit IW26

Units	Option	PV benefit (£k)	PV cost (£k)			B:C ratio		
			-30%	0%	+30%	-30%	0%	+30%
IW26	Do Nothing	0	0	0	0	/	/	/
	Do Minimum	2,042	565	695	825	3.6	2.9	2.5
	Maintain	5,355	4,340	5,345	6,345	1.2	1.0	0.8
	Sustain / Improve (1)	5,606	6,145	7,560	8,965	0.9	0.7	0.6

Table 7-16. Cost adjustment sensitivity test for unit IW27

Units	Option	PV benefit (£k)	PV cost (£k)			B:C ratio		
			-30%	0%	+30%	-30%	0%	+30%
IW27	Do Nothing	0	0	0	0	/	/	/
	Do Minimum	5,166	650	800	950	7.9	6.4	5.45
	Maintain	14,071	2,520	3,100	3,680	5.6	4.5	3.8
	Sustain / Improve (1)	17,477	2,755	3,390	4,030	6.3	5.2	4.3

Table 7-17. Cost adjustment sensitivity test for unit IW28

Units	Option	PV benefit (£k)	PV cost (£k)			B:C ratio		
			-30%	0%	+30%	-30%	0%	+30%
IW28	Do Nothing	0	0	0	0	/	/	/
	Do Minimum	226	110	135	160	2.1	1.7	1.4
	Maintain	521	950	1,165	1,385	0.5	0.4	0.4
	Sustain / Improve (1)	536	980	1,205	4,430	0.5	0.4	0.1

Table 7-18. Cost adjustment sensitivity test for unit IW15

Units	Option	PV benefit (£k)	PV cost (£k)			B:C ratio		
			-30%	0%	+30%	-30%	0%	+30%
IW15	Do Nothing	0	0	0	0	/	/	/
	Do Minimum	3,737	210	255	305	17.9	14.5	12.3
	Maintain	14,482	475	580	690	30.6	24.9	20.9
	Improve 75yr at Yarbridge	14,482	2,230	2,745	3,255	6.5	5.3	4.44
	Improve 75yr at Emb. Rd	15,295	10,705	13,175	15,645	1.4	1.2	1.0
	Improve 200yr at Yarbridge	14,482	2,280	2,805	3,330	6.4	5.2	4.3
	Improve 200yr at Emb. Rd	15,542	10,945	13,470	15,995	1.4	1.2	1.0
	Maintain then Improve 75yr at Emb. Rd	15,248	3,215	3,955	4,695	4.7	3.9	3.2
	Maintain then Improve 200yr at Emb. Rd	15,248	3,280	4,035	4,790	4.6	3.8	3.2
	Maintain then Improve 75yr at Yarbridge	14,482	940	1,160	1,380	15.4	12.5	10.5
	Maintain then Improve 200yr at Yarbridge	14,482	955	1,175	1,395	15.2	12.3	10.4
	Maintain then Improve 75yr at Yarbridge with habitat creation	13,678	3,415	4,205	4,995	4.0	3.3	2.7
	Maintain then improve 200yr at Yarbridge with habitat creation	13,678	3,430	4,225	5,015	4.0	3.2	2.7

Sea level rise – managing uncertainty

The study has adopted the recommended UKCP09 medium emissions scenario 95%tile (including surge factor) as the allowance for sea level rise. However, the large range of climate change scenarios evident in the UKCP09 estimates, demonstrate the considerable uncertainty in future sea level rise projections.

To accommodate this uncertainty into the study the options which have been developed incorporate a phased (adaptive) approach to implementing the intervention measures. With this approach the measures are implemented over time based on risk based triggers. If for instance sea levels rise more slowly than anticipated, the phased approach allows decision makers to delay raising crest levels. Conversely, should sea levels rise more rapidly than expected, crest levels can be brought forward or the new defences can be built to a higher standard of protection.

This approach therefore provides a great degree of flexibility and allows time to monitor sea level rise to ensure maximum benefits area generated. It also avoids implementing works now which we could potentially ‘regret’ in the future because they were not necessarily needed.

The adaptive capacity of the options and the ability to be flexible ensures that the economic case remains sound despite the future uncertainty.

7.3 Environmental appraisal

Environmental appraisal of options has been carried out by environmental specialists within the project team. The appraisal has identified indicative high level environment impacts of the different measures used within the shortlist options (e.g. seawall, groynes etc.) using a Red, Amber or Green system. The scale of impacts assessed do not include mitigation which could reduce and limit the environmental consequences, or change potential 'red' assessment to amber etc.

- Red – potentially substantial adverse environmental impacts
- Amber – environmental benefits and enhancements but also adverse environmental impacts, or unlikely to result in a substantial change to the current environmental baseline
- Green – environmental benefits and enhancements and no detrimental impacts

Each measure has been considered in isolation and measure combinations through time have not been scored at this stage. This is important when considering the results of some of the options, for instance, the tide gates at Yarbridge. In isolation this measure does not protect against erosion of Embankment Road and therefore some potentially substantial adverse impacts are picked up in the environmental appraisal. However, when implemented as part of a wider short list option, the Yarbridge tide gates are combined with ongoing maintenance at Embankment Road which mitigates the erosion risk and a number of the adverse impacts that were identified for this measure (without Embankment Road maintenance) in the environmental appraisal.

When selecting the preferred option (see Chapter 8), the short list options have been cross-checked against the results of the environmental appraisal to ensure that there are no significant environmental constraints which cannot be mitigated which may change the choice of the option. This has shaped the selection of the proposed preferred option in each unit.

The full environmental appraisal is appended to the back of this report in Appendix B. Table 7-19 below summarises the findings.

These areas all have Hold The Line policies set at SMP level (2011). Therefore impacts of coastal squeeze etc. were taken into account of at a high-level in the SMP approval and RHCP process.

Please also refer to the Environmental Baseline Report produced by this study (2017).

Table 7-19. Summary of environmental assessment

Unit(s)	Measure	Indicative impact (unmitigated)	Comments
Embankment Road – IW15	Reactive patch and repair	Amber	Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment	Amber	Temporary designation / ecological and landscape impacts (disruption) during works
	Gabions	Red	Potential for intertidal landtake and landscape impacts
	Setback floodwall	Red	Potential change to water percolation impact on some features and landscape impacts, but also providing protection from inundation to substantial freshwater designated habitat.
	Revetment	Red	Potential for intertidal landtake and landscape impacts
	Seawall	Red	Potential for intertidal landtake and landscape impacts
	Road raising	Amber	Landscape impacts and temporary disruption to ecology during works
	Tide gates (Yarbridge)	Red	Potential risk to heritage features / landfill sites from flooding. Potential risk to landfill sites from erosion of Embankment Road. Potential change in habitats
	Temporary defences	Amber	Potential for temporary impacts on ecology / conservation areas
Yaverland to Sandown – IW22-25	Reactive patch and repair	Amber	Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment (of existing seawalls / revetments)	Amber	Temporary designation / ecological and landscape impacts (disruption) during works
	Capital refurbishment (groynes)	Amber	Temporary landscape impacts. No extension seawards but potential for increase in footprint laterally (longshore)
	Beach recycling	Amber	Temporary ecological impacts during works. Sediment movement impacts

Unit(s)	Measure	Indicative impact (unmitigated)	Comments
	Beach nourishment		Large quantities of new sediment could impact ecological sites downdrift
	Gabions		Unlikely to require landtake from intertidal area but could impact proposed or recommended designated sites and landscape
	Groyne improvement (lengthening)		Temporary disturbance of intertidal and potential for permanent intertidal/subtidal landtake. Changing sediment movement patterns.
	Groyne construction		Temporary disturbance of intertidal and potential for permanent intertidal/subtidal landtake. Changing sediment movement patterns.
	Revetment		Potential for intertidal landtake and landscape impacts
	Seawall		Unlikely to require landtake from intertidal area (if built as close as possible to the current structure) but could impact proposed or recommended designated sites and landscape
	Crest raising / wave return		Permanent landscape impacts and temporary impacts during construction
	Setback floodwall		Permanent landscape impacts and temporary impacts during construction
	Road raising		Temporary adverse effects during construction
Lake and Shanklin (IW26-28)	Reactive patch and repair		Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment (of existing seawalls / revetments)		Temporary designation / ecological and landscape impacts (disruption) during works
	Capital refurbishment (groynes)		Temporary landscape impacts. No extension seawards but potential for increase in footprint laterally (longshore)
	Beach recycling		Temporary ecological impacts (disruption) during works and potential for sediment movement impacts
	Beach nourishment		Large quantities of new sediment could impact ecological sites downdrift
	Gabions		Unlikely to require landtake from intertidal area but could impact proposed or recommended designated sites and landscape
	Groyne improvement (lengthening)		Temporary disturbance of intertidal and potential for permanent intertidal landtake. Changing sediment movement patterns.
	Groyne construction		Temporary disturbance of intertidal and potential for permanent intertidal landtake. Changing sediment movement patterns.
	Revetment		Potential for intertidal landtake and landscape impacts
	Seawall		Unlikely to require landtake from intertidal area (if built as close as possible to the current structure) but could impact proposed or recommended designated sites and landscape
	Crest raising / wave return		Permanent landscape impacts and temporary impacts during construction
	Setback floodwall		Permanent landscape impacts and temporary impacts during construction
	Cliff stabilisation		Permanent landscape impacts and temporary impacts during construction

The environmental appraisal has also identified a number of environmental opportunities along the frontage which could be supported by the various defence measures. Table 7-20 below summarises the opportunities.

Table 7-20. Summary of environmental opportunities along the frontage

Opportunity		Supporting measures
	Public realm enhancements – such as landscape improvements, esplanades, information boards, public seating etc.	Hard defences at the back of the beach – for example seawalls, revetments, existing structure refurbishments.
	Beach levels – high beach levels to support tourism, recreation and visual aesthetics of the area	Groyne refurbishments or improvements, beach nourishment and recycling
	Flood and erosion protection – improvements to health, material assets and environmental designations	Refurbished defences, raising of existing defences, floodwalls, seawalls or revetments.
	Species colonisation – e.g. man-made rock-pools / Vertipools*	Groyne refurbishments / construction
	Habitat creation / protection – opportunities at Brading Marshes behind Embankment Road, subject to Regional Habitat Creation Programme objectives	Embankment Road or Yarbridge options in unit IW15
	Coastal processes – continuation of erosion of undefended cliffs at southern end of the site leading to natural exposure of sediments (supports species) and sediment input to the littoral system	NAI options for south side of the study site

*as occurring on Hope Groyne and also at the boundary of units 22 and 23.

7.4 Social / Stakeholder appraisal

7.4.1 Early stakeholder engagement

The IoW Council facilitated early stakeholder consultation during the initial stages of the study to gather the initial thoughts and aspirations of stakeholders on the constraints and opportunities along the frontage. This included elected representatives, statutory organisations, utilities and a wide range of local organisations, businesses and representatives with an interest in the coastline. This section of the report summarises these findings and relates them to the options which have been identified in the appraisal. The stakeholder feedback has been categorised into the following categories; Environmental, Economic / Commercial, Engineering and Miscellaneous. The Sandown Bay Study has been extended to include consideration of Embankment Road, Bembridge. The outputs of the work throughout the study area will be published for further consideration by stakeholders, leading towards the development of future coastal defence schemes.

<u>Environmental</u>

The 5-miles of beach in Sandown Bay is rare and the importance of it in supporting the community has been highlighted as well as the wide range of environmental designations present throughout the study area, reflecting the quality and importance of the natural environment.

Environmental and heritage designations - a number of stakeholders outlined the key environmental and heritage designations in the study area, including SAC, SPA, Ramsar, SSSI, pSPA, rMCZ, SINCS, three Conservation Areas and numerous heritage features. These have been identified and discussed in the Environmental Appraisal (section 7.3) and environmental baseline report..

Man-made rock-pools - as part of a local initiative a number of man-made rock-pools (vertipools) have been created across the frontage. The pools encourage species colonisation in the area. Rock-pools and tiles have been installed within the Sandown Bay groynes to the north of the Sandown Browns mini golf course (at Yaverland) and also on the north side of the concrete groyne at Hope Beach, Shanklin. The leading options outlined in this appraisal will support the ongoing use of the rock-pools along the frontage. Where the pools are already in place, defence works can be timed / designed to cause minimal disruption. Elsewhere, should finances permit, groyne refurbishments could incorporate a rock-pool design into the finish.

Marine dredging - the Marine Management Organisation (MMO) provided a list of the active aggregate licence areas offshore of the frontage and a link to the south coast cumulative impacts study. None of the shortlist options include beach nourishment measures and therefore the options will not be looking to obtain sediment from any of these licence areas. There has also been locally raised concern that offshore aggregate dredging might be an independent cause of beach depletion and an increase in wave heights reaching the frontage. This key concern is acknowledged, and independently-monitored beach level trends over the past twelve years have been examined as part of this study, however, as discussed in the accompanying coastal processes report, at the current time there is no evidence to support a causal link with offshore dredging.

Natural England engagement – a workshop was held with Natural England and the project team and the early options that were emerging from the appraisal were discussed. During this meeting Natural England highlighted their preferences for the management of the frontage and had no initial objections to 'softer' engineering approaches such as beach recycling or nourishment, provided the environmental impacts were fully assessed during scheme development. Natural England stated that any future assessment and scheme development at a later stage should consider the following:

- Landtake from designated sites
- Highlight any likely impacts on features to be designated by the rMCZ or pSPA
- Implications for other parts of the coastline / their designated features

Natural England confirmed that they will look provide continued input to the preferred options at Embankment Road but could not confirm their preference for the option during the meeting. However, following the initial consultation the impacts of allowing progressive saline ingress at Embankment Road were communicated by Natural England. The main impact will be to adversely modify the wetland habitat and seasonal vegetation inundation communities from their existing freshwater to a brackish/saline state. The following designated features will be negatively impacted:

- Assemblages of breeding birds – Lowland damp grassland SSSI, Lowland open waters and their margins SSSI
- Ditches
- Lowland mire grassland and rush pasture
- Lowland neutral grassland SSSI
- Lowland wet neutral grassland SSSI
- Lowland wetland including basin fen, valley fen, floodplain fen, water fringe fen, spring/flush fen
- Vascular plant assemblage

From a practical habitat management and ownership perspective, mitigation areas are not available locally, safe stocking for conservation grazing purposes becomes harder to achieve safely, and both Basic Payment Scheme land values and Countryside Stewardship Scheme values will reduce. These impacts are likely to be realised with any options at Embankment Road which do not involve raising of the frontline defences (e.g. Do minimum, maintain or the Yarbridge setback approach).

Economic / commercial

Train passengers - South West Trains provided the number of passengers in Island Line stations. This information was used to update the economic assessment and the valuation of indirect damages / benefits associated with disruption to rail travel through flooding or erosion.

Beach maintenance - a range of beach maintenance activities are currently undertaken along the frontage. For example, every spring the Longshoremen move sediment up the beach from the intertidal in some locations, notably parts of Sandown Esplanade, Small Hope Beach and Shanklin Esplanade. This is done mainly for the amenity benefit of the beach but it could also have a potential benefit of helping to protect the structures at the back of the beach. Other maintenance activities include mechanical beach cleaning in the summer (removing buried glass etc.) and litter picking by hand. For options which include beach recycling it would be important to assess the impact of these maintenance activities on the success of a recycling scheme (to develop the options further at a later stage if required, although this approach is not identified as the most cost-effective to date). Sandown and Shanklin beaches were given Seaside Awards in 2017.

Beach levels – The importance of beach and beach levels to the key tourism economy of the area was highlighted by stakeholders. This report has carefully sought and costed defence improvements both with and without groyne improvements, to seek options which can help maintain beach levels, as well as continue to prevent erosion and reduce increasing flood risks. This allows the costs and of the different approaches to be considered and future challenges and opportunities to be understood. Annual surveys of beach levels in Sandown Bay are undertaken by the Regional Coastal Monitoring Programme (available at https://www.channelcoast.org/reports/). The shorter-term variability of beach levels (dependent on a combination of storms, tides and wind directions) has also been highlighted by the stakeholders.

Access –Roads, footpaths and Rights of Way – Road access adjacent to the coast to communities and businesses is a key infrastructure asset in the area, as are esplanade footpaths along the waterfront, cliff foot and cliff-top. Ongoing minor maintenance of the defences and cliffs currently helps maintain these assets. The potential of future erosion and flooding to remove these access roads and footpaths has been considered within this study and opportunities to maintain these assets have been sought and costed. Whilst sea defences at the toe of the cliff reduce the rate of erosion of the cliffs, rockfalls and talus slope failures cannot be entirely prevented due to the impacts of weathering, climate change and vegetation on the cliff faces. The rights of way and footpaths along the seafront are also anticipated to be considered as part of the upcoming English Coastal Path initiative, which will highlight their importance, although challenges in funding their future maintenance remain.

Regeneration –There are aspirations to encourage and promote regeneration in The Bay area, and at specific sites along Shanklin Esplanade in particular. Any regeneration proposals would benefit from coastal defences being refurbished to protecting the access road to these sites (and protect the existing properties in the area), and benefit from any additional defence improvements reducing future risks in the area. Regeneration proposals and opportunities will continue to be considered alongside future development of coastal defence schemes in the Shanklin area and in the Bay.

Engineering

Southern Water assets - Southern Water provided a list of assets in the area which may / may not be impacted from flooding or erosion. These significant assets include the Sandown Water Treatment Works serving the Island, Eastern Gardens pumping station between Culver Parade and Sandown Esplanade and Hope Beach pumping station in Shanklin. The do something options outlined in the appraisal will protect these assets from erosion and/or flooding, and they would benefit from continued defence of the frontage. Southern Water has also announced an investment in improving water quality in the Shanklin area.

Key utilities – In addition to the Southern Water information above, Table 7-21 below summarises the key utilities along the Sandown frontage. Note that this list is not exhaustive and future appraisals should investigate utilities further. Schemes which protect these assets could provide indirect benefits to the area (including benefits to the wider communities beyond those immediately at risk) and potential financial contributions may be relevant from utility companies for schemes, although this will need to be explored in more detail during future appraisals.

Table 7-21. Key utilities identified in study area

Area	Key utilities present
Embankment Road (IW15)	- Telephone infrastructure and cables - Gas network located along embankment - SSE electricity cables
Yaverland to Sandown (IW22-24)	- BT openreach infrastructure at Yaverland village and behind defences (inc. poles, ducts and kiosk) - SSE high voltage and low voltage cables behind defences at Yaverland Road - SW Sandown Water Treatment works, Eastern Garden pumping station
Sandown (IW25)	- BT openreach infrastructure (inc. ducts & poles) behind defences - Gas network located close to frontage near Sandown Pier - SSE high voltage cables adjacent to Sandown Pier. Low voltage cables along Sandown frontage and behind defences, adjacent to pier and in Sandown town.
Lake cliffs (IW26)	- BT openreach infrastructure behind cliff top and adjacent to Hope beach - SSE cables at cliff top and along Cliff Road (High and Low voltage)
Shanklin (IW27-28)	- BT openreach infrastructure (inc. poles, jointbox) behind defences - SSE cables at cliff top - SW Hope Beach pumping station

Miscellaneous

Harbour creation at Luccombe – an idea to create a harbour at Luccombe was proposed by stakeholders. This suggestion has been taken on board by the project team when examining future alternatives, but regarding funding for this potential scheme idea, this is very uncertain at this stage (i.e. there is not a commitment from stakeholders to provide external contributions for their ideas). Therefore, given that the proposal did not have reasonable potential for funding through government 'flood and coastal defence grant in aid' funding it has not been taken forward in the option development. However, if alternative sources of external funding are obtained, aspirations could be revisited during subsequent design stages following this study.

In addition, this shoreline is currently undefended, and both this study, and the underlying Shoreline Management Plan (2011) policies on which it is based, do not recommend extending defences into undefended areas. It is essential that the erosion and retreat of the cliffs in the Luccombe area continues to supply sediment to the beaches of Sandown Bay. A harbour structure could bring economic benefits but would also interrupt the continuous natural longshore drift sediment supply from south to north along the bay, and impact upon the designated intertidal and subtidal zones. Further information is provided in Chapter 4.

Removal of the Osborne Groyne –This suggestion was made during the consultation, and the concerns over this structure were taken on board in the Study. A range of options for improving the defences along Shanklin Esplanade have been developed by the study, including changes from the current approach. Details of these, and their relative costs, are described in Chapter 6. It is also noted that beach levels updrift (south) of the Osborne Groyne have, over the past twelve years, overall remained stable or slightly accreted, therefore it is possible that removal of the groyne could result in lowered beach levels along the southern half of Shanklin esplanade. The appraisal has revealed it is difficult to fund groyne upgrades and replacements (even more so than repairing seawalls) and funding has not currently been identified to redesign and replace this groyne. However, the recommended preferred option involves refurbishments to Osborne groyne and the timber groynes along Shanklin Esplanade in the future (dependent on funding availability – see chapters 8 and 9). This will help to keep these structures functioning for as long as possible and potentially have a positive impact on the variable beach levels along the frontage.

Managed Realignment at Yaverland – an aspiration to breach the seawall and redesign the flood defences at Yaverland to allow better access from the lower land behind and potentially aid development in the area has been considered. However, the Eastern Yar valley is very low-lying (with much of the valley only approx. 1m above sea level, so vulnerable to inundation by the sea without the current defences). This longlist option has not been taken forward in this study for a number of reasons, including, the low land levels would mean an arc of new flood wall/embankment to protect the surrounding settlements would be very large and costly, any development in front of the new defence would be increasingly vulnerable to regular tidal inundation, and both the new setback floodwall and the remainder of the seawall preventing erosion would require ongoing maintenance costs. Also, the seafront road would have to be re-routed across a breach on a bridge, or the road moved permanently away from the seafront, and sediment accumulation could affect water flow and water quality in the area. Further information is provided in Chapter 4, and a range of alternative options and their benefits have been considered. Concerns were also raised on the suitability of rock armour as an alternative method of improving the defences, regarding the safety of this method (i.e. gaps between the rock armour boulders) in a popular family tourist area.

Summary

In summary, a range of suggestions and issues informed the option appraisal, and there were no significant constraints identified from the early consultation responses which may significantly alter the choice of the preferred options. However, there are a number of aspects which, if certain options are selected as the preferred option or scheme, will need to be investigated and developed further in subsequent design stages, including seeking local funding opportunities.

7.4.2 Isle of Wight Council option preferences

When undertaking the appraisal process the project team identified some preferences from the Isle of Wight Council for the options along the frontage. Where possible, the options should;

- consider working with existing structures to seek cost-efficient approaches and identify if options are available within the footprint of the existing defences; and
- help to maintain the beach levels along the frontage, including for the purposes of amenity and to encourage recreation / tourism in the area.

The option appraisal process has shown that options which meet these preferences are not necessarily the most cost effective approaches (particularly with regards to beach levels). However, meeting the preferences of the Council is important when selecting the preferred options and where the preferred option is not the leading economic option the case for change is discussed in detail (see chapter 8).

8. Preferred option selection

This study has examined and costed a range of possible approaches to delivering the current Hold the Line shoreline management policies in Sandown Bay (and Embankment Road Bembridge) to reduce future flood and erosion risks over the next 100 years. This chapter collates evidence from the appraisal process to identify the proposed preferred options. Funding will need to be secured to take forward these preferred options, discussed further below.

Early stakeholder engagement was fed into draft preferred approaches and schemes which were discussed and developed with statutory agencies, key representatives and major landowners, and the next stages will involve full discussions of the proposed preferred options (and proposed future schemes) with representatives and the wider community, including a full range of stakeholders, elected representatives and the general public.

As this study has not conducted a full suite of environmental assessments (which are undertaken at SMP and Scheme levels) the details of the preferred approaches being recommended to implement the SMP2 Hold the Line policies should be considered provisional and may require revision during scheme level appraisals (i.e. full HRA, WFD etc.).

8.1 Eastern Yar flood cell, units IW22-IW24 and IW15

8.1.1 Preferred option for Yaverland to Culver Parade (units IW22-24)

This area covers the defences from Yaverland Car Park to Culver Parade. A map is provided in Figure 8-1. The number of properties at risk from tidal flooding and erosion in each unit are summarised in sections 6.1 to 0. In total there are 26 properties currently at risk from a 1:200 year flood event, but by 2117 this number is expected to rise to 617 (largely due to the breach risk). There is also key utility infrastructure in this area (water treatment works) serving the Isle of Wight.

This report demonstrates that the leading economic option for each unit between IW22 to IW24 is to initially Maintain then Sustain a 75yr SoP (from 2055-60). For the units IW22 to 24 the flood cell merges across the units and therefore it is essential for the SoP provided in each unit to be the same.

The lower investment method of implementing the leading economic option in these units involves a series of seawall resurfacing works, and then an encasement of the structures located at the back of the beach (IW22 to 24). This option also involves crest raising of the defences from 2055-60, although the exact timing of this intervention will depend on future rates of sea level rise. It may be more economically advantageous and efficient to undertake the crest raising as part of the encasement works, but for the purpose of costing it has been assumed (conservatively) that these will be kept separate.

The lower investment approach does not include an allowance for refurbishing or replacing the existing groynes within these units and as a result there may be an increased risk that beach levels fall in the future. The community preferences for the frontage are therefore not supported by this approach and it may not be acceptable. With this in mind the lower investment approach has not been recommended as the approach to follow for these units. Instead a more expensive combination of measures to implement the leading option, which involves groyne refurbishments, is recommended. The details of the methods this approach will involve are described as ‘Approach 2’ to the Maintain then Sustain 75yr SoP (Standard of Protection) option in sections 6.1 to 6.3.

The preferred option is therefore to **Maintain then Sustain a 75yr SoP (from 2055-60) and additionally undertake groyne refurbishment works to help sustain beach levels.** The preferred option will protect at least 488 properties (318 residential and 170 commercial) from flooding up to a 1:75yr standard in 2055-60 and 593 properties (416 residential and 177 commercial) in 2117. The option will also prevent erosion to 50 properties over the next 100 years.

Table 8-1 provides a comparison of the lower investment and higher investment approaches to implement the proposed preferred option for these units (without or with groyne improvements). The PV cost (discounted cost) for the higher investment approach is estimated to be approximately £4.3m and the cash cost (non-discounted cost) is estimated to be just over £15m, over 100 years. The cost benefit ratio for the higher investment approach is approximately 12.2 and the PF score (to assess GiA eligibility) for an initial scheme including groyne improvements is approximately 84%. If an initial scheme is undertaken to refurbish the seawall only, the PF score rises to over 100%. For more details on funding and alternative Priority Schemes, refer to Chapter 9. A Priority Scheme has been proposed for this frontage due to the importance of minimising the breach risk.

The amount of GiA (government Grant in Aid funding) available to help fund the proposed preferred option is likely to be capped at the amount that is available for the lower investment approach. This is a significant constraint of GiA and means that the remaining cost to implement the preferred option will likely need to be sourced from a contribution(s). The difference in whole life cost between the lower investment and alternative approaches across units IW22-25 is approximately £1.5m in PV terms or £5.4m in cash terms, over 100 years. Should it not be possible to secure the additional funding required for the preferred approach (involving groyne maintenance as well as sea wall raising), the lower investment approach provides a sound technical alternative to mitigate erosion and breach risk in the area, although it would not assist in maintaining beach levels.

A comparison against the environmental impacts of the different measures (section 7.3) shows that both approaches to implementing the leading economic option are environmentally acceptable. It is considered that the identified environmental features do not present any significant environmental constraints which would change the choice of the preferred option.

Should an alternative method of refurbishment be preferred (e.g. early encasement of the seawall rather than extending the current concrete spraying), this would also add to the costs in these units, as discussed in Chapter 6.

Figure 8-1 shows the proposed preferred option in units IW22-24.

Table 8-1. Units IW22-24 -Summary of proposed preferred option selection

Preferred option - Maintain then Sustain 75yr SoP (2055-60)		
Unit	**Lower investment approach**	**Alternative (higher investment) approach**
22 (Yaverland Car Park)	- Resurface revetment (2027 & 2045-50) - Encase revetment (2065-70) - Crest raising in 2055-60	- Resurface revetment (2027 & 2055-60) - Encase revetment (2085-90) - Refurb timber groynes (2027, 2055-60 & 2085-90) - Crest raising in 2055-60
23 (IOW Zoo)	- Resurface seawall (2027 & 2045-50) - Encase seawall (2065-70) - Crest raising in 2055-60	- Resurface seawall (2027 & 2055-60) - Encase seawall (2085-90) - Refurb masonry groynes (2027, 2055-60 & 2085-90) - Crest raising in 2055-60
24 (Culver Parade)	- Resurface seawall (2027 & 2045-50) - Encase seawall (2065-70) - Crest raising in 2055-60	- Resurface seawall (2027 & 2055-60) - Encase seawall (2085-90) - Refurb timber groynes (2027, 2045-50, 2065-70 & 2085-90) - Refurb masonry groynes (2027 & 2065-70) - Crest raising in 2055-60
Selection criteria		
Cost (PV)	£2,840k	£4,330k
Cost (cash)	£9,615	£15,025
ABCR	18.5	12.2
Wider factors	Environmentally acceptable however this approach does not help to retain beach levels	Environmentally acceptable and additional groyne refurbishments could help with beach levels
Preferred approach		✓

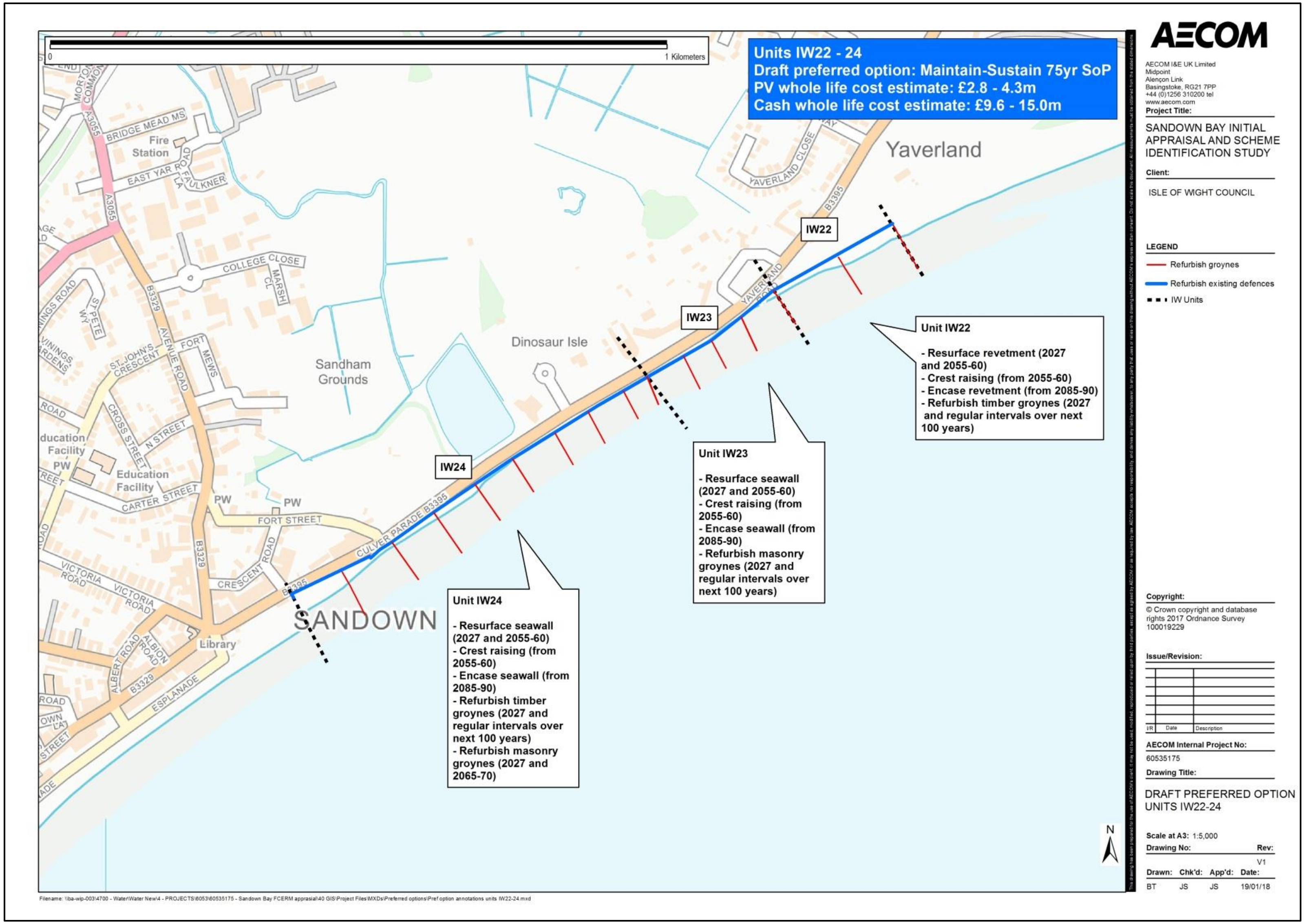

Figure 8-1. Proposed preferred option for units IW22-24

8.1.2 Preferred option for Embankment Road Bembridge (unit IW15)

This area covers Embankment Road at the back of Bembridge Harbour and the low-lying Eastern Yar valley floodplain behind. A map is provided in Figure 8-2. The number of properties at risk from tidal flooding is summarised in section 6.8. In total (between Embankment Road and Yarbridge), there is 1 property currently at risk from a 1:200 year flood event but by 2117 this number is expected to rise to 99. The Eastern Yar flood cell however also extends through to units IW22-24 at Yaverland (please see 8.1.1 for significant numbers of properties at risk) and therefore the preferred option at unit 15 also needs to be considered and delivered alongside that for units 22-24 to prevent the sea flooding the low-lying Eastern Yar valley.

The choice of the preferred option for Embankment Road in Bembridge (unit IW15) is driven largely by environmental factors and a steer from the Environment Agency and Natural England is required to identify the preferred approach to implementing the SMP2's Hold the Line Policy to reduce future risks in the Eastern Yar valley. With a formal decision on the future environmental objectives and requirements for this area not yet made at this stage, this study has stopped short of recommending a single preferred option/approach but presents the leading economic option and provides a commentary on the different options. This study has built on the conclusions of the Eastern Yar Flood and Erosion Risk Management Strategy (2010) which recommended (for this unit) to sustain the existing standard of protection for the next century (between 1:20 – 1:25yr SoP) at Embankment Road. This study has updated these costs for a 'frontline' defence and also (due to the costs and constraints involved in raising the frontline defence at this site) considered and identified an alternative 'setback' approach to tidal flood defence improvement further up the flood plain, in principle. This study has also fully considered the Culver Parade frontage (Units 22-24) in Yaverland/Sandown so the future defences at both ends of the Eastern Yar floodplain can now be further considered together.

There are three leading economic options for unit IW15 at Embankment Road; these are: Maintain the frontline defence at Embankment Road; Maintain the frontline defence at Embankment Road then Improve to a 75yr SoP (Standard of Protection) at a setback line **at Yarbridge** (in 2057); and Maintain as above then Improve to a 200yr SoP **at Yarbridge** (in 2057). Each option was identified as a leading economic option because they have similar positive ABCRs (Average Benefit Cost Ratio) and can all be economically justified, although funding constraints and contributions are a key issue for consideration for all future approaches in this area. The two options involving a new setback flood defence at Yarbridge (to protect Yaverland/Sandown) would also involve maintaining the frontline defence at Embankment Road at its current height to prevent a breach and so provide some notable benefit to the properties and important habitats located in the floodplain between Yarbridge and Embankment Road.

Additionally, there are the more costly options to Improve along the frontline by raising defences **along Embankment Road** with a floodwall (from present day or later on in the appraisal period), better protecting the properties and habitats in this unit and also upstream at Sandown from tidal flooding. These options have lower ABCRs (between 1.2 and 3.9 - although it is noted that the costs are based on conservative assumptions at this stage) and if the preferred option was selected on economic grounds alone, it would not be practical to select these options given that the benefits they provide are very similar to the alternative Yarbridge Improve options.

However, the economic case for options in this unit also depends on how benefits are apportioned between Units 22-24 (Yaverland) and 15 (Bembridge) as the same properties in the floodplain are at risk from two directions (inundation threat from Bembridge and Yaverland). The approach taken by this study to this issue, to avoid double counting or falsely claiming benefits is outlined in Appendix A (10.3.9). However future costs and benefits across all these units could be considered across the floodplain in their totality, and there may be opportunities to combine schemes in the future dependent on their outcomes, timing and SoP (this is discussed further in chapter 8.6, Priority schemes and funding).

On environmental grounds, the frontline Sustain/Improve options at Embankment Road may be favourable, because they would improve the SoP (Standard of Protection) of the frontline structure and minimise the future inundation frequency of the designated environmental sites in the future (Brading Marsh SSSI, Ramsar, SPA and SAC). However, any Maintain or Maintain and Improve option that prevents breach or removal of the current frontline embankment does provide some benefit for the area, as outlined in this report.

A further alternative approach that has been considered to provide an option for comparison in the option appraisal is to intentionally replace the existing freshwater (and some brackish) habitat behind Embankment Road with intertidal habitat. As part of this approach the 'setback' tide gates and flood wall at Yarbridge would be required (to manage the tidal flood risk to the Sandown/Yaverland frontage) and it is also recommended that 'frontline' Embankment Road is maintained so that the important transport link and service/utility corridor is not breached. The intertidal habitat would be created by deliberately managing the opening of the EA water level control sluices gates at the western end of Embankment Road to allow tide water to regularly flow through into the existing habitat area. The economic case for this option has been assessed and the benefit cost ratio is less favourable than the options which maintain the existing habitat, although it should be noted that the funding case for creating new intertidal habitat is different (see chapter 8.6, Priority schemes and funding).

The decision on whether to raise frontline Embankment Road and better protect the existing habitat, to use a setback structure at Yarbridge to control flooding (alongside maintenance of Embankment Road) but so accept gradual overtopping inundation of the existing freshwater habitat in the future, or to intentionally create intertidal habitat at the expense of the existing freshwater habitat will require further detailed analysis and discussions between Natural England, the Environment Agency and other key landowners, utilities and stakeholders with an interest in the area. A decision on the preferred future approach is likely to be dependant, in part at least, on the objectives of the Environment Agency's Regional Habitat Creation Programme, and also the potential compensatory habitat locations and requirements. A decision will be guided by legislative requirements (i.e. Habitats Regulations and Water Framework Directive) as well as objectives and priorities around whether freshwater habitat (existing) or intertidal habitat (potential new habitat) is more valuable. Integral to these decisions will also be the consideration of stakeholder 'wants and needs' for the area. Funding availability (and funding gaps) are also critical to the choice of approach and the implementation of potential schemes.

Should sea levels rise as per current guidance allowances and the existing structure at Embankment Road be maintained to remain in place, a natural transition to more saline based habitat is not expected to occur until the second half of the appraisal period (50 year onwards at the earliest).This has been estimated based on the elevation of the existing structure and the frequency of which it could be inundated / overtopped with sea level rise. Based on work undertaken in the Eastern Yar Strategy, a change to intertidal habitat would lead to loss of 291Ha of SPA (also designated as Ramsar and SSSI, and a small part of this area is also SAC), plus an additional 26.5ha of SSSI outside the boundary of the SPA (in their current form). In addition to this designated habitat, this Sandown Study has estimated an additional area of up to 75-85ha of non-designated potential freshwater habitat could also be impacted (based on theoretical consideration of the extent of the floodplain), leading to an overall estimated total (including both designated and non-designated freshwater habitats) of up to 400 hectares. However, regarding the designated areas, the environmental designations could potentially be re-designated based on the habitat that is produced.

Irrespective of whether a frontline (Embankment Road) or setback (Yarbridge) approach is favoured, it is **essential for the option for IW15 to deliver the same SoP as the preferred option in units IW22-24**. This is because of the strategic flood risk linkage between these units. The benefits of each scheme will only be realised if the equivalent standard of protection is achieved by the other. For this reason the Maintain option cannot be selected as the preferred option in the longer term because the existing SoP (currently between 1:20 – 1:25yrs SoP) will fall over time due to sea level rise. Given that the preferred option for IW22-24 involves sustaining a 75yr SoP from 2055-60, this suggests that any options to **Maintain and then Improve to deliver the 75yr SoP from 2057 for unit IW15 would be suitable**. This recommended SoP is different to that recommended in the Eastern Yar Strategy (which recommended sustaining the existing SoP from present day); this is because the frontage is not being considered in isolation in this study and the strategic linkage with the Sandown frontage has been taken into account.

With regards to timing of the approach at Embankment Road or Yarbridge, the Eastern Yar Strategy (2010) recommended that the existing standard of protection at Embankment Road is sustained for the next 100 years and that the defence is constructed from present day. However, funding has not yet been secured to do this and this study has found that the economic case of the options is much stronger if the construction of defences at Yarbridge or Embankment Road is delayed until 2057. By delaying the defences until this time period it also better aligns with the raising works recommended at Yaverland (units IW22-24) and provides the opportunity to deliver a joined up scheme (should this be preferred). However, it is important to note that further appraisal, design and construction of defence improvements at Embankment Road (or potentially Yarbridge) could be undertaken from the present day if preferred and funding became available.

The additional investment required to achieve a 200yr SoP at Embankment Road / Yarbridge would, in effect, be wasted if the SoP being provided at Yaverland (IW22-24) is lower (1:75yr SoP), due to the possibility of 'back-door' flooding from Yaverland for events between 1:75 to 1:200yr return periods. Funding opportunities and constraints at the time of crest-raising/defence improvement in the medium-term (approx. 2057) will determine if the additional investment required to raise the defences in both areas to a higher SoP of 1:200yr is available, the costs of which were also explored in this report (see chapter 6).

Table 8-2 provides a comparison of the alternative options for this unit, specifically the options with a delayed intervention (from 2057) as these options have the strongest economic case (nb. see chapter 6.8 for details of alternative option costs for improving from the present day). For the frontline option at Embankment Road, the cost of the preferred approach over 100 years (to a 1:75yr SoP) is approximately £4m in PV terms or £14.7m in cash cost (assuming implementation of the scheme in 2057). For the alternative setback approach at Yarbridge the cost of the preferred approach over 100 years (to a 1:75yr SoP) is approximately £1.2m in PV terms or £4.1m in cash cost (assuming implementation of the scheme in 2057). Requiring lower investment, the Yarbridge approach has an average benefit cost ratio of 12.5 compared to the Embankment Road approach which has a ratio of 3.9. The third option of deliberately creating intertidal habitat (e.g. from 2057) has the highest PV cost (£4.2m, or £15.6m in cash cost) due to the inclusion of costs for creating the necessary compensatory freshwater habitat elsewhere.

In terms of GiA eligibility, an initial high level assessment has been made for each approach as well as a combined approach with the defences proposed at Yaverland. The results are presented in section 0 (refer to this section for assumptions and limitations of this approach).

The significant costs and likely requirement for sizeable funding contributions in this area, especially for the higher-cost options, means it is important to highlight and maintain awareness of the future tidal flood risk to the Eastern Yar valley (that would be evident without the present embankments at Embankment Road and Culver Parade). Until such time as an intervention to mitigate increasing future tidal flood risks is delivered, and whilst such an aim remains an aspiration and funding is unsecured, it is essential to ensure that current and potential future risk continues to be carefully considered in decision-making in the area, for landowners, utilities and relevant authorities. This is also important due to the further work assessing future potential combined flood risk (fluvial and tidal) that would be required to be sought to further develop the lower cost 'setback' alternative options at Yarbridge, which is beyond the scope of this current study.

A cross check of the setback (Yarbridge) approach against the environmental appraisal (section 7.3), it is indicated that if such an option was carried out in isolation (e.g. without continued maintenance of Embankment Road) then this approach could potentially lead to significant detrimental environmental impacts resulting from saline inundation of designated freshwater habitats. However, as part of the setback option if continued maintenance of the Embankment Road at the current height is included this mitigates a number of the impacts associated with the setback approach until the longer term.

The use of Armourlock / gabions has been identified in the option appraisal as a suitable approach to help maintain Embankment Road (specifically for the exposed sections near Bembridge Sailing Club, see section 6.8.3). However the environmental appraisal suggests that use of gabions in this location may lead to negative impacts, the most significant associated with intertidal landtake. To mitigate this impact every effort would be made to place the gabions within the footprint of the existing structures and if this approach is deemed to be environmentally unacceptable then alternative measures (such as sheet piled toe protection) could be used. Alternatively the use of Armourlock would be on the existing slope of the embankment and therefore there would be no direct landtake with the approach. Further environmental assessments (HRA, WFD etc.) are recommended during future scheme development if this approach is identified as the preferred option. Further discussion on the methods proposed for the different 'Sustain/Improve' options is provided in Chapter 6.8.

Figure 8-2 shows the different preferred option alternatives approaches in unit IW15.

Table 8-2. Unit IW15 – summary of proposed preferred option alternatives

Option requirements for IW15 – To deliver the same SoP as preferred option in units IW22-24 (75yr SoP from 2055-60)			
Unit	**Delayed 'frontline' intervention (2057) at Embankment Road - Higher investment approach**	**Delayed 'setback' intervention (2057) at Yarbridge - Lower investment approach**	**Delayed 'setback' intervention (2057) at Yarbridge - Lower investment approach and intentional intertidal habitat creation**
15 (Embankment Road)	- Maintenance of frontline Embankment Road for full 100 years - Raising of Embankment Road in 2057	- Maintenance of frontline Embankment Road (no raising) to prevent breach for full 100 years - Setback tide gates and wall at Yarbridge in 2057	- Maintenance of frontline Embankment Road (no raising) to prevent breach for full 100 years - Setback tide gates and wall at Yarbridge in 2057 - Opening of EA sluices at Embankment Road to allow tidal flow and transition to intertidal habitat
Selection criteria			

Option requirements for IW15 – To deliver the same SoP as preferred option in units IW22-24 (75yr SoP from 2055-60)			
Unit	**Delayed 'frontline' intervention (2057) at Embankment Road - Higher investment approach**	**Delayed 'setback' intervention (2057) at Yarbridge - Lower investment approach**	**Delayed 'setback' intervention (2057) at Yarbridge - Lower investment approach and intentional intertidal habitat creation**
Cost (PV)	£3,955k	£1,160k	£4,205k
Cost (cash)	£14,650k	£4,130k	£15,630
ABCR	3.9	12.5	3.3
Wider factors	- Protects habitats behind Embankment Road -Better protection to properties downstream of Yarbridge than the lower investment approach	- Potential for increased fluvial flood risk upstream of the Yarbridge tidal flood gates during periods of operation (although needs further investigation during future appraisal work) - Potential gradual change to habitats behind Embankment Road due to future overtopping	- Intentional creation of intertidal habitat - Requirement to compensate very large area of freshwater habitat in the region which may not be possible - Potential for increased fluvial flood risk upstream of the Yarbridge tidal flood gates during periods of operation (although needs further investigation during future appraisal work)
Preferred approach	To be decided by discussions with EA / Natural England / IWC / Stakeholders during future appraisal work		

In the short to medium term, all the proposed approaches involve essential continued maintenance of the existing embankments and flood defence structures at both ends of the Eastern Yar valley, at Embankment Road in Bembridge Harbour (Unit 15) and at Culver Parade in Yaverland, Sandown (Units 22-24) to reduce current and future risks.

Going forward there are a number of steps required to make a decision on the preferred option in this unit. These include undertaking further discussions with Natural England, the RSPB (land owners behind Embankment Road), the Environment Agency, the IOW Council, Utilities (including Southern Water), the Regional Habitat Creation Programme (RHCP), and other stakeholders, to determine the preferred way forward, implications, funding gaps and potential funding avenues. Further work to understand combined flood risk will be required if the Yarbridge alternatives are to be further developed, and the undertaking of a Habitat Regulations Assessment (HRA) and Water Framework Directive Assessment (WFD) to ensure environmental compliance and any potential compensatory habitat requirements of the preferred option and future Scheme.

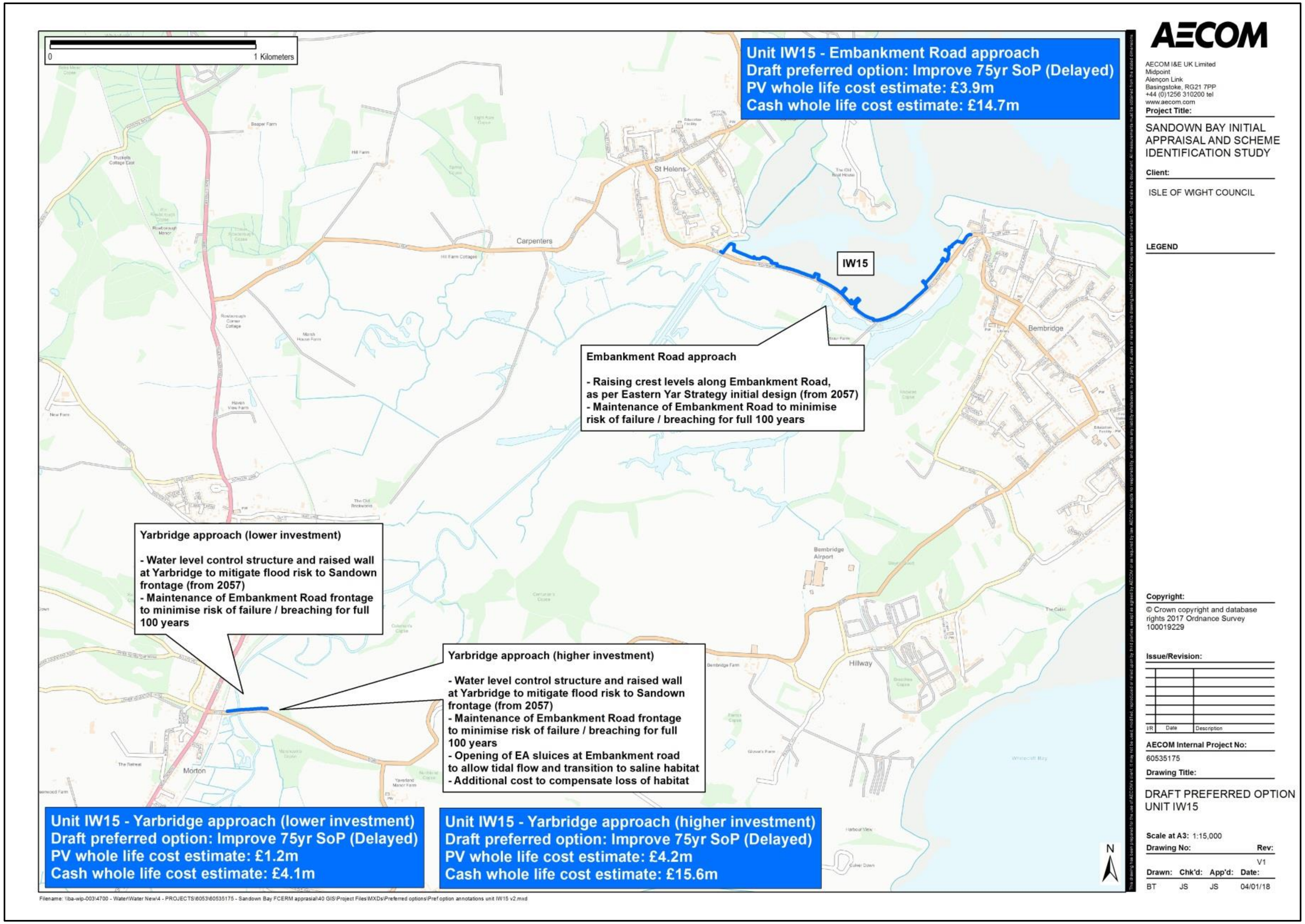

Figure 8-2. Proposed preferred option alternatives for unit IW15 (nb. for further alternatives improving from the present day, please see Chapter 6.8).

8.1.3 Coastal processes

IW22-24 (Yaverland Car Park to Culver Parade)

The proposed preferred options for these units involves refurbishments to the groynes which could have an impact on the beach levels by interrupting the natural movement of sediment along the beach. However, the groyne refurbishments will be working with the existing structures and will not involve constructing or removing groynes from the system. Therefore, compared to the existing baseline, significant changes to coastal processes in the area are not anticipated.

In the future, due to sea level rise, there could be scope to raise the groyne structures as part of the refurbishments. Numerical modelling of the beach system is needed to determine whether this may or may not be required, and also to determine the potential impact that this may have on the coastal processes.

Down-drift of IW22 (towards Culver cliff) there is a large undefended stretch of coastline with an SMP management policy of No Active Intervention. By refurbishing the existing groynes in unit IW22 the defences will continue to reduce sediment movement down-drift to this area, which is currently affected by variable beach levels, with sand covering or exposing the wave-cut platform at different times. This is likely to lead to a continuation of the erosion experienced to the north of the study site, although this is considered to be acceptable because it does not change the existing situation and supports the SMP management policy.

IW15 (Embankment Road, Bembridge)

Depending on which option is taken forward as the preferred option, there could be impacts on the coastal processes within the unit.

If the frontline option is identified, which involves raising of the existing defences at Embankment Road, then there are unlikely to be significant impacts on the coastal processes in the area.

However, the setback option at Yarbridge has a greater potential to impact the coastal processes in the area, in this reclaimed valley, although this would be minimised by also continuing to maintain Embankment Road at the current height. In the future a transition to a different habitat type behind Embankment Road could significantly alter the character and processes in the area. Whether this transition is favourable will need to be decided alongside the objectives of the Regional Habitat Creation Programme.

In addition, the operation of tide gates at Yarbridge has the potential to impact the fluvial flood risk of the River Yar Valley. This would not be the case during normal tide conditions when the tide gates remained open. However, when the structure was closed it could potentially have the effect of ‘backing up’ fluvial flows behind the structure leading to an increased fluvial flood risk elsewhere. The magnitude and extent of this impact is unknown at this time but it will be essential to undertake a joint probability analysis and modelling study to determine this impact prior to this option going ahead.

8.1.4 Residual risk

The preferred options for IW22-24 and IW15 recommend protecting to a 1:75yr SoP (from 2055-60 onwards), and contributions will be required to achieve this. As with any SoP, there is also always a residual risk that an above design standard event may occur which could overtop and/or inundate the raised defences and lead to flooding to properties, key transport infrastructure and environmental designations. The residual risk will increase without an intervention as a result of sea level rise, therefore, by delaying the implementation of crest raising until 2057 it increases the likelihood of an above design standard event occurring in the interim.

In IW15, should the setback option be taken forward at Yarbridge it may be worth considering the use of PLP for properties which would be located in front of the new defences. However, this should be investigated in more detail at Outline Design / scheme appraisal stage.

8.2 Sandown Esplanade, unit IW25

8.2.1 Preferred option for Sandown Esplanade (unit IW25)

This area covers the defences along Sandown Esplanade. A map is provided in Figure 8-3. The number of properties at risk from tidal flooding and erosion in unit IW25 are summarised in sections 6.4. In total there are 6 properties and the road currently at risk from a 1:200 year flood event (and in 2117) and 203 properties at risk of erosion by 2117.

Chapter 7 demonstrates that the leading economic option for unit IW25 is to initially Maintain then Sustain a 75yr SoP (from 2055-60). The lower investment method of implementing the leading economic option in this unit involves a series of seawall resurfacing works and then an encasement. This option also involves crest raising of the defences from 2055-60, although the exact timing of this intervention will depend on future rates of sea level rise. It may be more economically advantageous and efficient to undertake the crest raising as part of the encasement works, but for the purpose of costing it has been assumed (conservatively) that these will be kept separate.

The lower investment approach does not include an allowance for refurbishing or replacing the groyne within this unit and as a result there may be an increased risk that beach levels fall in the future (although this is not expected to be significant given that there is only one groyne in this unit). It is possible therefore that the community preferences for the frontage will not be supported by the lower investment approach and it may not be acceptable. With this in mind the lower investment approach has not been recommended as the approach to follow and a more expensive combination of measures to implement the leading option, which involves groyne refurbishments, is recommended. The details of the methods this approach will involve are described as 'Approach 2' to the Maintain then Sustain 75yr SoP (Standard of Protection) option in section 6.4.

The preferred option is therefore to **Maintain then Sustain a 75yr SoP (from 2055-60) and additionally undertake groyne refurbishment works to help sustain beach levels.** The preferred option will prevent erosion to 203 properties over the next 100 years and will also help to reduce flooding along the esplanade and waterfront (protecting at least 6 properties from flooding).

Table 8-3 provides a comparison of the lower investment and higher investment approaches to implement the proposed preferred for IW25, over 100 years (i.e. without or with refurbishment of the one groyne). The PV cost (discounted cost) for the higher investment approach is estimated to be approximately £2.5m and the cash cost (non-discounted cost) is estimated to be just over £8.7m.The cost benefit ratio for the higher investment approach is approximately 3.1. The difference in whole life cost between the lower investment and higher investment approach in unit IW25 is approximately £50k in PV terms or £200k in cash terms, over 100 years.

The amount of GiA (government Grant in Aid funding) available to help fund the proposed preferred option is likely to be capped at the amount that is available towards the lower investment approach. This is a significant constraint of GiA and means that the remaining cost to implement the preferred option will likely need to be sourced from a contribution(s). Should it not be possible to secure the additional funding required for the preferred approach (involving groyne maintenance as well as sea wall raising), the lower investment approach provides a sound technical alternative to mitigate erosion and flood risk in the area, although it would not assist in maintaining beach levels. As a comparison, the Maintain approach (not including the element of crest-raising) has a PV cost of approximately £2m and a cash cost of approximately £7m over 100 years. Delivering crest raising in this Unit will provide the same Standard of Protection as that recommended for neighbouring units 22-24 to the north (Culver Parade to Yaverland). Chapter 9.4 discusses potential Grant in Aid (GiA) eligibility for this unit and estimates, over the whole 100 year appraisal period, an approximate 20% GiA contribution (based on the current system), therefore contributions will be required for Sandown Esplanade. A Priority Scheme is not identified at this stage for this unit, as the seawalls are in reasonable condition (assisted by the current beach level), and the risk in this unit is not the same as the breach risk in the units to the north. However, when the proposed Priority Scheme for units 22-24 is developed further (for approximately 10 years time) the condition and risk in this unit is recommended to be considered at the same time seeking efficiencies in approach in future refurbishments, especially where the same SoP is recommended.

A comparison against the environmental impacts of the different measures (section 7.3) shows that both approaches to implementing the leading economic option are environmentally acceptable. It is considered that the identified environmental features do not present any significant environmental constraints which would change the choice of the preferred option, although it is noted that a significant part of unit 25 (Sandown Esplanade) is a Conservation Area (Sandown Conservation Area).

Should an alternative method of refurbishment be preferred (e.g. early encasement of the seawall rather than extending the current concrete spraying), this would also add to the costs in these units, as discussed in Chapter 6.4. Also presented in this section are costs for replacement of the masonry sections of the defence (IW25/03 and 25/05) with a similar masonry structure. The PV cost estimates for this approach are presented and can be compared against should an alternative approach to refurbishing the existing structures be required. At this stage these alternative approaches have not been recommended as they represent a more costly approach.

Figure 8-1 shows the proposed preferred option in unit IW25.

Table 8-3. Unit 25 Summary of proposed preferred option selection

Preferred option - Maintain then Sustain 75yr SoP (2055-60)		
Unit	**Lower investment approach**	**Alternative (higher investment) approach**
25 (Sandown Esplanade)	- Resurface seawall (2027-32 & 2045-50) - Encase seawall (2065-70) - Crest raising (2055-60)	- Resurface seawall (2027-32 & 2045-50) - Encase seawall (2065-70) - Refurb 1 timber groyne (2027, 2045-50, 2065-70 & 2085-90) - Crest raising in 2055-60
Selection criteria		
Cost (PV	£2,470k	£2,520k
Cost (cash)	£8,575k	£8,785k
ABCR	3.2	3.1
Wider factors	Environmentally acceptable however this approach does not help to retain beach levels	Environmentally acceptable and additional groyne refurbishments could help with beach levels
Preferred approach		✓

Note that alternative methods to maintain the existing structure are presented in section 6.4 – including like-for-like replacement of the masonry structures and early encasement.

8.2.2 Coastal processes

The proposed preferred option for this unit involves refurbishments to the single groyne located in this unit. This could potentially have an impact on the beach levels by interrupting the natural movement of sediment along the beach. However, the groyne refurbishments will be working with the existing structures and will not involve constructing or removing groynes from the system. Therefore, compared to the existing baseline, significant changes to coastal processes in the area are not anticipated.

8.2.3 Residual risk

The preferred option for IW25 recommends protecting to a 1:75yr SoP (from 2055-60 onwards). As with any SoP, there is always a residual risk that an above design standard event may occur which could overtop and/or inundate the raised defences and lead to flooding to properties and transport infrastructure along the frontage.

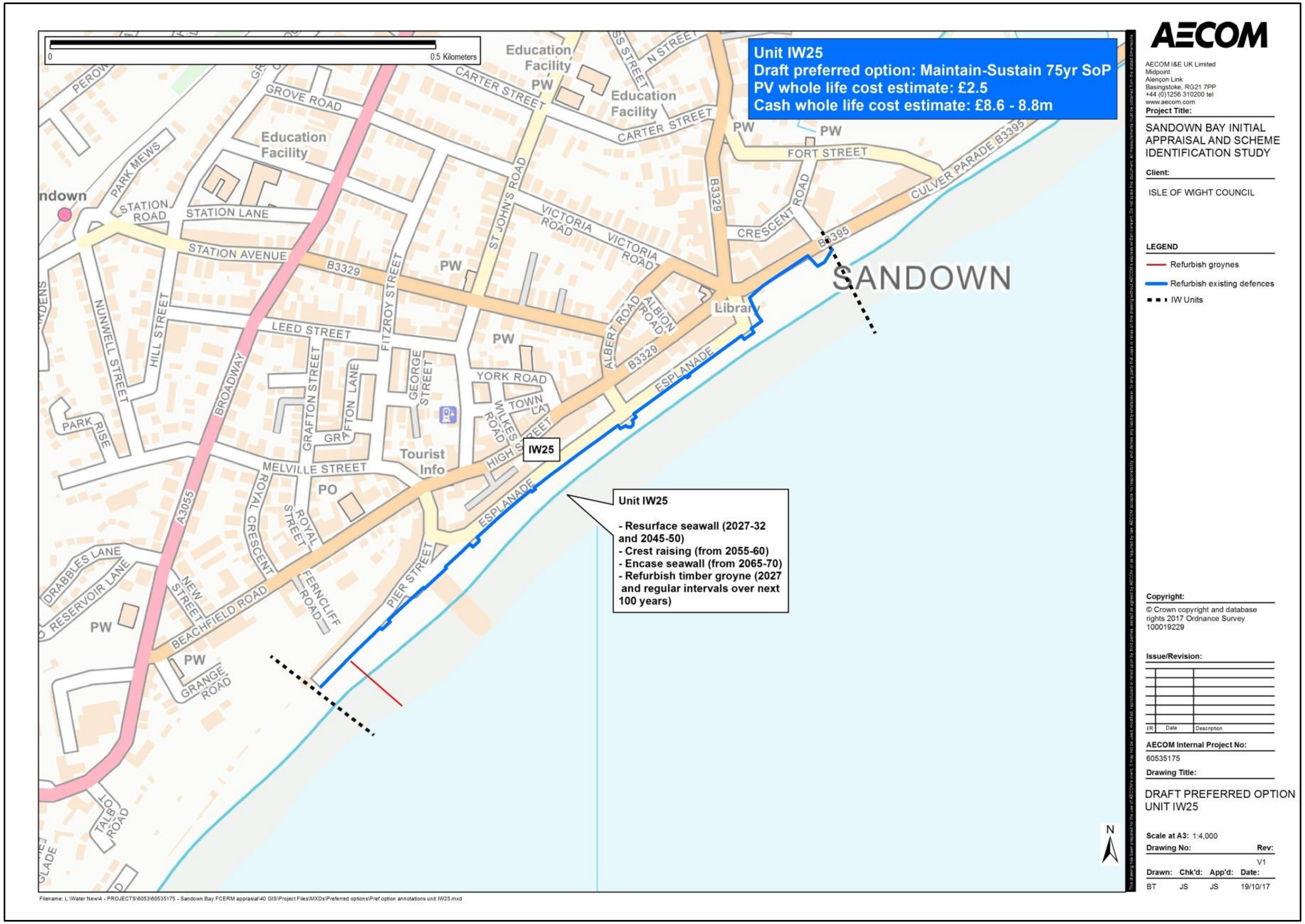

Figure 8-3. Proposed preferred option for unit IW25

8.3 Lake Cliffs, unit IW26

8.3.1 Preferred option

This unit covers the defences along Lake cliffs, linking Sandown and Shanklin Esplanades. A map is provided in Figure 8-4. The number of properties at risk from tidal flooding and erosion in unit IW26 are summarised in sections 6.5. There are expected to be 229 properties at risk of erosion by 2117 (due to potential cliff retreat).

The leading economic option for unit IW26 is to Do Minimum. This would involve continued patch and repair maintenance alongside the continued small scale cliff stabilisation measures which are currently undertaken. It has been assumed in the economic appraisal that this approach would delay the onset of erosion damages by approximately 10 years, although it is not a long term solution and eventually the existing defences would fail.

Whilst it is the leading economic option, Do Minimum is not likely to be an acceptable long term solution for the frontage and is therefore not recommended as the preferred option. The shortlist option in this unit with the next highest ABCR is to Maintain. This option has an ABCR of 1, which shows that the cost of implementing the option matches the benefits that it provides. This option is much more acceptable, and while it is costly (due to the long length of the frontage), it will considerably reduce the risk of erosion to over 100 properties and produce erosion benefits compared to the Do Minimum option in excess of £3.3m.

The proposed preferred option for this unit is to **Maintain**.

The Maintain option involves recommending resurfacing sections (IW26/01, 02 and 07) of the revetment at the end of its service life, expected to be from approximately 2027-32, and again in 2045-50 for the full length of the defences (IW26/01 to 07). From 2065-70 a full encasement will be required which will include new toe protection and reduce the defence's vulnerability to low beach levels in the future. The details of the methods recommended in this approach are described in sections 6.5.3.

The recommended approach to maintaining the defences in IW26 also includes refurbishments to the groynes which supports aspirations to sustain beach levels along the frontage. The groyne works in this unit are considered important because evidence summarised in the coastal processes report identifies some areas within this unit where beach levels have lowered ,which could undermine the refurbishment works to the revetment at the back of the beach.

The cost of the preferred approach over 100 years is approximately £5.3m in PV terms (discounted) or approximately £20.5m in cash (un-discounted) cost, combining both seawall and groyne refurbishments.

In terms of funding, the amount of GiA available is low given the modest ABCR of 1 (Average Cost Benefit Ratio). In addition, GiA availability will be capped at the amount available for the leading economic option which is Do Minimum. As a result, in order to deliver the preferred option in this unit, there will need to be significant contributions to fund the schemes in this unit. The reason GiA is low towards future schemes (e.g. less than 10%) is due to the fact that most properties at risk along the cliff tops are at risk in the long term, rather than the short term and therefore benefits of holding the line are discounted heavily in the economic appraisal. Refurbishment of the groynes (over time), including those in poorest condition in the south of the unit, may help to retain beach levels to extend the life of the current seawall.

A comparison against the environmental impacts of the different measures (section 7.3) shows that the Maintain option is environmentally acceptable. It is considered that the identified environmental features do not present any significant environmental constraints which would change the choice of the preferred option.

Should an alternative method of refurbishment be preferred (to the relatively low-cost sprayed concrete technique used elsewhere in The Bay, that is recommended for the first refurbishments to the seawall) , this would also add to the costs and further environmental impacts in these units, as discussed in Chapter 6.5.

Figure 8-4 shows the proposed preferred option for unit IW26.

Table 8-4. Summary of proposed preferred option selection for unit IW26

Preferred option - Maintain		
Unit	**Do Minimum**	**Maintain**
26 (Sandown Esplanade)	- Patch and repair	- Refurbish timber groynes (immediately, 2030-35, 2050-55, 2070-75, 2090-95 and 2110-2117) - Refurbish revetment / seawall (2027-32, 2045-50 and encase in 2065-70) - Refurbish Small Hope groyne at the end of service life
Selection criteria		
Cost (PV	£695k	£5,345k
Cost (cash)	£2,335k	£20,450k
ABCR	2.9	1.0
Wider factors	Would not support Hold the Line SMP policy or provide continued protection against erosion to cliff top properties, therefore unlikely to be an acceptable approach	Acceptable approach, supports SMP policy. Provides protection against erosion to hundreds of properties. Likely to be dependent on funding contributions.
Preferred approach		✓

8.3.2 Coastal processes

The proposed preferred option involves periodically refurbishing the groynes which is likely have an impact on the beach levels by interrupting the natural movement of sediment along the beach. Within this unit there are some areas where beach levels have fallen over the last decade, and downdrift of unit IW26, in the western part of IW25 (south of the pier) there has also been some erosion. However, there has also been variability, with other areas within these units showing no significant change(refer to coastal processes report for further information).

In the absence of numerical modelling it is difficult to predict the magnitude of the impact on beach levels in these units. However, it is expected that there would be a general accretion trend or a continuation of the status quo (i.e. beach levels remain unchanged). Further downdrift, in units IW22-24 over the last decade there has been a mixed trend, with some bays accreting and others eroding. Refurbishing the groynes in unit IW26 could potentially decrease the sediment availability to units IW22-25 temporarily (whilst any improved areas refilled with sediment) but modelling would be required to confirm and investigate the impact of this.

The groyne refurbishments will work with the existing structures and avoid constructing new groynes or removing groynes from the system. Therefore the relative impact on beach levels is expected to be reduced compared to a scenario in which new, possibly longer groynes were installed. Numerical modelling would be required to determine the impact of a new groyne layout, longer groynes or higher groynes, although are not currently proposed.

The Maintain option (maintenance of coastal defences) will help to reduce wave action at the toe of the steep cliffs located behind the defences. This is expected to reduce the rate at which the cliffs erode, compared to the natural rate if the cliffs were undefended. However, given that the existing defences are in place and performing the same function, the Maintain option represents a continuation of the existing baseline rather than a distinct change in the approach.

8.3.3 Residual risk

The recommended preferred option for IW26 does not involve raising of the defence crest and therefore the risk of periodic wave overtopping of the defences would increase over time. This could potentially have impacts upon the beach huts and businesses along the esplanade at the foot of the cliff.

Continuing to maintain the defences would significantly reduce the risk of erosion and cliff retreat (as well as providing continued pedestrian access along the coastline), but would not prevent all rock falls, as weathering, climate change and vegetation also play a role in causing failures in the cliff face and talus slope. The impact of waves overtopping the defences at the cliff toe in the future could also increase the risk of recession and even though the defences will be maintained / refurbished, there will be a continued reliance on the existing structures. This could be associated with a higher risk of defence failure (compared to constructing new structures) and has been considered in the economics assessment when determining the option benefits.

There is an aspiration to continue to maintain and refurbish the seawalls, and/or the groynes in this unit, however if local funding cannot be secured to do this, risks of erosion and reducing beach levels will increase.

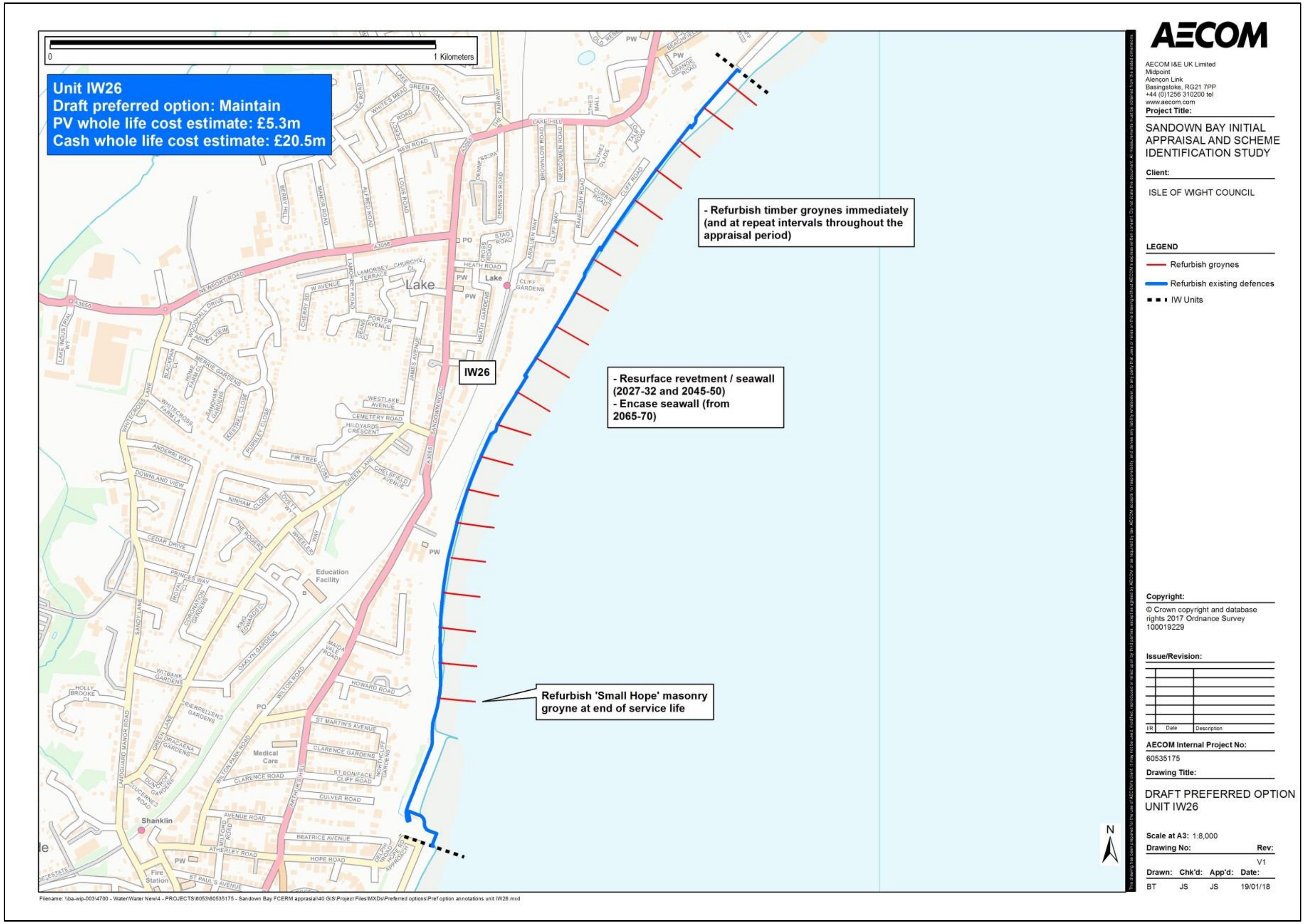

Figure 8-4.Proposed preferred option unit IW26

8.4 Shanklin Esplanade, unit IW27

8.4.1 Preferred option

This unit covers the defences along Shanklin Esplanade. A map is provided in Figure 8-5. The number of properties at risk from erosion in unit IW27 are summarised in section 6.6. By 2055 there are expected to be 151 properties at risk of erosion, many of which would first lose their only road access should the existing defences fail, then the properties themselves would be lost (see section 6.6).

If the defence line is not maintained the future risk in this unit is from erosion of the seafront esplanade and if the defences are not raised in the future to account for sea level rise there is also a risk that waves could increasingly overtop of the defences affecting the road and the properties along the seafront. The existing average crest level of the defences ranges between 2.8 – 4.9m AOD. In the longer term, overtopped flood waters could interact with the cliff toe affecting future stability of the former sea cliff.

There are three leading economic options identified for IW27; Do Minimum, Maintain and Sustain / Improve. Each of the options was selected as a leading economic option because the ABCRs (Average Benefit Cost Ratio) are similar, ranging between 4.5 to 6.4, and each option could be economically justified. Do Minimum would not protect properties and infrastructure in the area from future erosion and loss, once the current structures can no longer be maintained, and reach the end of their lives, and would not implement the 'Hold the Line' policy set by the Shoreline Management Plan. The options to Maintain and Sustain/Improve defences would address future erosion risk, and (dependent on the option chosen) localised flood risks in the area.

For options mitigating erosion risk only, FCERM-AG does not recommend the use of IBCRs (Incremental Benefit Cost Ratios) to inform the appraisal (typically used for flood risk mitigation options only). However, IBCR's are a useful tool for determining whether an additional investment is justified. The IBCR between Do Minimum and Maintain is 3.9 and the IBCR between Maintain and Sustain / Improve is 11.7. These ratios are both significantly greater than 1 which suggests that the increased investment required to deliver the Sustain / Improve option is justified. On this basis the proposed preferred option for unit IW27 is to **Sustain / Improve the performance of the defences.**

In layman's terms, the additional investment required to move from an approach of 'Maintain' (at the existing height of the defences) to implement a 'Sustain/Improve' option instead (which would raise the height of the defences to keep pace with sea level rise) is proportionally not a great increase in the costs, and would protect the road, properties and minimise the risk of reactivation of the cliff face as sea levels rise. As discussed in section 6.6.4, for the sustain/improve performance option it has been assumed that provision of a 1:75yr SoP will limit wave overtopping to a low enough frequency to minimise impacts.. This is a high level assumption (as the current detailed EA coastal modelling does not extend to include this unit) and in future appraisal work it is recommended to undertake a wave overtopping assessment to investigate this and to confirm the standard of protection required.

Four different approaches to implementing the Sustain / Improve protection option have been developed, using alternative defence methods, with estimated PV costs ranging from £3.3m to £5m, or cash costs between £7m to £15.1m. Even with the most costly of these approaches, the ABCR is 3.5, with an IBCR relative to the Maintain option of 1.8. Details of these alternatives can be found in Chapter 6.6, and the most cost effective methods have been brought forward in this assessment.

The lowest cost approach (when considering whole life costs over 100 years) involves encasing the existing defence at the end of its service life. For the section of defence in IW27/02 (the northern half of Shanklin Esplanade) which is in a poor condition, this would be recommended to be encased immediately (i.e. an initial scheme), whilst the remaining seawall sections in the unit will be encased from year 2027-32 towards the end of their existing service life (and timber breastwork north of the Chine could also be replaced with a seawall at this time).

However, the concrete encasement approach does not include an allowance for refurbishing or replacing the existing groynes within these units (groynes would not be required as toe protection would be included in the encasement). The recent beach level trends summarised in the coastal processes report indicate a mixed trend in this unit, with some areas overall stable or accreting and other areas eroding over the past twelve years. At first glance this suggests that refurbishing the groynes in this unit is not as essential as in neighbouring IW26 (Lake Cliffs) where there are some locally high rates of erosion and the groynes are in a poor condition. However, it is important to note that the beach level trends are collected over a relatively short term period (the last decade) and they include the influence of the existing groynes. There is no data available for this unit to indicate what could happen if the groynes were to be abandoned, however, it is reasonable to assume that the beach levels would fall.

Choosing which approach to use to implement the proposed preferred option in this unit needs also to consider funding availability. Whilst the encasement option (which would not be reliant on or include groyne works) is the most cost effective option over the whole appraisal period (e.g. lowest whole life costs), the initial costs to encase the structure are high, compared to an alternative approach of a combination of retaining the groynes and resurfacing the seawall through concrete spraying (a technique which has been used elsewhere in The Bay). This lower-cost refurbishment technique would require a lower initial investment and potentially improve the feasibility of an initial scheme to upgrade the defences along Shanklin Esplanade. Given the general constraints on funding and with no private contributions currently secured for this area (at the time of writing this report) the encasement approach may not be deliverable in the short term. Therefore the alternative approach which involves concrete spraying and groyne refurbishments and has a lower initial scheme cost is preferable, but should external funding be secured the encasement option can be taken forward.

Given the beach's influence in protecting the hard defences from wave attack, and the IWC and community aspirations to maintain a healthy beach, the preferred approach to implement the proposed preferred option is to **Sustain / Improve protection and additionally undertake groyne refurbishment works to help sustain beach levels.** This is described as 'Approach 2' to the Sustain / Improve option in section 6.6.4. Table 8-5 provides a comparison of different approaches to implement the proposed preferred option for this unit, over 100 years.

Table 8-5. Summary of proposed preferred option selection

Preferred option – Sustain / Improve performance				
Unit	**Approach 1**	**Approach 2**	**Approach 3**	**Approach 4**
27 (Shanklin Esplanade)	- Encase and raise seawall, replace timber breastwork with seawall (immediately/2027-32 and 2075 onwards)	- Refurbish IW27/02 seawall (immediately, 2045-50) and encase (2065-70) - Refurbish remaining seawall and breastwork in unit (2027-32, 2045-50) and encase (2065-70) - Refurbish timber groynes (2027, 2045-50, 2065-70, 2085-90 and 2105-2110) - Refurbish concrete groynes (2032 and 2075 onwards) - Crest raising in two intervals (to be confirmed during future appraisal)	- As per approach 2, except; - Construction of large concrete groyne to replace existing timber groynes (around 2030)	- Beach recycling to improve beach levels in the area - Refurbish seawall and breastwork (present day & 2027-32, 2055-60 then encase later) - Refurbish timber groynes - Crest raising in two intervals (to be confirmed during future appraisal)
Selection criteria				
Cost (PV)	£3,390k	£4,170k	£4,515k	£5,030k
Cost (cash)	£7,070k	£11,265k	£11,340k	£15,075k
ABCR	5.2	4.2	3.9	3.5
Wider factors	- Environmentally acceptable however this approach does not help to retain beach levels	- Groyne works expected to improve retention of beach levels - Lower cost initial intervention than approach 1 with greater chance of attracting GiA funding	- Sediment modelling would be required to investigate impact of new large concrete groyne - Greater potential for objections, uncertainties and cost increases associated with changing the existing groyne layout and determining optimum number of new groynes.	- Groyne works expected to improve retention of beach levels - Suitable location for sediment source would require investigation - Sediment modelling would be required to investigate impact of sediment recycling
Preferred approach		✓		

The cost of the preferred approach over 100 years is approximately £4.2m in PV terms or £11.3m in cash cost. The preferred approach has a benefit cost ratio of 4.2. Compared to approach 1 (encasement), an initial scheme for the preferred approach (refurbishment by concrete spraying) is less costly and therefore has a greater possibility to attract GiA funding (refer to section 9.1 for more details).

A comparison against the environmental impacts of the different measures (section 7.3) shows that both the Maintain and Sustain/Improve options are environmentally acceptable. The most cost-effective measures proposed to deliver this option do not lead to any significant environmental impacts which would change the choice of the proposed preferred option, although the location of rocky reef features within the bay and updrift should continue to be considered when improved environmental information is anticipated to be published shortly and in future Scheme level appraisals. It is also noted that Shanklin Esplanade is a Conservation Area (Shanklin Conservation Area), which has resulted in alternative methods being considered as summarised below.

Should an alternative method of seawall refurbishment or defence be preferred, due to this constraint or stakeholder preference (e.g. early encasement of the seawall rather than concrete spraying of the sections which are currently failing masonry), this would add to the costs in these units, as discussed above and in Chapter 6.6. It is noted that the cost-effective concrete spraying technique is already present within The Bay, undertaken at Culver Parade in 2006 (see section 4.1). If local funding contributions are available for Shanklin Esplanade, this could influence the method preferred.

A Priority Scheme is proposed for this unit in the short term, due to the poor condition of much of the seawall, to potentially upgrade nearly the whole length of the esplanade seawall at the same time. Alternative methods and costs for this initial Priority Scheme are provided in Chapter 9, comparing the approaches of refurbishment by concrete spraying and encasement, and also considering the inclusion or exclusion of potential early crest raising and groyne works. There is potentially a high proportion of Grant in Aid available to fund an initial scheme (up to 100%), although if the higher cost alternatives are preferred, the element of contribution required will rise. There would also be the potential to include elements of masonry wall refurbishment in an initial scheme if this was preferred in the Conservation Area and sufficient funding contributions were available. The Priority Schemes and funding of these alternatives and methods is explored in more detail in Chapter 9.

Figure 8-5 shows the proposed preferred option for unit IW27.

8.4.2 Coastal processes

The preferred option involves groyne refurbishments which could have an impact on the beach levels in the local area. However, the groyne refurbishments will be working with the existing structures and will not involve constructing or removing groynes from the system. Therefore, compared to the existing baseline, significant changes to coastal processes in the area are not anticipated. Further information is available in chapter 6.6 and chapter 7.4.

Given the mixed trend in beach levels along Shanklin Esplanade (when trends are examined over the past twelve years, with some areas accreting, others eroding), it is difficult to predict the impact of groyne refurbishments on the levels in the immediate area. However, it is expected that there would be a general accretion trend or a continuation of the status quo (i.e. beach levels remain unchanged), depending on localised defence condition of each structure. Refurbishing the groynes in unit IW27 could potentially decrease the sediment availability to units to the north/downdrift temporarily (whilst any improved areas refilled with sediment). Numerical modelling would be required to confirm and investigate this further.. It is noted that (as advised by stakeholders) beach levels can fluctuate in the shorter term due to the impact of storms, wind/wave direction etc., but the general role of the groynes to help retain beach levels would be anticipated to continue.

The Sustain / Improve option would continue to hold Shanklin Esplanade in place and prevent coastal retreat through the area which would over time also lead to reactivation of the former sea cliff at the back of the esplanade. Periodic rockfall risk will remain from the cliff line and talus slope, due to the impacts of weathering and climate change.

8.4.3 Residual risk

The preferred approach of sustaining/improving the performance of the defences (in terms of erosion risk) will significantly reduce the risk of erosion and cliff retreat.

Depending on the height to which the defences are raised in the future (depending on rates of SLR) there will remain a risk that an above design standard flood event could cause overtopping of the defences. This would impact first upon the road and seafront properties behind the defences.

If the funding cannot be secured to implement the preferred option including that required to refurbish and retain the groynes there could be a fall in beach levels in the area.

The risk of periodic rock falls from the former sea cliff at the back of Shanklin Esplanade will remain (from both the cliff face and the talus slope), as weathering, climate change, vegetation and steepening of the talus all play a role in cliff stability. Retaining the coastal defence line along the esplanade (as recommended in the preferred option) and raising the defences over time to keep pace with sea level rise will continue to prevent erosion reactivating the former sea cliff to wave attack over time.

8.5 Luccombe cliffs, Shanklin, Unit IW28

8.5.1 Preferred option

This unit covers the defences along the cliffs in the south of Shanklin Bay, just south of Shanklin Chine. A map is provided in Figure 8-5. Currently timber defences are present along the cliffs in this unit. South of this unit, the coast is undefended. The number of properties at risk from erosion in unit IW28 are summarised in section 0. By 2117 there are expected to be 28 properties at risk of erosion.

The leading economic option for IW28 is to '**Do Minimum**'. This option has the highest ABCR of the shortlist options and it is not economically justifiable to implement a 'do something' option as both the Maintain and Sustain / Improve options have an ABCR <1.

However, the least cost option that would deliver the current Shoreline Management Policy of 'Hold the Line' for this transitional unit (with hard defences to the north, and undefended cliffs to the south), would be to '**Maintain'**.

In the short term, under both these approaches, the existing defences would be maintained with 'patch and repair' maintenance (dependent on risk and the resources available), to extend their remaining life.

When the current structures reach the end of their life (as outlined in Chapter 6.7 and the Defence Appraisal Report) the two approaches would diverge, dependent on whether the timber defences were replaced (maintain option) or allowed to fail (do minimum option).

For this reason, the two approaches are highlighted, and future updates of the Shoreline Management Plan (SMP) are recommended to consider this unit further, with the more detailed economic appraisal now undertaken in this study.

Doing Minimum in this unit will involve small scale reactive maintenance and 'patch repair' work to the existing timber revetment and groynes alongside the continued small scale cliff stabilisation measures which are currently undertaken.

Maintain would involve refurbishment and replacement of the timber defences and groynes (to extend the life of the timer revetment) with further details on the methods outlined further in Chapter 6.7.

Table 8-6 provides a comparison of the alternative options for this unit . The cost of the Maintain over 100 years is £1.2m in PV terms or £4m in cash cost, whilst the cost of Do Minimum is £135k PV terms or £455k in cash terms.

Table 8-6. Comparison of Do Minimum and Maintain options

Unit	Do Minimum option	Least cost Maintain option
28 (Luccombe Cliffs)	- Reactive patch and repair and cliff stabilisation	- Refurbish timber groynes (2027, 2045-50, 2065-70, 2085-90, 2105 onwards) - Refurbish timber breastwork (2027, 2045-50, 2065-70, 2085-90, 2105 onwards)
Selection criteria		
Cost (PV	£135k	£1,165k
Cost (cash)	£455k	£4,015k
ABCR	1.7	0.4
Wider factors	Favoured economic approach	Supports existing SMP policy but not economically justified
Preferred approach	Policy to be reviewed at SMP level	

As Do Minimum would be recommended as the proposed preferred option for this unit based on economic grounds, GiA (government grant in Aid funding) is not anticipated to be available for this unit, therefore contributions will be required from the local community to fund works in the area. The cost benefit ratio is not high due to the number of properties at risk being limited compared to the cost of the works required to protect them, and the fact that most properties at risk along the cliff tops are anticipated to be affected in the longer term rather than the short term.

The current Shoreline Management Plan policy in this unit is to Hold the Line, therefore refurbishment activities from private landowners / the local community would be permitted under this SMP policy, subject to acquiring the relevant consents. It is recommended that SMP policy is kept under review in future updates of the Shoreline Management Plan. A comparison against the environmental impacts of the different measures (section 7.3) shows that both the Do Minimum and Maintain options are environmentally acceptable. Ongoing patch and repair and continuation of existing activities or refurbishment used to deliver these options do not lead to any significant environmental constraints which would change the choice of the proposed preferred option.

Figure 8-5 shows the leading economic option for unit IW28.

8.5.2 Coastal processes

Doing minimum or Maintain is unlikely to significantly change the coastal processes in this unit. Under a Do Minimum approach, as the existing groynes come towards the end of their service life and become less efficient at trapping sediment there could be an increase in the volumes of beach material moving alongshore. This could benefit the units to the north (IW22-27) in that more sediment may be available to be trapped by the groyne bays in these locations. Under a Maintain approach. groyne refurbishments would be working with the existing structures therefore significant changes to coastal processes in the area are not anticipated.

However, even with ongoing patch and repair works, over time it is likely that the existing defences will reach the end of their service life and will fail. This could potentially lead to greater exposure of the cliff toe to wave action / attack which could increase the rate of cliff recession in this unit, if the funding is not available to replace the defences.

8.5.3 Residual risk

The main residual risk associated with the Do Minimum approach is the future risk of cliff recession in currently defended parts of the frontage as defences come towards the end of their service lives. Even with the existing defences in place, the risk of periodic rock falls from the cliff will remain (from both the cliff face and the talus slope), as weathering, climate change, vegetation and steepening of the talus all play a role in cliff stability.

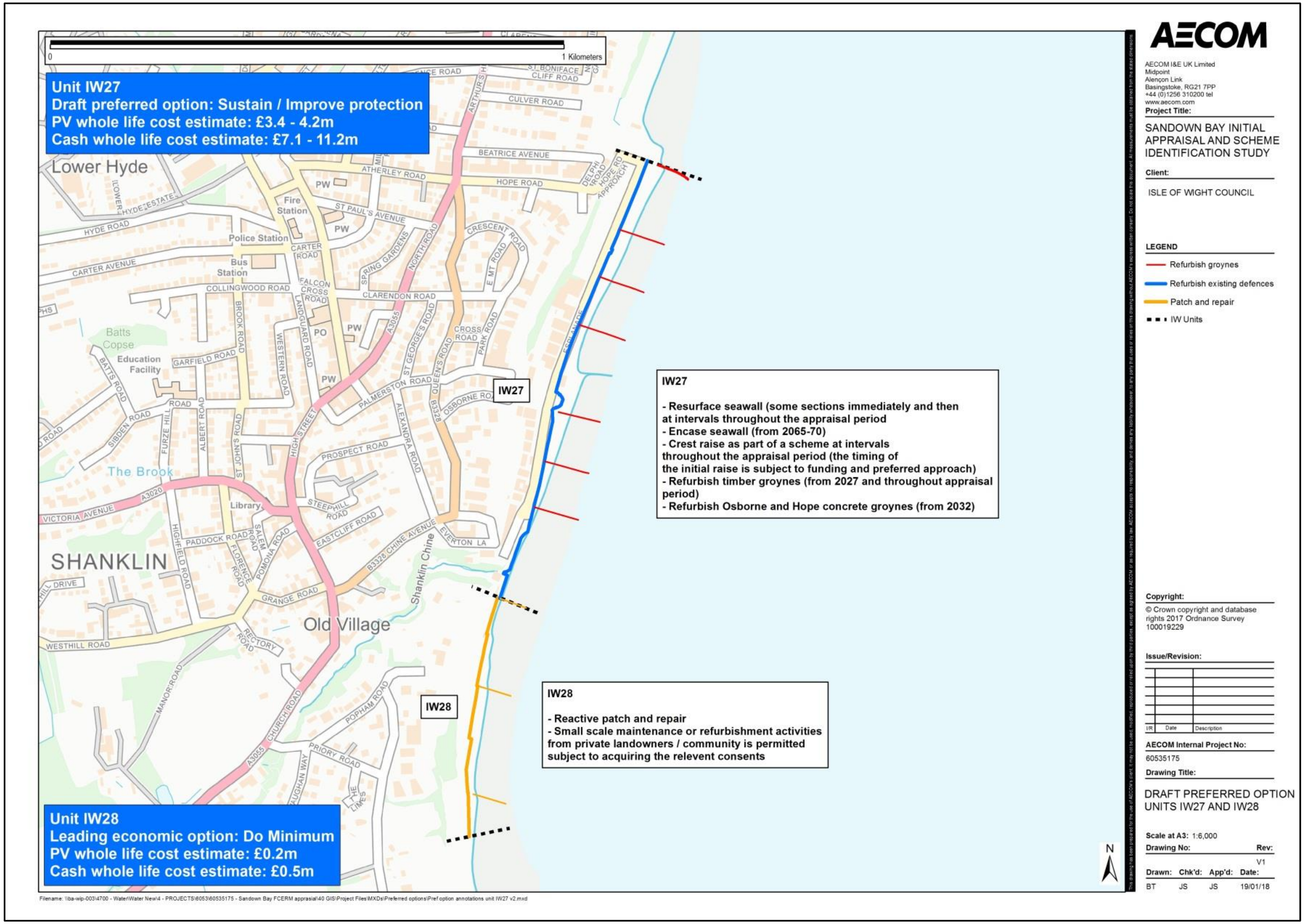

Figure 8-5. Proposed preferred option for IW27 and leading economic option for unit IW28

8.6 Summary of preferred options

Over the next 100 years, in Sandown Bay and the adjacent low-lying Eastern Yar valley, there are 661 properties at risk of coastal erosion, plus an additional 722 properties at risk of tidal flooding (of which two thirds of which are residential). Damages over the next 100 years are anticipated to be £105 million in PV terms or £435 million in cash terms. Further information on the Do Nothing damages is provided in section 10.3.9. This study has explored how the *Hold the Line* policies set by the Shoreline Management Plan in 2010 for this area can be delivered and has identified priority schemes.

A summary table is provided below showing the costs and benefits of the proposed preferred options and approaches which have been recommended by this study. This includes proposals to reduce flood risk to over 600 properties and reduce erosion risk to over 600 properties.

Table 8-7. Summary of preferred option costs and benefits

(nb. the table below provides PV costs. Cash costs (undiscounted) are also provided in Chapters 6 and 8).

Unit	Lower investment approach		Higher investment approach	
	Cost (PV)	Benefits (PV)	Cost (PV)	Benefits (PV)
IW22-24: **Yaverland to Culver Parade** ***(Maintain then Sustain 75yr SoP)***	£2,840k	£52,640k	£4,330k	£52,640k
IW25: **Sandown Esplanade** *(Maintain then Sustain 75yr SoP)*	£2,470k	£7,849k	£2,520k	£7,849k
IW26: **Lake Cliffs** ***(Maintain)***	£5,345k	£5,355k	As per the lower investment approach	
IW27: **Shanklin Esplanade** ***(Sustain/Improve)***	£3,390k	£17,477k	£4,170k	£17,477
IW28: **Luccombe road, Shanklin** ***(Do Minimum* or *Maintain)*** ***–TBC by SMP review***	£135k*	£226k	£1,165k*	£521k
IW15: **Embankment Road, Bembridge** *(Maintain then Improve to 75yr SoP)* ***–TBC by further environmental/ funding steer***	£1,160k**	£14,482k	£3,955k** (or £4,205k***)	£13,678k
TOTAL	**£15,340k**	**£98,029k**	**£21,485**	**£97,520k**

Please note –Explanation of 'Lower' and 'Higher' investment approaches in the table above:

In Units 22 to 27, the 'Lower investment approach' involves refurbishments/upgrades the seawall/revetment defences only, whereas the 'Higher investment approach' typically includes groyne refurbishments too (to provide protection to and extend the life of the seawalls/revetment).This definition varies in the following units:-

**In Unit 28 the lower investment approach listed is for 'Do Minimum' and higher investment approach listed is for 'Maintain'.*

***In Unit 15 the lower investment approach includes the new setback defence at Yarbridge, whereas the higher investment approach is for the frontline defence raising at Embankment Road.*

****In Unit 15, the third alternative option includes the lower investment approach plus habitat creation (and compensation). This alternative, if preferred, will change the Total costs of the Higher investment approach in the table above to £21,735k (PV).*

9. Priority schemes and funding

The preferred option coastal and flood defence schemes with the greatest possibility of attracting FCERM Grant in Aid (GiA) funding have been identified. These are termed the 'priority schemes' and are discussed in more detail in this chapter. The schemes are eligible for a proportion of GiA, and in situations where the schemes are unlikely to be fully funded then the Isle of Wight Council and Environment Agency will actively seek the remaining funding for these schemes. Seeking to deliver broader outcomes and wider benefits as part of schemes may be useful to open up additional potential funding streams.

The amount of GiA available for a coastal or flood defence scheme is variable and determined by four Outcome Measures (OMs). These are:

1. All benefits arising as a result of the investment, less than those valued under the other outcome measures (OM1).
2. Number of households moved from one category of flood risk to another lower category (OM2)
3. Number of households better protected against coastal erosion (OM3)
4. Statutory environmental obligations met through flood and erosion risk management (OM4)

Schemes are prioritised on a national basis, dependent on the Outcome Measures they provide and the balance of the costs and benefits.

The Environment Agency has issued a standard Partnership Funding (PF) spreadsheet / calculator to calculate the potential level of GiA for future schemes based on a series on input parameters.

The PF calculator therefore identifies a GiA contribution (£) and an initial raw OM score (%) which can be used to assess the likelihood of a scheme attracting funding. The GiA contribution represents a theoretical maximum funding value that could be available based upon the outcomes delivered by the scheme. The raw OM score (%) represents the percentage of GiA contribution (compared to the PV costs of a scheme) that could be justified from Environment Agency national budgets (up to the full limit of the scheme cost). The calculator then considers any other potential financial contributions secured against the project to produce a 'PF score'.

It is Defra policy for scheme to reach a minimum OM threshold of 100% to enable it to receive national funding. This is normally achieved through a combination of national and local funding contributions. Any contributions secured towards projects securing 100% or above can either a) reduce the cost of the scheme to the national taxpayer, making it more likely to go ahead sooner or b) be used to help fund other local schemes.

For example, a scheme with a strong benefit cost ratio and capital cost of £1million, achieving a raw OM score of 90% could receive up to £900k in GiA, with the remaining £100k required from contributions to achieve at least the 100% target. If a private £200k contribution to this same scheme was available it improves the OM score to 110%, and the GiA required funding could be reduced to £800k. In this example situation the likelihood of funding is higher if this scheme is in competition with a similar project only scoring 100%.

Therefore local funding contributions can often 'unlock' a national government contribution to a proportion of the costs of a scheme, dependent on the outcomes it delivers.

For more details on Partnership Funding refer to the Defra Policy Statement; *on an outcome-focussed, partnership approach to funding flood and coastal erosion risk management* (2011).

9.1 Shanklin seawall / groyne refurbishment

The section of wall along the northern half of Shanklin Esplanade (unit IW27/02) is in a poor condition and has a low residual life. The wall was constructed pre 1900 and there are a number of large cracks with the fill material exposed in many locations. The proposed preferred option for this unit (Sustain / Improve performance) recommends an initial refurbishment of this section of defence (using a sprayed concrete technique to extend the life of the existing seawall, as has been used previously along Culver Parade in The Bay).

Elsewhere in unit IW27 (along the southern half of Shanklin Esplanade) the seawall is generally in a fair condition but notable areas are also in poor condition. The timber breastwork at the southern end of the unit is in a fair condition. To deliver the preferred option these sections of defence will also require refurbishment before the end of their service life. For the purpose of costing (in Chapter 6) it was assumed that the initial refurbishments in this unit would be carried out in two stages; the first phase for the wall in unit IW27/02 and then the second phase for the remaining sections of defence from year 2027-32. However, in order to maximise the benefits of the scheme the full length of defence could be refurbished in one go. This would provide a consistent Standard of Protection and ensure that the benefits for the whole unit could be counted (rather than just IW27/02) and for the full service life of the newly refurbished defence. This includes a significant number of properties at risk of erosion including permanent loss of access, discussed further below.

The proposed preferred option for this unit also recommends the refurbishment of the groynes which could help to control beach levels and extend the life of the seawall. The cost of refurbishments to the timber groynes (20% material replacement) and also to the concrete groynes (Hope and Osborne groynes) have been included in the funding calculations (unless otherwise stated). Hope and Osborne groynes typically have a longer service life (15-25yrs) than the timber groynes (8-20 years) and therefore GiA calculations with/without costs to refurbish the concrete groynes have been undertaken.

In order to Sustain / Improve the performance of the defences it could also be necessary to raise the height of the defences at some point over the next 100 years, although without flood modelling in the area it is difficult to establish the requirement for this. The purpose of this raising would be to reduce the potential for waves to overtop the defences in the future (due to sea level rise) and affect esplanade properties and infrastructure and eventually interact with the cliff toe which could potentially reactivate the former sea cliff and lead to cliff top erosion. Numerical modelling is not currently available for this unit, however the EA flood zone 2 mapping (see Figure 9-1) indicates that there is currently no inundation of the defences and no properties at risk of flooding behind the defences from a present day 200yr event. However, the extent to which wave overtopping is considered in flood zone 2 is unclear and once current and future wave overtopping is factored in, as well as sea level rise, risk is likely to increase, as typical defence heights in the unit are 2-8-4.9m with low spots of 2.2m. The 2010 SFRA (IW Strategic Flood Risk Assessment Mk II) indicated flooding starts to overtop parts of the esplanade once sea level rise is considered. In addition there are a number of properties and boundary walls located along the esplanade and between the defences and the cliff toe and therefore without detailed numerical modelling of the area it is not possible to estimate if/when the raising would be required. It is therefore recommended that to support delivery of the scheme in the future that numerical modelling of the area is undertaken to better determine the need for crest raising and when it may be required. In addition, the numerical modelling will enable the number of properties between the defences and the cliff toe that are potentially at risk from wave overtopping to be quantified and an economic benefit of the scheme (in terms of flood risk) to be established.

For assessing GiA eligibility, Partnership Funding calculations have been undertaken for the initial schemes with / without crest raising (to a 2057 1:75yr SoP). In reality crest raising may not be required until the latter part of the 100 year appraisal period but for comparison purposes the case for including initial raising in the scheme has been included. Crest raising of the defences in this unit increases scheme costs by approximately £800k (cash cost) which significantly impacts the amount of GiA which is available for the scheme.

An alternative approach to deliver the preferred option that was discussed in section 8.4.1 would be to encase the entire length of the seawall (which includes raising to desired SoP), but not undertake any groyne refurbishments (as the encasement would include strengthening the toe of the seawall). This approach is higher cost for the initial intervention but has a longer estimated service life (50 years compared to 30) and is a lower total investment over the full appraisal period. For comparison purposes this alternative has also been evaluated.

As a further addition a scheme comprising a hybrid of approaches has also been considered whereby the section of wall in the worst condition is encased (located between Hope Car Park and Shanklin Rowing Club) and the remaining wall is resurfaced with concrete spraying. With the scheme the timber breastwork and timber groynes would also be refurbished, but concrete groyne works would not be undertaken. Given that only a section of the defence would be encased with this approach the scheme life is limited to 30 years.

Table 9-1 below summarises the PF scores for the different scheme approaches to implement the initial phase of the coastal defence improvements recommended in the preferred option in unit IW27. The shortfall (contribution required) for each option is listed in the column on the right.

If crest raising is included in an early scheme, access points to the beach, steps and slipways would need to be adapted, as part of future detailed scheme design, as would a tie in point of the crest raising to the rising road at the northern end of the esplanade.

Table 9-1. Partnership Funding scores for an initial scheme at Shanklin Esplanade (IW27)

Shanklin seawall / groyne refurbishments									
Approach	**Scheme duration (years)**	**Capital cost***	**Whole life costs (Present value)**	**OM1 benefit (PV)**	**OM3 properties benefiting**	**PF score (raw)**	**Shortfall**	**Likely GiA (should score reach 100%)**	**Indicative maximum GiA (based on outcomes delivered)**
- Refurbish seawall full length (concrete spraying 814m) **- Refurbish timber breastwork (87 m)** **- Crest raise** **- Refurbish groynes (all timber and concrete groynes)**	30	£2,920k	£3,015k	£16,276k	75	66%	£1,005k	£1,915k	£1,975k
- Refurbish seawall full length (concrete spraying 814m) **- Refurbish timber breastwork (87m)** **- Refurbish groynes (all timber and concrete groynes)** **- (no crest raising; to be implemented later in appraisal period)**	30	£2,135k	£2,225k	£16,276k	75	89%	£240k	£1,895k	£1,975k
- Refurbish seawall full length (concrete spraying 814m) **- Refurbish timber breastwork (87m)** **- Refurbish timber groynes only (no refurbishing of concrete groynes)** **- (no crest raising; to be implemented later in appraisal period**	30	£1,555k	£1,645k	£16,276k	75	120%	NA	£1,555k	£1,975k
- Encase part of the seawall (in unit IW27/02 - Hope car park to Shanklin Rowing club, 491m) **- Refurbish remaining seawall and timber breastwork (total 410m)** **- Refurbish timber groynes only (no refurbishing of concrete groynes)**	30	£2,580	£2,670	£16,276k	75	74%	£670k	£1,910k	£1,975k
- Encase seawall full length (including crest raising 814m) **- Replace breastwork with seawall (87m)** **- (no groyne refurbishments)**	50	£3,335k	£3,480k	£16,503k	75	66%	£1,140k	£2,195k	£2,290k

** Note that capital costs include appraisal costs*

Table 9-1 shows that 75 residential properties have been included in the OM3 counts for the PF calculations. It is anticipated that up to 74 of these properties will not be directly eroded during the lifetime of the initial scheme, however if the existing seawall was to fail then all 75 properties would have their only access route permanently cut-off (due to erosion of Shanklin Esplanade carriageway) and it would be considered unsafe to attempt to access and live in these properties. There is not a viable alternative for a new access route to the properties due to the 45m high vertical cliff behind them. The project team have liaised with the Environment Agency who have confirmed that the write-off of these properties following erosion of the carriageway is and acceptable approach and the approach would appear to be compliant with the Partnership Funding guidance which specifies that ‘for coastal erosion, OM3 qualifying households are those where a scheme prevents occupancy from becoming unsafe’. However, the guidance is unclear as it then states that ‘households indirectly benefitting, through for example loss of services or access, or where flood water isn’t expected to enter a dwelling may not contribute’ but this has been interpreted by the project team to apply more to flood risk situations (rather than erosion) where flooding may lead to temporary rather than permanent loss of access. It is recommended that further clarification with the EA is undertaken during subsequent appraisal work and when developing the business case for the schemes.

As shown in Table 9-1 the PF scores for the different approaches to implementing the initial phase of the proposed preferred option fall between 66-120%. The approach with the most favourable score involves refurbishing the full length of the seawall (via resurfacing – spraying) and also the timber groynes. However, it does not include costs for crest raising of the defences at the low spots (e.g. next to Sail/Surf and ‘Lazy Wave’ establishments) and refurbishing the concrete groynes (Hope groyne and Osborne groyne) and in order to deliver the proposed preferred option to Sustain / Improve performance this may need to be undertaken at a later stage (depending on rates of sea level rise and the onset of risk). Further analysis of the inundation and wave overtopping and how this propagates inland in this unit is recommended at a later stage to investigate whether this approach is suitable for implementation of the proposed preferred option– i.e. is crest raising required immediately or can it be delayed until later on in the appraisal period?

If crest raising were to be undertaken as part of the initial scheme it would decrease the PF score and increase the shortfall from approximately £240k to £1,005k. There are potentially a number of benefits associated with initially crest raising in this unit which have not been included in the economic assessment. For example, there are a row of properties located between the cliff toe and the defence line and these properties could potentially be at risk from flooding in the future should the defences overtop. However, with no numerical modelling in this area the potential flood risk benefits associated with crest raising cannot be accurately quantified. Other potential benefits include avoidance of road disruption along this frontage should it flood during an extreme event. These non-quantified benefits could be assessed in more detail during further scheme development and potentially enhance the OM1 (and OM2) benefits and the case for funding.

The full encasement option has a PF score of 66% and an estimated shortfall just over £1m. The main advantage of this approach is that it has an estimated service life of 50 years and includes crest raising within the measure. However, the approach does not allow for groyne refurbishments and therefore there is greater uncertainty in the beach levels in the future. If encasement is the preferred method for refurbishing the defences along Shanklin Esplanade (in the Conservation Area), refurbishments to the groynes could still be carried out during the lifetime of the scheme, although these would require full local funding.

Alternatively, if some lengths of masonry wall refurbishment like-for-like were preferred (in the Conservation Area), this would add approximately £300 per metre cost (based on an approx. 4m wall height, including early optimism bias, as outlined in Appendix A), although the cost difference could be higher and depends on the type of masonry wall and the finish that is required. Upgrading all 814m of seawall in this way would add approximately £250k to the contributions likely to be required to fund the scheme (in addition to the shortfall listed in the table above).

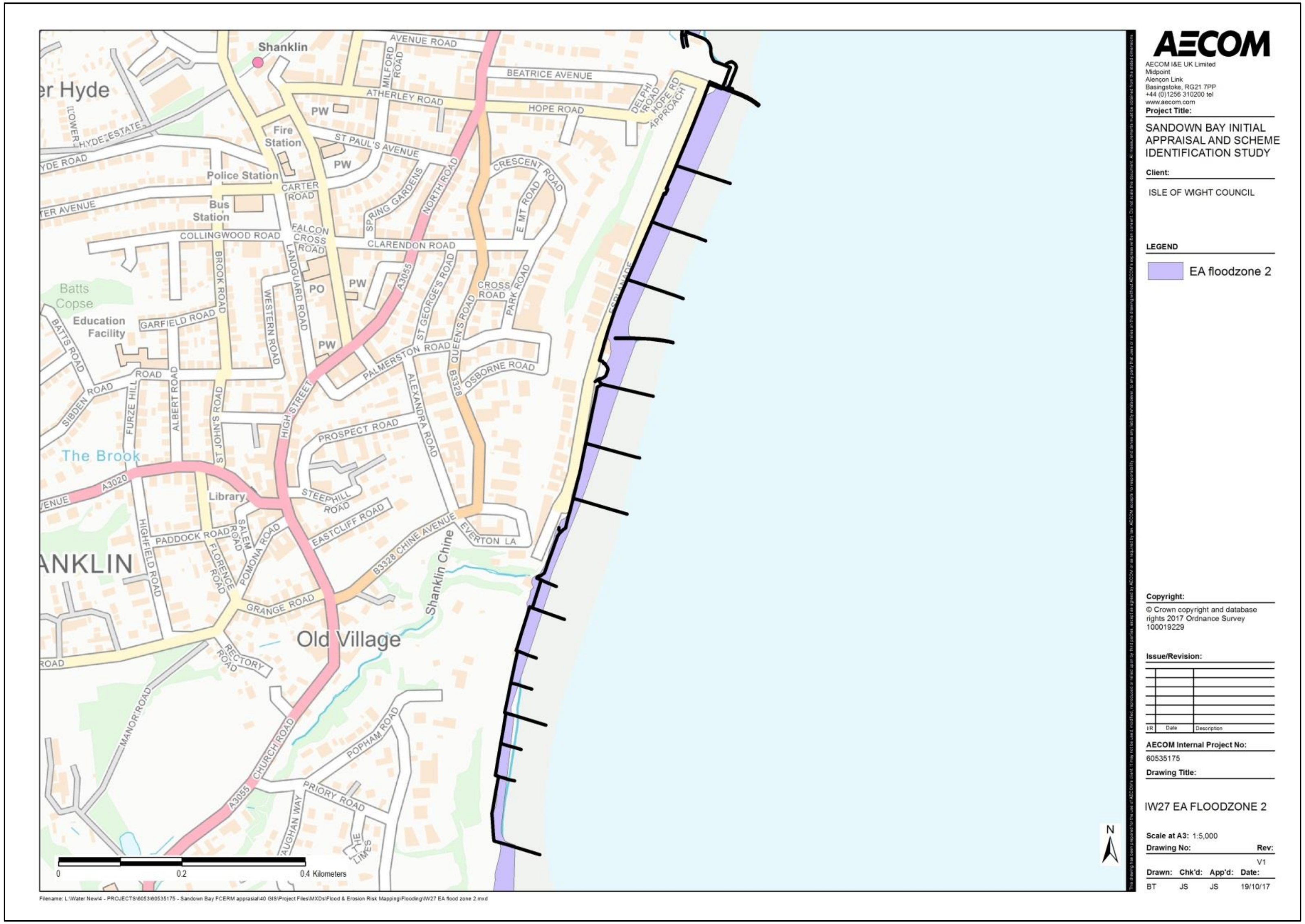

Figure 9-1 EA flood zone 2 mapping for unit IW27

9.2 Yaverland seawall / groyne refurbishments (IW22-24)

The proposed preferred option for units IW22 to IW24 initially involves maintaining and refurbishing the defences at the back of the beach and the groynes (masonry and timber groynes, timber groynes with a 20% material replacement). This is the recommended approach until 2055-60 when crest raising will be undertaken to provide a 1:75yr SoP.

The initial refurbishment intervention is not proposed until 2027 for the length of the frontage. For the purpose of assessing the GiA availability it has been assumed that the works for the entire frontage will take place together in 2027 by hypothetically 'jumping forward' in time and resetting the economics discounting at this point (PF calculations are not intended for schemes set in the future so therefore it is necessary to reset the baseline date).

Similar to the financing assessment for unit IW27, an alternative approach to implementing the preferred option without groyne refurbishments has also been assessed. This refurbishment of only the seawall is more cost effective initially, although it would be anticipated to have a shorter lifespan overall, as beach levels would not necessarily be retained to help protect it (without the groyne refurbishments), so the concrete spraying refurbishment would require repeating sooner (in 20 years rather than 30 years).

Table 9-2 below summarises the PF scores for the different scheme approaches to implement the initial phase of the proposed preferred option in units IW22-24. The method of improving the defences proposed is repeating and extending the concrete spaying of the face of the seawall which has already been undertaken along part of Culver Parade (in 2006). If this method is not preferred, alternative costs for other methods are discussed in Chapter 6 and would result in increased costs and shortfalls.

Table 9-2. Partnership Funding scores for an initial scheme in at Yaverland & Culver Parade (units IW22 – 24) (nb. 2027 baseline)

Yaverland defence / groyne refurbishments (2027 baseline)									
Approach	**Scheme duration (years)**	**Capital cost***	**Whole life costs (PV)**	**OM1 benefit (PV)**	**OM3 properties benefiting**	**PF score (raw)**	**Shortfall**	**Likely GiA (should score reach 100%)**	**Indicative maximum GiA (based on outcomes delivered)**
- Refurbish seawalls and revetment (spraying – 1160m) - (no groyne refurbishments)	20	£1,610k	£1,645k	£37,142k	1	126%	£0k	£1,610k	£2,075k
- Refurbish seawalls and revetment (spraying – 1160m) - Refurbish all groynes – 10 timber groynes, 6 masonry/concrete	30	£3,890k	£3,955k	£59,374k	1	84%	£635k	£3,255k	£3,310k

**Note that capital costs include appraisal costs*

As shown in Table 9-2 the PF scores for the different approaches to implementing the initial phase of the proposed preferred option fall between 84-126%. The more favourable score is for the 20-year refurbishment approach which does not include groyne works (126%) (therefore any groyne works during this time would need to be funded locally). The shortfall for the alternative 30-year refurbishment approach which includes groyne works is approximately £0.6m. Should the shortfall be found through contributions, the amount of GiA available for approach including groyne refurbishments would be approximately £3.3m.

The damages associated with a breach risk are discussed further in Appendix A (Economic Appraisal). Commercial properties will also benefit from continued defence in this area, as well as residential properties.

Repairs and outflanking of the slipway at the northern end of the area (e.g. with gabions) will require further consideration at the time of detailed design in the future, dependent on the progress of erosion in the intervening period, with potential interim repairs. Future works should also consider potential implications for the environmental enhancement techniques currently being tested on the groynes near Browns mini golf course.

The approach and future scheme for Unit 15 (Embankment Road and the Eastern Yar floodplain) also requires careful consideration alongside this scheme outlined above, and is discussed further below, including consideration of funding contributions.

The Priority Scheme outlined above is for a Scheme for units 22-24 commencing in approximately ten years time, lasting for 20 or 30 years, dependent on the alternative chosen, and justified by the benefits in units 22-24.

In the medium term (approx. 2055-60) crest-raising and further refurbishments are proposed for this area (units 22-24), and defence improvement is also proposed for unit IW15 (at Embankment Road and/or Yarbridge), With this in mind, potential costs and benefits for a Scheme in 2057 combining defence elements in both units (at both ends of the floodplain) have also been assessed, at a preliminary level, with costs and benefits for those units potentially combined in the medium to long term. This would be a potential change in method from the initial priority scheme but would still ensure double-counting of benefits is avoided. Please see section 9.3.2 below for further details.

9.3 Further works

In addition to the priority schemes outlined above, the following locations have also been identified for further consideration. However, generally these GiA eligibility of these further works is much reduced and a significant part of the funding will be need to be sourced from external contributions.

9.3.1 Lake groynes

A section of groynes in the southern section of unit 26 (Lake cliffs) are currently in a very poor condition, and some areas along this frontage have shown localised fall of beach levels over the past decade of approx.15 to + 30%, although the overall pattern is mixed with other areas in the unit are more stable (re. Figure 4-8 in the Coastal Processes Baseline Report). Repairing/refurbishing the groynes in the worst condition could help retain beach levels and extend the life of the existing seawall and esplanade (potentially delaying the time when seawall refurbishment will be required in the future). This relates to 8 groynes in the south of the unit (in a very poor condition shown in red in Figure 3-2 of the Defence Condition Report), although detailed consideration of potential groyne repairs throughout this unit would identify priorities for localised repairs (another 12 groynes in this unit are also in a poor condition).

As outlined in Chapter 8.2 above, it is not anticipated these works could be funded by GiA, therefore they would depend on availability of funding contributions.

Currently structures are inspected and assessed alongside other maintenance needs. Repairs are prioritised and undertaken based on risk, with regard to urgency, budgetary constraints and seasonal working.

Costs of a new groyne are estimated at approx. £1,000 to £3,000 per metre. Example costs for groyne refurbishment elsewhere the country (approximate length of 60m) have estimated 10% material replacement on a groyne at approx. £21k, or 20% replacement at £42k, and £30% replacement at 64k (including 60% optimism bias).

9.3.2 Embankment Road, Bembridge

This study has updated options and costs for potential future works in the area of Embankment Road at the back of Bembridge Harbour, to address tidal flood risks in Eastern Yar valley, including different Standards of Protection (SoP) and alternative locations.

The leading economic options identified for unit IW15 involve constructing Tidal flood gates at Yarbridge from 2057. An alternative to this involves raising Embankment Road. Given that the initial capital investment in this unit may be in 40 years time (although it could be progressed sooner if funding is secured, as the SoP is currently 1:20 to 1:25yrs) it is unlikely that the current partnership funding rules will still be in place. However, despite this, indicative partnership funding scores have been calculated to give a general idea of how forthcoming government funding may be when the future scheme alternatives are constructed (note that there is considerable uncertainty in this approach and the existing funding system may change entirely by this time period). Further information on the alternative approaches for this unit can be found in Chapters 6.8 and 8.1.2 above.

Scores for a combined scheme at the Embankment Road / Yarbridge frontage (unit IW15) and at Yaverland (units 22-24) in approx. 40 years time have also been considered, assuming the lower investment alternative for the preferred option at Yaverland (note that with this combination it has been assumed that the encasement construction works at Yaverland are brought forward by approx. 8 years to 2057 to tie in with Embankment Road scheme. This timing deviates from the original options developed for Yaverland but is acceptable as an exercise to assess potential funding levels (nb. refurbishment intervals prior to this would need consideration). The encasement would include crest raising, subject to rates of sea level rise. The scores consider the combined benefits and costs of the schemes across these units at this time (but do not double count benefits). The partnership funding scores assume a 2057 baseline representing a 'jump forward' in time, and are presented in Table 9-3 below.

Whilst this unit is not classified as a priority for an immediate scheme, maintenance requirements on the Embankment should be carefully considered in the short term and it is recommended further work is undertaken as a priority to confirm the preferred timing and funding of future capital works. This is required to ensure a coordinated approach and SoP is achieved with the Priority Scheme identified above for Yaverland. There remains considerable uncertainty in the funding for a scheme in this area and there is the flexibility to undertake improvements to the SoP sooner should funding become available. Both the properties at risk and the environmental habitats at risk are important drivers and factors in this area and should be considered going forward.

Table 9-3. Indicative partnership funding scores for unit IW15, assuming a 2057 baseline

Embankment Road / Yarbridge (2057 baseline)			
Approach	**Approximate scheme duration (years)**	**Whole life costs (PV)**	**Indicative PF score (raw)**
Scheme alternatives based on Unit IW15 costs and benefits alone:			
Embankment Road defence raising to 75yr SoP	60	£13,110k (Capital cost: £12.8m)	17%
Yarbridge alternative, 75yr SoP	60	£2,670k (Capital cost: £2.2m)	77%
Yarbridge alternative, 75yr SoP with intentional habitat creation	60	£14,200k (Capital cost: £13.7m)	146%*
Scheme alternatives based on combined costs and benefits in units IW22-24 and IW15:			
Embankment Road defence raising to 75yr SoP and Yaverland encasement	60	£17,415k (Capital costs: £12.8m Embankment Road £4.2m Yaverland)	32%
Yarbridge alternative, 75yr SoP and Yaverland encasement	60	£6,975k (Capital costs: £2.2m Yarbridge £4.2m Yaverland)	81%
Yarbridge alternative, 75yr SoP with intentional habitat creation and Yaverland encasement	60	£18,505k (Capital costs: £13.7m Yarbridge £4.2m Yaverland)	133%*

**note that the options marked with a * include OM4s for creation of 400 hectares of intertidal habitat, but would also require freshwater habitat compensation (at a significant cost) and finding the land for this is likely to be extremely challenging due to the size of the compensation required (approx. up to 400ha, including both designated and non-designated habitat –see section 8.1.2 for details).*
Please note: The approach taken to considering 'OM2' properties at risk in the table above is as follows:
-The economic assessment used an equivalencies approach to determine flood depths for future return periods with the existing defences in place or raised (i.e. for the Do Something options). This was necessary because there were not enough future return periods provided in the original modelling and it was proportionate and cost effective/efficient for the project to consider equivalencies rather than undertake additional modelling. However, as a result, only a selection of return periods were available for future time epochs for Do Something options and

these did not allow OM2 properties to be determined for schemes occurring from year 40 onwards (note however that the equivalency approach was suitable for determining OM2s for present day or schemes in the near future). This is not considered to be a major issue / risk for the project because the funding calculations for schemes this far into the future (i.e. 40 years) are inherently highly uncertain, given the fact that funding arrangements are very likely to change by this time period and realised rates of climate change could differ to those considered in the assessment.
-As a sensitivity test to consider the potential impact of including OM2s, the following scenario illustrates the impact of including approximately 600 OM2 properties benefiting from the scheme involving raising Embankment Road defence to 75yr SoP and Yaverland encasement scheme (original PF score of 32%). Assuming all of these properties are at significant risk (when in fact a number of the properties could be moderate or very significant risk), and as an illustration assuming they were in the 21-40% most deprived, prior to the scheme, and then moved to moderate risk after the scheme, the PF score increases only 10% (to 42%). This shows that even with a large amount of OM2s included, the impact on the PF score is limited (in this particular example of the combined scheme).
-When the preferred approach at Embankment Road is decided and at the time of scheme appraisal, it is recommended that further supporting modelling is undertaken. The modelling should be undertaken in line with the requirements of the FCERM appraisal guidance at the time to support a robust economic assessment and counting of OM2s (if they are still relevant, i.e. in ~40 years' time).

It should be noted (regarding table 9-3 above, and as further discussed in section 8.1.2) that for the majority of approaches/future schemes to mitigate increasing tidal flood risk to the Eastern Yar valley area, these are likely to require significant contributions, which have not currently been identified based on discussions to date. The indicative scheme costs and Partnership Funding scores listed in the table above, and also the map provided below in section 9.4, provide an indication of the scale of this future funding requirement to aid further discussions with key stakeholders and the community on the future of these vulnerable communities, infrastructure and important habitats.

It should also be noted that the scheme alternative listed in the table above with an indicative score above 100% (involving additional creation of intertidal habitat, consequent loss of freshwater habitat, and resulting freshwater habitat compensatory requirements) would require careful further consideration, and may not be acceptable or feasible due to stakeholder wishes, residual risk and/or whether or not there is an appropriate location(s) at which the necessary compensatory habitat could be provided within the required geographical area. This is likely to be extremely challenging due to the potential size of the compensation required.

Presently, embankment structures at Embankment Road and Culver Parade are reducing the risk of tidal (sea) flooding in this low-lying valley area, and continuing to maintain these structures in the short and medium term (as proposed by this study) provides time for further discussion on the future of this area, to consider of the implications of the new alternatives provided, and to seek funding contributions towards future investments to reduce risk. However, all future decision-making within this vulnerable floodplain area should continue to be made in full accordance with an awareness of the increasing potential future risks.

9.3.3 Maintenance

Existing maintenance plays a key role in reducing risks along the coastal defences and cliffs present in the Sandown Bay and Embankment Road study areas. Coastal defence structures are inspected and assessed alongside other maintenance needs based on risk. Repairs are prioritised and undertaken based on risk, with regard to urgency, budgetary constraints and seasonal working.

The study recognises the important role that continued maintenance plays in extending the life of existing coastal defences, having recognised the significant financial challenges in replacing the structures at the end of their service lives. Existing defences will continue to be maintained where the Isle of Wight Council, Environment Agency and asset owners decide to commit resource.

9.4 Indicative GiA availability and shortfalls along the frontage

Mapping showing the indicative funding availability for the proposed preferred options along the frontage has been developed. The maps show the PF scores and GiA percentage for the whole life options and benefits over 100 years, rather than the initial schemes (which are discussed earlier in this chapter). It is a useful tool to illustrate the areas along the frontage where funding is likely to be limited or more widely available. However, it should *not* be used to indicate the funding availability for the initial schemes or for schemes later on in the appraisal period. For each unit the scheme costs and benefits differ, and future costs are discounted in the assessment, as explained below. The mapping has been produced with the following assumptions and limitations:

- PF score and GiA percentage is based on the whole life option costs and benefits over 100 years and is therefore not representative of a score for initial schemes or later schemes.
- The economic discounting (which is required by national guidance, to take account of risk later in the appraisal period rather than immediately) is based on a present day baseline. This means that for schemes not needed until years 10-15 from now and the capital cost are reduced in the assessment because they are discounted). The maps show the costs in 'present value' (discounted) terms. The cash costs are higher, and are provided in Chapter 6 and 8.
- The map should be used to compare the potential for funding between options but does not indicate the exact amount of funding which may be available.
- A range of assets are at risk within the Eastern Yar Valley floodplain. These 'benefits' (i.e. what would be protected by works) are divided between the units at either end of the floodplain, at Yaverland (units 22-24) and Bembridge Harbour (unit 15). However, in reality, the flood cell will merge between these units to a different extent depending on the magnitude of the event.

The mapping is shown in Figure 9-2 and Figure 9-3.

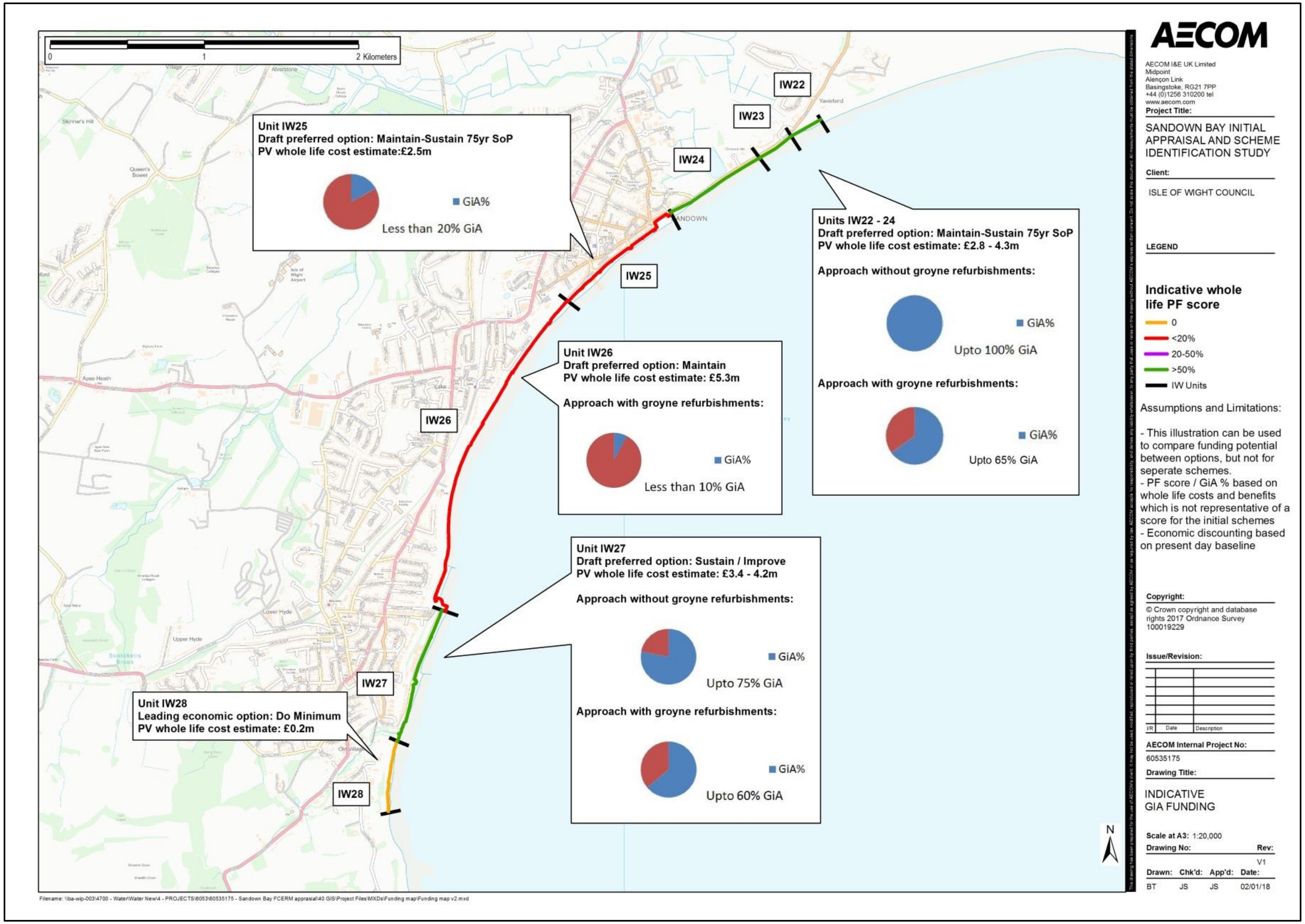

Figure 9-2. Indicative funding map for units IW22-28 (note PV refers to present value which takes into account cost discounting)

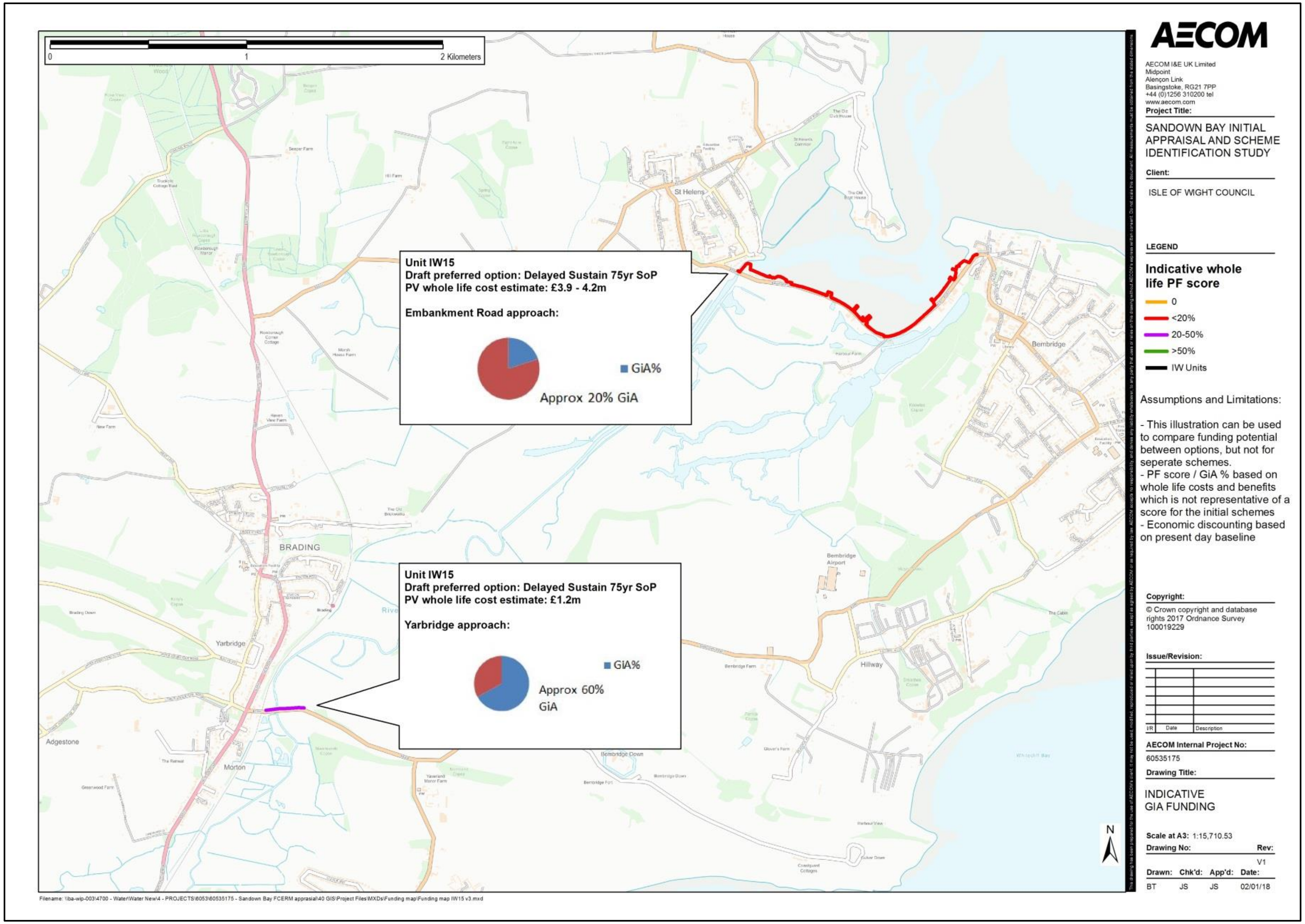

Figure 9-3. Indicative funding map for alternative approaches in unit IW15

10. Appendix A: Economic damages appraisal and costing

10.1 Background

An economic appraisal was carried out to determine the economic damages, option benefits and option costs. This appendix presents the methodology of the economic appraisal and a breakdown of the economic damages of the Do Nothing scenario.

10.2 Purpose of the economic appraisal

An economic appraisal compares the costs of particular coastal management options to the benefits arising from these options. Costs are associated with constructing and maintaining coastal defence structures and/or providing environmental enhancement opportunities. The benefits from implementing these options arise from protecting people, assets, infrastructure and the environment from flooding and coastal erosion.

The comparison is known as a cost-benefit analysis (CBA) and provides a rational and systematic framework for assessing the advantages and disadvantages of alternative options. This is achieved by expressing all of the potential costs and benefits of an option in a directly comparable unit of measurement; in monetary terms. By doing so, the costs and benefits of different options can be directly compared and treated consistently during the analysis. In simple economic terms, the most favourable option is defined as that which provides the greatest level of well-being for society as a whole for the lowest cost. An option is considered to be economical justifiable if the benefits outweigh the costs. This doesn't necessarily mean it should or will be implemented however, as there may be a more cost effective alternative, or an option which provides greater additional benefit for the extra cost required. Also just because it is economically advantageous doesn't necessarily mean there will be funding to deliver it.

The cost-benefit appraisal has been carried out as part of this study using the framework of the HM Treasury and Environment Agency Flood and Coastal Erosion Risk Management appraisal guidance (FCERM-AG, 2010). FCERM-AG represents the latest standard of cost-benefit analysis for all flood and coastal erosion risk projects in England.

10.3 Estimating Do Nothing Damages

An integral part of CBA is the baseline scenario of 'Do Nothing'. This scenario represents a hypothetical situation where no action is taken to manage flood and erosion risks. Do Nothing is effectively a 'walkaway' approach. For more information on the assumptions behind the Do Nothing scenario, refer to section 5.1.1.

Deriving the economic damage associated with Do Nothing is essential for the CBA as it provides the baseline to determine the benefits associated with the 'Do Minimum' and 'Do Something' options. For more information of the assumptions of the Do Minimum scenario, refer to section 5.1.2.

10.3.1 Estimating flood depths and extents

For the development of the economic appraisal the Do Nothing and Do Minimum flood depths in the study area were determined through hydrodynamic modelling and a GIS based approach.

The Environment Agency Coastal Modelling (2015) was supplied and used in this study (originally undertaken by Haskoning and updated by JBA). The TuFLOW hydrodynamic modelling software had previously been used to simulate flood depths in the study area for a selection of return period events for present day, 2025, 2070 and 2115. These modelling outputs were adopted and an equivalency approach was used to reclassify the return periods to the time epochs used in this study; present day, 2027, 2057 and 2117. Additional modelling was also undertaken for a selection of return periods for 2117.

The model simulations included the latest estimates of extreme water levels, corrected for future sea level rise changes. Wave overtopping was also applied where required.

Under the Do Nothing scenario the existing defences will be breached between IW22 and IW24 and it is assumed that this will occur between 2027 and 2057 when the defences have reached the end of their service life and erosion has commenced throughout the units. The existing hydrodynamic modelling does not include enough breach scenarios to undertake a robust economic appraisal and therefore additional return period flood depths following a breach were identified using a GIS based approach.

The damages associated with a breach were applied over time in increments to reflect the increasing risk of the defences breaching in the future (as they reach the end of their design life). This probabilistic approach is necessary because the exact timing of when the defences may fail / breach is unknown and it is not representative to lump all the breach damages into one year in the economic appraisal.

Table 10-1 provides a summary of the return periods that were used in the economic appraisal and how they were derived.

Table 10-1. Return periods used in the economic appraisal

Time period	Do Nothing		Do Minimum	
	Return period	Approach	Return period	Approach
Present day	1:5	Model	1:5	Model
	1:20	Model	1:20	Model
	1:50	Model - equivalency	1:50	Model - equivalency
	1:100	Model	1:100	Model
	1:200	Model	1:200	Model
	1:400	Model	1:400	Model
2027	1:2	Model - equivalency	1:2	Model - equivalency
	1:50	Model - equivalency	1:50	Model - equivalency
	1:100	Model - equivalency	1:100	Model - equivalency
	1:150	Model - equivalency	1:150	Model - equivalency
2057	1:2	GIS (breach)	1:1	Model - equivalency
	1:20	GIS (breach)	1:5	Model - equivalency
	1:75	GIS (breach)	1:20	Model - equivalency
	1:200	GIS (breach)	1:1000	Model - equivalency
2117	1:2	GIS (breach)	1:2	Model - equivalency
	1:20	GIS (breach)	1:5	Model
	1:75	GIS (breach)	1:20	Model
	1:200	GIS (breach)	1:50	Model – equivalency
			1:10000	Model - equivalency

The flood model results were output to GIS to facilitate the inspection of flood depths for assets within the flood areas for the range of return periods.

10.3.2 Identifying properties at risk - erosion

The latest erosion zones were provided by the Isle of Wight Council for the time epochs through the appraisal period (present day-2027; 2027-2057; 2057-2117), based on when each defence is expected to fail and a scenario of No Active Intervention.

The erosion zones were initially mapped for the Shoreline Management Plan (2010) but subsequent updates to these erosion zones have been made to account for an updated defence condition assessment and residual life (2016), as well as updated climate change and sea level rise allowances and a new baseline year.

For more information on how the erosion zones have been derived, refer to the Coastal Processes Report.

To identify properties at risk the Isle of Wight Council provided an address point dataset (National Receptor Database, 2011) which included the property address, post code, property type (e.g. residential, commercial, industrial etc.) and coordinates for all property assets in the study site. This point dataset was used in combination with OS building outlines to assess the assets at risk by comparing their position in relation to the erosion zones. Based on the distance of the property from the start of each zone, the year when the property is expected to erode was identified. Assets were included in the erosion risk areas if any part of the property falls within 5m of the zone (determined by buffering the zones in GIS).

The erosion zones correspond with a No Active Intervention (NAI) approach and are suitable to represent the Do Nothing scenario. However, Do Minimum assumes that the existing defences will be maintained to prolong their life slightly and that the residual life of the defences will be extended by approximately 10 years. Therefore, to identify when assets will be lost to erosion under the Do Minimum scenario, the year of loss from the NAI erosion zones has been delayed by 10 years.

10.3.3 Identifying properties at risk – flooding

To identify properties at risk, the address point dataset (National Receptor Database, 2011) was used. The database was checked to remove duplicate address points and also to remove upper floor properties from accruing flood damages.

Flood depths for each individual property were obtained by conducting a point inspection in GIS. The depths were determined using the property location and the flood modelling for each return period. A property threshold level of 0.001m was applied. This is justified because no basement areas have been allowed for in the economic analysis, therefore flood damages were only counted for flood depths greater than the property level.

10.3.4 Residential Flood depth damages

Residential flood damages were obtained from the Multi-Coloured Manual (MCM, Penning-Rowsell, 2013) and updated to the latest prices (March, 2017) using the Consumer Price Index (see Table 10-2). The value of flood damage was based on the residential property type (detached, semi, terrace, flat etc.) and the depth of flooding for each property for each flood scenario. Values for ‘short duration, salt water, major flood, sewage’ were adjusted by a factor of 1.056 to allow for the emergency costs that can be justified as real economic costs, not counted elsewhere in the benefit appraisals as recommended in the MCM.

Intangible health damages were also included in the appraisal at a rate of £2,513 per residential property at risk of flooding (in accordance a study published by Middlesex University; *Appraisal of local economic and social benefits of Exeter flood alleviation scheme, 2013*). Damage to vehicles affected by flooding was considered at a rate of £3,100 per vehicle (in accordance with MCM, 2015). An evacuation cost of £793 per household at risk of flooding was also included in the appraisal (in accordance with MCM, 2015).

10.3.5 Commercial Flood depth damages

Commercial property damages were also obtained from the Multi-Coloured Manual (MCM, Penning-Rowsell, 2013) and updated to the latest prices (March, 2017) using the Consumer Price Index (see Table 10-3). The property damages are based on the commercial property type, the footprint area (m^2) and the depth of flooding for each of the modelled water levels. Values for ‘short duration, warning, no cellar, salt water’ were used.

Emergency evacuation costs, vehicle damages and intangible health benefits are not applicable to commercial properties.

Properties at the Sandown waste water treatment works have been included in the assessment. In future work and scheme appraisals it is recommended that site specific information from this site is obtained for more detailed consideration in the scheme benefits. Aspects to consider include the strategic importance of this site to the Isle of Wight, the provision of any onsite measures to reduce the vulnerability to flooding or to reduce the risk, and the standard of protection provided to which buildings.

10.3.6 Write off and capping damages - valuing property loss

In accordance with FCERM-AG, residential and commercial properties were defined as written off once flooded by an event of 1:3 year return period or less, as the property would be no longer habitable or functional. Once written off, these properties would no longer accrue flooding or erosion damages. The guidance also requires that property flood damages over the appraisal period must not exceed the property market value. The cumulative damages were monitored for each property and once they exceeded the property value, further flood damages were capped and the property was written off.

The value of each residential property was required to consider potential write off within the economic analysis. Average house price sales for 2016 were obtained from home.co.uk (April, 2017). The data was averaged by post code region (PO33, PO35, PO36 and PO37) for each residential property type (detached, semi, terrace, bungalow and flat). These were then applied to each property in the appraisal, for the purpose of write off and capping.

The commercial properties were valued on the rateable value for their business type (provided by the valuation office). Average values for retail, workshops, industry, warehouses and offices between £35/m^2 and £155/m^2 were estimated and then multiplied by the building floor space to estimate the rentable value of the business. In accordance with FCERM-AG, the rentable values were then divided by the business yield (~6%) to provide an estimate of the market value for flood damage, capping and write off purposes.

A manual check was carried out to ensure that the property valuations were realistic in relation to asset size and function. Where required these property values were estimated based on the construction costs of similar commercial properties or developments. The values of the top 15 properties were manually inspected and verified.

Table 10-2. Residential flood damages adopted from the MCM (2015). Values adjusted to account for emergency uplift and March 2017 (latest available) CPI.

Short duration, salt water, major flood, sewage. March 2017 CPI uplift inc. Emergency Costs.															
Property type	Component	Depths (m)													
		<0.05	0.05	0.1	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3
Detached	Total damage	1038	9905	16578	28650	35302	42179	46334	51063	55932	61320	65736	69536	78028	82370
Semi-detached	Total damage	1389	6979	11228	19009	23174	27985	30305	33366	36250	39605	42676	45730	51858	54777
Terrace	Total damage	1207	6465	10218	17457	21191	25793	27812	30427	32793	35505	37815	40148	45771	48119
Bungalow	Total damage	970	10548	17024	27517	33096	40012	44273	49093	54099	59743	64489	68899	77629	81965
Flat	Total damage	810	6755	11021	18856	22921	28070	30326	32677	34689	36986	38822	40248	45042	46968

Table 10-3. Non-residential flood damages adopted from the MCM (2015). Values adjusted to account for emergency uplift and March 2017 (latest available) CPI.

Short duration, warning, no cellar, indicative. March 2017 CPI uplift inc. Emergency Costs													
Property type	Depths (m)												
	<0.25	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3
Retail	46	268	426	586	739	855	964	1062	1208	1295	1358	1387	1428
Offices	55	282	447	572	693	768	853	957	1089	1181	1248	1279	1322
Warehouses	18	297	518	675	821	933	1023	1114	1161	1180	1210	1219	1248
Public buildings	28	163	235	298	364	411	469	533	614	684	721	736	756
Industry	10	62	99	127	159	185	212	239	278	304	329	347	368
Leisure	197	531	647	743	842	915	1005	1101	1223	1321	1389	1420	1458
Playing field	1	3	5	7	8	9	9	10	12	13	13	14	15
Sports centre	23	130	177	219	264	292	350	411	485	545	571	582	596
Sports stadium	5	31	49	64	81	90	104	114	134	143	150	154	157
Marina	11	34	46	66	84	97	108	122	144	165	182	195	213
Car park	2	9	12	15	20	24	30	38	51	83	97	103	115
Substation	13	979	1311	1638	2574	3205	4136	4471	5766	5791	5815	5831	5841

10.3.7 Discount rate

Discounting is a technique used to compare benefits (and costs) that occur at different points in time over the appraisal period (i.e. the next 100 years). Standard discount rates have been used to convert all cash damages to 'present values' (PV). This enables the whole life benefits (and costs) of each management option to be compared and also leads to a realistic assessment of the cost implications of each option in today's terms. According to FCERM-AG, the following variable discount rates have been used within the economic appraisal; 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 (HM Treasury Green Book, 2003).

The annual average (non-discounted, cash) damages were discounted over the appraisal period to calculate the discounted whole life Do Nothing PV damages.

As an example of discounting applied to the economics assessment, if a property valued at £100k (in cash terms) was to be written off in year 10 (i.e. towards the start of the appraisal period) the discount applied in year 10 is 0.71 so therefore the economic damage associated with loss of the property (in PV terms) would be £71k. If the property was instead not written off until year 80 (towards the end of the appraisal period) the discount applied in year 80 is 0.08 so therefore the economic damage would be £8k (in PV terms)

10.3.8 Indirect flood and erosion damages

In addition to the direct flood and erosion damages to residential and commercial property, indirect losses have also been considered. Indirect flood losses reflect deviations from the economic theory that suggests that in a perfectly competitive world, all sales or production would simply transfer to a competitor with no financial loss to the nation as a whole. In reality, deviations from the competitive model exist and trade cannot simply be transferred, leading to indirect damages.

With regard to this study, the transport infrastructure, environment and recreation were identified as three areas likely to benefit from improved flood protection.

Travel disruption - road

Under the Do Nothing scenario Embankment Road is expected to at risk of erosion (severance) at some point during epoch 2, between years 10 and year 40 (at the start of epoch 3). Erosion impacts or a breach could occur before this, but conservatively this has been assumed to occur towards at the end of the residual life of the structure. Erosion / a breach of the road will leave it impassable and vehicles will need to be re-routed by at least an additional 10.1km to get to their desired location. There is not a clear alternative location for a new road to be constructed and therefore in the economic appraisal the annual indirect damages associated with the loss of the road have been accrued from year 40 to year 99.

The Environment Agency approved Eastern Yar Strategy provides annual traffic disruption costs associated with temporary closure / loss of Embankment Road. These costs have been sense checked and adopted in this economic appraisal. The damages estimated in the Eastern Yar Strategy were derived in 2010 and given their magnitude in relation to other damages, and in order to be conservative in this appraisal, the damages have not been uplifted to present day costs.

The total annual damage in year 2057 (year 40 in the appraisal) is estimated to be £639k. By 2117 the annual damage is estimated to be £1,573k. The increase in damage over the appraisal period reflects the predicted rise in resource cost of fuel, predicted fuel efficiencies and increases in the relative value of time (Eastern Yar Strategy, Economics Appendix, 2010).

An additional road traffic damage associated with a potential breach at Culver Parade (between Yaverland and Sandown) has also been included in the Do Nothing damages. If the Culver Parade defences were to breach (as per the Do Nothing scenario) the road at Culver Parade (due to erosion) and also the obvious diversion route following the main road between Sandown and Brading would be inaccessible (due to inundation). Therefore, to travel between Sandown and Brading traffic would need to take a much longer diversion through Winford and Alverstone. The indirect damage associated with this diversion has been calculated at approximately £3.6m each year after the breach has occurred. However, rather than applying this damage annually it has been considered more conservative to apply a one-off cost of protecting the main road between Sandown and Brading from inundation as this damage would only be required once and not on a recurring basis. The cost of protecting the road from inundation (construction of a setback floodwall approx. 600m long) has been estimated to be £3.6m.

Travel disruption – rail

Under the Do Nothing scenario a breach of Embankment Road (or Culver Parade) increases the flood risk to the national rail line between Brading and Shanklin. Inspection of the flood mapping suggests with a breach of Embankment Road, by 2057 the rail line adjacent to Brading Marshes (near Yarbridge) floods from a 1:2 year event or greater.

The potential damage associated with flood risk to the rail line has been quantified in accordance with the MCM guidance by using the 'Passenger Value of Time (VOT)' method. Passenger numbers from Sandown station were used in the valuation (approximately 97,000 passengers per year) and for each flood event which leads to a delay or closure of the rail line, the estimated economic damage is £403k.

The rail line is also at risk from erosion between Lake and Shanklin from year 92 onwards. There is no alternative route to relocate the rail line along this frontage and the damages associated with a permanent loss of the track have been valued at £1,680k per year after erosion.

Environment – loss of habitat

One of the key features of the study site is the SPA freshwater marshes at Brading. Under the Do Nothing scenario, a breach of Embankment Road and the defences at Sandown will lead to this area inundating on a regular basis, potentially damaging and destroying the current habitat.

The economic value of the existing habitat has been monetised in the approved Eastern Yar Strategy (2010). The valuation was based on the Woodward and Wui (2001) estimate value of wetland provision which gives a value of £200, £700 and £2200 per hectare for low, mid and high value wetland.

Brading Marsh is a BAP habitat, SPA, Ramsar site with SAC lagoons and therefore this was given a high value (£2200) for its 291.1 Ha. There is an additional 26.5 Ha of SSSI habitat which was given the mid value (£700). These values are summed to provide a total annual value of £659k.

Under the Do Nothing scenario the habitat is expected to be lost after the existing defences breach. This has conservatively been assumed to be from year 40 in the economic appraisal (at the end of epoch 2) because the defences are expected to have breached at some point before this (during epoch 2) at the end of the defence residual life. The indirect damages associated with the loss of the habitat have been accrued annually from year 40 through to year 99. However, in reality there is a risk that a breach could occur before this point which would bring forward in time the significant economic damages associated with the environment.

Recreation – loss of visitors

The waterfront at Sandown / Shanklin is a popular tourist location with a long beach, promenade and popular seafront amenities. This recreational environment is an important source of income to the area.

Using visitor count data collected during a site visit to the study area it was estimated that there are approximately 550,000 visits per year to the Sandown / Shanklin frontage. The visitor count was collected during a weekday in the month of May (2017) and it is considered representative of the daily average (not during peak season or winter). The Bay Coastal Community Team also estimates a figure of half a million visitors per year to the area (http://arc-consulting.co.uk/projects/the-bay-coastal-community-team/) and a separate visitor count carried out by an IWC project team member estimated visitor numbers to be similar.

Under a Do Nothing scenario the promenade and beach are expected to erode in the future which is likely to leave the site inaccessible. Typically the method to estimate damages associated with loss of visitors is to multiply the number of visitors by the cost of the visit. However, in instances where visitors can be transferred to a nearby area, the MCM recommends that the economic damage is worked out by determining the total additional travel costs incurred to visit the nearby area.

The nearest comparable alternative is Ventnor, approximately 7km away by road and it was assumed that approximately 25% of the existing visitors would travel by vehicle to the alternative site. This equates to an annual economic damage of approximately £315k.

Loss of life

The indirect damages associated with potential loss of life from a flood event have been estimated by following the Defra *Flood and Coastal Defence appraisal guidance; Social Appraisal, Supplementary Notice to Operating*

Authorities – Assessing and Valuing the Risk to Life from Flooding for the Use in Appraisal of Risk Management Measures (2008).

By utilising this guidance and following the 'Risks to People' method, the loss of life (£) per magnitude of flood event was estimated. This calculation was based upon a number of variables for the appraisal area that included the flood hazard rating (variables include the depth and flow of water and the debris factor), the area vulnerability rating (variables include presence of a flood warning system, speed of flood onset and the nature of the area), and the people vulnerability rating (age of population, health of population). The loss of life (£) for each magnitude of flood event was then factored by the probability of the flood event occurring to determine an annual loss of life damage.

Under the Do Nothing scenario there is no loss of life damage during epochs 1&2, and it is not until the start of epoch 3 that a loss of life damage is accrued (approximately £5.5m as a one-off cash damage).

10.3.9 Do Nothing damages

The number of properties expected to be at risk over the next 100 years from both flooding (1:200 year event) and erosion for the Do Nothing scenario are presented in Table 10-4 below.

Table 10-4. Properties at risk of flooding (1:200 year event) and erosion (cumulative) over the next 100 years

Year	Residential properties at risk of flooding (1:200 year event)	Commercial properties at risk of flooding (1:200 year event)	Total properties at risk of flooding (1:200 year event)	Total properties at risk of erosion (cumulative)
Present day	10	23	33	0
2057*	358	232	590	300
2117	469	253	722	661

**Note that the drastic increase in properties at risk between present day and 2057 relates to the assumed breach of the defences between Yaverland / Sandown and/or Embankment Road that is expected to occur between 2027 and 2057.*

The present value (PV) damages across the study area under the Do Nothing scenario are presented in Table 10-5 below. The total PV damages for the next 100 years are approximately £105m.

Table 10-5. Present value and cash damages over the next 100 years under the Do Nothing scenario

PV Flood (£k)	PV Erosion (£k)	PV indirect (£k)	PV total (£k)
48,009	30,805	26,199	105,014
Cash Flood (£k)	**Cash Erosion (£k)**	**Cash indirect (£k)**	**Cash total (£k)**
138,588	116,746	179,490	434,824

Cumulative PV damages for the entire study frontage are presented in Figure 10-1 below. The large step in damages at year 10 and years 20, 30 and 40 relate to the assumptions of the Do Nothing scenario; a number of properties at Shanklin are written off in year 10 (loss of access) and the damages associated with a breach of the existing defences at Embankment Road and Sandown have been applied incrementally in years 10, 20, 30 and 40 (leading to flood write off damages to the area behind).

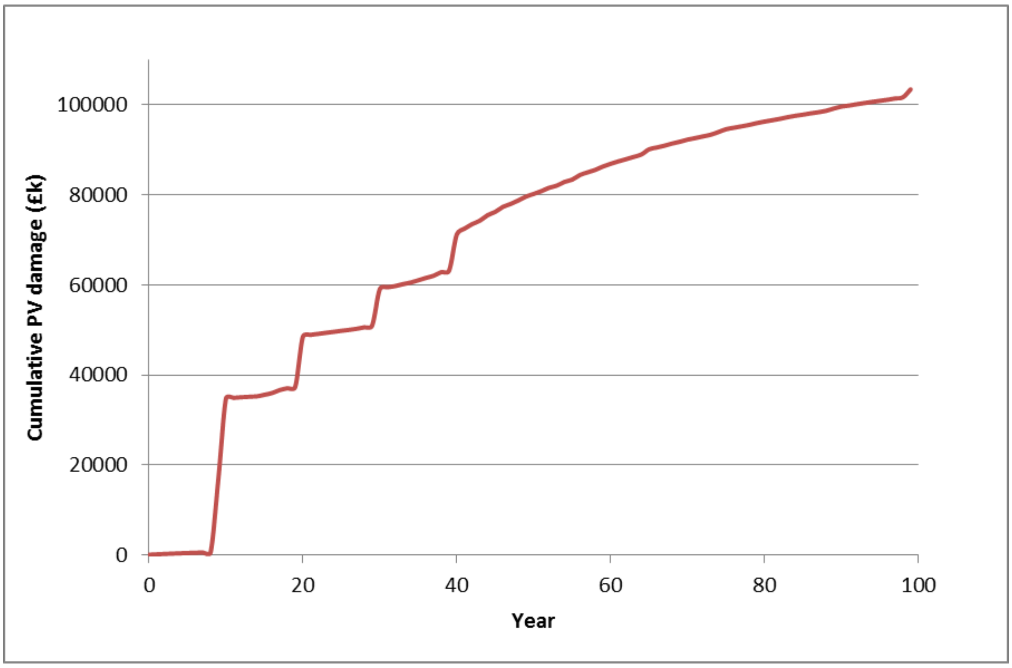

Figure 10-1. Cumulative PV Do Nothing damages

To inform the option appraisal process the Do Nothing damages have been split up and distributed by unit (or unit groups). Based on this division the damages for IW15 refer to the area to the north of Yarbridge, between Embankment Road and downstream of where the Eastern Yar channel flows beneath Marshcombe Shute Road. Whilst the damages have been divided in this way it is important to recognise that the Eastern Yar floodcell merges across units (IW15, 22, 23 and 24) and therefore in order to deliver options with a certain SoP in one of these units, it will also be necessary to provide the same standard in the other units of this flood cell.

Table 10-6. Present value damages over the next 100 years under the Do Nothing scenario; distributed by unit

Unit	PV Flood (£k)	PV Erosion (£k)	PV indirect (£k)	PV total (£k)	% of total PV damages
IW15*	6,027	0	9,646	15,673	15
IW21	0	370	0	370	0
IW22	7,037	100	3,597	10,734	10
IW23	0	151	1,816	1,967	1
IW24	34,608	1,098	8,695	44,401	42
IW25	338	7,295	618	8,251	8
IW26	0	4,382	1,224	5,606	5
IW27	0	16,874	602	17,477	17
IW28	0	536	0	536	1
Total	**48,010**	**30,805**	**26,199**	**105,014**	**100**

**Note that IW15 damages refer to the area to the north of Yarbridge, between Embankment Road and downstream of where the Eastern Yar channel flows beneath Marshcombe Shute road.*

10.4 Estimating Option costs

Cost estimates for the different management options have been developed on a unit by unit basis. Whole life costs for the options consider the combination of different measures through time, the length and height of the measures and their capital cost, and also the maintenance costs required to sustain the performance and operation of the measures. Whole life costs are also discounted by applying the same discount rates as the option benefits / damages.

10.4.1 Approach to capital construction costs

The cost estimations for capital works were undertaken using the best available information from a variety of sources. In the first instance, where actual defence costs were available from previous projects or published data, these costs have been used as a basis for relevant options in this study.

Values have been estimated from rates provided in civil engineering price books (e.g. SPONS, 2016) and Environment Agency guidance, coupled with experience of costs from similar projects. The Environment Agency guidance documents utilised in the costing exercise are;

- *Environment Agency (2015) Delivering benefits through evidence, cost estimation for coastal protection – summary of evidence. Report SC080039/R7*
- *Environment Agency (2015) Delivering benefits through evidence, cost estimation for fluvial protection – summary of evidence. Report SC080039/R2*
- *Environment Agency (2015) Delivering benefits through evidence, cost estimation for control assets – summary of evidence. Report SC080039/R5*

For a number of the defence structures considered, the cost of the structure varied with height (e.g. floodwalls, crest raising, seawalls, revetments and embankments). Therefore, it was necessary to determine the height of the structure that was required. This information was attained by undertaking a GIS analysis of the existing defence/shoreline elevation and the elevation required to achieve a desired SoP. This allowed the necessary height of each defence structure to be established.

A suitable allowance for preliminary costs, which include appraisal costs have been included in the capital cost estimates. These costs are expected to cover the additional studies / appraisal works which have been mentioned / recommended in this report.

Optimism Bias

In line with FCERM-AG policy, an optimism bias of 60% was applied to the capital construction costs for each management option. Optimism bias;

"is included to account for the tendency for appraisers to be overly optimistic in early assessment of project costs, timescales and benefits in comparison to the final values. This 'optimism' is a result of uncertainty in the final design detail and implementation as a result of high level approach required at this stage.

To counter this, the HM Treasury issued guidance in the form of a percentage to increase the present value costs depending on the uncertainty surrounding the estimates. This guidance has been adopted within the FCERM-AG. With regard to Coastal Strategies the FCERM-AG recommends an optimism bias level of 60% as these projects are typically at an early stage and adopt a higher level approach to design and costing" (Flood and Coastal Erosion Risk Management appraisal guidance – environment agency, 2010).

A few exceptions have been made when applying optimism bias. The costs of Property Level Protection have not included any optimism bias because they are based on a standard grant allowance any therefore are unlikely to differ from this. Note also that the cost for maintenance does not include optimism bias because this is based on actual spend rates obtained from the Council (see section 10.4.2 for more details).

Unit costs

Table 10-7 below provides a summary of the estimated unit costs for the different measures which were used when producing the management options.

Table 10-7. Summary of measure unit costs (including 60% optimism bias)

Measure	Units	Cost (£) inc. 60% OB	Source
Capital refurbishment – resurface / spraying	Per m length, 2-4m high	Up to £1400 per m of structure	Scaled from contractor price estimate – WW Strategy
Capital refurbishment – masonry seawall refurbishment	Per m length, 1-4m high	Up to 3k per m of structure	SPONS unit costing. Varies depending on masonry type and finish. Mid-range estimate adopted in costing
Capital refurbishment – encasement	Per m length, 4m high	£3600	Cromer cost example. Includes sheet pile toe protection
Capital refurbishment – timber **groynes**	Per groyne, 10-30% material replacement	£21,000 – £64,000	Contractor price estimate - Mundesley groyne refurbishment costs
Beach nourishment	Per m^3 of material	£14-51	Adopted mid-point of EA guidance range in costing
Beach recycling	Per m^3 of material (2.5km haul)	£13	ESCP cost example. More conservative than EA example.
Groynes – timber	Per m length	£2,900	Contractor price estimate - Mundesley groyne costs. Roughly mid-range of EA cost estimate
Groynes – concrete	Per m length	£7,200	First principals scaled up approach
Gabions	Per m length (1-3m high)	£600 – £1,800	SPONS build-up (2016)
Concrete Revetment	Per m length (up to 1m higher than existing defences)	£4,900 - £7,400	EA guidance
Rock Revetment	Per m length	Approx. £3k	SPONS build-up (2016). Prices can vary depending on size / rock import arrangements so there is a lot of variability in potential costs.
Seawall	Per m length (up to 1m higher than existing defences)	Up to £7,400	EA guidance
Crest raising	Per m length (up to 1m high)	£1,000 – £2,400	EA guidance
Wave return	Per m length	£2,400	EA guidance
Setback floodwall	Per m length (0.5-1.5m high)	£2,000 - £6,400	SPONS build-up (2016)
Setback embankment	Per m length (1-4.5m high)	£1,900 - £10,600	SPONS build-up (2016)
Road raising	Per m length	£7,600	SPONS build-up (2016)
Temporary defences	Per m length, 0.9m high	£900	Contractor price estimate – WW Strategy
PLP	Per property	£5,000 (not including OB)	Grant eligibility
Yarbridge tide gates	Per set of gates, 10m wide	£520,000	EA guidance

10.4.2 Approach to maintenance costs

In addition to the capital (design and construction) costs, maintenance costs also contributed to the whole life option costs that were estimated. Maintenance costs refer to the costs for periodic or annual maintenance works that are required to maintain the structural integrity of the defences.

Patch and repair maintenance costs were based on information from the IoW Council who provided information on the expenditure on maintaining the Sandown to Shanklin coastal frontage over the last several years. Excluding costs associated with cliff stabilisations works, the current average maintenance expenditure for the frontage between Yaverland and Shanklin (IW22 to IW28) is estimated to be approximately £32k per year. The frontage in these units is approximately 5.8km long so annual expenditure equates to approximately £5.5 per metre of shoreline (the total defence length exceeds 5.8km due to presence of groynes perpendicular to the frontage). It is recognised that this is not necessarily the required or desired level of investment to maintain coastal defence assets but it is reflective of the current economic climate and budgetary constraints. It is therefore a realistic cost to use for this measure which will help ‘sweat the assets’ to prolong their life.

In units IW26-28 maintenance costs also include an allowance for cliff stabilisation measures. The same approach to costing cliff stabilisation has been used whereby costs are based on the recent expenditure of the IoW Council. An average cost of £4 per metre of cliff frontage per year has been applied.

10.4.3 Whole life costs

The capital and maintenance costs were combined for the sequence of measures in each management option to produce a whole life cash cost. Discounting was then applied to allow the whole life ‘present value’ cost of options to be compared to the option benefits. The present value and cash costs of the options are outlined in Chapter 6. For further details and information on options costing see supporting cost build-up spreadsheet.

Appendix B: Environmental Appraisal

Sandown Bay Initial Appraisal and Scheme Identification Study – High Level Environmental Appraisal of the Longlist Options

Classifications

Red – Potentially substantial adverse environmental impacts

Amber – Environmental benefits and enhancements but also adverse environmental impacts, or unlikely to result in a substantial change to the current environmental baseline

Green – Environmental benefits and enhancements and no detrimental impacts

Please also refer to the Environmental Baseline Report (2017) for this study, for full supporting information.

Note: These areas all have Hold The Line policies set at SMP level (2011). Therefore impacts of coastal squeeze etc. were taken into account of at a high-level in the SMP approval and RHCP process.

IW 15 – Embankment Road

Assumptions - Defences will be proposed along the full extent of the study area. It is assumed that the gabions, revetment and seawall options presented will be frontline and installed in front of the existing defences and that they would therefore encroach into the intertidal area. However, it is assumed that that defences would be designed to limit the amount of encroachment. It is assumed that the setback flood wall would be built along the existing road and that it would not encroach and involve landtake from the designations that lie behind the road in this study area.

Option (Method)	Environmental Score	Comments on scoring
Reactive patch and repair		This option provides initial protection from coastal erosion but no additional protection against flooding. Therefore, properties and parts of the Bembridge Conservation Area within the study area could remain at risk of flooding as overtopping risk increases. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. Impacts will worsen once existing structures reach the end of their life. There is the potential for temporary adverse impacts due to disruption to the Solent and Southampton Water SPA and Ramsar and Bembridge rMCZ should any of the maintenance activities be undertaken within the intertidal zone. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could be experienced during the periods of maintenance.
Capital Refurbishment		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties and parts of the Bembridge Conservation Area within the study area could remain at risk of flooding. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. There is the potential for temporary adverse impacts due to disruption to the Solent and Southampton Water SPA and Ramsar and Bembridge rMCZ should any of the maintenance activities be undertaken within the intertidal zone. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could be experienced during the periods of maintenance.
Gabions		This option provides protection from coastal erosion but no additional protection against flooding. Some properties and parts of the Bembridge Conservation Area within the study area could remain at risk of flooding. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the designated sites present in this area. It could lead to coastal squeeze and loss of intertidal habitat within the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Setback Floodwall		This option provides an increased standard of protection to properties within the study area. This option could provide protection from flooding to a small part of the Bembridge Conservation Area and associated listed buildings, depending on how far the flood wall is setback at its eastern end. Construction activities could potentially take place within the footprint of both the 'Embankment Road' and 'Pilots House Site' historic landfill sites, but once constructed would protect both sites from erosion and flooding. This option could prevent water percolation and have permanent adverse impacts on the Solent & Isle of Wight Lagoons SAC. However, it would also provide protection from saltwater inundation to substantial freshwater designated habitats . It is assumed that the setback floodwall could be located on the existing embankment (e.g. at the back of the road) and would not encroach into the Solent and Southampton Water SPA and Ramsar site, Bembridge rMCZ and the Solent & Isle of Wight Lagoons SAC designations that lie behind the road in this location. By contrast, as new setback embankment (which was scoped out) would encroach into the designated areas and would require landtake from the designated sites..

Option (Method)	Environmental Score	Comments on scoring
		This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Revetment		This option provides protection from coastal erosion and is likely to provide some additional protection against flooding. However, some properties and parts of the Bembridge Conservation Area within the study area could still remain at risk of flooding. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the designated sites present in this area. It could lead to coastal squeeze and loss of intertidal habitat within the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Seawall		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings and the Bembridge Conservation Area and Eastern Yar valley from coastal erosion and flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the designated sites present in this area. It could lead to coastal squeeze and loss of intertidal habitat within the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Road Raising		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings and the Bembridge Conservation Area from coastal erosion and flooding. This option is likely to result in some changes to the local landscape and has the potential to result in some adverse effects on the setting of the Bembridge Conservation Area. There is the potential for temporary adverse effects in relation to disturbance to the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ during construction, but any adverse effects are likely to be temporary.
Water Level controls (at Yarbridge)		This option will provide a cut-off point to surface waters within the Eastern Yar valley floodplain, protecting residential properties in the Sandown area. However, this option does not mitigate flood risk at Embankment Road and could result in the inundation of land behind Embankment Road when operational. Therefore, this option could result in structural damage to listed buildings that are located within the floodplain at Brading Station. It could also result in the inundation of 'Yar Bridge', 'Yaverland Old Tip', 'Embankment Road' and 'Pilots House Site' historic landfill sites. 'Embankment Road' and 'Pilots House Site' historic landfill sites would also be at risk from coastal erosion. Inundation of the floodplain could lead to the creation of new habitats, but this would need to be considered against the potential loss of the existing habitats within this area which is designated as the Solent and Southampton Water SPA and Ramsar site, Brading Marshes to St Helen's Ledges SSSI and the Solent & Isle of Wight SAC.
Temporary Defences and Property Level Protection		The option provides additional flood protection to properties within the study area, but it cannot provide a high standard of protection. Both the 'Embankment Road' and 'Pilots House Site' historic landfill sites would remain at risk from flooding. This option would provide some protection from flooding to listed buildings and parts of the Bembridge Conservation Area but could result in temporary adverse setting impacts when the temporary defences are in place. The Property Level Protection measures may also have some permanent adverse setting impacts, particularly if installed within the Conservation Area or to any of the listed buildings. Given the nature of this option, it will not impact on the ecologically designated sites within the study area and will have limited potential for impacts on the existing local landscape.

IW 22-25 –Yaverland to Culver Parade, Sandown

Assumptions - Defences will be proposed along the full extent of the study area. It is assumed that the only options which will extend into the intertidal area are the groyne improvement and groyne construction options, and new revetment..

Option (Method)	Environmental Score	Comments on scoring
Reactive patch and repair		This option provides initial protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding as overtopping risk increases. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. Impacts would worsen once existing structures reach the end of their life. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Solent and Dorset Coast pSPA and Bembridge rMCZ. If any of the maintenance activities be undertaken within the intertidal zone, there could also be disruption to the South Wight Maritime SAC. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could also be experienced during the periods of maintenance.
Capital Refurbishment of seawall / revetments		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Solent and Dorset Coast pSPA and Bembridge rMCZ.
Capital Refurbishment of groynes		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option will not involve lengthening of the groynes into the sub-tidal areas. For timber groynes the refurbishment will be within the existing footprint of the defence. For masonry groynes additional concrete used to refurbish the defence could potentially be applied either side of the structure minimally increasing the footprint (longshore) but will not extend the structure seawards. Consequently, there is the potential for temporary adverse impacts due to disruption to the Solent and Dorset Coast pSPA and Bembridge rMCZ. If any of the maintenance activities are undertaken within the intertidal and especially the subtidal zone (especially in the north of this frontage), there could also be disruption to the South Wight Maritime SAC. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Beach Recycling		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ during the beach recycling process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The movement of sediment within the existing frontage could have impacts on local features within the South Wight Maritime SAC and also have impacts further down the coast at Bembridge Down SSSI (also SAC) as a result of changes in sediment movements. Potential for impacts at both the collection and distribution sites within Sandown Bay (designated sites, including the South Wight SAC and Bembridge Down SSSI).

Option (Method)	Environmental Score	Comments on scoring
Beach Nourishment		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ during the beach nourishment process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The provision of large quantities of new sediment could also have impacts on designated features within the Bay and further down the coast at Bembridge Down SSSI and Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements.
Gabions		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ, but is unlikely to require landtake from the intertidal area. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument.
Groyne Improvement		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat (e.g. due to groyne lengthening). The extension to existing groynes could also have impacts further down the coast at Bembridge Down SSSI and the Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Groyne Construction		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat. The provision of new groynes could also have impacts further down the coast at Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Revetment		This option provides protection from coastal erosion and is likely to provide some additional protection against flooding. However, some properties within the study area could still be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not entirely from flooding.

Option (Method)	Environmental Score	Comments on scoring
		Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Solent and Dorset Coast pSPA and Bembridge rMCZ. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument.
Seawall		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Solent and Dorset Coast pSPA and Bembridge rMCZ, but is unlikely to require landtake from the intertidal area if built as close as possible to the current structures. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction.
Crest Raising / wave return		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area as a result of the introduction of extension of existing structures within and in close proximity to the Conservation Area and Scheduled Monument. There is the potential for temporary adverse effects in relation to disturbance to the Solent and Dorset Coast pSPA and Bembridge rMCZ during construction.
Setback Floodwall		This option provides an increased standard of protection to properties within the study area. However, whilst this option will provide protection from erosion and flooding to large parts of the Sandown Conservation Area, associated listed buildings and Sandown Barrack Battery Scheduled Monument, not all parts would be protected depending on how far the flood wall is setback. It is assumed that the setback floodwall would not encroach into any designated sites within the area. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument.
Road Raising		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some changes to the local landscape and has the potential to result in some adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. There is the potential for temporary adverse effects in relation to disturbance to the Solent and Dorset Coast pSPA and Bembridge rMCZ during construction.

IW 26 – 28 – Lake cliffs, Shanklin Esplanade and Luccombe cliffs

Assumptions - Defences will be proposed along the full extent of the study area. It is assumed that the options presented will be frontline and installed within the intertidal area, unless stated that the option is set back or on the road.

Option (Method)	Environmental Score	Comments on scoring
Reactive patch and repair		This option provides initial protection from coastal erosion but no additional protection against flooding/overtopping. Therefore, properties within the study area could be at risk of flooding (overtopping). This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion. Impacts will worsen once existing structures reach the end of their life. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Bembridge rMCZ. If any of the maintenance activities be undertaken within the intertidal zone, there could also be disruption to the adjacent South Wight Maritime SAC. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could also be experienced during the periods of maintenance.
Capital Refurbishment of seawalls / revetments		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Bembridge rMCZ.
Capital Refurbishment of groynes		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option will not involve lengthening of the groynes into the sub-tidal areas. For timber groynes the refurbishment will be within the existing footprint of the defence. For masonry groynes additional concrete used to refurbish the defence could potentially be applied either side of the structure minimally increasing the footprint (longshore) but will not extend the structure seawards. Consequently, there is the potential for temporary adverse impacts due to disruption to the Bembridge rMCZ. If any of the maintenance activities will be undertaken within the intertidal and subtidal zone, there could also be disruption to the South Wight Maritime SAC (generally below the LWM). This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Beach Recycling		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Bembridge rMCZ during the beach recycling process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The movement of sediment within the existing frontage could have impacts on local features within the South Wight Maritime SAC (including near Hope beach) and also have impacts further down the coast at Bembridge Down SSSI (also SAC) as a result of changes in sediment movements. Potential for impacts at both the collection and distribution sites within Sandown Bay (designated sites, including the South Wight SAC and Bembridge Down SSSI).

Option (Method)	Environmental Score	Comments on scoring
Beach Nourishment		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Bembridge rMCZ during the beach nourishment process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The provision of large quantities of new sediment could also have impacts on designated features within the Bay (including near Hope beach) and further down the coast at Bembridge Down SSSI Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements.
Gabions		This option provides protection from coastal erosion but no additional protection against flooding and. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Bembridge rMCZ, but is unlikely to require landtake from the intertidal area. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Groyne improvement		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat (e.g. due to groyne lengthening). The extension to existing groynes could also have impacts further down the coast at Bembridge Down SSSI and the Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Groyne construction		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat. Providing new groynes could also have impacts further down the coast at Bembridge Down SSSI and the Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Revetment		This option provides protection from coastal erosion and is likely to provide some additional protection against flooding. However, some properties within the study area could still be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not entirely from flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Bembridge rMCZ (& pSPA in part of unit 26). It could lead to coastal

Option (Method)	Environmental Score	Comments on scoring
		squeeze and loss of intertidal habitat within the South Wight Maritime SAC and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Seawall		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Bembridge rMCZ (& pSPA in part of unit 26), but is unlikely to require landtake from the intertidal area, if built as close as possible to the current structure. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction.
Crest Raising / wave return		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of extensions to existing structures within and in close proximity to the Conservation Area. There is the potential for temporary adverse effects in relation to disturbance to the Bembridge rMCZ during construction.
Setback Floodwall		This option provides an increased standard of protection to properties within the study area. However, whilst this option will provide protection from erosion and flooding to large parts of the Shanklin Conservation Area, the Sandown Barrack Battery Scheduled Monument and listed buildings, not all parts would be protected depending on how far the flood wall is setback. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on non-statutory designated sites for nature conservation located behind the frontage. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Cliff Stabilisation		This option reduces risk from cliff falls but would not on its own (without toe protection) provide protection from coastal erosion and additional protection against flooding. Therefore, properties within the study area could be at risk of erosion and flooding, including overtopping. This option will continue to provide some protection to listed buildings, parts of the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument.. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area, although some cliff stabilisation measures have already been undertaken in the area and are minimally intrusive . Slowing down the rate of cliff retreat, without toe protection, could in the future lead to coastal squeeze and loss of intertidal habitat within the Bembridge rMCZ and South Wight Maritime SAC . There will also be temporary adverse impacts caused by disturbance during construction.

Appendix C: Long list Appraisal

Scoring		
Risk management	-1	Measure does not support the strategic option. Flood and Erosion Risk is not reduced
	0	Measure partially supports the strategic option by either reducing the flood or erosion risk
	1	Measure fully supports the strategic option by reducing both the flood and erosion risk (for the maintain option, a +1 score if erosion risk is reduced. For areas at erosion risk only, +1 if risk reduced
Capital cost	-1	Measure has a high capital cost relative to the other measures being considered
	0	Measure has an average capital cost relative to the other measures being considerd
	1	Measure has a low capital cost relative to the other measures being considered
Ongoing cost	-1	Measure has high ongoing costs (e.g. maintenance) relative to the other measures being considered
	0	Measure has average ongoing costs (e.g. maintenance) relative to the other measures being considered
	1	Measure has low ongoing costs (e.g. maintenance) relative to the other measures being considered
Service life	-1	Measure has a short service life
	0	Measure has an average service life
	1	Measure has a long service life
Technical feasibility	-1	Measure is not technically feasible and constraints cannot be mitigated
	0	Measure is technically feasible. Constraints can be mitigated
	1	Measure is technically feasible with no known constraints
Environment	-1	Measure is likely to have a negative impact on the environment
	0	Measure will not impact the environment
	1	Measure is likely to have a postive impact on the environment
Coastal processes	-1	Measure is likely to have a negative impact on natural coastal processes (i.e. sediment movement, hydrodynamics etc.)
	0	Measure will not impact natural coastal processes
	1	Measure is likely to have a positive impact on natural coastal processes
Stakeholder / broader outcomes	-1	Measure unlikely to support stakeholder aspirations and will not provide broader outcomes (i.e. improve tourism etc)
	0	No impact (or mixed impacts)
	1	Measure likely to support stakeholder aspirations and will provide broader outcomes

IW15

Option	Measure	Risk managment (F&E risk)	Capital Cost (relative)	Ongoing Cost (relative)	Service life	Technical feasibility	Environment	Coastal Processes	Stakeholder / Broader outcomes	Total	Comments / justification
Do min	Reactive patch and repair	1	1	-1	-1	1	0	0	-1	0	Achieves option objective. Low capital cost but potentially high ongoing cost relative to Do Nothing. Low service life and not acceptable to stakeholders
Maintain	Reactive patch and repair	-1	1	0	-1	1	0	0	0	0	Does not achieve option objective. Low service life
	Capital refurb - embankment	1	0	0	0	1	0	0	0	2	Fully supports option objective and technially feasible
	Gabions	1	0	0	0	1	0	0	-1	1	Supports option objective and technically feasible although placement infront of existing defence on the beach is unlikely to support stakeholder aspirations
Sustain	Revetment	1	-1	1	1	0	-1	0	0	1	Costly but fully supports option objectives. Space shortages in front of the embankment could make measure technically challenging. Landtake from designated sites (footprint)
	Seawall	1	-1	1	1	0	0	0	0	2	Costly but fully supports option objectives. Space shortages in front of the embankment could make measure technically challenging
	Refurb of embankment + setback floodwall	1	0	0	0	1	0	0	0	2	Fully supports option objectives, less costly than new frontline structure but still relies on existing embankment w refurb therefore shorter service life
	Road raising	0	-1	0	0	1	0	0	0	0	Does not mitigate erosion risk. Likely to be costly due to length of raising required
	New control structure at Yarbridge	0	1	0	1	1	-1	0	0	2	Does not mitigate erosion risk. Relatively low cost solution to 'back-door' flooding problem. Potential loss of freshwater designated habitats in the future
	Setback embankment	0	-1	0	1	0	-1	0	-1	-2	Likely to impede into environmental designations and be high cost due to height and width required. Does not address erosion risk, potential loss of road.
	Beach nourishment	1	-1	-1	0	-1	-1	-1	0	-4	Not technically feasible (no space for new beach in most locations), high cost, environmental and coastal process impacts.
	Offshore breakwater	0	-1	0	1	-1	-1	-1	-1	-4	Insufficient space, likely to be met by stakeholder opposition, does not mitigate flood risk, environment and coastal process impacts
	Temporary defences & PLP	0	1	0	-1	1	0	0	-1	0	Low cost but does not mitigate erosion risk. Environmental impact
Improve	Revetment	1	-1	1	1	0	-1	0	0	1	Costly but fully supports option objectives. Space shortages in front of the embankment could make measure technically challenging. Landtake from designated sites (footprint)
	Seawall	1	-1	1	1	0	0	0	0	2	Costly but fully supports option objectives. Space shortages in front of the embankment could make measure technically challenging
	Refurb of embankment + setback floodwall	1	0	0	0	1	0	0	0	2	Fully supports option objectives, less costly than new frontline structure but still relies on existing embankment w refurb therefore shorter service life
	Road raising	0	-1	0	0	1	0	0	0	0	Does not mitigate erosion risk.
	New control structure at Yarbridge	0	1	0	1	1	-1	0	0	2	Does not mitigate erosion risk. Relatively low cost solution to 'back-door' flooding problem. Potential loss of freshwater designated habitats in the future
	Setback embankment	0	-1	0	1	0	-1	0	-1	-2	Likely to impede into environmental designations and be high cost due to height required. Does not address erosion risk, potential loss of road
	Beach nourishment	1	-1	-1	0	-1	-1	-1	0	-4	Not technically feasible (no space for new beach in most locations), high cost, environmental and coastal process impacts
	Offshore breakwater	0	-1	0	1	-1	-1	-1	-1	-4	Insufficient space, likely to be met by stakeholder opposition, does not mitigate flood risk, environment and coastal process impacts
	Temporary defences & PLP	0	1	0	-1	1	0	0	-1	0	Low cost but does not mitigation erosion risk

High scoring measures

Measures scoped out

Options to exclude / non-starters

Sustain:
Offshore breakwater
Setback embankment
Beach Nourishment

Improve:
Offshore breakwater
Setback embankment
Beach Nourishment

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Option	Measure	Risk managment (F&E risk)	Capital Cost (relative)	Ongoing Cost (relative)	Service life	Technical feasibility	Environment	Coastal Processes	Stakeholder / Broader outcomes	Total	Comments / justification
Do Min	Reactive patch and repair	1	1	-1	-1	1	0	0	-1	0	Achieves option objective. Low capital cost but potentially high ongoing cost relative to Do Nothing. Low service life and not acceptable to stakeholder
Maintain	Reactive patch and repair	-1	1	0	-1	1	0	0	0	0	Does not achieve option objective. Low service life
Maintain	Capital refurb - wall/revetment	1	0	0	0	1	0	0	0	2	Fully supports option objective and technially feasible
Maintain	Capital refurb - groynes	1	0	0	0	1	0	0	0	2	Fully supports option objective and technially feasible
Maintain	Beach recycling	0	1	0	-1	1	0	0	1	2	Lower costs than nourishment scheme.
Maintain	Gabions	1	0	0	0	1	0	0	-1	1	Not likely to be effective as primary defence, but could be used to stop outflanking
Sustain / Delay Sustain	Groyne extension and raising	0	1	1	0	1	0	-1	1	3	Could be used with other measure. Unlikely that groyne improvements will sustain SoP in future (as an alone measure). Coastal processes impacts. Working with existing structures is lower cos
Sustain / Delay Sustain	New groynes	0	0	0	1	1	0	-1	1	2	Could be used with other measure. Unlikely that groyne improvements will sustain SoP in future (as an alone measure). More costly than working with existing groyne structure
Sustain / Delay Sustain	Beach nourishment	1	-1	-1	0	1	0	-1	1	0	High cost
Sustain / Delay Sustain	Offshore breakwater(s)	0	-1	0	1	-1	-1	-1	0	-3	High cost, environmental and coastal process impacts. Benefits for tourism where beach is gained, but potential beach loss downdrift. Significant landscape change. Likely mixed reactions by stakeholders affecte
Sustain / Delay Sustain	Revetment	1	-1	1	1	1	-1	0	0	2	Costly but fully supports option objectives. Potential landtake from designated sites (footprint)
Sustain / Delay Sustain	Seawall	1	-1	1	1	1	0	0	0	3	Costly but fully supports option objectives
Sustain / Delay Sustain	Crest raising / wave return (+refurb)	1	1	0	0	1	0	0	0	3	Costly but fully supports option objectives
Sustain / Delay Sustain	Setback floodwall	0	-1	1	1	0	0	0	0	1	Does not mitigate erosion risk
Sustain / Delay Sustain	Setback embankment	0	0	0	0	-1	0	0	0	-1	Techncially challenging due to height required and space restrictions in some areas, high cost, does not address erosion, breach risk in front of setback embankment affecting road and access.
Sustain / Delay Sustain	Road raising	0	0	0	0	1	0	0	0	1	Does not mitigate erosion risk.
Sustain / Delay Sustain	Temporary defences & PLP	0	1	0	-1	-1	0	0	-1	-2	Low cost but unlikely to be supported by stakeholders. Does not mitigation erosion risk and not sufficient to address breach risk
Improve / Delay Improve	Groyne extension and raising	0	1	1	0	1	0	-1	1	3	Unlikely that groyne improvements will improve SoP in future (as an alone measure). Coastal processes impacts. Working with existing structures is lower cost
Improve / Delay Improve	New groynes	0	0	0	1	1	0	-1	1	2	Unlikely that groyne improvements will improve SoP in future (as an alone measure). More costly than working with existing groyne structure
Improve / Delay Improve	Beach nourishment	1	-1	-1	0	1	0	-1	1	0	High cost
Improve / Delay Improve	Offshore breakwater(s)	0	-1	0	1	-1	-1	-1	0	-3	High cost, environmental and coastal process impacts. Benefits for tourism where beach is gained, but potential beach loss downdrift. Significant landscape change. Likely mixed reactions by stakeholders affecte
Improve / Delay Improve	Revetment	1	-1	1	1	1	-1	0	0	2	Costly but fully supports option objectives. Potential landtake from designated sites (footprint)
Improve / Delay Improve	Seawall	1	-1	1	1	1	0	0	0	3	Costly but fully supports option objectives
Improve / Delay Improve	Crest raising (+refurb)	1	1	0	0	1	0	0	0	3	Costly but fully supports option objectives
Improve / Delay Improve	Setback floodwall	0	-1	1	1	0	0	0	0	1	Does not mitigate erosion risk
Improve / Delay Improve	Setback embankment	0	0	0	0	-1	0	0	0	-1	Techncially challenging due to height required and space restrictions in some area, high cost, does not address erosion, breach risk in front of setback embankment affecting road and acces
Improve / Delay Improve	Road raising	0	0	0	0	1	0	0	0	1	Does not mitigate erosion risk.
Improve / Delay Improve	Temporary defences & PLP	-1	1	0	-1	1	0	0	-1	-1	Low cost but unlikely to be supported by stakeholders. Does not mitigation erosion risk and not sufficient to address breach risk

High scoring measures

Measures scoped out

Options to exclude / non-starters

Sustain / Delay Sustain:

Offshore breakwater
Setback embankment
Temporary and PLP

Improve / Delay Improve:

Offshore breakwater
Setback embankment
Temporary and PLP

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Option	Measure	Option goal (F&E risk)	Capital Cost (relative)	Ongoing Cost (relative)	Service life	Technical feasibility	Environment	Coastal Processes	Stakeholder / Broader outcomes	Total	Comments / justification
Do Min	Reactive patch and repair	1	1	-1	-1	1	0	0	-1	0	Achieves option objective. Low capital cost but potentially high ongoing cost relative to Do Nothing. Low service life and not acceptable to stakeholders
Maintain	Reactive patch and repair	-1	1	0	-1	1	0	0	0	0	Does not achieve option objective. Low service life
	Capital refurb - wall/revetment	1	0	0	0	1	0	0	0	2	Fully supports option objective and technially feasible
	Capital refurb - groynes	1	0	0	0	1	0	0	0	2	Fully supports option objective and technially feasible
	Beach recycling	1	1	0	-1	1	0	0	1	3	Lower costs than nourishment scheme. Will support option by keeping beach in place where required
	Gabions	1	0	0	0	0	0	0	-1	0	Not likely to be effective as primary defence, but could be used to stop outflanking
	Cliff stabilisation	1	1	0	0	1	-1	-1	0	1	Feasible but likely to require additional measure.
	Cliff regrading	0	1	0	0	-1	-1	-1	-1	-3	Potential loss of building at cliff top during re-profiling - technical feasibility and stakeholder impacts. Will require other additional measures
Sustain / Improve performance	Beach nourishment	1	-1	-1	0	1	0	-1	1	0	High cost. Unlikely to be effective without groynes
	Beach recycling	1	1	0	-1	-1	0	0	1	1	Unlikely to be effective without groynes. Would be very frequent which isn't very feasible
	New groynes	1	0	0	1	1	0	-1	1	3	Fully supports option objective and technically feasible.
	Offshore breakwater(s)	1	-1	0	1	-1	-1	-1	0	-2	High cost, environmental and coastal process impacts. Benefits for tourism where beach is gained, but beach loss downdrift. Significant landscape change. Likely mixed reactions by stakeholders affected
	Gabions	1	0	0	0	0	0	0	-1	0	Not likely to be effective as primary defence, but could be used to stop outflanking
	Revetment	1	-1	1	1	1	-1	0	0	2	Costly but fully supports option objectives. Potential landtake from designated sites (footprint)
	Seawall	1	-1	1	1	1	0	0	0	3	Costly but fully supports option objectives
	Crest raising (+ refurb)	1	1	0	0	1	0	0	0	3	Costly but fully supports option objectives
	Setback wall (+ refurb)	1	0	0	1	0	0	0	0	2	Requires existing defences to remain in place
	Setback embankment	0	0	0	0	-1	0	0	0	-1	Not suitable for option / local environment. Techncially challenging due to lack of space
	Cliff stabilisation	1	1	0	0	1	-1	-1	0	1	Feasible but likely to require additional measure.
	Cliff regrading	1	1	0	0	-1	-1	-1	-1	-2	Potential loss of building at cliff top during re-profiling - technical feasibility and stakeholder impacts
	Temporary defences and PLP	-1	0	0	-1	-1	0	0	0	-3	Does not meet option objective

High scoring measures

Measures scoped out

Options to exclude / non-starters

Maintain:

Cliff regrading

Sustain / Improve performance:

Offshore breakwater
Setback embankment
Cliff regrading
Temporary defences and PLP

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Coastal Processes Baseline Report

Sandown Bay Initial Appraisal and Scheme Identification Study

Isle of Wight Council

60535175 / CPB002

January 2018

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Tables

1. Introduction

1.1 Background

AECOM Infrastructure and Environment UK Limited has been appointed by Isle of Wight Council to undertake an initial appraisal and scheme identification study for Sandown Bay. The frontage extends 5.8km from Yaverland to Shanklin, comprising Shoreline Management Plan 2 policy units 3C.2 and 3C.3 (SMP2, 2010).

The study will identify and develop future schemes for this urban frontage which faces significant risks. Along this eroding coastline the existing defences are deteriorating and properties and assets along the frontage are at risk from erosion and flooding.

1.2 Purpose of this report

This Stage 1 & 2 report sets out the coastal processes and baseline for the study area. This understanding of the physical conditions provides a robust platform from which to develop and appraise schemes for the study.

1.3 Overview of study area

The study area encompasses two SMP2 policy units which both have a 'hold the line' policy (units 3C.2 and 3C.3) – see Figure 1-1.

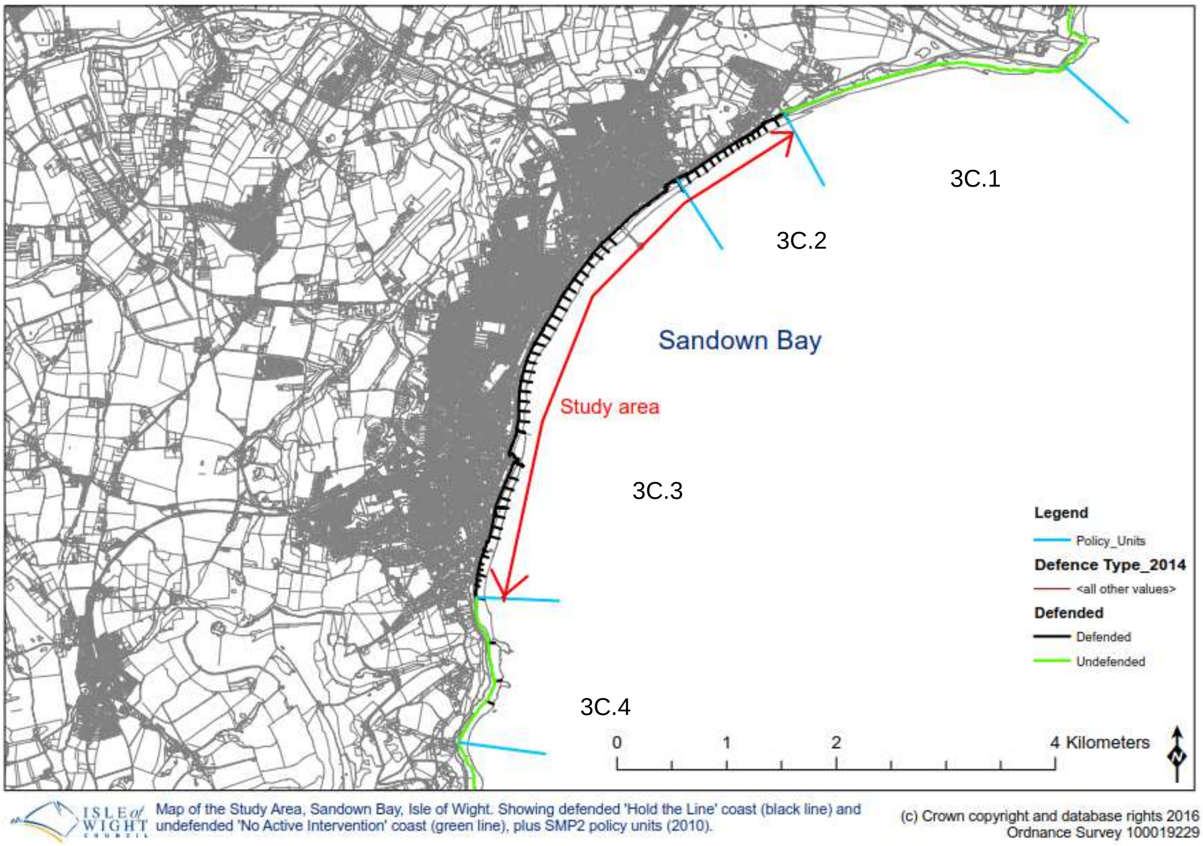

Figure 1-1. Study area and SMP Policy Units.

The study frontage is lined by the settlements/towns of Yaverland, Sandown, Lake and Shanklin (from north to south). In the south of the study area the coastal frontage is backed by steep ferruginous sandstone cliffs, up to 35m high (Figure 1-2).

Figure 1-2. Steep sandstone cliffs south of Shanklin Chine.

The northern side of the study site is more low-lying whilst the southern side of the site is backed by steep cliffs, with development at both the cliff top and cliff foot. The frontage is lined by a popular seafront esplanade, roads and footpaths and is the entire study site area is characterised by a wide sandy beach which is important for tourism in the area (Figure 1-3). There are aspirations for regeneration in the Bay communities including at two sites of limited size on Shanklin Esplanade.

Figure 1-3. Sandown beach and Seafront (north of the Pier).

The entire length of the frontage is vulnerable to erosion. The defences along the frontage are a combination of seawalls and groynes which help to hold the beach material in place. The defences help to reduce the rate of erosion but the defences are ageing and in a deteriorating condition. In some locations the beach levels are very low and without timely renewal of the defences, significant asset losses are anticipated in the future. There is potential for widespread cliff reactivation and retreat, and for erosion to encroach further into developed areas.

There are significant numbers of properties and assets at risk from tidal flooding within the Eastern Yar floodplain (Figure 1-4) especially on the outskirts of Sandown in the north of the study area. Assets at risk include the primary water treatment works for the island.

Figure 1-4. Low lying Eastern Yar Flood Plain behind the coastal defences at the northern end of Sandown).

1.4 Structure of this report

This report provides information on the coastal processes of the area, which are broken down into the following chapters:

2. Geology and geomorphology
3. Hydrodynamics
4. Littoral sediment transport and beach morphology
5. Climate change
6. Flood and erosion risks

2. Geology and geomorphology

2.1 Geology

Sandown Bay has formed through long term marine erosion of the clays, shales and sandstones of the Wealden and Lower Cretaceous formations (Figure 2-1). The formations are moderate to weakly resistant and erosion has operated over the past 5-6 thousand years since the postglacial (Holocene) sea level stabilised 3-5m below its present elevation (Bray et al. 1994).

At each end of the bay the headlands are formed of more resistant materials; resistant Chalk and Upper Greensand strata at Culver Cliff (northern headland) and boulder aprons fronting the ancient landslides of the eastern undercliff (southern headland). The headlands form stable anchor points whilst erosion has progressively shaped the inner bay into its present arc shaped planform.

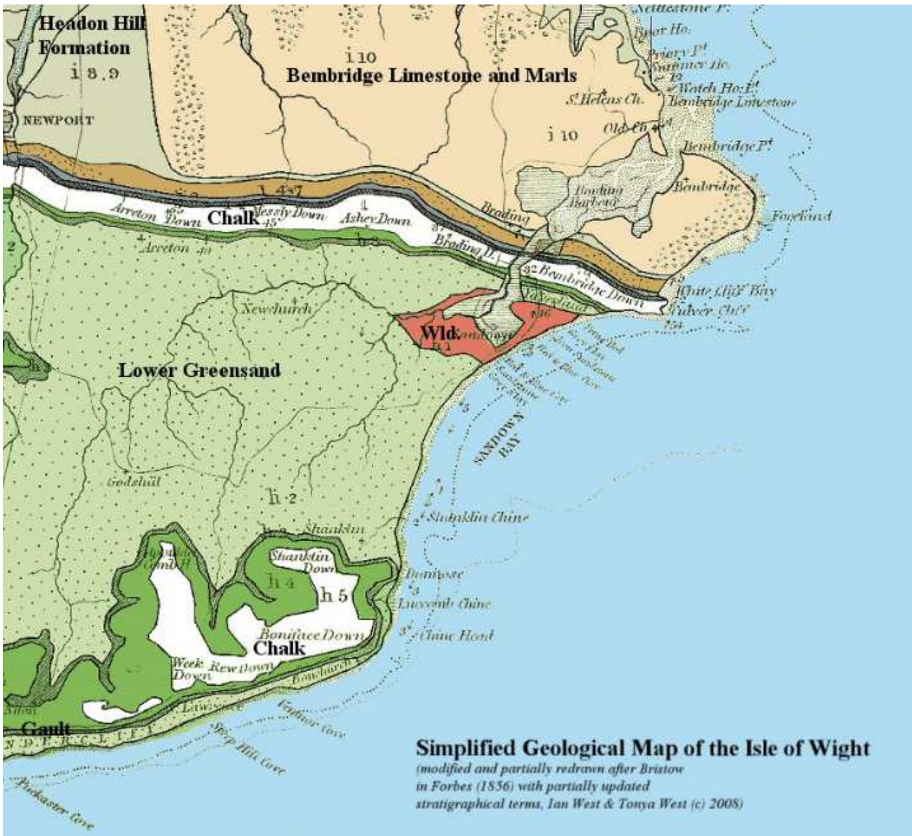

Figure 2-1.Simplified Geologial Map of the study area (http://www.southampton.ac.uk/~imw/wight.htm)

At the northern end of the bay, between Yaverland and Sandown, the hinterland is low lying. South of this area the frontage is backed by steep eroding cliffs which expose the geological make-up of the area.

Under natural conditions the cliffs within the bay would be eroded by direct wave attack at the cliff toe. However, the progressive installation of sea walls and promenades at the toe of the cliffs has significantly reduced the role of direct wave attack in cliff erosion and has decreased the supply of fresh sediment into the system. Groynes have operated along much of the developed frontage since the mid-nineteenth century and have helped to stabilise the beach material. However, the condition of the seawalls and groynes are deteriorating and without future maintenance / upgrade works, the role of direct wave attack in eroding the cliff line could increase.

In front of the cliffs at the southern side of the study site the beach elevation is low in places, exposing extensive shore platforms (Figure 2-2). These provide evidence for long term recession in outcrops of more resistant bedrock. It is thought that several kilometres of recession has occurred over a timescale in excess of ten millennia. This has released large quantities of predominantly sandy sediment into the coastal system, some of which has remained in the bay but most has been removed from the local transport system (SCOPAC, 2014, in press 2017).

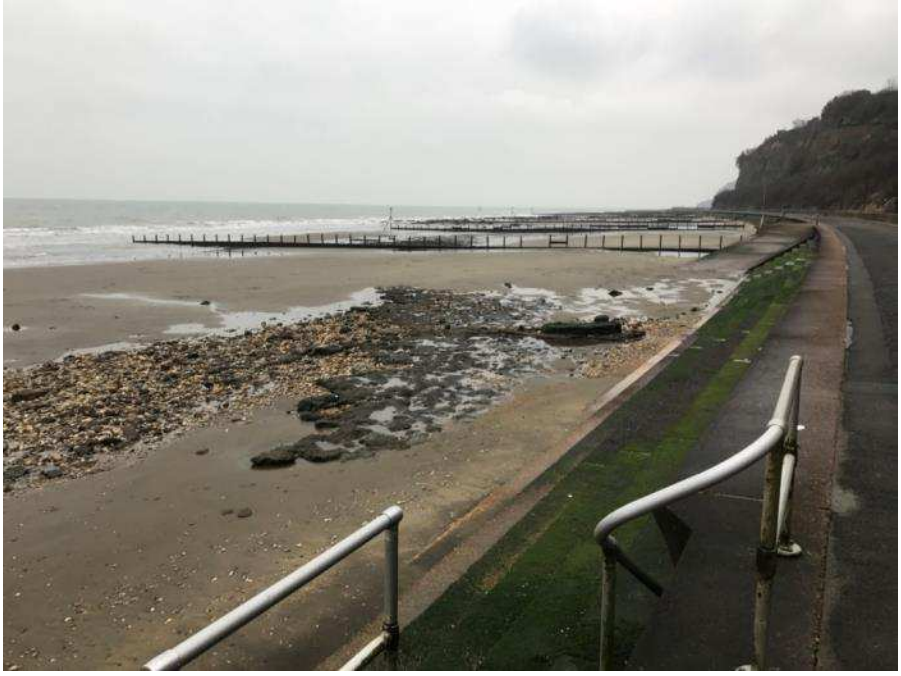

Figure 2-2. Shore platforms evident where littoral sediment has depleted in groyne bays towards the southern end of the frontage (February 2017).

2.2 Geomorphology

Between Yaverland and Sandown a sand and shingle barrier beach has formed with a wide sandy lower foreshore. Behind the beach is the valley floor of a tributary of the Eastern Yar river. The beach appears to have prevented marine inundation, preserving the regular planform of Sandown Bay (SMP2, 2010).

Along much of the urbanised study frontage the hard defences such as seawalls, revetments and promenades (and groynes) override and prevent the natural geomorphological trend for erosion and thereby hold the bay in its current form.

To the south the frontage is characterised by steep cliffs which are actively eroding. This provides vital sediment input to feed the down drift beaches within Shanklin and Sandown Bay. The following text is taken from the SMP2 (2010) which describes the cliff geomorphology in the study area:

Although isolated from wave activity by sea defences, the former sea-cliffs remain geomorphologically active, due to sub-aerial weathering and mass movement. Movements are primarily infrequent rockfalls from free faces (detached masses of up to 2m width) and also slides within the talus slopes that accumulate at the cliff toe. Barton (1985) estimates 5m of slope crest recession between 1907 and 1969 (0.08m/yr) for part of the cliff line between Shanklin Chine and Hope Road, a figure derived from measurement of the dimensions of basal scree deposits. Another value of 0.02-0.03m/yr is quoted incorporating behaviour up to 1981 (Barton, 1991). Not only does recession cause hazards at the cliff top, but also at the toe, where Victorian and later developments have allowed too little space for extension of stable talus slopes. Removal of talus exacerbates the situation by increasing the likelihood of further rockfalls. A variety of remedial measures have been applied to control immediate problems (i.e. re-profiling, netting, catch-fencing, rock bolting etc.) but planning measures involving development / redevelopment exclusion zones are needed to provide a long term solution in this sensitive amenity area.

The photograph shown in Figure 2-3 shows the sandstone cliffs and the catch fencing that has been installed to collect rockfall debris.

Figure 2-3. Sandstone cliffs and catch fencing between Sandown and Shanklin (February 2017).

3. Hydrodynamics

3.1 Wave climate

The east coast of the Isle of Wight, including the Sandown Study area, is relatively protected from waves generated by dominant westerly or south-westerly winds. The Dunnose headland (to the south of the bay) also provides a degree of shelter from swell waves from the Atlantic. However, the study site is exposed to a 170km fetch extending east and south-east and also from residual Atlantic swell waves that propagate through the western and central English Channel and are refracted by the southern Isle of Wight.

The Sandown Bay directional waverider buoy is positioned in 11m CD water depth at OS grid coordinates 461479 E, 83826 N. Data collected by the buoy is used in the Southeast Strategic Regional Coastal Monitoring Programme (Channel Coastal Observatory, ongoing). The prevailing wave direction is from the south and the annual significant wave height statistics between the years 2003 and 2014 are presented in Table 3-1 below.

Table 3-1. Sandown significant wave height statistics (2003/14), obtained from the Southeast Strategic Regional Coastal Monitoring Programme (CCO, 2015)

Year	Annual H_s exceedance (m)						Annual Maximum H_s	
	0.05%	0.5%	1%	2%	5%	10%	Date	A_{max} (m)
2003	-	2.21	2.02	1.65	1.35	1.13	29 November	2.79
2004	2.64	2.11	1.82	1.61	1.29	0.97	08 January	3.17
2005	3.23	2.15	1.69	1.44	1.11	0.86	02 December	3.79
2006	2.47	1.97	1.80	1.61	1.33	1.10	30 December	2.75
2007	3.06	1.91	1.64	1.44	1.18	0.96	18 November	3.22
2008	3.11	2.23	1.91	1.64	1.26	0.99	10 March	3.63
2009	2.56	2.07	1.81	1.61	1.31	1.01	18 November	2.70
2010	2.66	2.06	1.8	1.52	1.13	0.89	09 November	2.93
2011	2.52	1.92	1.62	1.37	1.12	0.90	12 December	2.87
2012	2.55	2.16	1.84	1.62	1.24	0.96	25 April	2.87
2013	3.24	2.31	1.97	1.73	1.34	1.08	24 December	3.51
2014	3.24	2.61	2.25	1.91	1.46	1.11	05 February	3.40
Average	2.84	2.14	1.85	1.60	1.26	0.99	**Maximum**	3.79

The 10% significant wave height exceedance is 0.99m between 2003 and 2014. The largest annual maximum significant wave height over this period was recorded in 2005, with a wave height of 3.79m. This extreme wave height is in agreement with research undertaken between 1977 and 2010 which suggested that the significant fetch distance from the east and south-east can propagate waves up to 3.8m in height in association with easterly gale force winds (Hydraulics Research, 1977; 1984; 1991; HR Wallingford, 1992; Royal Haskoning, 2010).

The observed wave heights from the waverider buoy are greater than the modelled heights in the DEFRA Futurecoast project (Halcrow, 2002). Sandown Bay was one of the select locations for which wave modelling exercises were undertaken as part of the DEFRA Futurecoast project (Halcrow, 2002). Data from the Met Office Wave Model (between 1991-2000) was used to synthesise an offshore wave climate which was then transformed inshore to a point at -4.44m OD. The modelling results indicated that the highest waves are typically up to 2.5m in height.

The dominant wave direction is from the south / south-east, as shown by the data collected by the waverider buoy (between 2004 -14). A wave rose, extracted from the Strategic Regional Coastal Monitoring Programme report (CCO, 2015) is shown in Figure 3-1below.

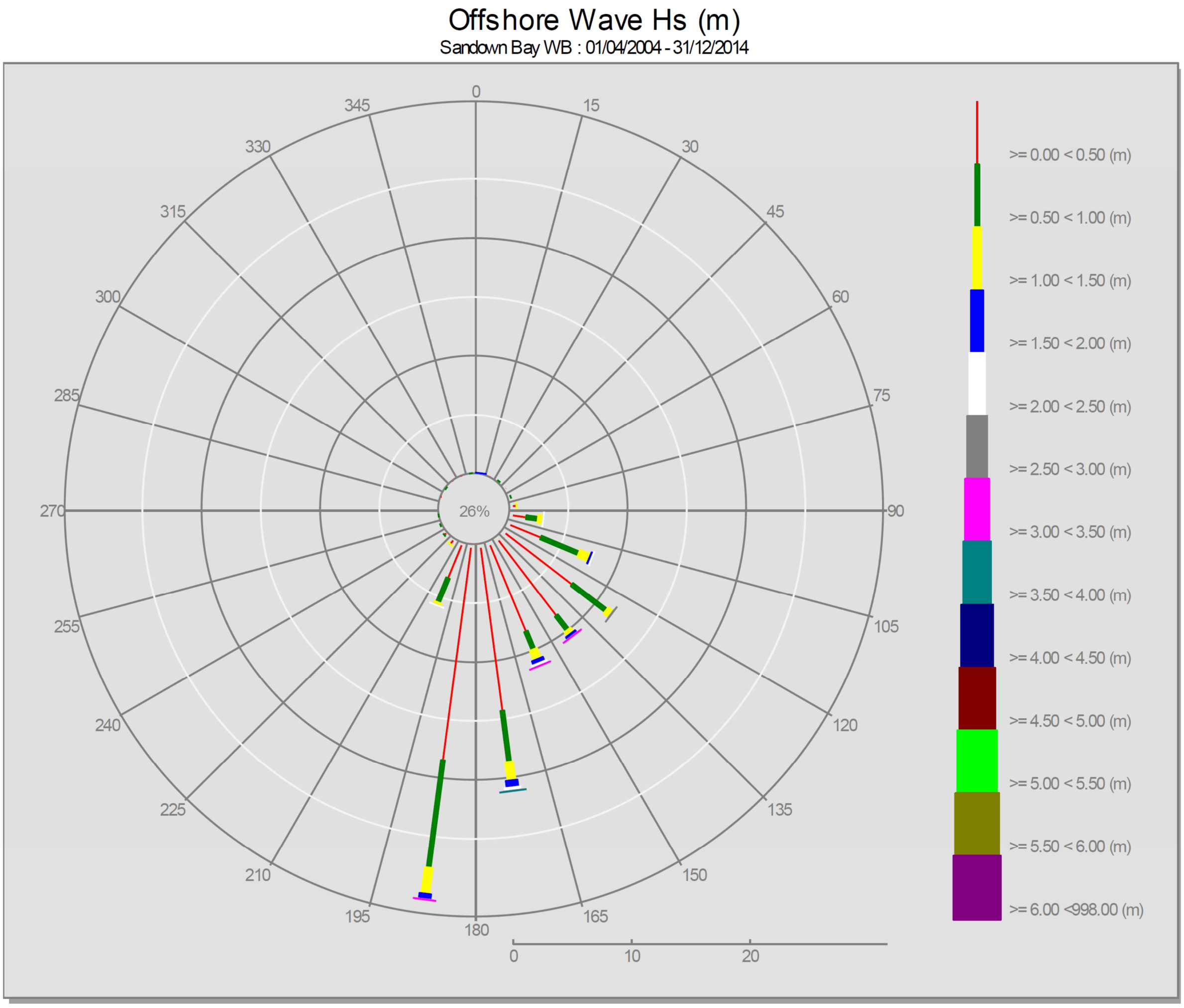

Figure 3-1. Wave rose (2004-2014), obtained from the Southeast Strategic Regional Coastal Monitoring Programme (CCO, 2015)

In the winter of 2013/14 there were six major storms which occurred, with a mean maximum wave height of 3.2m measured by a buoy 1.5km offshore of the Sandown coastline (SCOPAC, 2014, in press 2017). This demonstrates that the study site is exposed to the effects of storm waves of high energy which have the potential to lead to substantial erosion of the beach and cliffs. The storm analysis data from the waverider buoy for the year 2014 is shown in Table 3-2.

Table 3-2. Sandown storm wave statistics (2014), obtained from the Southeast Strategic Regional Coastal Monitoring Programme (CCO, 2015)

Date / Time	H_s (m)	T_p (s)	T_z (s)	Dir (^{o})	Water level elevation (OD)	Tidal stage (hours rel. to HW)	Tidal range (m)	Tidal surge (m)
05 February 2014	3.40	9.1	6.3	151	2.44	HW	3.6	0.39
12 February 2014	3.35	8.3	6.2	176	-0.07	HW +4	2.4	0.70
1 January 2014	3.26	7.7	5.9	155	1.53	HW +2	3.3	0.31
7 November 2014	2.92	7.7	5.7	160	0.82	HW +3	3.4	0.08
6 October 2014	2.87	7.1	5.5	158	1.98	HW +1	3.4	0.25

Since the waverider buoy has been deployed for more than 5 years, the return periods for significant wave height can be estimated. The CCO have made this assessment using a Weibull distribution. The return periods are based on 3-hourly records from the buoy and are calculated for periods up to 10 times the record length. The significant wave heights produced by the CCO (2015) are presented in Table 3-3 below.

Table 3-3. Significant wave height return periods, obtained from the Southeast Strategic Regional Coastal Monitoring Programme (CCO, 2015)

Return period (years)	Significant wave height (m)
1	3.2
2	3.4
5	3.7
10	3.9
20	4.1
50	4.3
100	4.5

3.2 Water levels

Water level data is available from Sandown Pier which is centrally located in the study site. The pier is on open coast, with no nearby estuaries which might otherwise influence readings. The buoy has been collecting data since 2006 at an interval of 10 minutes, with a recovery rate of 93%. A summary of the water levels over the observation period to 2012 is provided in Table 3-4.

Table 3-4. Tide levels, June 2006 – December 2012, Sandown Pier, obtained from the Southeast Strategic Regional Coastal Monitoring Programme (CCO, 2015)

Observation period	June 2006 to December 2012	
Tide level	**Elevation (OD)**	**Elevation (CD)**
HAT	2.36	4.80
MHWS	1.96	4.40
MHWN	1.18	3.62
MSL	0.31	2.75
MLWN	-0.55	1.89
MLWS	-1.34	1.10
LAT	-1.99	0.45

Annual extreme water levels and surge maxima for the years 2007 to 2015 are available and are presented in Table 3-5 below.

Table 3-5. Annual extreme maxima, 2007 – 2015, Sandown Pier, obtained from the Southeast Strategic Regional Coastal Monitoring Programme (CCO, 2015)

Year	Annual extreme maxima		Annual surge maxima	
	Elevation (OD) (Surge)	**Date**	**Value (m)**	**Date**
2007	2.54 (0.50)	18 March	0.78	09 November
2008	2.53 (0.52)	10 March	0.88	10 March
2009	2.55 (0.47)	09 February	0.73	23 January
2010	2.48 (0.24)	30 March	0.63	16 December
2011	2.48 (0.33)	27 October	0.63	16 December
2012	2.61 (0.46)	17 October	0.73	17 October
2013	2.86 (0.85)	06 December	0.88	06 December

Year	Annual extreme maxima		Annual surge maxima	
	Elevation (OD) (Surge)	Date	Value (m)	Date
2014	2.67 (0.91)	14 February	1.00	14 February
2015	2.48 (0.15)	28 October	0.69	13 January

Coastal flood boundary data extreme water levels (Environment Agency, 2011) for the study area have been obtained for locations at the southern end and northern end of the site. The extreme water levels have a base date of 2008 and are presented in Table 3-6 and Table 3-7 below.

Table 3-6. Coastal Flood Boundary Data extreme water levels, northern end of study site (base year 2008)

Return period	Water level (m OD)
1	2.47
2	2.55
5	2.63
10	2.70
20	2.76
50	2.85
75	2.88
100	2.91
150	2.95
200	2.97
500	3.06
1,000	3.12

Table 3-7. Coastal Flood Boundary Data extreme water levels, southern end of study site (base year 2008)

Return period	Water level (m OD)
1	2.22
2	2.29
5	2.37
10	2.44
20	2.50
50	2.58
75	2.61
100	2.64
150	2.68
200	2.70
500	2.78
1,000	2.83

4. Sediment transport & beach morphology

The sediment transport processes within the study site are described in detail in the recent SCOPAC Sediment Transport Study update (2014, in press 2017) which has been provided for use in this study. The findings and extracts from this study are presented in this chapter.

Analysis of Coastal monitoring programme data, lidar and aerial photography and topographic baseline survey data, combined with other datasets, academic research and historical studies has enabled transport rates and directions to be identified and verified. The sediment types, net flows and mechanisms of transport within the bay are shown in Figure 4-1.

Figure 4-1. Sediment transport on the south east coast of the Isle of Wight, SCOPAC (2014, in press 2017)

4.1 Sediment supply

Supply from cliffs from Shanklin Chine to Yaverland

Due to the presence of seawalls and groynes along the frontage the eroding cliffs are no longer subject to marine erosion and cannot make a contribution to the local sediment supply. Prior to the construction of the seawall at the Littlestairs cliffs in the 1970s, Barret (1985) quoted a figure of 0.2-0.4m retreat per year. This rate of recession would yield a former supply of about 3,000m^3 of sand per year from this location (assuming no change in cliff height).

The reduced sediment supply from the eroding cliffs has been linked to a pattern of shore lowering in some locations along the frontage. For instance, Barret (1985) estimated that foreshore lowering of 0.3m per year between 1960 and 1970 occurred.

Although isolated from wave activity, the former sea cliffs in the study area remain geomorphologically active, due to sub-aerial weathering and mass movement (Rendel Palmer and Tritton, 1988). Barton (1985, 1991) estimated 5m of slope crest recession between 1907 and 1980 (0.06m per year), for part of the cliffline between Shanklin Chine and Hope Road. Various protection techniques including cliff top regrading, drainage, timber shuttering, geofabric / grass matting, netting, rock bolting, catch fencing and talus re-profiling and removal have been implemented in an attempt to manage this problem. The interventions have reduced risks, but periodic failures in the cliff face and talus slope still occur, for example in March 2001 there were several small free face detachments and a major talus slope failure. This major failure released 5,000m^3 of material following intense rainfall and sustained period of easterly winds. Table 4-1 below presents information from notable recent cliff falls along the frontage. There have been many more cliff falls which have occurred since regular monitoring began, but it is not practical to list all of the events in this report.

Table 4-1 Recent notable cliff falls along the frontage

Date	Cliff fall location	Additional Info
28/02/2007	Lake cliff path	Failure of cliff retaining works
11/2007	Behind Scollers Café	New catch fendering installed
19/10/2010	Lake Revetment	Smashed catch fencing
02/03/2011	Dunroamin beach hut 35	Accumulation of material behind beach hut
08/01/2013	Small hope beach	Four beach huts pushed forward / leaning street light

Supply from the cliffs from Dunnose to Shanklin Chine

From Dunnose to Shanklin Chine there is a 3.2km stretch of cliffs where the cliff toe is undefended and the toe of the cliffs are subject to direct wave attack (Figure 4-2). A large part of this frontage is outside of the study area but the eroding cliffs are important because they provide a major source of sediment input to the Sandown Bay beaches.

Figure 4-2. Undefended sandstone cliffs to the South of Luccombe Chine.

There are a number of estimates for the rate of cliff top recession, although the accuracy of some are in doubt. Estimates of the recession rate vary from 0.2 – 0.5m per year for this stretch of shoreline (e.g. Barret, 1985; Halcrow, 1997; Posford Duvivier, 1981, 1987).

Historic black and white aerial photographs for the area have been made available for the years 1946 and 1988. The photo quality of the 1946 photographs is poor and in this photograph it is difficult to identify the cliff top for much of the frontage. In 1988 the cliff top can be identified for approximately 1.3km of the 3.2km section of cliffs and in the areas where it has been identified a cliff top recession analysis has been undertaken to compare the position of the cliff top in 1988 and in 2016. Figure 4-3 provides an example of the recession analysis comparing the 1988 and 2016 cliff top positions. The background imagery in the figure is from 2016.

Based on this analysis the mean annual recession rate between 1988 and 2016 is approximately 0.4m/yr. This recession rate is within the range provided in the literature but there are a number of limitations associated with interpreting cliff top recession from aerial photographs and therefore the rate should be treated as indicative. In addition, this rate is specific to only 1.3km of the 3.2km stretch of cliffs where the 1988 cliff top could be identified. It is likely that this is representative but further analysis using alternative data sources would be required to confirm this.

Figure 4-3 **Example of the cliff top recession analysis undertaken where the 1988 cliff top was identified**

The cliffs are composed of a mixture of fine-grained material and Greensand. There is limited accretion at the cliff toe which indicates that the fine-grained sediments are not retained on the foreshore. A photograph showing the composition of the cliff is shown in Figure 4-4 below.

The continuation of erosion along this No Active Intervention frontage south of Shanklin Chine is essential to maintain beach feeding sediment to Sandown Bay. Although some of the fine grained sediments are likely to be removed from the system through suspension or solution, a significant quantity of the coarser grained sands and shingle will continue to feed the downdrift beaches to the north.

An estimate of the volume of beach material supplied to the beach from this section of cliffs was made by Posford Duvivier (1999), in which a mean recession rate of 0.4m per year was assumed, providing a total potential sediment yield of 75,000m^3 per year. However, SCOPAC analysis of the Coastal Monitoring Programme data suggests that this volume is an overestimate, as it does not account for the large proportion of available material which would be fine grained and not readily retained on the foreshore.

Based upon the evidence presented above an estimate of the sediment volume supplied to the foreshore which is likely to stay on the beach has been made. This estimate is for the stretch of cliffs between Dunnose and Shanklin Chine and excludes the volume of sediment which is likely to enter suspension and be removed from the beach system. This desk based estimate is based on the available information and is based upon a number of assumptions and the limitations of this approach should be recognised. More detailed investigation and measurements would be needed in order to provide a more reliable estimate. The following assumptions have been made:

- The input of sediment is from the 3.2km stretch of eroding cliffs between Dunnose and Shanklin Chine.
- It is assumed that the cliffs are on average 60m high.
- From a visual assessment of the cliffs and beaches during a site visit it is reasonable to assume that approximately half of the material of the cliff face is composed of sandy material or gravels that are sufficiently coarse to stay within the beach system when eroded from the cliffs. The other half is made up of material which is likely to enter suspension or may leave the system.
- An average recession rate of 0.4m/yr has been assumed based upon the cliff top recession analysis undertaken in this study and the rates quoted in the supporting literature.

Based on these assumptions, the cliffs are estimated to be able to supply a potential 37,500m^3 of sandy material to the littoral system each year. This is one half of the total erosion volume estimated by Posford Duvivier (1999). It should be noted that given the limitations and assumptions, that is an approximate estimate, and should be validated by further more detailed sediment and littoral transport analysis.

Figure 4-4. Photographs showing the composition of the cliffs south of Shanklin Chine (site visit March 2017)

4.2 Littoral transport

South of the study site to Shanklin

There is a net northward littoral drift through the study site, from Luccombe Bay (south of the study site) towards Shanklin (Figure 4-1). To the south of the study site, Horse Ledge intercepts the littoral transport of sand, but this feature is easily by-passed judging by the rapid extension in the width of sandy foreshore at the southern end of the study site.

Shanklin to Yaverland

The beach along this frontage comprises homogeneous sand. There are clearly defined offsets in beach width associated with the numerous groynes, which indicate that the dominant longshore transport is from south to north. Occasional severe drawdown of the sandy beach at Shanklin and Sandown reveals a shingle basement (Lewis and Duvivier, 1974).

Data from the Coastal Monitoring Programme swath bathymetry indicates that the seabed in the study area is predominantly covered with sufficient thickness of sediment to mask the underlying bedrock. Rock outcrops can be seen below thinner areas of sediment in various areas throughout Sandown Bay (Figure 2-2).

There are various records of sand volumes, accretion and erosion following the construction of the groynes along the frontage. Records suggest that south of Shanklin Chine, there has been some 12m of seaward migration of the mean high water line since 1896. However, there are also records which demonstrate where inter-groyne sectors of the beach have suffered depletion and where mean high water has migrated landwards and the beach has steepened in response.

Because of the arcuate shape of Sandown Bay, the rate of littoral transport diminished northwards in response to a reduction in the obliquity of the angle of wave approach. Volumes of littoral drift also diminish in this direction, because of increasing distance from supply sources. The long term problems of retaining a wide and stable beach have therefore been greater in the northern part of the frontage. It is probable that volumes of sediment moving downdrift also decrease in the same direction as a consequence of storage in groyne bays. There is also a supply deficit resulting from the removal of sediment supply from cliff erosion as a direct result of seawall / esplanade construction. Coastal monitoring programme data confirms a net north-eastward littoral along-shore drift with rates of movement 1,000-3,000m^3 per year for this frontage.

Surveys and observations carried out in the 1980s (Posford Duvivier 1989) appear to indicate that some of the inter-groyne beaches have stabilised and achieved an equilibrium condition adjusted to the current volumes of input and output. In others, the absence of a permanent backshore shingle berm has promoted wave reflection from seawalls, and therefore beach drawdown.

4.3 Offshore dredging

As elsewhere along the south coast of England, there has been speculation that offshore aggregate dredging might be an independent cause of beach depletion, and even that it increases wave heights reaching the frontage. Marine aggregate removal has occurred for more than 30 years in various locations around the Island, including off the south-eastern coastline (at least 8 kilometres offshore of the study site - Figure 4-5).

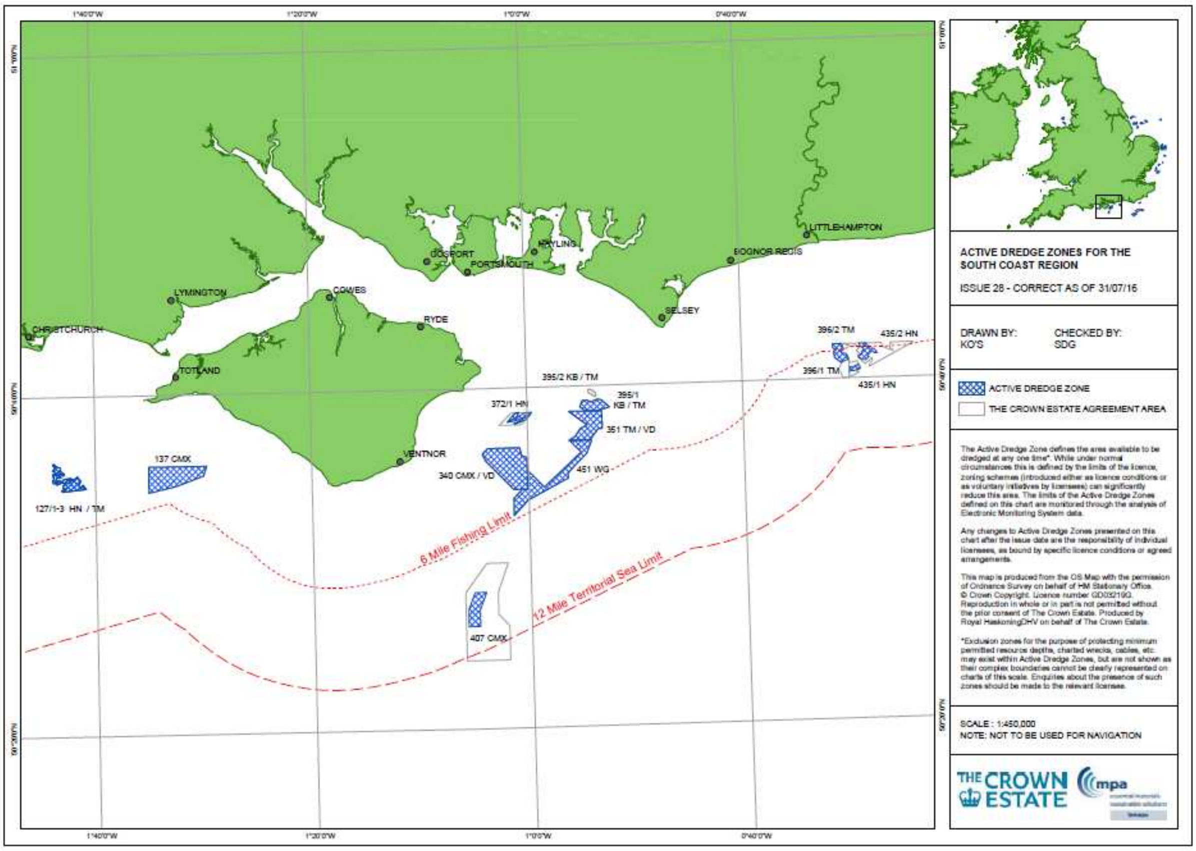

Figure 4-5. Licenced offshore dredging zones several kilometres offshore of the study area. Source – Crown Estate.

Previous research, documented in the SCOPAC Sediment Transport Study (2017), has suggested that offshore sediment from the dredging areas does not contribute to the littoral beach system and sediment budget. Hydraulic Research (1977, 1984; in SCOPAC 2017) investigated the effects of proposed dredging for gravel at a site in a water depth of 20m, approximately 6km due east of Dunnose (offshore of the study site). The research concluded that gravel up to a medium diameter of 25mm may, exceptionally, be mobilised in water depths of up to 22m, but is nominally immobile below a depth of 15m. The prevailing wave climate of the area is incapable of moving gravel at that depth onto the beaches of Sandown Bay, suggesting that the dredge material does not contribute to the sediment budget.

Based upon the evidence presented in SCOPAC 2017, given the distance offshore and depth of recorded dredging activities there is not likely to be a potential impact of dredging on waves reaching the coastline. There are no significant shallow offshore banks or features which might influence wave heights that are located within the licenced dredging areas. In addition, the wave heights reaching the defences are also limited by the typically shallow depths of the beach profile in front of the defences.

The aggregates industry has undertaken Regional Environmental Assessments for the south coast which includes a cumulative Coastal Impact Study. They are available at http://www.marine-aggregate-rea.info/. The South Coast Dredging Association MAREA (Marine Aggregate Regional Environmental Assessment) Summary Report 2010 (SCDA, 2010, re. sections 2.2 and 4) states *'It has long been recognised that adverse changes to the coast arising from marine aggregate dredging would be unacceptable, so the assessment of potential physical effects on coastlines forms a key part of the Environmental Impact Assessment of marine aggregate dredging proposals.'* The report outlines that *'a broad-scale assessment of the effects of past and proposed future dredging on the physical environment of this region has been carried out using reviews of both data and previous scientific papers and reports, together with computational modelling.'* This is for a large area lying offshore of the central South Coast of England between the Isle of Purbeck and Brighton. It concludes *'Neither past nor future dredging was predicted to have any effect on the coastline of the study region.'*

Information on beach levels in The Bay has been collected since 2004 by the Regional Coastal Monitoring Programme. This is part of a National Network of Regional Coastal Monitoring Programmes, which collect and distribute the necessary data to underpin evidence-based decisions in flood and coastal erosion risk management. Funding for the Programmes is secured in five-year cycles from DEFRA and administered through the Environment Agency. The data on beach levels from 2004 to present in Sandown Bay is discussed below in section 4.4 of this report. 28 beach profile lines are regularly surveyed in the area. Annual Reports are published each year to detail the latest survey results, including showing a) change over the past year and b) change since the original baseline survey. These are available online on www.channelcoast.org (see 'Reports', 'South East', 'Survey Reports', then 'Isle of Wight').

4.4 Beach morphology

4.4.1 Beach profiles

The Southeast Regional Coastal Monitoring Programme has routinely collected beach profiles from the study site between the years 2004 to 2016. In total there are 28 profiles collected in the study area, from 5e0079 to 5e00191. Detailed cross sections for each profile can be found in the Southeast Regional Coastal Monitoring Programme Report (CCO, 2016) available at www.channelcoast.org.

Analysis has been undertaken by the CCO (2016) comparing the latest (2016) profiles to the base profiles collected in 2004 (see Figure 4-7 to Figure 4-9). To best describe the spatial trends of the profiles in this report the study site has been split into three sections; south, central and north. The south section is located between Horse Ledge and Hope Beach, the central section is located between Hope Beach to Ferncliffe Road, and the north section is located between Ferncliffe Road to Yaverland beach car park.

In the north section of the site there are no consistent trends observed in terms of cross sectional areas changes between 2004 and 2016, with some profiles exhibiting net accretion and others net erosion. It is noticeable that the profiles showing net accretion are located immediately downdrift of Sandown Pier.

The situation in the central section of the site is similar to that in the north, with different profiles showing signs of erosion and accretion. In total 7 out of 13 (54%) of the profiles between Sandown Pier and 'Hope' groyne show a net loss in cross sectional area, 4 out of 13 (31%) of the profiles show net gain in cross sectional area, and the remaining 2 profiles (15%) show no change. Of the profiles that show a net loss in cross sectional area, profiles 5e00129 and 5e00145 have the most significant erosional trend, with a >30% loss in cross sectional area between 2004 and 2016.

In the southern section of the site the general trend is of erosion or no change, with 4 out of 9 (44%) of profiles showing a loss in cross sectional area and 3 out of 9 (33%) showing no change. Only two profiles (22%) in this section have accreted, with one of these profiles located immediately updrift of 'Hope' terminal groyne.

The beach profiles from the different sections are presented in Figure 4-7 to Figure 4-9.

Figure 4-6. Photo (February 2017) showing low beach levels at the central section of the study site. The beach levels are low enough to expose 4 steps of the concrete revetment, which is buried elsewhere in the study site.

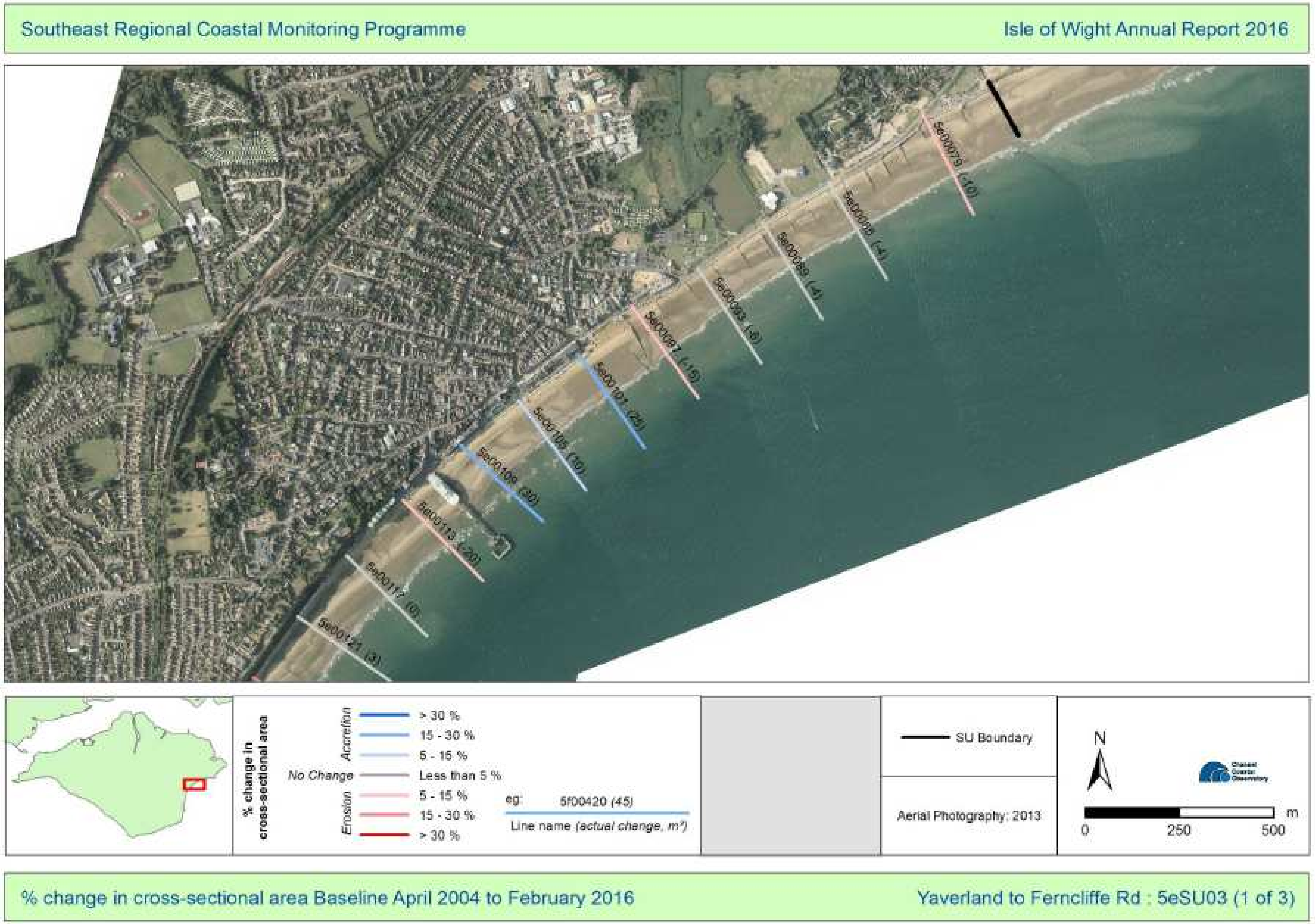

Figure 4-7. Beach profiles in the north section of the study site (obtained from the CCO, 2016)

Figure 4-8. Beach profiles in the central section of the study site (obtained from the CCO, 2016)

Figure 4-9. Beach profiles in the south section of the study site (obtained from the CCO, 2016)

4.4.2 Topographic difference models

Using data collected between 2003 and 2012 the CCO developed a topographic difference model for the beach in the study site in 2013. The difference model can be used alongside the beach profiles to help explain patterns in sediment movement, erosion and accretion. A summary table has been produced showing the results from the beach profile change and topographic difference models and is presented in Table 4-2 below.

Table 4-2. Comparison of CCO beach profile change and topographic difference model change

Zone	Beach profile location	Beach profile change (%) (2004-2016)	Topographic difference model change (2003-2012)
North section	5e00079	Loss (5-15%)	Loss at mid beach
	5e00085, 5e00089, 5e00093	No change	Loss at the top of the beach, gain at the base of the beach.
	5e00097	Loss (5-15%)	Loss at top of the beach
	5e00101, 5e00105, 5e00109	Gain (5-15% and 15-30%)	Substantial gain at mid and base of beach but loss at top of beach for profile 5e00109
Central section	5e00113	Loss (5-15%)	Loss at the top of the beach, gain at the base of the beach
	5e00117, 5e00121	No change	Gain at the base of the beach, some loss at the top of the beach in locations
	5e00125, 5e00129	Loss (15-30% and >30%)	Significant loss mid beach, gain at the top and base of the beach
	5e00133, 5e00137A	Gain (5-15%)	Loss at the top of the beach, gain at the base of the beach
	5e00141, 5e00145, 5e00149	Loss (5-15%, 15-30% and >30%)	Losses mid and upper beach
	5e00153	Gain (5-15%)	Minor loss top and bottom of the beach
	5e00157	Loss (5-15%)	Gain at the base of the beach, loss of mid and upper beach
	5e00159A	Gain (>30%)	No change
South section	5e00161	Gain (5-15%)	Gain, mainly at top of beach
	5e00165, 5e00167	Loss (5-15% and 15-30%)	Loss, mainly at top of beach
	5e00171, 5e00175	No Change	Some loss, but sporadic

4.4.3 Assessment of groyne performance

An assessment of the groyne performance at the study site has been made by considering the erosion / accretion trends of the CCO beach profiles and factors such as groyne type and condition. Conceptually the groynes should help to sustain the volume of beach material on the beach by trapping longshore sediment movement within the groyne bays. However, this is not always the case, with some groynes in an unfavourable condition or too short which allows sediment to bypass. Alternatively the groyne bays may be filled to capacity allowing sediment to pass over the top of the groynes at high tides.

Table 4-3 below summarises the findings from the assessment. A map showing the location and type of the coastal defences (including groynes) and the SMP defence units is presented in Figure 4-11.

Table 4-3. Assessment of groyne performance

SMP Unit	Groyne type	Groyne condition and residual life (March 2017)	Beach profiles included (updrift)	Beach CSA profile change (2004-2016)	Comment
IW22	Timber groynes (in front of Yaverland Car Park)	Good to fair, 10-20yrs	5e0079	Loss	Good condition but still erosional trend
IW23	Masonry groynes	Good, 10-20 yrs	No beach profile immediately in-front or updrift	NA	No profile to analyse
IW24	Timber groynes (ref 002 / 003)	Good, 10-20 yrs	5e00085, 5e00089, 5e00093, 5e00097	Mixed	No clear trend, mixture of erosion and no change within area of same groyne type and condition
	'Herne Hill' Concrete / Masonry groyne (ref 004)	Good, 10-20 yrs	5e00101, 5e00105, 5e00109	Gain	Three beach profiles updrift of this large groyne are all accreting. Approx. 1m fall in beach levels immediately down drift of groyne (February 2017).
IW25	Timber groyne	Fair, 10-15 yrs	5e00113	Loss	Timber groyne in poor condition with erosional trend updrift
IW26	Timber groynes (ref 001-004)	Poor to very poor, 2-7, 1-3 and 0 yrs	5e00117, 5e00121, 5e00125, 5e00129, 5e00133, 5e00141, 5e00145, 5e00149, 5e00153	Mixed	Large number of timber groynes in poor condition. Profile change is mixed with some areas showing erosion, others accretion. However there are locally high rates of erosion which are likely related to poor groyne condition.
	Concrete groyne	Good, 15-20 yrs	5e00157	Loss	Loss of sediment but likely to be related to adjacent terminal groyne in IW27
IW27	Terminal 'Hope' concrete groyne (ref 001)	Good, 15-20 yrs	5e00161	Gain	Updrift of terminal groyne showing accretion trend. Approx. 1.5m fall in beach levels immediately down drift of groyne (February 2017).
	Timber groynes (ref 002)	Good, 15-20 yrs	5e00165, 5e00167	Loss	Loss in timber groynes, despite fair condition
	Concrete 'Osborne' groyne (ref 003)	Good, 15-25 yrs	No beach profile immediately in-front or updrift	NA	No profile to analyse
	Timber groynes (ref 005)	Good to Fair, 8-12, 10-20 yrs	5e00171, 5e00175	No change	Stable beach in this location
IW28	Timber groynes	Fair, 8-12 yrs	5e00178, 5e00183, 5e00187, 5e00191	Mixed	No clear trend, mixture of erosion and accretion within area of same groyne type and condition

** reference numbers displayed in groyne field column refers to defence reference in the Defence Condition Assessment*

Table 4-3 shows that in many of the areas managed by timber groynes the beach had an erosional trend between 2004 and 2016, for example at IW22, IW25 and IW27002. In IW26 the timber groyes are in a poor to very condition and the beach demonstrates locally high rates of erosion in this location (profiles 5e00129 and 5e00145 have a >30% loss in cross sectional area). Where beach levels are low, it increases the potential for wave attack with a risk of scour, undermining and potentially reducing the service life of the defences.

The impact of the terminal groynes at Herne Hill and Hope groyne is also clear to see. Both of these groynes are large concrete / masonry structures which extend far into the intertidal zone, and these groynes are considerably larger than the adjacent timber structures. Updrift of the terminal groynes there is a trend of accretion, but downdrift there is evidence of erosion. This is demonstrated in Figure 4-10, which shows the different beach levels on either side of the groyne suggesting that the groyne forms an effective barrier to downdrift sediment movement.

There are some areas within the study site where there is no clear trend within areas of equal groyne type and condition. For example within the timber groynes of IW24 and IW28 there are some profiles showing erosion and others accretion. This is likely due to the inherent natural variability within the system and further monitoring may be necessary to establish long term trends.

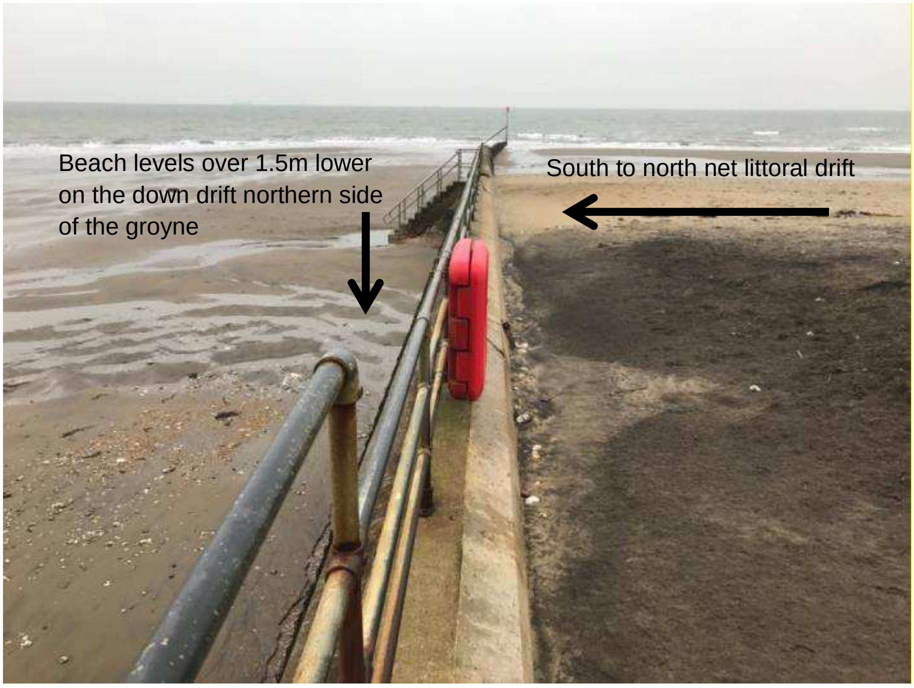

Figure 4-10. Concrete terminal 'Hope' groyne near Shanklin trapping significant volumes of littoral sediment on its southern side (February 2017).

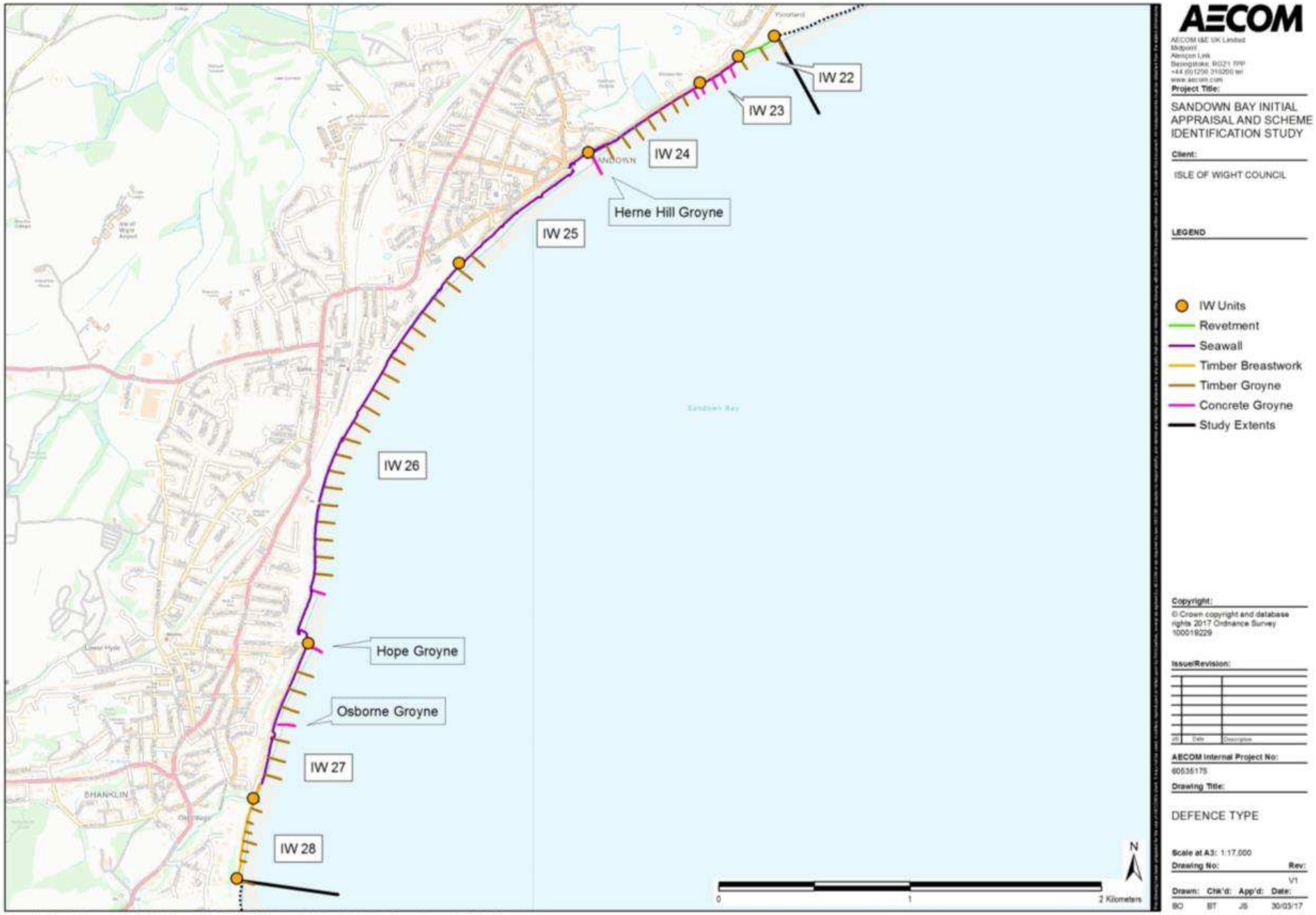

Figure 4-11 **Map showing the location and type of defences and the defence units**

4.5 Beach maintenance

The beach in parts of the study site is subjected to maintenance activities in order to preserve its recreational value and to help attract tourism to the area. In preparation for the summer months, in May and June longshoreman at Sandown routinely move sediment up the beach from the intertidal to the beach crest to provide more sand higher up the beach. No studies have been undertaken to assess the impact of this cross shore sediment movement but it is not expected to have a significant long term impact on the sediment budget or on the littoral sediment movement patterns and exposure of sea defences to wave action.

4.6 Summary

a. The bay has formed through preferential erosion of soft, sandy sediments at its core and is occupied by sandy beaches and is anchored by headlands. An equilibrium planform does not appear to have been achieved yet by the bay so the tendency for erosion is likely to continue.

b. Cliff erosion constitutes the main source of sandy shoreline sediments, but the bay does not appear to be a location of long-term accumulation commensurate with the erosion yields.

c. Drift is northward within the bay, although there is no major sediment accumulation at Culver Cliff, suggesting that the bay contributes sediments elsewhere and is not an entirely closed system. Long term maintenance of the beaches of the bay is therefore critically dependent upon continuation of cliff erosion inputs.

d. Continued cliff retreat around Luccombe will cut further into the flanks of Shanklin and Luccombe downs and is likely to further re-activate relic landslides, potentially leading to rapid landward progressions of cliff top instability by several tens, or even hundreds of metres within specific events.

e. Without improved protection the Yaverland barrier beach could be susceptible to breaching. An extensive low-lying area of the Eastern Yar valley could become inundated to generate a tidal prism sufficiently large to maintain a new permanent tidal inlet.

5. Climate change

5.1 Current guidance

Given the long intended lifetime and high value of the built (and natural) environment, it is imperative that flood and coastal erosion management plans and investment projects take into account, in an appropriate way, the changing risks over the coming century. This includes designing for adaptation to a changing climate where appropriate.

In 2014 the Environment Agency (EA) issued updated advice for adapting to climate change (Adapting to Climate Change: Advice to Flood and Coastal Risk Management Authorities, 2014). The EA advice is based on the Governments' policy for climate change adaption, and is specifically intended for projects or strategies seeking Government Flood and Coastal Erosion Risk Management Grant in Aid. The climate change allowances are based on UKCP09 or research using UKCP09 data.

5.2 Change to relative mean sea levels

The Environment Agency guidance recommends that the UKCP09 upper confidence band (95th percentile) medium emissions projection is used as the 'change factor' allowance for mean sea levels. This relative sea level rise projection is shown in Figure 5-1 below.

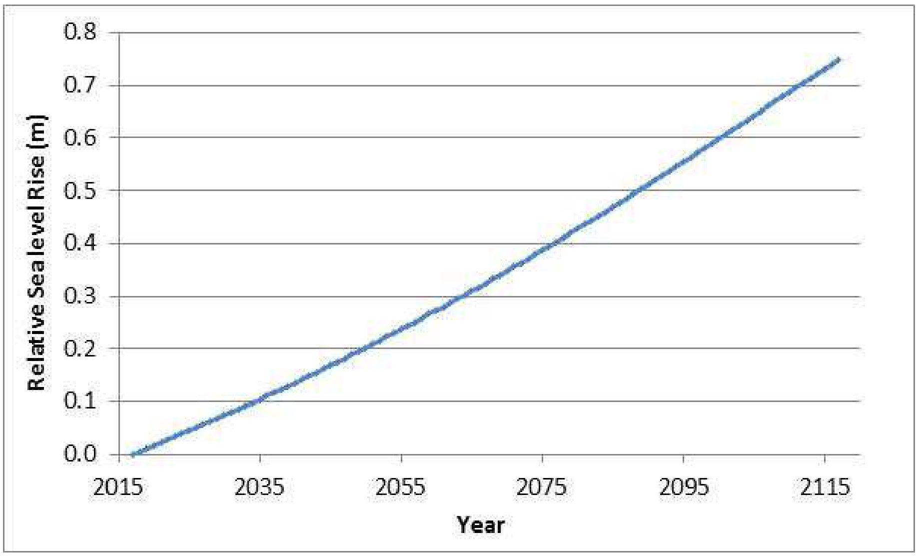

Figure 5-1. Projected relative sea level rise at the study site, medium emissions scenario 95th percentile, UKCP09

Table 5-1 presents the relative sea level rise projected for different years during the study appraisal period, assuming a base year of 2017.

Table 5-1. Projected relative sea level rise, medium emissions scenario 95th percentile, UKCP09, base year 2017

Year	2025	2050	2060	2100	2117
Relative sea level rise (m)	0.045	0.202	0.273	0.599	0.749

5.3 Changes to storm surges due to climate change

Extreme water levels occur as a resultant combination of mean sea level, astronomical tide levels and non-tidal components (such as storm surge). Climate change is expected to lead to increased storminess and changes in storm tracks over the UK in the future and therefore storm surge level are expected to increase.

The extreme water levels for the frontage that are provided in Section 3.2 are extracted from the Coastal Flood Boundary Dataset and include tidal surge. However, the extreme water levels are available for 2008 only and therefore a change factor has to be applied to account for surge when projecting future extreme water levels.

The EA guidance (2014) recommends applying storm surge change factors to account for potential increased surge in the future. It is recommended that the change factor for storm surges is based on a rigorous assessment of the current coastal extreme water levels.

The latest research into future storm surges presented in UKCP09 is based on the National Oceanography Centre storm surge model (CS3). This model is currently used to provide coastal forecasts of surge in the UK, as part of the UK Coastal Monitoring and Forecasting service, to support the issue of flood warnings by the Environment Agency and similar bodies.

There is a long-period natural variability known to affect European storminess and over the century–scale, change has been reported to be of the order of 50cm. The EA guidance (2014) explains that there is significant uncertainty in the projected change to the storm surge track over the UK which is the primary driver of storm surge intensity and frequency.

The advice for allowing for potential increases in storm surge from the new guidance is given in Table 5-2.

Table 5-2. Advised change factors for storm surges (extracted from EA guidance (2014)

	Total potential change anticipated up to the 2020s	**Total potential change anticipated up to the 2050s**	**Total potential change anticipated up to the 2080s**
Upper end estimate	20cm	35cm	70cm
Recommended climate change allowance	Ensure a rigorous assessment of the current coastal extreme water level has been undertaken	Ensure a rigorous assessment of the current coastal extreme water level has bene undertaken	Ensure a rigorous assessment of the current coastal extreme water level has been undertaken

The surge change factor for the study site has been downloaded from the UKCP09 user interface and a description of how it has been accounted for in future extreme water levels is provided below.

Table 5-3. Allowances for change in the height of storm surges for various return periods over time for the medium emissions scenario (data downloaded from the UKCP09 user interface)

Uncertainty level (%)	**Long term linear trend in skew surge (1951-2099) for the return level of 2 years (mm/yr)**	**Long term linear trend in skew surge (1951-2099) for return level of 10 years (mm/yr)**	**Long term linear trend in skew surge (1951-2099) for return level of 20 years (mm/yr)**	**Long term linear trend in skew surge (1951-2099) for return level of 50 years (mm/yr)**
5	0.139	0.231	0.262	0.299
50	0.232	0.381	0.433	0.499
95	0.325	0.531	0.605	0.698

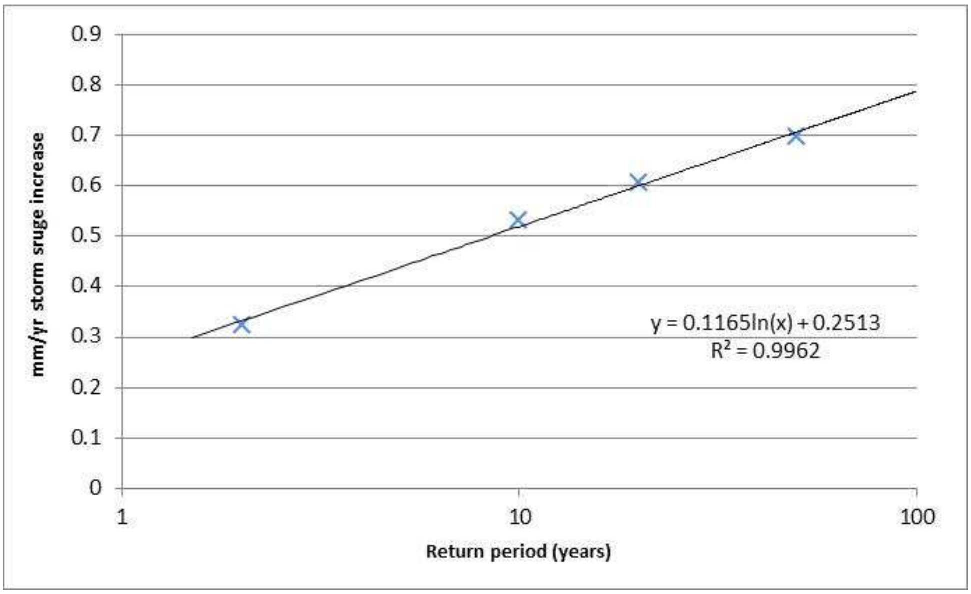

Figure 5-2. Extrapolation of annual storm surge increased based on data obtained from UKCP09

Table 5-4. Extrapolated surge increase for a range of return period events

Return period	mm / yr +
1	0.251
2	0.325
5	0.439
10	0.531
20	0.605
50	0.698
100	0.788
200	0.869
500	0.975
1,000	1.056

Extrapolation of the downloaded data points has been undertaken to establish the change factor for the full range of return period events (Figure 5-2 and Table 5-4). A graphical representation of the projected change to the 1:200 year water levels at the northern and southern ends of the site is provided in Figure 5-3 and Figure 5-4.

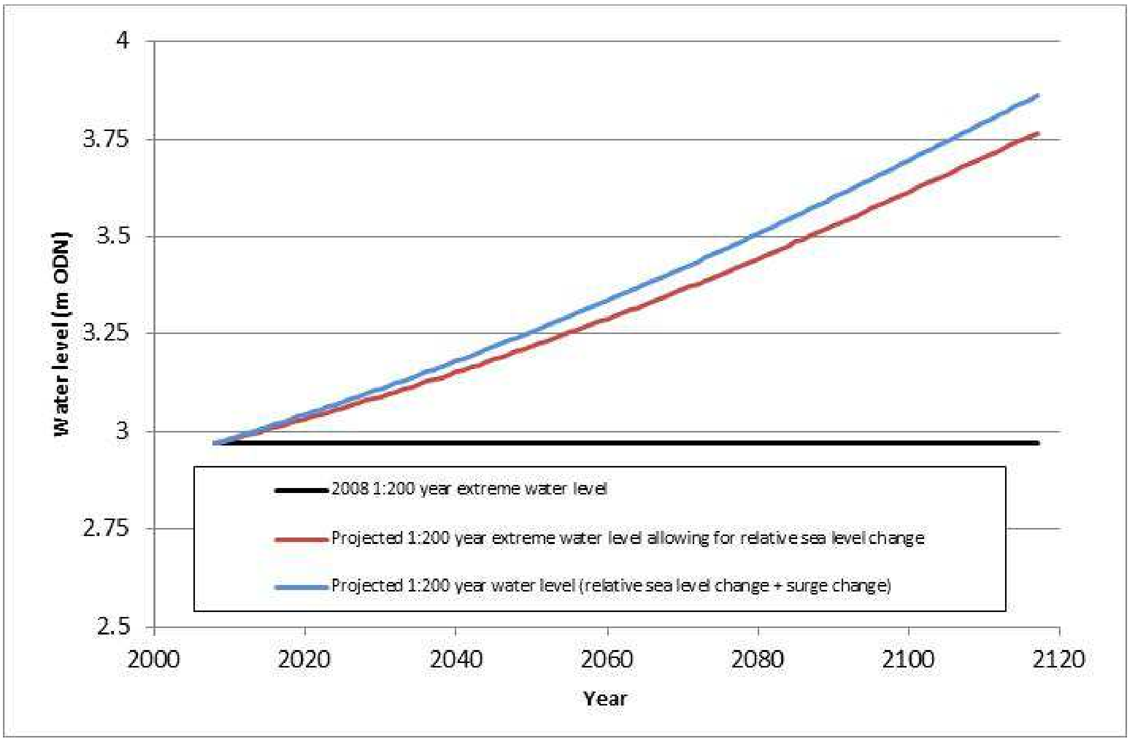

Figure 5-3. Graphical representation of how the future extreme water levels are predicted by combining the storm surge and still water increases at the north end of the study site

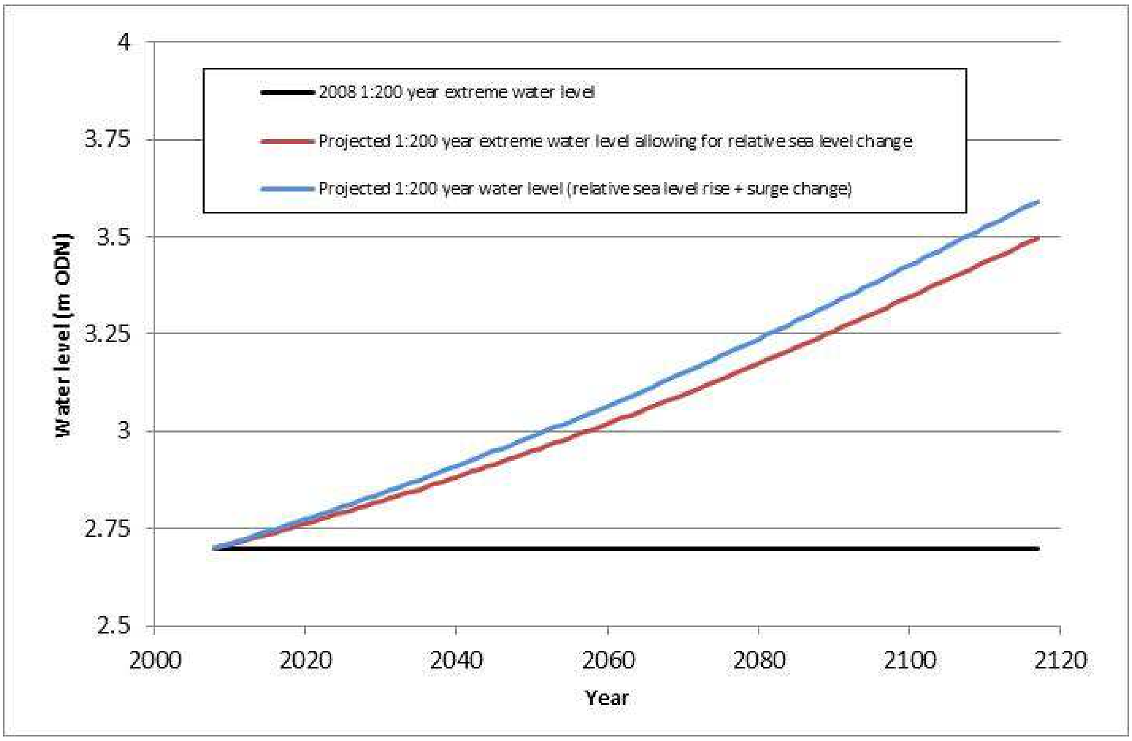

Figure 5-4. Graphical representation of how the future extreme water levels are predicted by combining the storm surge and still water increases at the south end of the study site

5.4 Future extreme water levels

Future extreme water levels have been evaluated by adding the mean sea level changes and surge increases to the extreme water levels provided in section 3.2 (base year 2008). The predicted future extreme water levels have been produced using the EA guidance (2014). This includes allowances for changes in relative mean sea level based on the medium emissions scenario 95th percentile and also for increases in storm surges. The predicted future extreme water levels for the north and south ends of the study site are presented in Table 5-5 and Table 5-6.

Table 5-5. Predicted future extreme water levels (mOD) for the north end of the study site (medium emissions scenario 95%tile including the storm surge factor)

North end	Medium emissions scenario 95% + surge			
	Extreme water level (m ODN)			
Return period (years)	2017	2025	2060	2117
1	2.526	2.578	2.836	3.361
5	2.686	2.738	2.996	3.521
20	2.816	2.868	3.184	3.651
75	2.936	2.988	3.246	3.771
100	2.966	3.018	3.276	3.801
200	3.026	3.078	3.336	3.861
1000	3.176	3.228	3.486	4.011

Table 5-6. Predicted future extreme water levels (mOD) for the south end of the study site (medium emissions scenario 95%tile including the storm surge factor)

South end	Medium emissions scenario 95% + surge			
	Extreme water level (m ODN)			
Return period (years)	2017	2025	2060	2117
1	2.276	2.328	2.644	3.111
5	2.426	2.478	2.736	3.261
20	2.556	2.608	2.866	3.391
75	2.666	2.718	2.976	3.501
100	2.696	2.748	3.006	3.531
200	2.756	2.808	3.066	3.591
1000	2.886	2.938	3.196	3.721

6. Flood and erosion risks

6.1 Coastal flood risk

The Environment Agency, with support from consultants JBA produced a flood model for this area of the Isle of Wight which covers the study site. Simulations from the model show that there is tidal and wave overtopping flood risk at the northern end of the site. During larger return period events the flood cell adjoins to the Eastern Yar flood cell to the north east, which propagates from Embankment Road.

Figure 6-1 and Figure 6-2 show the present day flood extents for 1:75 (1.33% AEP) and 1:200 year (0.5% AEP) return period events, respectively. The figures show that the flooding extent does not dramatically increase between these events but the flooding gets deeper, most notably around the northern part of Sandown where flood depths of >1m are observed during the 1:200 year (0.5% AEP) event.

Figure 6-3 shows the 1:200 year (0.5% AEP) flood extent for 2115. Compared to the equivalent event in the present day, the flood extent is significantly larger and deeper. Much of the flood cell has depths >2.5m, although these deep areas are typically located in wetland areas away from properties and assets. The extent of flooding along the coast at Sandown is significantly more than at present day.

6.2 Other flood risks

Additional sources of flooding exist along the frontage including fluvial, surface water and groundwater. These sources of flooding are localised. Any future schemes will need to ensure that proposals put forward to manage the tidal flood risk do not have a negative impact and increase the risk of the other sources of flooding.

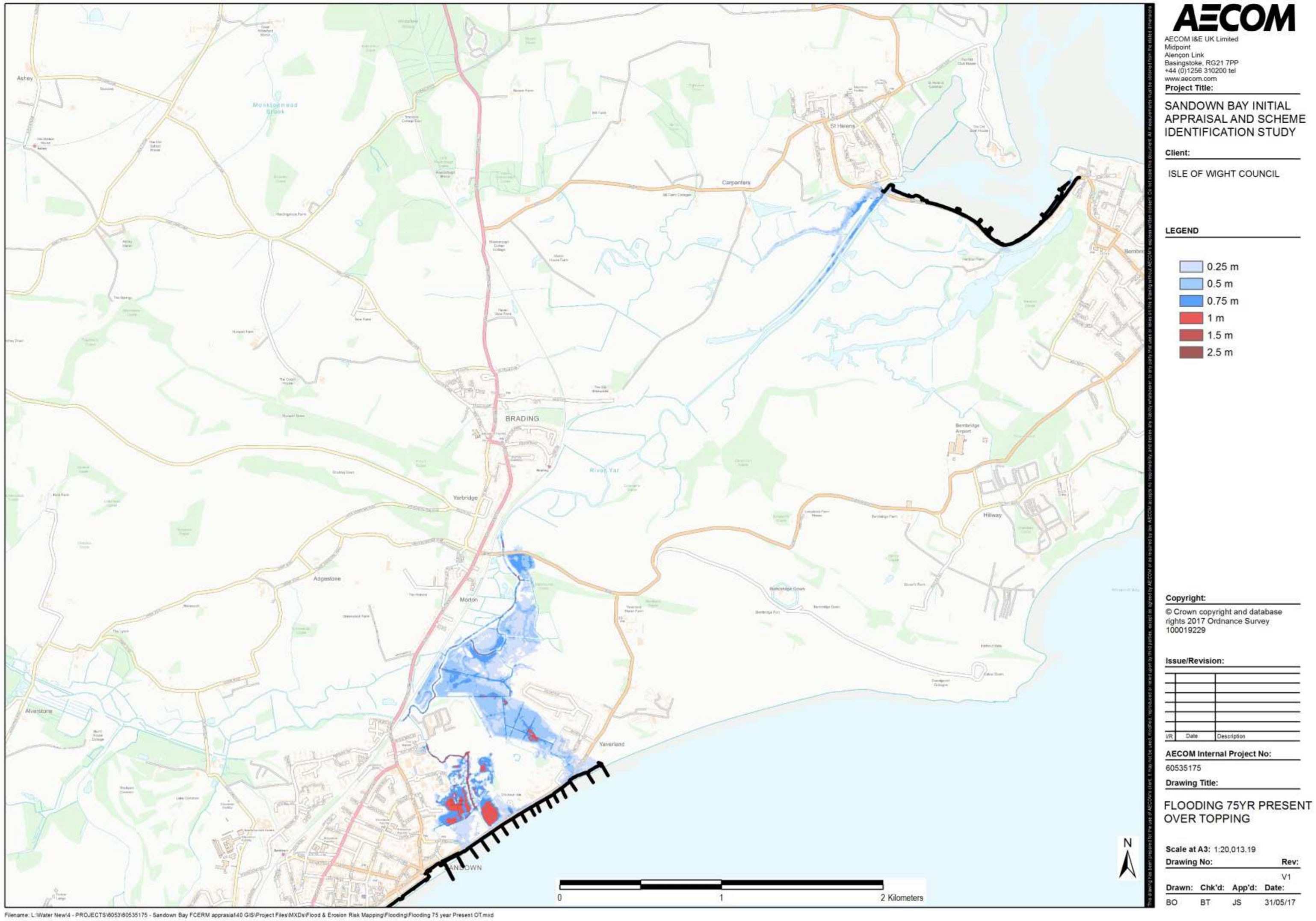

Figure 6-1. Present day 1:75 year flood extent, including overtopping

Prepared for: Isle of Wight Council

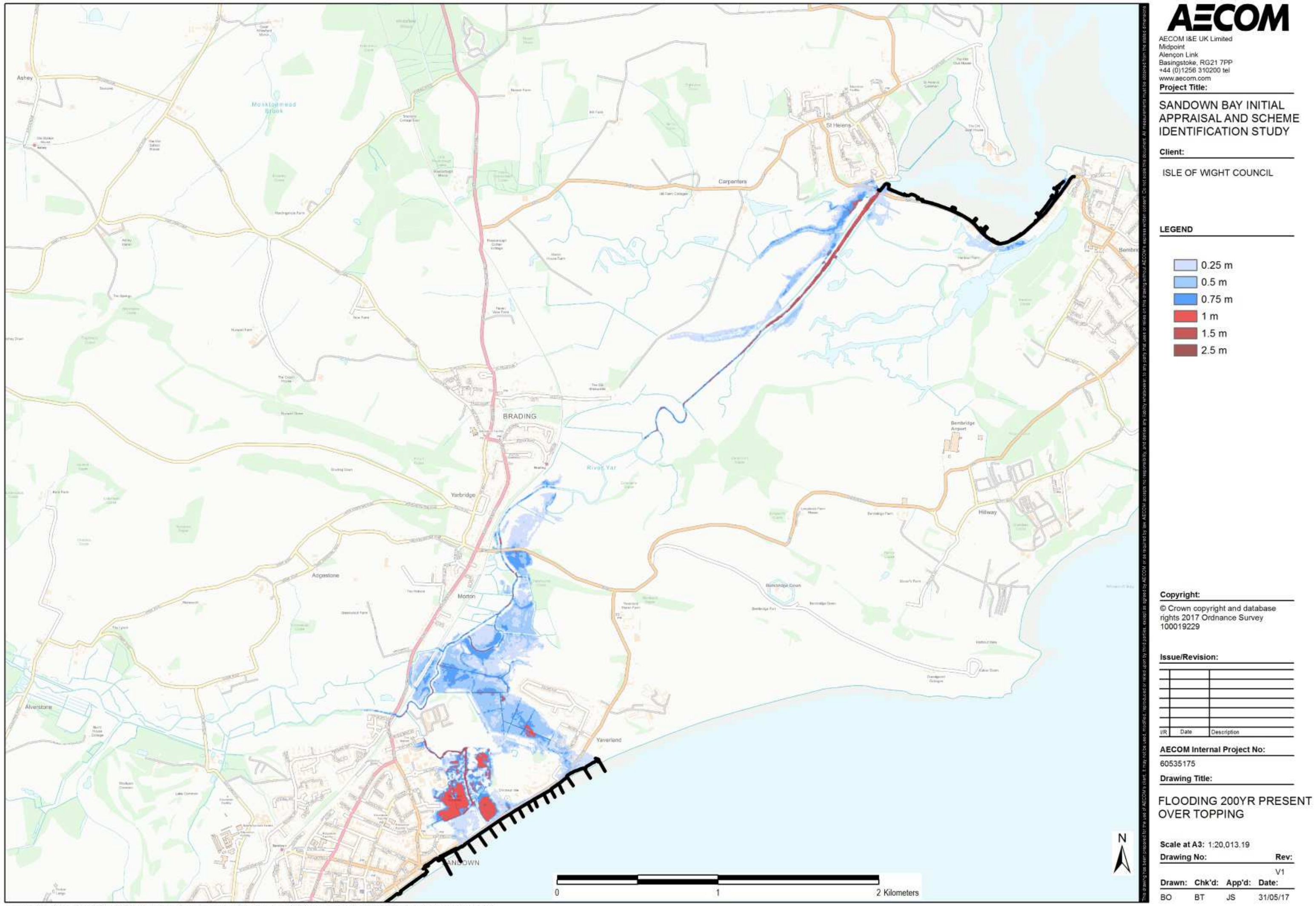

Figure 6-2. Present day 1:200 year flood extent, including overtopping

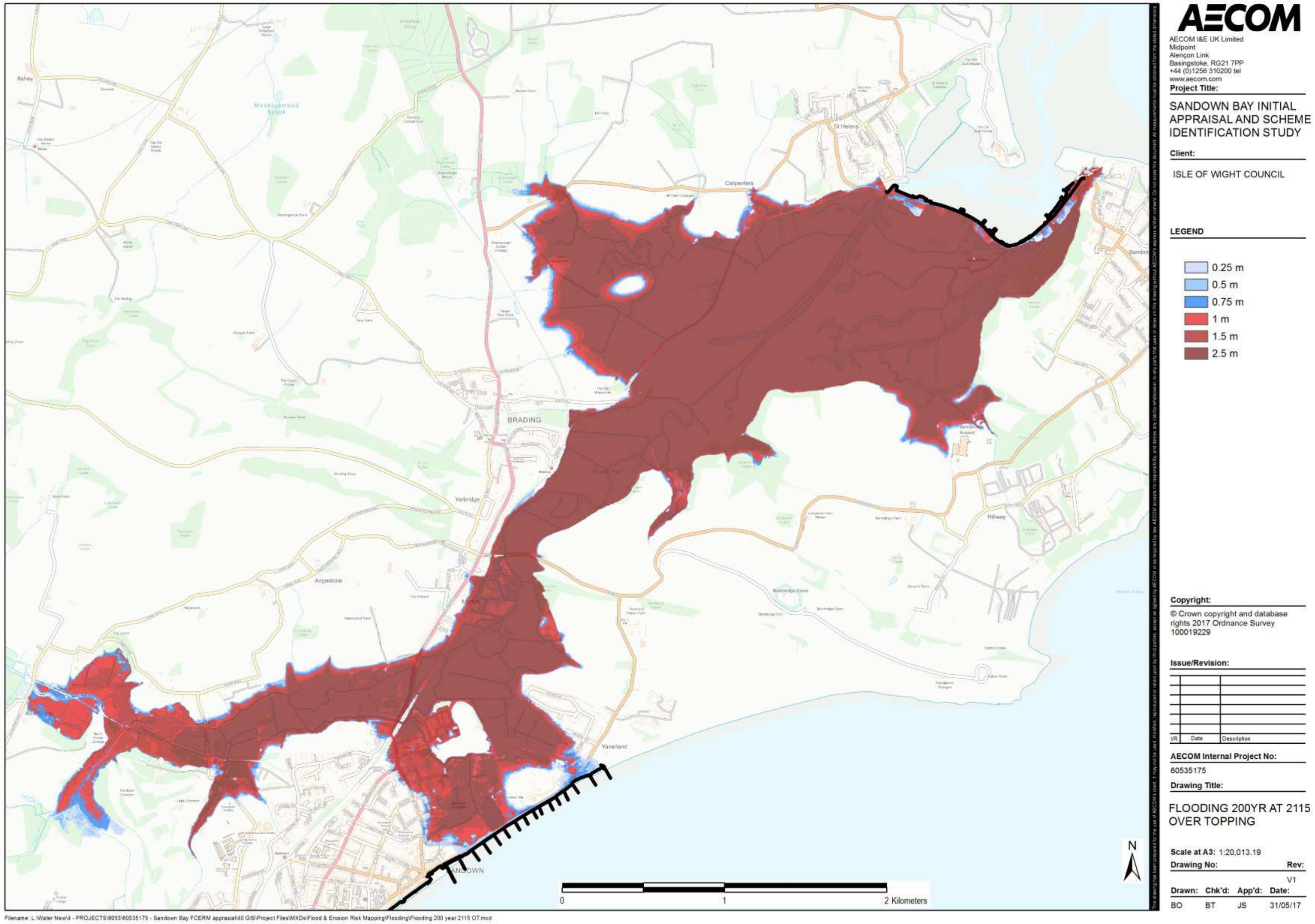

Figure 6-3. 2115 1:200 year flood extent, including overtopping

6.3 Erosion risk

Erosion lines for the study area have been provided by Isle of Wight Council for time periods through the appraisal period.

The erosion lines were initially mapped for the Shoreline Management Plan (2010) but subsequent updates to these erosion lines zones have been made to account for an updated defence condition assessment and residual life (2016), as well as updated climate change and sea level rise allowances and a new baseline year.

The baseline 'No Active Intervention' erosion lines have been mapped, with the following notes on the methodology:

- The baseline erosion rates used were the same as those used in the SMP2 (typically 0.3 or 0.4 metres per year for this frontage) but these baseline current rates were subject to an updated calculation of the impacts of sea level rise and climate change, in accordance with the methodology used in the recent neighbouring *West Wight Coastal Flood and Erosion Risk Management Strategy, 2016, Appendix C, Annex C* (www.coastalwight.gov.uk).
- The latest aerial photography available at the time of the assessment to map the existing clifftop line on the undefended coast was from 2015, as an updated baseline.
- The defence condition assessment has been updated since the SMP2 and the latest condition and residual life estimates have been used in the erosion zone predictions.
- The first year of potential defence failure was used in the erosion predictions, so for example, if a defence has an estimated residual life of 10-15 years, year 10 was taken as the potential year of defence failure.
- The first two epoch time boundaries match those in the SMP2, so the three epoch lengths for the erosion lines are 2015-2025 (10 years), 2025-2055 (30 years) and 2055-2115 (60 years).
- The erosion zones / retreat positions are mapped from the current defence line, and take account of the steep sea-cliff profile where it is present. Once erosion reaches the cliff toe, it will continue retreating inland from the cliff top line. This can result in an apparent difference in the visible width of the zones which is dependent on the steepness of the cliff profile when it is viewed in plan form.
- In the update, the consequence and timing of failing defences have been considered as follows; where a seawall / esplanade is directly located against the base of the cliff / talus slope (for example, at Lake cliffs), following the first defence failure it has been assumed that it would take 5 years for the destruction of the seawall / esplanade structure and reactivation of the cliff profile and clifftop erosion / retreat to commence.

Figure 6-4 to Figure 6-12 present the 'Do Nothing' erosion risk along the frontage.

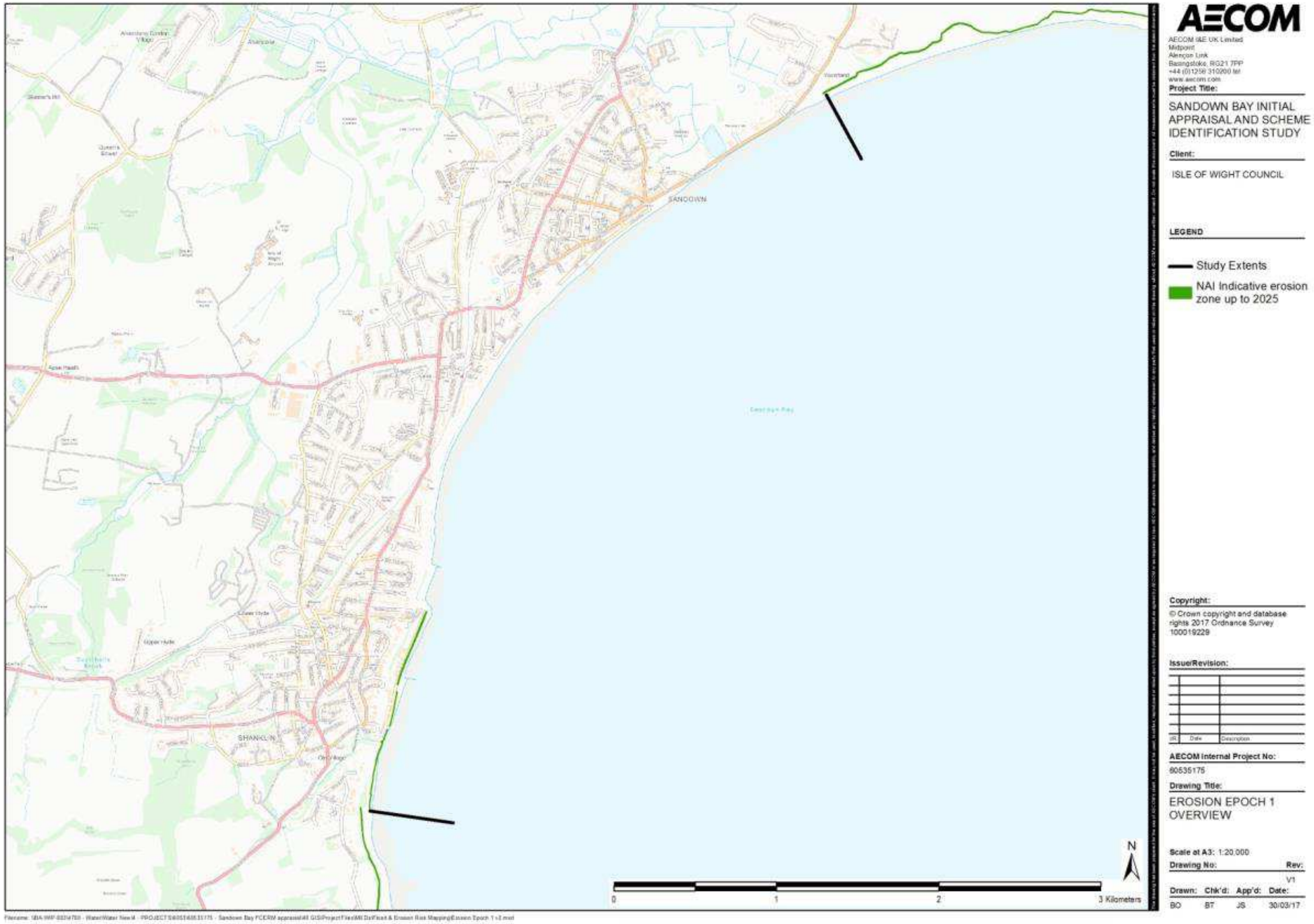

Figure 6-4. Predicted erosion up to 2025, full study site

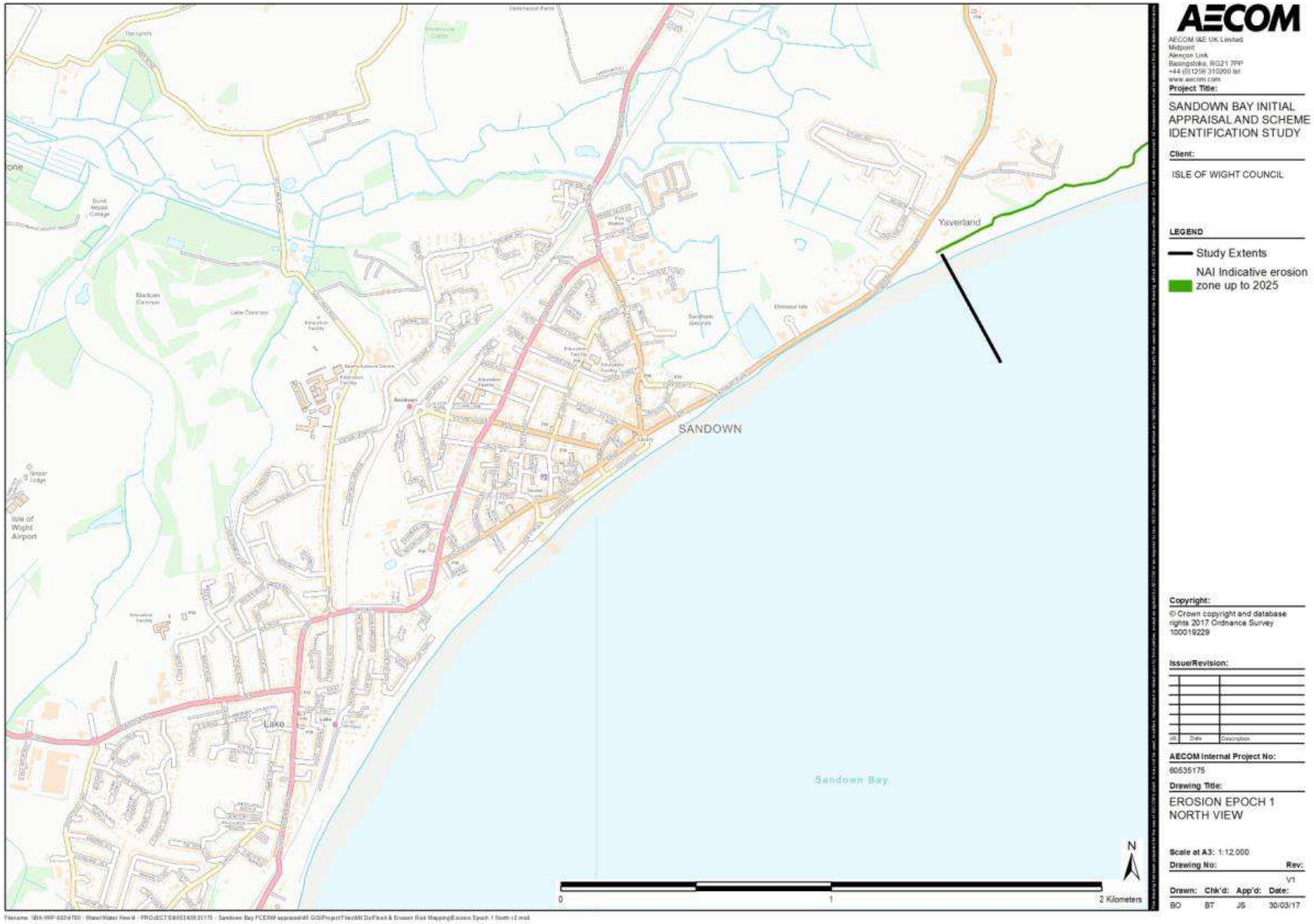

Figure 6-5. Predicted erosion up to 2025, north side of the study site

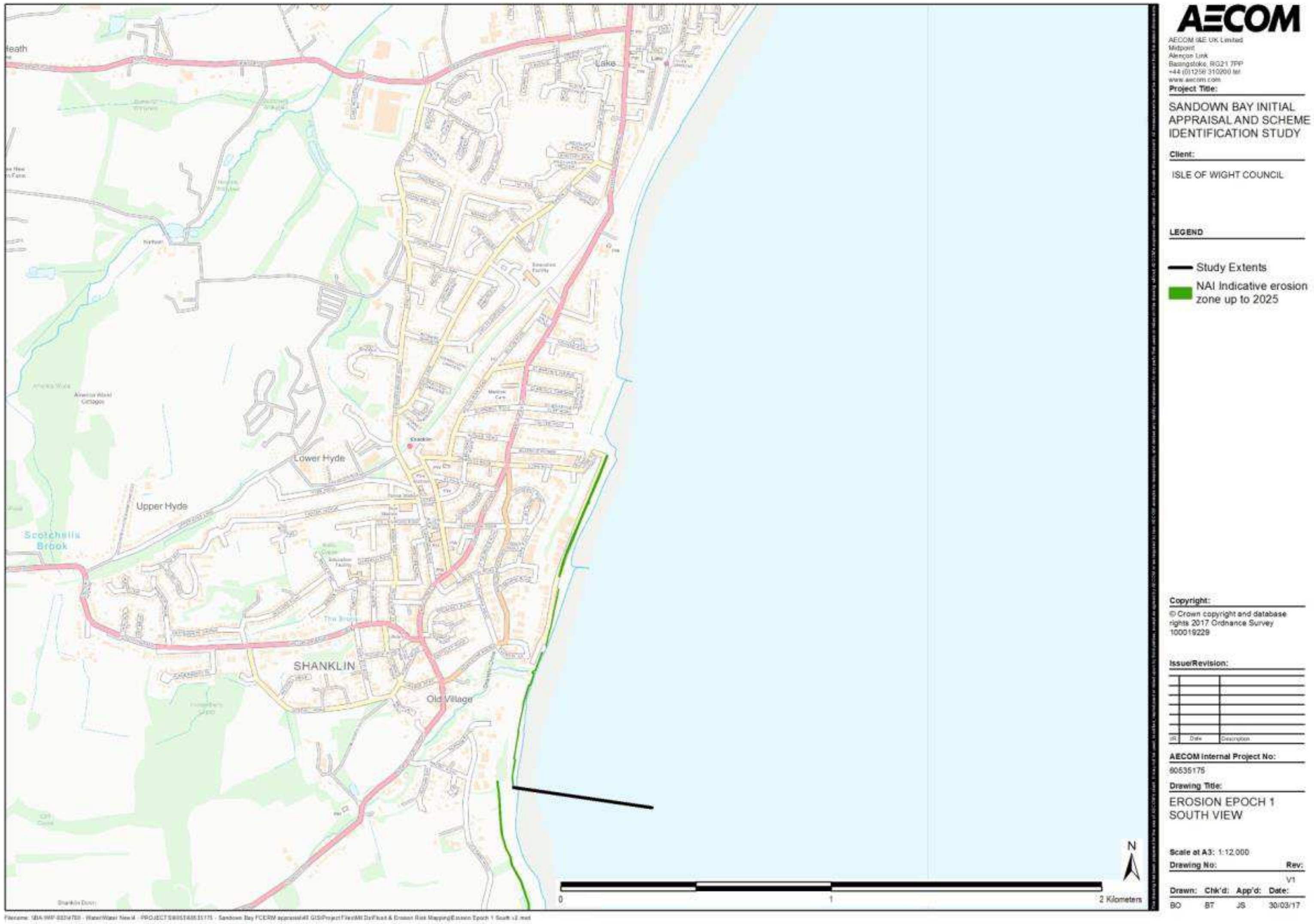

Figure 6-6. Predicted erosion up to 2025, south side of the study site

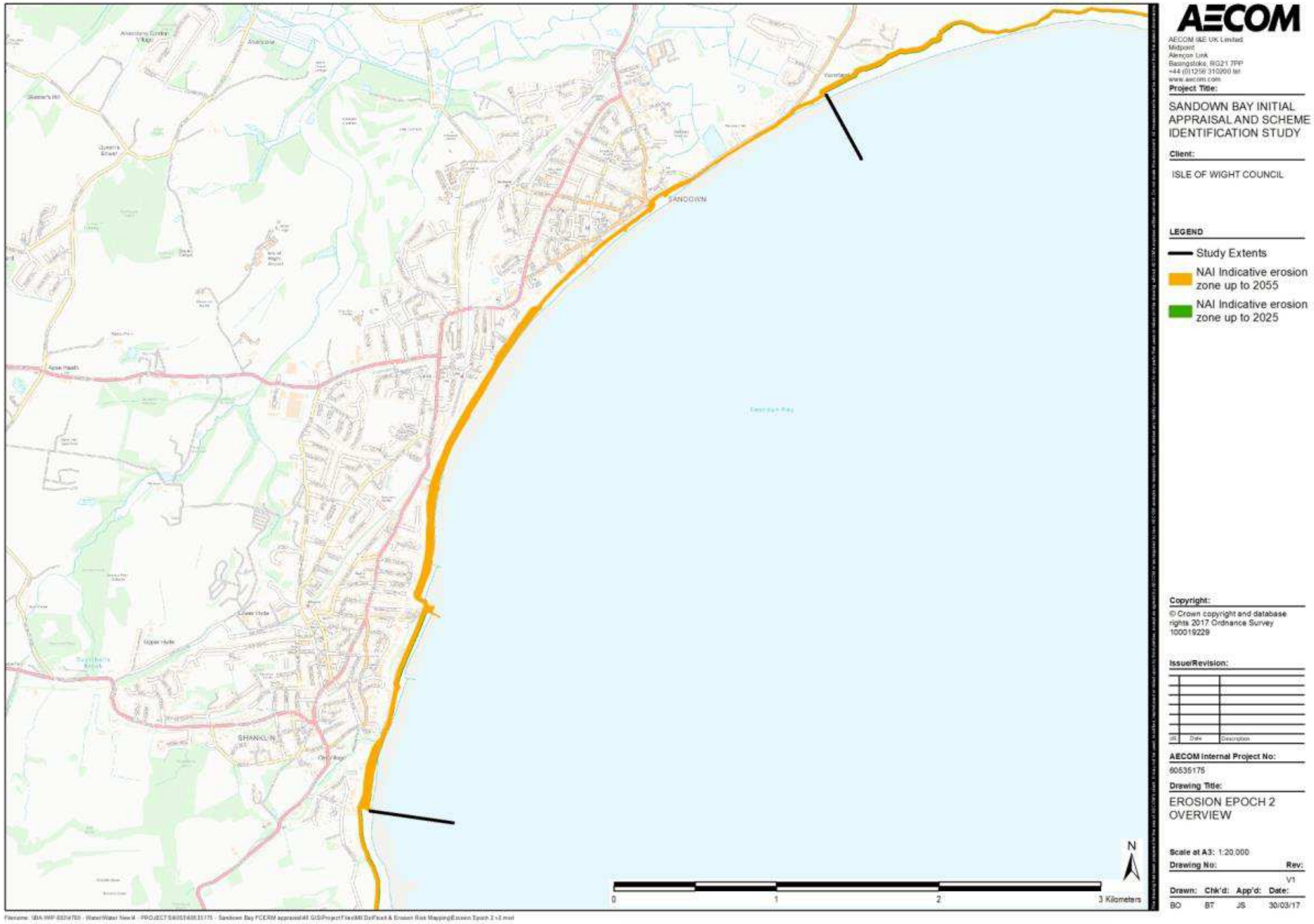

Figure 6-7. Predicted erosion up to 2055, full study site

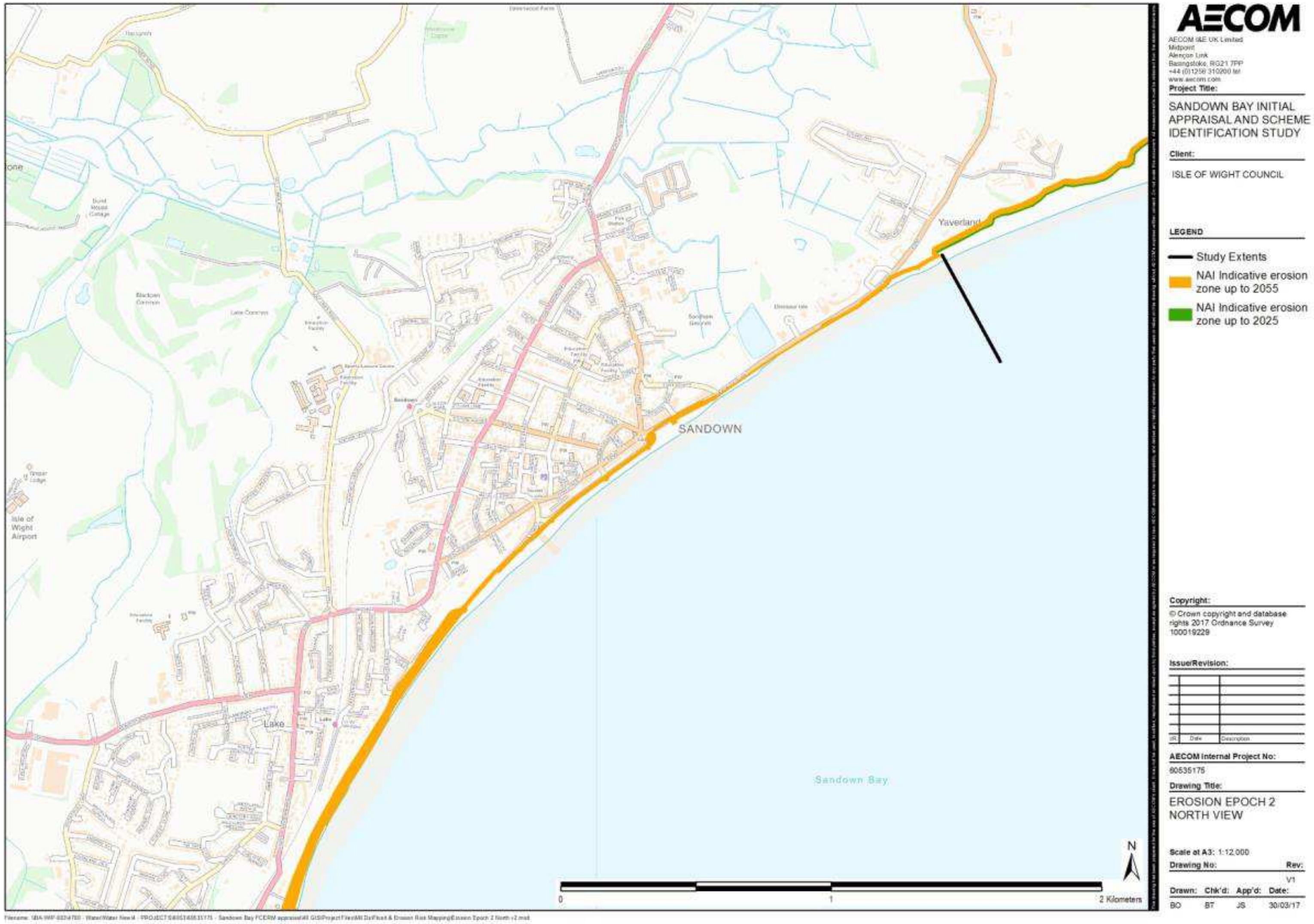

Figure 6-8. Predicted erosion up to 2055, north side of the study site

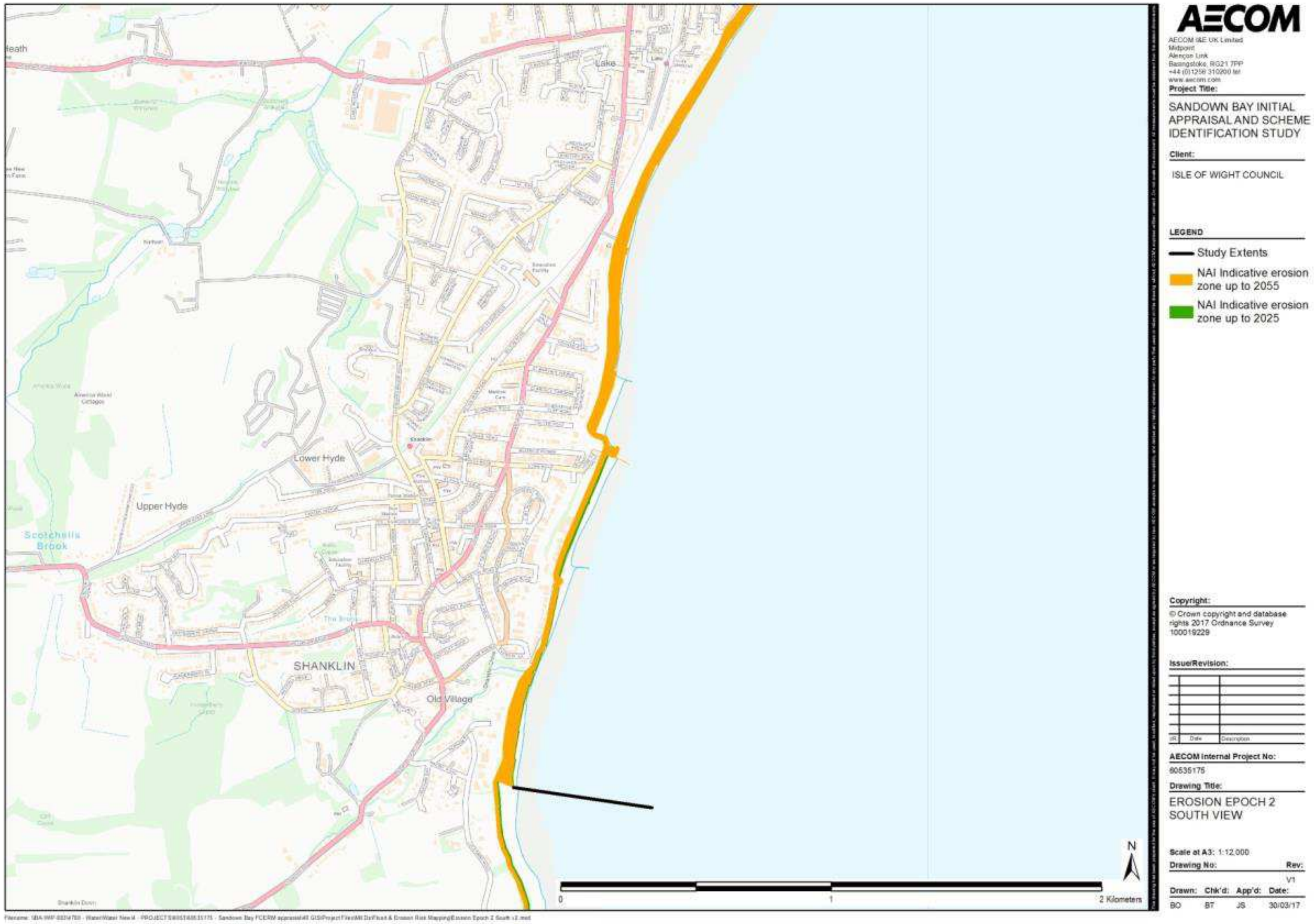

Figure 6-9. Predicted erosion up to 2055, south side of the study site

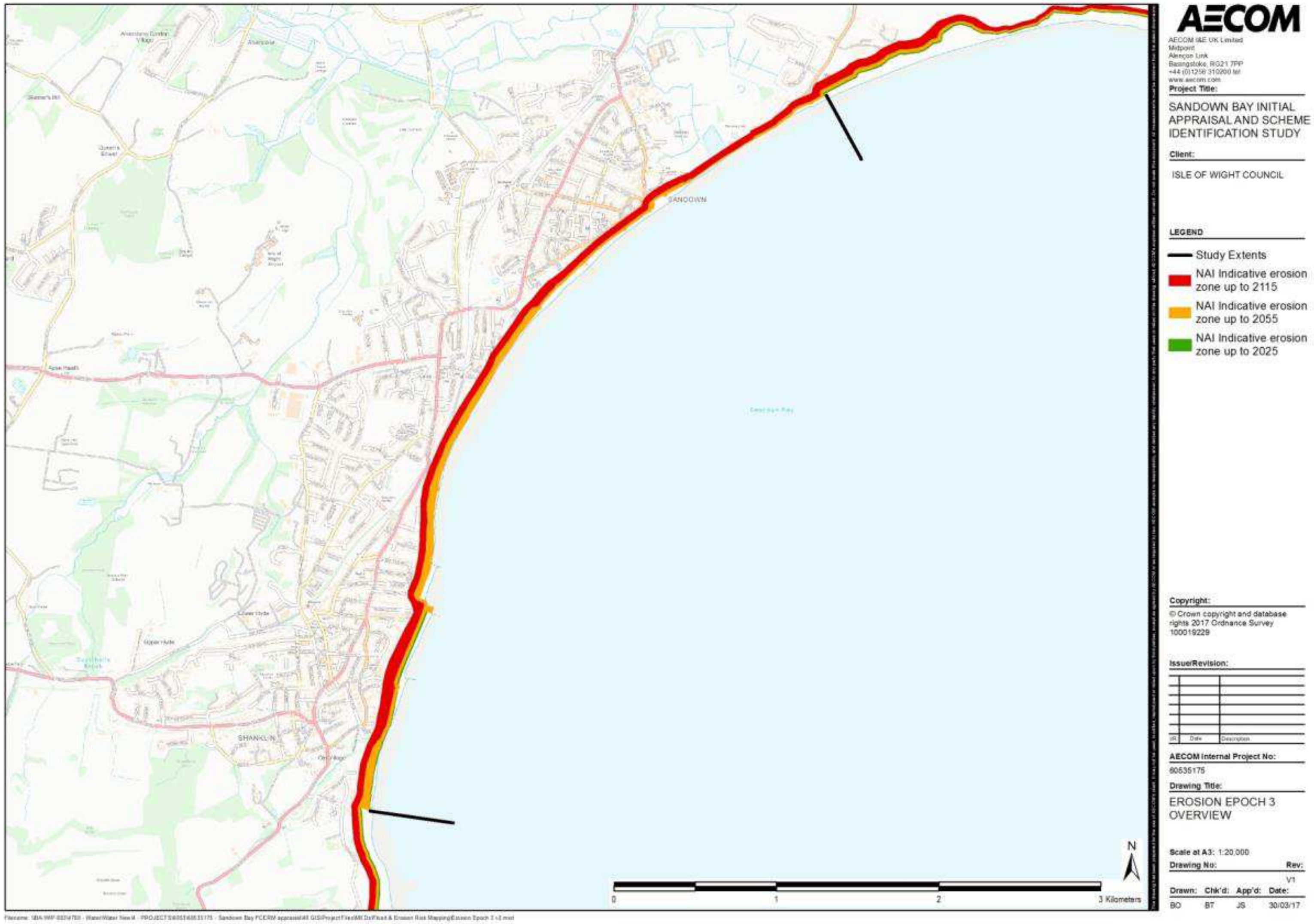

Figure 6-10. Predicted erosion up to 2115, full study site

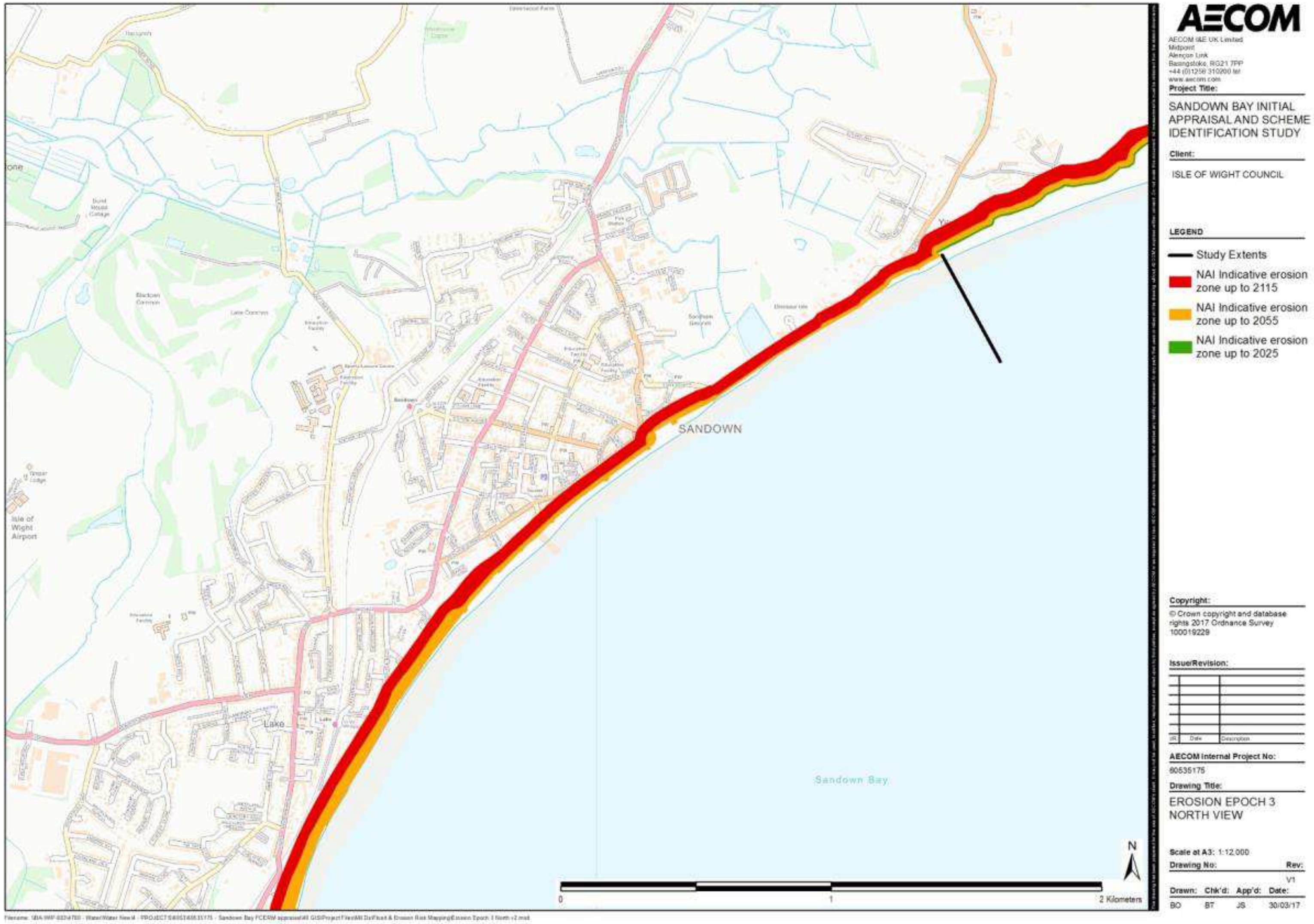

Figure 6-11. Predicted erosion up to 2115, north side of the study site

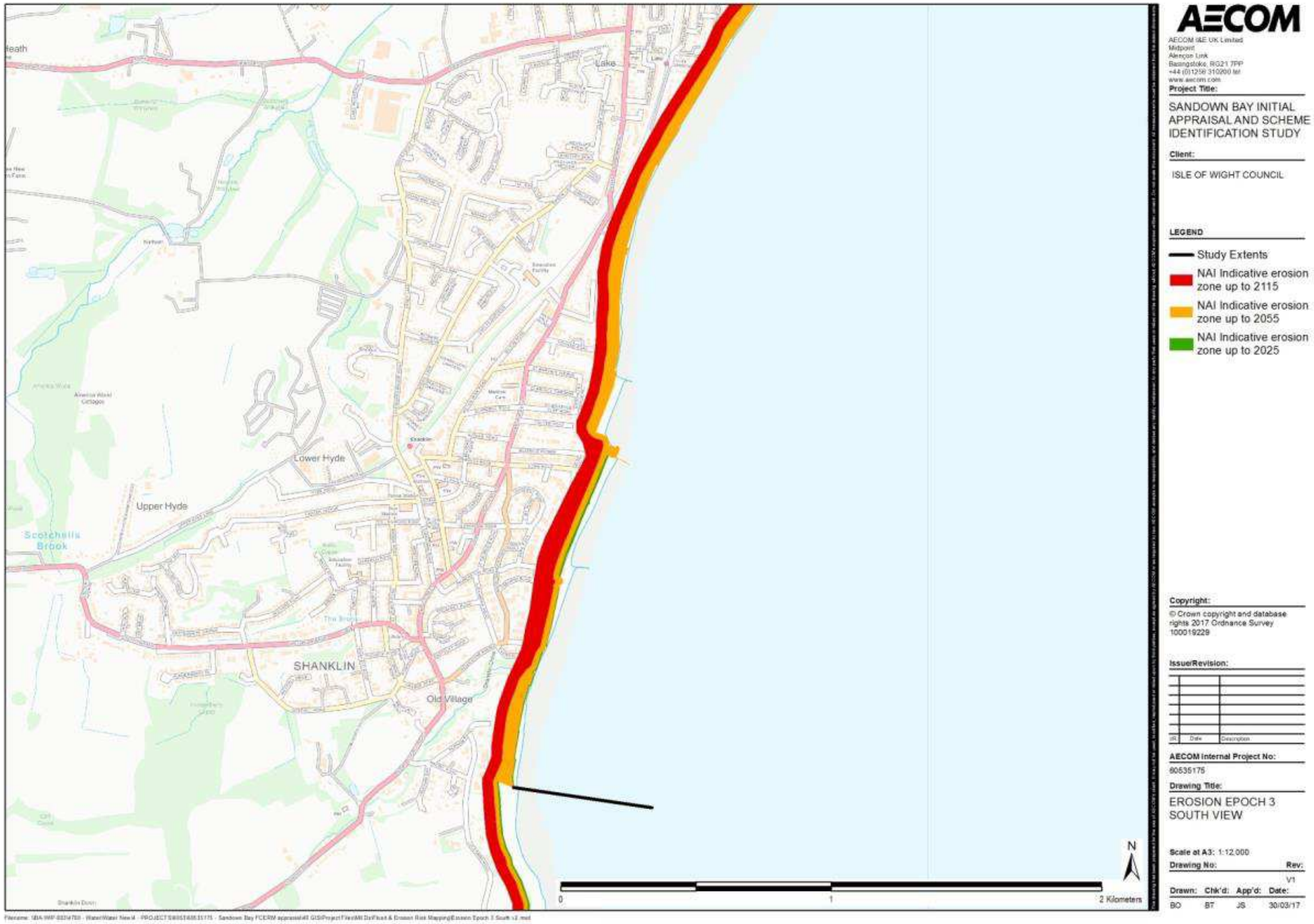

Figure 6-12. Predicted erosion up to 2115, south side of the study site

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8. Addendum – impact of preferred options on coastal processes

8.1 Introduction

This addendum has been added following the recommendation of the preferred options for the study frontage. This addendum describes the potential impact of the preferred options on the coastal processes along the frontage. Note that at this stage the potential impacts have been assessed based on the project team's understanding of the frontage and recommended options. There has not been any numerical modelling (e.g. beach response or morphological modelling) undertaken to support the desk based data review assessment and this is recommended to improve the validity and robustness of potential future trends and predictions.

8.2 Eastern Yar Flood cell (units IW22-24 and unit IW15)

8.2.1 IW22-24 (Yaverland Car Par to Culver Parade)

The draft preferred options for these units involves refurbishment of the groynes which has the potential to impact beach levels by trapping littoral sediment and interrupting the natural movement along the beach. However, the groyne refurbishments will be working with the existing structures and will not involve constructing or removing groynes from the system. Therefore, compared to the existing baseline, significant changes to coastal processes in the area are not anticipated.

In the future, due to climate change, the influence of the existing groynes on beach levels may not be as strong. For example, higher sea levels and increased storminess could lead to greater movement of beach materials in certain parts of the beach and potentially more material passing over / through the existing groyne structures. Higher / longer groynes are not currently proposed but as part of future refurbishments there could be scope to investigate this, for example raising the existing structures to help maintain beach levels or rationalising the number of groynes and replacing shorter structures with longer terminal groynes which are shown to be most effective at trapping sediment and stabilising beach levels. The coastal process impacts of different size structures / structure layouts could be more significant and in order to support these type of decisions it will be necessary to continue to regularly monitor beach level trends; such analysis will also be important when carrying out more detailed appraisals and scheme designs. This data will also be important for setting up and calibrating any future numerical modelling of the beach system and defence proposals. Future numerical modelling should consider sediment type, beach profile, water level and wave conditions (amongst other factors) to simulate the littoral drift rates and volumes and the impact of different groyne options and layouts on the size of the beach. Periodically refurbishing the groynes in the units to the south at Lake and Shanklin could potentially decrease the sediment availability to units to the north in the bay temporarily (whilst any improved areas refilled with sediment).

Yaverland to Culver Cliff

Down-drift of IW22 (from Yaverland to Culver Cliff) there is a large undefended stretch of coastline with high cliffs and an SMP management policy of No Active Intervention. By refurbishing the existing groynes in unit IW22 the defences will continue to reduce sediment movement down-drift to this area, which is currently affected by variable beach levels, with sand covering or exposing the wave-cut platform at different times. This is likely to lead to a continuation of the erosion experienced to the north of the study site, although this is considered to be acceptable because it does not change the existing situation and supports the SMP management policy.

Beach recycling was an option considered in this study but not taken forward as a preferred option. However, if sediment recycling or replenishment were reconsidered in the future, and a local source of sediment were to be sought for beach recycling (as opposed to beach replenishment, which would use sediment from an external source), this area to the north of IW22 could be considered a potential source area, due to the fact that longshore drift gradually transports sediment north-westwards along the bay to this northern end. However, this would require careful further evaluation as this may not be suitable as a source area, due to the variable/fluctuating beach levels in this area, the multiple environmental designations of the cliffs and beach (SSSI, SAC, pSPA and rMCZ), and it is also a popular year-round amenity beach.

8.2.2 IW15 (Embankment Road, Bembridge)

The study has stopped short of recommending a single preferred option for this unit because environmental issues and funding challenges require further discussion between the relevant stakeholders in this area, a process which has been begun but will be progressed beyond the scope of this early stage assessment. The decision of the preferred option is essentially between three alternatives;

1) Raising defences along Embankment Road

2) Maintaining Embankment Road and constructing flood gates at Yarbridge.

3) Maintaining Embankment Road, constructing flood gates at Yarbridge and then operating the sluice gates at Embankment Road to allow tidal flows into the existing freshwater / brackish habitat areas behind the structure.

Depending on which option is taken forward as the preferred option, there could be impacts on the coastal processes within the unit.

If approach 1 is taken forward, which involves raising of the existing defences at Embankment Road, then there are unlikely to be significant impacts on the coastal processes in the area. This is because this scenario represents a continuation of existing activities.

Approaches 2 and 3 have a greater potential to impact the coastal processes in the area. Both of these approaches could lead to a transition to a different habitat type behind Embankment Road in the future, although the transition is likely to be more rapid with approach 3. This could also potentially alter the character and coastal processes within and surrounding the Harbour, dependent on the water flows through the Harbourt.

In addition, the operation of tide gates at Yarbridge has the potential to impact the fluvial flood risk of the River Yar Valley. This would not be the case during normal tide conditions when the tide gates remained open. However, in the short periods when the structure was closed to prevent tidal flood risk, it could potentially have the effect of 'backing up' fluvial flows behind the structure leading to an increased fluvial flood risk elsewhere. The magnitude and extent of this impact is unknown at this time but it will be essential to undertake a joint probability analysis and modelling study to determine this impact prior to either of the Yarbridge options going ahead, with the intention of this option being to reduce future flood risk to low-lying parts of Sandown.

8.3 Sandown Esplanade (IW25)

The draft preferred option for this unit involves refurbishments to the single timber groyne located in this unit. This could potentially have an impact on the beach levels by interrupting the natural movement of sediment along the beach. However, there is only one timber groyne in this unit, and the groyne refurbishments will be working with the existing structures and will not involve constructing or removing groynes from the system. Therefore, compared to the existing baseline, significant changes to coastal processes in the area are not anticipated. The concrete/masonry 'Herne Hill' terminal groyne at the northern end of this unit has an impact on beach levels this unit. In the past, some localised sediment has been moved up the beach in this unit for amenity purposes.

Periodically refurbishing the groynes in the units to the south at Lake and Shanklin could potentially decrease the sediment availability to the neighbouring units to the north in the bay temporarily (whilst any improved areas refilled with sediment).

8.4 Lake Cliffs (IW26)

The draft preferred option involves periodically refurbishing the groynes which is likely have an impact on the beach levels by interrupting the natural movement of sediment along the beach. Within this unit there are some areas where beach levels have fallen over the last decade. However, there has also been variability, with other areas within this unit showing no significant change (refer to 4.4 for further information).

In the absence of numerical modelling (beyond the scope of this study) it is difficult to predict the magnitude of the impact on beach levels in these units. However, it is expected that dynamic processes will continue (including variability due to storm impacts, wave direction etc) but overall a continuation of the slight accretion or status quo caused by maintaining the groynes (rather than removing them) is expected, with beach levels remaining relatively unchanged and locally improved in the groyne bays where refurbishments are carried out, as these cells refill with sediment to reach a new equilibrium. Further downdrift, in units IW22-24 over the last decade there has been a mixed trend, with some bays accreting and others eroding. Refurbishing the groynes in unit IW26 could potentially decrease the sediment availability to units IW22-25, at least temporarily (whilst any improved areas refilled with sediment). In order to investigate the potential impacts further it will be necessary to continue to monitor beach level trends in the future and this data will also be useful to support scheme designs with numerical modelling of the beach system and defence proposals. Future numerical modelling should consider sediment type, beach profile, water level and wave conditions (amongst other factors) to simulate the littoral drift rates and volumes and the impact of different groyne options and layouts on the size of the beach, both in the immediate vicinity (IW26) and also downdrift in units IW22-25 and beyond.

The groyne refurbishments proposed will work with the existing structures and the aim at present is to avoid constructing new groynes or removing groynes from the system. Therefore the relative impact on beach levels is expected to be reduced compared to a scenario in which new, possibly longer groynes were installed. Numerical modelling would be required to determine the impact of a new groyne layout, longer groynes or higher groynes, although are not currently proposed.

The Maintain option (maintenance of coastal defences) will help to reduce wave action at the toe of the steep cliffs located behind the defences. This is expected to reduce the rate at which the cliffs erode, compared to the natural rate if the cliffs were undefended. However, given that the existing defences are in place and performing the same function, the Maintain option represents a continuation of the existing baseline rather than a distinct change in the approach. Weathering processes will continue to impact on the cliffs.

8.5 Shanklin Esplanade (IW27)

The preferred option involves groyne refurbishments which could have an impact on the beach levels in the local area. However, the groyne refurbishments will be working with the existing structures and will not involve constructing or removing groynes from the system. Therefore, compared to the existing baseline, significant changes to coastal processes in the area are not anticipated.

Given the mixed trend in beach levels along Shanklin Esplanade (when trends are examined over the past twelve years, with some areas accreting, others eroding), it is difficult to predict the exact impact of groyne refurbishments on the levels in the immediate area.. However, it is expected that dynamic processes will continue (including variability due to storm impacts, wave direction etc) but overall a continuation of the slight accretion or status quo caused by maintaining the groynes (rather than removing them) is expected, with beach levels dependent on the localised defence condition of each structure, remaining relatively unchanged and locally improved in the groyne bays where refurbishments are carried out, as these cells refill with sediment to reach a new equilibrium. Refurbishing the groynes in unit IW27 could potentially decrease the sediment availability to units to the north/downdrift temporarily (whilst any improved areas refilled with sediment).). In order to investigate the potential impacts further it will be necessary to continue to monitor beach level trends in the future to support scheme designs, and with the potential for numerical modelling of the beach system and defence proposals. Future numerical modelling should consider sediment type, beach profile, water level and wave conditions (amongst other factors) to simulate the littoral drift rates and volumes and (if considered) the impact of different groyne options and layouts on the size of the beach, both in the immediate vicinity (IW27) and also downdrift in units IW22-26 and beyond. It is noted that (as advised by stakeholders) beach levels can fluctuate considerably over shorter timescales (week to week) due to the impact of precedent conditions e.g. storms, prevailing wind/wave direction etc., but the general role of the groynes to help retain beach levels would be anticipated to continue so long as their condition is maintained..

The Sustain / Improve option would continue to hold Shanklin Esplanade in place and prevent coastal retreat through the area which would otherwise over time also lead to reactivation of the former sea cliff at the back of the esplanade. Periodic rockfall risk will remain from the cliff line and talus slope, due to the impacts of weathering and natural processes.

8.6 Luccombe Cliffs (IW28)

A long-term preferred option in this unit has not been finalised by the study because there is not an economic case to Maintain which represents the lowest investment approach to implement the SMP policy of Hold the Line. Therefore, both the Maintain and the economically preferred option, Do Minimum, could be considered in this unit going forward. These approaches both involve the potential maintenance of the existing timber structures in the short to medium term, diverging at the point the structures would require replacement, dependent on the policy set in future SMP reviews and on funding availability (requiring contributions).

Either Doing Minimum or Maintaining is unlikely to significantly change the coastal processes in this unit in the short term. However going forward, under a Do Minimum approach when the existing timber revetment and groynes come to the end of their service life and become less efficient at trapping sediment, beach levels are likely to lower and there will be an increase in the volumes of beach material moving alongshore and into units to the north. Under a Maintain approach the timber revetment and groyne refurbishments would be working with the existing structures therefore significant changes to coastal processes in the area are not anticipated.

However, even with ongoing patch and repair works, over time it is likely that the existing defences will reach the end of their service life and will fail. This could potentially lead to greater exposure of the cliff toe to wave action / attack and a return to the natural rate of cliff recession in this unit.

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Defence Condition Report

Sandown Bay Initial Appraisal and Scheme Identification Study

Isle of Wight Council

60535175 / DCR_003

October 2017

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Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
Version 1	16/03/17	Draft	PAN	Paul Norton	Technical Director
Version 2	04/04/17	Updated following client review	PAN	Paul Norton	Technical Director
Version 3	24/10/17	For consultation	PAN	Paul Norton	Technical Director
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1. Introduction

1.1 Introduction

AECOM Infrastructure and Environment UK Limited has been appointed by Isle of Wight Council to undertake an option appraisal and scheme identification study for Sandown Bay. The frontage extends 5.8km from Yaverland to Shanklin, comprising Shoreline Management Plan 2 policy units 3C.2 and 3C.3 (SMP2, 2010).

The study will identify and develop future schemes for this urban frontage which faces significant risks. Along this eroding coastline the existing defences are deteriorating and properties and assets along the frontage are at risk from erosion and flooding.

1.2 Purpose of this report

This report details the findings of the Sandown Bay defence condition assessment undertaken by IoW Council Coastal Engineers in June 2016, and reviewed and updated by AECOM coastal engineers in March 2017. This visual defence condition assessment provided the following:

- An update to previous asset inspections undertaken in 2014 and prior to that the IoW SMP2 (2010);
- Indication of asset condition through visual inspection; and
- An assessment of performance of the defences through estimating the residual life.

This information has been used to support the assessment of future deterioration of assets, form Do Nothing and Do Minimum failure scenarios, and underpin the assessment of future erosion and flood risk within the study area.

No intrusive surveys or material testing were carried out as part of the assessment. The interpretation of information within this report is intended to inform appraisal defence options for different frontages. It should not be used to make an assessment of specific defence sections without further observation and investigation of potential material, structural, and geotechnical defects which may be present.

1.3 Overview of study area

The study area encompasses two policy units in the SMP2 both with a ‘hold the line’ policy (units 3C.2 and 3C.3). The study frontage is lined by the settlements/towns of Yaverland, Sandown, Lake and Shanklin (from north to south). In the south of the study site the coastal frontage is backed by steep ferruginous sandstone cliffs, up to 35m high, with development at both the cliff top and cliff toe. The northern side of the study site is more low-lying. The frontage is lined by a popular seafront esplanade, roads and footpaths and is characterised by a wide sandy beach which is important for tourism in the area.

The entire length of the frontage is vulnerable to erosion. The defences along the frontage are a combination of seawalls and groynes which help to hold the beach material in place. The defences help to reduce the rate of erosion but the defences are ageing and in a deteriorating condition. In some locations the beach levels are very low and without timely renewal of the defences, significant asset losses are anticipated in the future. There is potential for widespread cliff reactivation and retreat, and for erosion to encroach further into developed areas.

There are significant numbers of properties and assets at risk from tidal flooding within the Eastern Yar floodplain, especially on the outskirts of Sandown in the north of the study area. Assets at risk include the primary water treatment works for the island.

The frontage is a tourist area, with the wide sandy beach and esplanade frontage key assets in attracting visitors to the area. There are aspirations for regeneration in the Bay communities.

1.4 Structure of this report

This report provides information on the defences in the area and on how the Do Nothing and Do Minimum scenarios have been established. The report is broken down into the following chapters:

2. Methodology
3. Summary of defence condition assessment by unit
4. Key priority areas and recommendations
5. Do Nothing and Do Minimum scenarios

2. Methodology

2.1 Isle of Wight Council Defence Condition Appraisal

In 2016, the Isle of Wight Council revised the original SMP2 defence appraisal (2010) for assets within Sandown and Shanklin study area. This was facilitated by a walkover visual survey by a coastal engineer in June 2016.

Assets were graded using the EA Condition Assessment Manual (2006). Based on the condition grade an estimation of residual life has been made using SMP guidance derived from previous NADNAC (National Appraisal of Defence Needs and Costs) deterioration profiles (Table 2-1).

Table 2-1: Estimation of Residual Life (from SMP guidance)

Defence description	Estimation of Residual Life (years)				
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Seawall (concrete/masonry)	25 to 35	15 to 25	10 to 15	5 to 7	0
Revetment (concrete/rock)	25 to 35	15 to 25	10 to 15	5 to 7	0
Timber groynes/ timber structures	15 to 25	10 to 20	8 to 20	2 to 7	0
Gabion	10 to 25	6 to 10	4 to 7	1 to 3	0

Note that in this study, identification of assets by location is based on smaller units (‘IW’ units), rather than the broader SMP2 policy units.

AECOM undertook a visual inspection on the 6th March 2017 (Figure 2-1) to validate and update the Defence Appraisal undertaken by the Isle of Wight Council (2016). In addition a photographic record of key assets and features was captured during the inspection. The findings will be utilised in the option appraisal phase of the project, to underpin the assessment of options, and the basis of damages under the “Do Nothing” scenario.

Figure 2-1. AECOM visual asset inspection (March 6th 2017).

2.2 Condition Assessment

The condition of the defences was assessed in accordance with the Environment Agency Condition Assessment Manual (2006). The manual provides a condition grading scheme and description to aid a robust and consistent approach to evaluating the condition and residual life of coastal defences. The assets along the study frontage have been categorised into a condition grade (1-5) based on criteria set out in this manual (Table 2-2).

Table 2-2: Extracts from EA (2006) Condition Assessment Manual

Grade	Description of grade	Extent of defects
1	Very good	Cosmetic defects that will have no effect on performance
2	Good	Minor defects that will not reduce overall performance of asset
3	Fair	Defects that could reduce performance of asset
4	Poor	Defects that would significantly reduce performance of asset
5	Very poor	Severe defects resulting in complete performance failure

Estimation of residual life for each asset has been determined using the latest Environment Agency guidance (2013). This guidance is more recent than the SMP guidance for residual life estimations as used in the Isle of Wight Council Defence Appraisal. This method uses probabilistic deterioration curves based on factors which influence the asset life and the predicted maintenance regime. The aforementioned condition grade for each asset is used to determine the location of that asset on the grading curve and subsequently used to determine the residual life of the structure. For the purposes of this study, the following assumptions were made for all assets:

- Maintenance Regime 1: Low/basic-do minimum.
- A medium deterioration scenario has been selected as the most likely deterioration curve.
- The residual life is said to be the time taken for the asset to go from its current condition to condition grade 5, where the asset has essentially failed.

A comprehensive catalogue of photos of the defence assets was obtained for the IoW SMP2 and a selection of more recent photos capturing key interest features have been included in Chapter 3 for each unit. The images provide a record of the current defence condition and evidence for the condition gradings provided and support the assessment of the deterioration of the defences.

2.3 Defence crest heights

Defence crest heights along the frontage have been measured using data collected from a laser scan topographic survey of the entire frontage carried out by the Channel Coastal Observatory in 2012.

The scan generated a high resolution point cloud coverage of the foreshore and defences and the data was interrogated in GIS to work out average, minimum and maximum crest heights along each defence section. The crest levels for the defences to the nearest 0.1m are presented in Chapter 3.

The point cloud data was obtained from instruments deployed on the beach and therefore in some locations the data does not cover the defence crest. However, these locations are limited and for the most part the data coverage is very good.

3. Defence Condition by Unit

The defences along the frontage are split into a series of sub-units; IW 22 to IW 28. A map showing the sub-unit areas and types of defence is shown in Figure 3-1. A map showing the estimated residual life of the defences is shown in Figure 3-2.

A more detailed overview of defence types, locations, lengths and ID’s is provided in Figure 3-3 to Figure 3-6.

The following tables in this section provide an overview of the defence condition and residual life in each sub-unit.

Figure 3-1. Defence sub-units and type

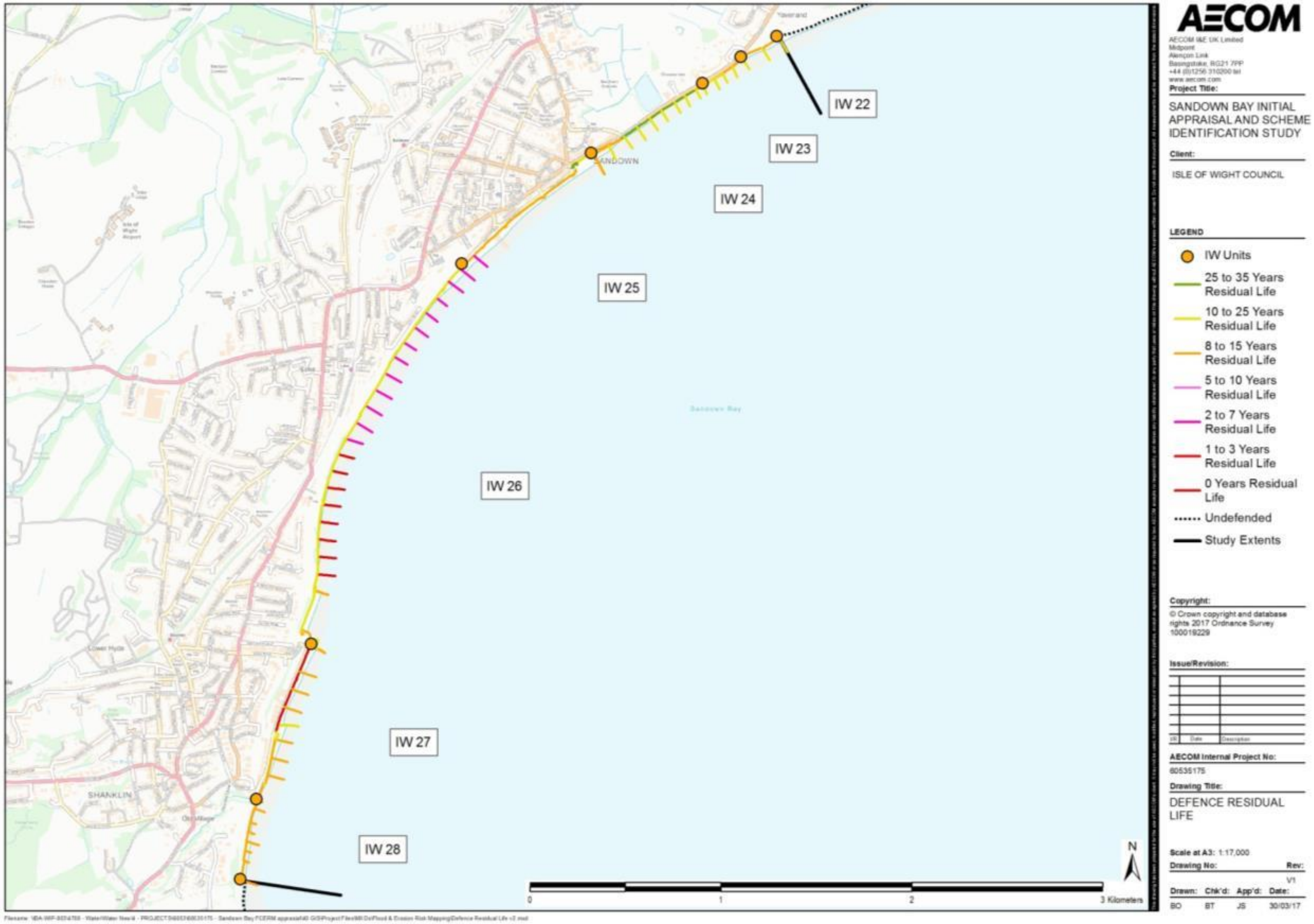

Figure 3-2. Defence residual life estimates

Figure 3-3. Defence locations, lengths and IDs – Yaverland to Sandown

Figure 3-4. Defence locations, lengths and IDs –Sandown to Lake

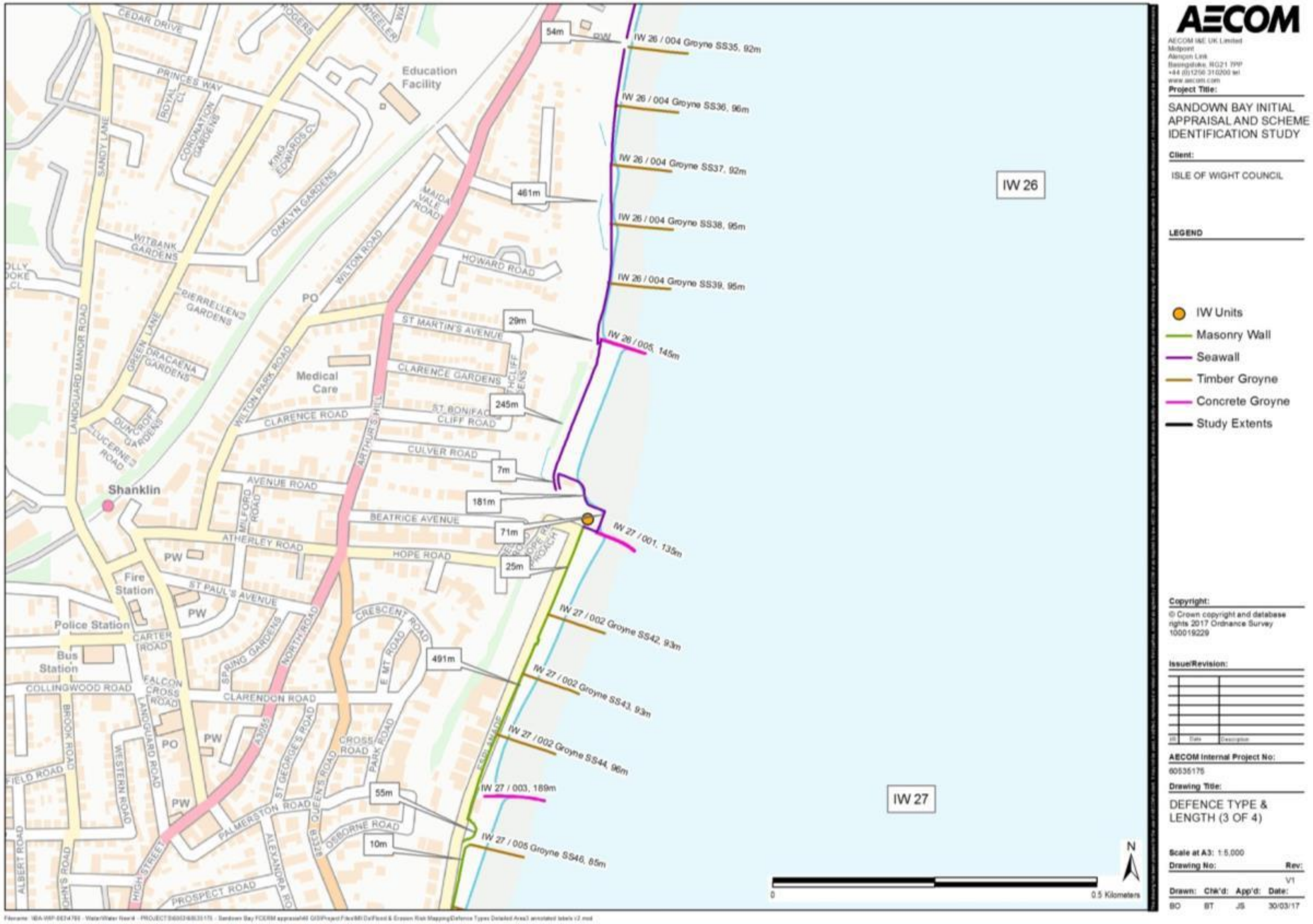

Figure 3-5. Defence locations, lengths and IDs – Lake to Shanklin

Figure 3-6. Defence locations, lengths and IDs –Shanklin to Luccombe

Asset Location - Unit IW 22 - Yaverland carpark			
SMP Unit:	IW22	**Survey Date:**	March 2017
IoW SMP2 Policy:	**Short term (to 2025)**	**Medium term (2026 – 2055)**	**Long term (2056 - 2105)**
	Hold the Line	Hold the Line	Hold the Line
Coastal Defence Condition			
Defence Description:	Revetment, Groynes	**Approx. OS Coordinates:**	SZ61258, 85049 SZ61082, 84938
		Defence Length:	258m
History:	Revetment constructed 1960. Lower stepped apron and sheet toe piling constructed 1977 to protect toe of concrete revetment. Groynes constructed 1977. Concrete cope constructed 1992 on crest of revetment. Slipway extended 1994. Stone masonry splash wall constructed 2008		
Foreshore Type:	Yellow and brown sandy foreshore derived from the lower green sand. Outcrops of a brown calcareous sandstone in the Wessex Marls exposed at MLW during periods of low sediment levels.		
Exposure:	Medium		
Ownership:	IoW Council		
Condition Grade:	Revetment - Fair (Grade 3) Gabions (immediately to the north of the slipway) – Failed Groynes - Good (Grade 2) to Fair (Grade 3)		
Residual Life:	Revetment - 10 to 15 years Groynes - 10 to 20 years		
Crest height (m ODN)	**Min:** 3.4m **Mean** : 5.1m **Max:** 7.2m		
Description			
Rock filled gabions adjacent to slipway. Concrete step block. Timber groyne extending from concrete flank wall. Navigation aid. Concrete slipway. Outfall. Concrete revetment fronting public car park, with steel sheet piled toe and stepped concrete apron of mean crest level +5.1m Ordnance Datum Newlyn (ODN). Low point in the crest level (+3.4m) is localised, adjacent to the slipway at east end of the defence. Double step block. Timber groyne. Concrete step block. Timber groyne. Double concrete step block.			
Photographs			

Asset Location - Unit IW 23 – Sandown Zoo			
SMP Unit:	IW23 / 001/2	**Survey Date:**	March 2017
IoW SMP2 Policy:	**Short term (to 2025)**	**Medium term (2026 – 2055)**	**Long term (2056 - 2105)**
	Hold the Line	Hold the Line	Hold the Line
Coastal Defence Condition			
Defence Description:	Seawall, groynes	**Approx. OS Coordinates:**	SZ61082, 84938 SZ60878, 84795
		Defence Length:	256m
History:	**IW 23 / 001** - Seawall constructed 1930. Lower stepped apron and sheet toe piling constructed 1977.Groynes constructed 1930, encased with concrete and height extended with bull head rails and timber planks during the 1990's **IW 23 / 002 -** Seawall constructed 1930, concrete encased 1977. Lower stepped apron and sheet toe piling constructed 1977. Groynes constructed 1930 but extended with bull head rails and timber planking during the 1990's.		
Foreshore Type:	Yellow and brown sandy foreshore derived from the lower green sand. Clay exposed during periods of low sediment levels.		
Exposure:	Medium		
Ownership:	IoW Council		
Condition Grade:	**IW 23 / 001** Wall - Fair (Grade 3) Groynes – Good (Grade 2)	**IW 23 / 002** Wall - Good (Grade 2) Groynes – Good (Grade 2)	
Residual Life:	**IW 23 / 001** Wall – 10 to 15 years Groynes – 10 to 20 years	**IW 23 / 002** Wall – 15 to 25 years Groynes – 10 to 20 years	
Crest height (m ODN)	**Min:** 3.5 **Mean:** 5.8 **Max:** 7.3	**Min:** 3.5 **Mean:** 4.3 **Max:** 5.9	

Description

IW 23 / 001 - Masonry block wall, with concrete block coping to small re-curve section. Piled toe and stepped concrete apron of mean crest level +5.8m Ordnance Datum Newlyn (ODN). Low point in the crest levels (+3.5m) is localised, approximately 5m from the start of the defence section, in front of the IoW Zoo carpark. Apart from this locally low point, crest levels >4.2m. Double concrete step block. Masonry groyne with concrete capping, timber attached to bullhead railings. Double step block. Masonry groyne with concrete capping, timber attached to bullhead railings. Rock debris located at base of groyne (seaward end) which could cause damage to the structure if mobilised. Masonry groynes working well – between a 1-2m difference in beach levels adjacent to the groynes.
IW 23 / 002 - Battered concrete wall with wave return and steel sheet piled toe and stepped apron of mean crest level +4.3m ODN. Low point in the crest level (+3.5m) spans 15m in front of The Grand Hotel. Two double step blocks. Two masonry groyne with concrete capping, timber attached to bullhead railings.

Photographs

Asset Location - Unit IW 24 – Culver Parade				
SMP Unit:	IW 24 / 001 to 004	**Survey Date:**	March 2017	
IoW SMP2 Policy:	**Short term (to 2025)**	**Medium term (2026 – 2055)**	**Long term (2056 - 2105)**	
	Hold the Line	Hold the Line	Hold the Line	
Coastal Defence Condition				
Defence Description:	Seawall, groynes	**Approx. OS Coordinates:**	SZ60878, 84795 SZ60303, 84435	
		Defence Length:	683m	
History:	**IW 24 / 001** -Seawall constructed around 1911. Groyne constructed 1930 but extended with bull head rails and timber planking during the 1990's. **IW 24 / 002** - Seawall constructed around 1911, rendered 2006. Construction of groynes 1977. 6 off navigation markers installed by the Environment Agency 2012. **IW 24 / 003** -Seawall constructed 1930. Groynes constructed 1977. **IW 24 / 004** - Constructed in 1893 replacing existing timber groyne. Encased 1992.			
Foreshore Type:	Yellow and brown sandy foreshore derived from the lower green sand.			
Exposure:	Medium			
Ownership:	IoW Council (masonry groyne (x1) in IW 24/001, wall and timber groyne (x1) in IW 24/003, masonry groyne (x1) in IW24/004 Environment Agency (wall in 24/001, wall and timber groynes (x6) in 24/002)			
Condition Grade:	**IW 24 / 001** Wall – Fair (Grade 3) Groynes – Good (Grade 2)	**IW 24 / 002** Wall – Very good (Grade 1) Groynes – Good (Grade 2)	**IW 24 / 003** Wall – Good (Grade 2) Groynes – Good (Grade 2)	**IW 24 / 004** Groyne – Good (Grade 2)
Residual Life:	**IW 24 / 001** Wall – 10 to15 years Groynes – 10 to20 yrs	**IW 24 / 002** Wall – 25 to 35 yrs Groynes – 10 to20 yrs	**IW 24 / 003** Wall – 15 to 20 years Groynes – 10 to20 yrs	**IW 24 / 004** Groyne – 10 – 20 yrs
Crest height (m ODN)	**Min:** 3.2 **Mean:** 3.6 **Max:** 4.8	**Min:** 2.4 **Mean:** 3.6 **Max:** 5.3	**Min:** 2.3 **Mean:** 3.8 **Max:** 4.6	NA
Description				

IW 24 / 001 - Un-rendered vertical masonry wall (EA owned) with concrete coping of mean crest level +3.6m Ordnance Datum Newlyn (ODN). From 25m defence length in front of the operation Pluto pump house the defence crest is <+3.5m ODN. Double concrete step block. Masonry groyne (IoWC owned) with concrete capping, timber attached to bullhead railing. Outfall.
IW 24 / 002 - Rendered vertical masonry block wall (EA owned) with concrete coping of mean crest level +3.6m Ordnance Datum Newlyn (ODN). A localised low point in the crest level (+2.4m) between the Dinosaur Isle museum and the Lake, otherwise crest levels >3m. Six double concrete step blocks. Six timber piled and boarded groynes (EA owned). Two outfalls. Remains of timber groynes exposed during periods of low sediment levels. Navigation markers.
IW 24 / 003 - Concrete access steps. Remains of timber groyne.
Concrete access ramp. Vertical stone masonry wall (IoWC owned) of mean crest level +3.8m Ordnance Datum Newlyn (ODN). A localised low point in the defence crest level (+2.3m) located at the steps, near the intersection of Fort Street and Culver Parade. Double concrete step block. Timber groyne (IoWC owned). Concrete access steps.
IW 24 / 004 - 'Herne Hill' concrete and masonry groyne (IoWC owned).

(photographs overleaf)

Photographs	
	

Asset Location - Unit IW 25 – Sandown Esplanade			
SMP Unit:	IW 25 / 001 to 005	**Survey Date:**	March 2017
IoW SMP2 Policy:	**Short term (to 2025)**	**Medium term (2026 – 2055)**	**Long term (2056 - 2105)**
	Hold the Line	Hold the Line	Hold the Line
Coastal Defence Condition			
Defence Description:	Sewall and groynes	**Approx. OS Coordinates:**	SZ60303, 84435 SZ59636, 83864
		Defence Length:	1023m
History:	**IW 25 / 001 to 004** - unknown I**W 25 / 005 -** Seawall constructed pre 1900. Sandown Pier opened in 1897.		
Foreshore Type:	Yellow and brown sandy foreshore derived from the lower green sand. Sediment accumulation against Herne Hill Groyne		
Exposure:	Medium		
Ownership:	IoW Council		
Condition Grade:	**IW25/001 to 003** Wall – Good (Grade 2)	**IW25/004** Wall – Very Good (Grade 1)	**IW25/005** Wall – Good (Grade 2) to Fair (Grade 3) Groynes – Fair (Grade 3)
Residual Life:	**IW25/001 to 003** Wall – 15 to 20 years	**IW25/004** Wall – 25 to 35 years	**IW25/005** Wall – 10 to 20 years Groynes – 10-15 years
Crest height (m ODN)	**Min:** 4.0 **Mean:** 4.3 **Max:** 4.8	Data does not cover crest alignment	**Min:** 3.1 **Mean:** 4.4 **Max:** 8.5

Description

IW 25 / 001 -Concrete steps. Outfall. Beach widens, as height retained by Herne Hill Groyne. Concrete rendered wall to property frontage.
IW 25 / 002 -Concrete rendered retaining wall to highway at rear of beach huts. Beach ridge level of +4.0m above Ordnance Datum Newlyn (ODN)
IW 25 / 003 - Stone masonry retaining wall to highway at rear of beach huts
IW 25 / 004 - Concrete rendered wall forms Southern Water Pumping station and toilets. Access steps.
IW 25 / 005 - Vertical masonry wall, with battered section below. Concrete top forms nosing and parapet of mean crest level +4.4m Ordnance Datum Newlyn (ODN). Three localised low points in the defence crest at the waterfront monument between Albert Road and Esplanade Road, immediately to the west of the monument in front of the Ocean Hotel, and in front of the Trouville Hotel. Two access ramps. Double step block, now location of Sandown Life Guard Station. Two access ramps. Masonry buttresses. Double step block. Step block. Access ramp. Two step blocks either side of Sandown Pier. Sandown Pier. Masonry buttress. Step block. Access ramp. Step block. Bullhead piled, timber planked groyne with timber railing. Navigation aid. Step block. Access ramp.

Photographs

Asset Location - Unit IW 26 – Lake Cliffs						
SMP Unit:	IW 26 / 001 to 007		**Survey Date:**		March 2017	
IoW SMP2 Policy:	**Short term (to 2025)**		**Medium term (2026 – 2055)**		**Long term (2056 - 2105)**	
	Hold the Line		Hold the Line		Hold the Line	
Coastal Defence Condition						
Defence Description:	Sewall and groynes		**Approx. OS Coordinates:**		SZ59636, 83864 SZ58818, 81864	
			Defence Length:		2474m	
History:	**IW 26 / 001 to 002 -** Seawall constructed 1977. Groynes constructed 1977. **IW 26 / 003 -** Seawall constructed 1971. Groynes constructed 1971. **IW 26 / 004 -** Littlestairs Sea Defence Scheme completed 1971. **IW 26 / 005 -** Reconstructed in 1901 but in existence prior. Encased and extended 1992. **IW 26 / 006 -** Seawall constructed 1974. **IW 26 / 007 -** Seawall constructed 1920, and refurbished around 2002.					
Foreshore Type:	Yellow and brown sandy foreshore with occasional rock scars					
Exposure:	Medium					
Ownership:	IoW Council					
Condition Grade:	**IW26/ 001 to 002** Wall – Fair to Good (Grade 2/3) (002) Groynes – Poor (Grade 4)	**IW26 /003** Wall – Good (Grade 2) Groynes – Poor (Grade 4)	**IW26/ 004** Wall – Good (Grade 2) Groynes – Very Poor (Grade 5)	**IW26/ 005** Groyne – Good (Grade 2)	**IW26/ 006** Wall – Good (Grade 2) Groynes – Fair (Grade 3)	**IW26/ 007** Wall – Fair (Grade 3) Rock – Good (Grade 2)
Residual Life:	**IW25/001 to 002** Wall – 10 to 20 years (002) Groynes – 2 to 7 years	**IW26/ 003** Wall – 15 to 25 years Groynes – 2 to 7 years	**IW26/ 004** Wall – 15 to 25 years Groynes – 0 years	**IW26/ 005** Groyne – 15 to 20 years	**IW26/ 006** Wall – 15 to 25 years Groynes – 8 to 12 years	**IW26/ 007** Wall – 10 to 15 years Rock – 15 to 25 years
Crest height (m ODN)	**001 Min:** 3.2 **001 Mean:** 4.0 **001 Max:** 6.0 **002 Min:** 2.7 **002 Mean:** 3.2 **002 Max:** 3.4	**Min:** 1.7 **Mean:** 3.1 **Max:** 4.4	**Min:** 2.3 **Mean:** 3.0 **Max:** 4.8	NA	**Min:** 2.9 **Mean:** 3.8 **Max:** 4.2	**Min:** 3.0 **Mean:** 4.1 **Max:** 5.6
Description						

IW 26 / 001 & 2 Concrete wall (001). Stepped wall (apron) with steel sheet piled toe of mean crest level +3.2–4.0m Ordnance Datum Newlyn (ODN). Localised low point in the crest levels adjacent to the slipway at the end of Pier Street. Double step block. Bull head piled, timber planked groyne with timber railing. Timber access ramp. Double step block. Bull head piled, timber planked groyne with timber railing. Concrete slipway (Inshore Rescue Slipway). Navigation aids.

IW 26 / 003 - Concrete wall with wave return and stepped concrete apron with steel piled toe section of mean crest level +3.1m Ordnance Datum Newlyn (ODN). Low points in the crest level adjacent to the slipways at the Pioneer Café and the Tradewinds Café. Four double step blocks. Four bull head piled, timber planked groynes with timber railing. Concrete slipway (Lake Slipway). Double step block. Bull head piled, timber planked groyne with timber railing. Double step block. Three double step blocks. Three bull head piled, timber planked groynes with timber railing. Concrete slipway (Dunromin Slipway). Double step block. Bull head piled, timber planked groyne with timber railing. Bull head piled, timber planked groyne with timber railing. Concrete slipway (Wight Waters Slipway). Navigation aids.

IW 26 / 004 - Concrete wall with wave return and stepped concrete apron with steel piled toe section of mean crest level +3.0m Ordnance Datum Newlyn (ODN). Low spots in the defence crest level in front of the beach huts and between 90-120m south of the Slipway near Blueberrys café. Three double step blocks. Three bull head piled, timber planked groynes with timber railing. Concrete slipway (Winchester House Slipway). Bull head piled groyne with timber top railing and sheet-piled lower section below timbering. Step block. Four double step blocks. Four bull head piled, timber planked groynes with timber railing. Concrete / stone set slipway (Journeys End Slipway). Navigation aids.

IW 26 / 005 - 'Small Hope' Groyne constructed of masonry blocks, over capped with concrete. Seaward section is constructed with concrete planks laid in piled channels. Navigation aid. Significant fall in beach levels downdrift of small Hope groyne compared to the updrift side (approx. 1-1.5m observed during site visit in March 2017).

IW 26 / 006 - Concrete wall with single step and toe section of mean crest level +3.8m Ordnance Datum Newlyn (ODN). Buried timber groynes. Concrete slipway (Small Hope Slipway). Low point in defences (+2.9m) near slipway adjacent to Hope Road long stay car park.

IW 26 / 007 - Concrete wall fronting pumping station with wave return and a stepped apron and foundation toe of mean crest level +4.1m Ordnance Datum Newlyn (ODN). Rock armouring has been added to the southern section.

The project team visited the IW 26 defence unit in separate site visits in February and March 2016. During the first visit the beach levels in this location were particularly low in some areas and the defence foundations were at risk of being exposed. However, during the second visit the beach levels appeared to have accreted over the past month suggesting that levels in this location change frequently depending on recent storm occurrences and seasonal fluctuations.

Photographs

<table>
<tr><td colspan="7">Asset Location - Unit IW 27 – Shanklin Esplanade</td></tr>
<tr><td>SMP Unit:</td><td colspan="2">IW 27 / 001 to 006</td><td colspan="2">Survey Date:</td><td colspan="2">March 2017</td></tr>
<tr><td>IoW SMP2 Policy:</td><td colspan="2">Short term (to 2025)</td><td colspan="2">Medium term (2026 – 2055)</td><td colspan="2">Long term (2056 - 2105)</td></tr>
<tr><td></td><td colspan="2">Hold the Line</td><td colspan="2">Hold the Line</td><td colspan="2">Hold the Line</td></tr>
<tr><td colspan="7">Coastal Defence Condition</td></tr>
<tr><td rowspan="2">Defence Description:</td><td colspan="2" rowspan="2">Seawall, groynes, revetment</td><td colspan="2">Approx. OS Coordinates:</td><td colspan="2">SZ58818, 81864
SZ58538, 81059</td></tr>
<tr><td colspan="2">Defence Length:</td><td colspan="2">1349m</td></tr>
<tr><td>History:</td><td colspan="6">IW 27 / 001 -Constructed in 1901. Encased in 1990.
IW 27 / 002 - Seawall constructed pre 1900. Groynes constructed 1980. Concrete ramp replaced with concrete steps 2014.
IW 27 / 003 - Constructed in 1878 to replace existing timber groyne. Extended in 1907. Encased in 1990.
IW 27 / 004 – Former Shanklin Pier constructed around 1880's.
IW 27 / 005 - Seawall constructed pre 1900. Groynes constructed 1980.
Palestine Slipway extended 1995.
IW 27 / 006 - Timber breast work constructed 1970. Groynes constructed 1980.</td></tr>
<tr><td>Foreshore Type:</td><td colspan="6">Coastal structure protects ferruginous sandstone cliffs from coastal erosion.
Yellow and brown sandy foreshore derived from the lower green sand. Increased accumulation of flint cobbles. Shanklin Chine.</td></tr>
<tr><td>Exposure:</td><td colspan="6">Medium</td></tr>
<tr><td>Ownership:</td><td colspan="6">IoW Council</td></tr>
<tr><td>Condition Grade:</td><td>IW 27 / 001
Hope Groyne – Good (Grade 2)</td><td>IW 27 / 002
Wall - Poor (Grade 4 locally 5)
Groynes - Good (Grade 3)</td><td>IW 27 / 003
Osborne Groyne – Good (Grade 2)</td><td>IW 27 / 004
Wall - Good (Grade 2)</td><td>IW 27 / 005
Wall - Fair (Grade 3 locally 4)
Groynes – Good (Grade 2) to Fair (Grade 3)</td><td>IW 27 / 006
Revetment - Timber breastwork - Fair (Grade 3)
Groynes - Fair (Grade 3)</td></tr>
<tr><td>Residual Life:</td><td>IW 27 / 001
Hope Groyne – 15 to 20 years</td><td>IW 27 / 002
Wall - Residual Life - <10 years
Groynes -15 to 20 years</td><td>IW 27 / 003
Osborne Groyne - 15 to 25 years</td><td>IW 27 / 004
Wall - 15 to 25 years</td><td>IW 27 / 005
Wall - 10 to 15 years Groynes – 10 to 20 years</td><td>IW 27 / 006
Revetment - 8 to 12 years Groynes - 8 to 12 years</td></tr>
<tr><td>Crest height (m ODN)</td><td>NA</td><td>Min: 3.2
Mean: 4.7
Max: 5.6</td><td>NA</td><td>Min: 2.7
Mean: 4.9
Max: 6.8</td><td>Min: 2.4
Mean: 3.5
Max: 5.4</td><td>Min: 2.2
Mean: 2.8
Max: 3.2</td></tr>
<tr><td colspan="7">Description</td></tr>
</table>

IW 27 / 001 - 'Hope' groyne constructed of concrete encasement over original masonry groyne. Approx. a 3m difference in beach levels either side of groyne.
IW 27 / 002 - Concrete steps (Shanklin Esplanade). Vertical wall with battered lower section in masonry block work, with a concrete coping and a parapet wall of mean crest level +4.7m Ordnance Datum Newlyn (ODN). No localised low sections but crest level does drop to 3.2m in places. Double groyne concrete step block. Bullhead piled timber planked groyne with timber top railing. Remains of timber groynes exposed when sediment levels are low. Double step block. Two double groyne concrete step blocks. Two bullhead piled timber planked groynes with timber top railing. Concrete steps. Brick masonry pier apron incorporating two step blocks. Navigation aids.
IW 27 / 003 - 'Osborne' concrete and masonry groyne. Evidence of some accretion on the updrfit side of the groyne was obsevered during the site visit,, however given the smaller differential in beach levels either side of this groyne it does not appear to be as effective at trapping sediment as other terminal groynes along the frontage e.g. Hope Groyne with much larger differentials.
IW 27 / 004 - Brick masonry Shanklin pier apron incorporating two step blocks. Low point in the defences in front of the esplanade next to the Sail and Surf establishment.
IW 27 / 005 -Stone set slipway (Pier Slipway). Bull head piled, timber planked groyne with timber railing. Concrete step block. Battered concrete wall with a curved top forming coping section of mean crest level +3.5m Ordnance Datum Newlyn (ODN). Low point in the defence crest adjacent to the slipway adjacent to the Lazy Wave establishment. Groyne concrete step block. Two bullhead piled timber planked groynes with timber top railing. Stone set / Concrete slipway (Palestine Slipway). Navigation aids.
IW 27 / 006 - Timber revetment of mean crest level +2.8m Ordnance Datum Newlyn (ODN). Generally a low defence crest along this defence section which is adjacent to Shanklin Chine. Southern Water outfall from Shanklin Chine with natural stone masonry wall. Timber groyne with Southern Water outfall from Shanklin Chine on south side. Navigation aids.

Photographs

Asset Location - Unit IW 28 – Luccombe Road, Shanklin			
SMP Unit:	IW 28/001	**Survey Date:**	March 2017
IoW SMP2 Policy:	**Short term (to 2025)**	**Medium term (2026 – 2055)**	**Long term (2056 - 2105)**
	Hold the Line	Hold the Line	Hold the Line
Coastal Defence Condition			
Defence Description:	Revetment, groynes,	**Approx. OS Coordinates:**	SZ58538, 81059 SZ58478, 80631
		Defence Length:	454m
History:	Timber breast work constructed 1970. Groynes constructed 1980.		
Foreshore Type:	Timber Breast work protects ferruginous sandstone cliffs from coastal erosion. Yellow and brown sandy foreshore derived from the lower green sand. Upper beach of flint cobbles		
Exposure:	Medium		
Ownership:	IoW Council		
Condition Grade:	**IW 28 / 001** Revetment - Fair (Grade 3) Groynes - Fair (Grade 3, some 4)		
Residual Life:	Revetment - 8 to 12 years Groynes - 8 to 12 years		
Crest height (m ODN)	**Min:** 2.0 **Mean:** 3.1 **Max:** 4.8		

Description

IW 28 / 001

Timber revetment of mean crest level +3.1m Ordnance Datum Newlyn (ODN). The lowest defence crest levels for this defence section are located near to Shanklin Chine. Two timber slipways. Six Timber groynes. Navigation aids. Metal groyne at southern end of study site is in poor condition.

Photographs

4. Priority areas

Based upon the information presented above, the following areas have been identified as priority areas because they either have a poor defence condition, show evidence of recent or potential imminent future defence failure (i.e. <5 years residual life) and/or have a low defence crest and standard of flood protection.

4.1 IW 23 & IW24

The frontage that encompasses IW23 and IW24 is situated between Sandown Zoo and Culver Parade. The defence comprises sections of seawall constructed between 1911 and 1930 (some of it encased in 1977) and various groyne structures (Figure 4-1). Ownership of the defences is split between the Isle of Wight Council (IW23 and parts of IW24) and the Environment Agency (parts of IW24).

The minimum defence crest level is +3.5m ODN and +2.3m ODN for IW23 and IW24 respectively. In IW23 the minimum crest levels are located in front of the IoW Zoo carpark (localised) and the Grand Hotel (approx. 15m in length). In IW24 there are localised low points at the Dinosaur Island museum and near the intersection of Fort Street and Culver Parade.

Unlike elsewhere in the study area, the land behind the defences is low lying and is not backed by steep cliffs. The frontage is therefore the pathway for flood water into the main flood cell in the study area. Therefore these defences are identified as a priority area, as breaching or overtopping of these defences could lead to significant flood risk to assets behind.

Figure 4-1. Seawall between Sandown Zoo and Culver Parade

4.2 IW26 003 & 004

IW26 is situated in front of Lake cliffs and is characterised by a seawall and timber groynes. The seawall and groynes in zones 003 and 004 were constructed in the 1970's. The timber groynes are in a poor (grade 4) and very poor (grade 5) condition respectively, with 'very poor' denoting failure or imminent failure. The groynes have a number of planks missing or damaged which is significantly impacting their performance and allowing sediment to pass through the area without being retained (Figure 4-2). The defence condition assessment provides a general condition for the timber groyne field as a whole, rather than individual groynes, and therefore all the groynes in IW26 003 and 004 are included in the priority area.

The Channel Coastal Observatory beach profiles collected in this area show a long term erosional trend which could be linked to the poor condition of the groynes in this location. Exposure of the wave cut platform at this location provides further evidence for the low beach levels. For more details of the erosion trend, refer to the Coastal Processes Report (AECOM, 2017a).

The seawall behind the groynes is in a good condition, but its exposure and vulnerability to damage could be increased if beach erosion trends continue due to increased toe scour and a risk of undermining.

Figure 4-2. Photograph showing the groynes and exposure of wave cut platform (at Lake)

4.3 IW27 002 & 005

IW27 is situated in front of Shanklin and comprises a seawall and timber groynes. The groynes were constructed in 1980 and are generally in a good condition, however, the seawall, constructed pre 1900 has deteriorated badly and is in a poor condition particularly in IW27 002 (Figure 4-3 and Figure 4-4) and locally in IW27 005 (Figure 4-5). The wall has numerous large cracks, the fill material is exposed in many locations and the masonry blocks are extremely thin.

The Isle of Wight Council has to regularly organise the repair of voids and surface defects on this structure. It is also noted that the beach in front of the wall has areas of large shingle and it is likely that this material exaggerates the damage to the wall during storm conditions.

Figure 4-3. Photograph showing the seawall at North Shanklin (in-front of the 'crazy golf' area) - IW27 002.

Figure 4-4. Photograph showing the seawall at North Shanklin (IW27 002).

Figure 4-5. Close up photograph of the seawall condition at Shanklin (IW27 005).

5. Do Nothing and Do Minimum Scenarios

Establishing the Do Nothing and Do Minimum scenarios is an important stage in developing and appraising management options for the study area.

Based upon the findings from this report, the Do Nothing and Do Minimum scenarios have been established (see below). It should be noted that the 'storylines' of these scenarios, and their specific impacts and damages in terms of flood and erosion risk, will be further developed and defined as part of the option development and appraisal phase.

5.1 Do Nothing

The Do Nothing scenario is a hypothetical 'walk away' scenario which can be used as a baseline to appraise various 'Do Something' management options.

Under the Do Nothing scenario all the existing defences are abandoned in terms of maintenance or repair, and no remedial or additional protection works are carried out. In addition, adaptation to sea level rise or other climate change responses are not addressed.

Under this scenario the existing defences along the frontage will fail at the end of their residual life and the land behind will be subject to erosion. In the southern side of the study site the defences are backed by steep cliffs and erosion would lead to loss of assets at both the cliff foot and at the cliff top. The erosion risk under the Do Nothing scenario has already been established and is represented by the No Active Intervention (NAI) erosion lines. These are presented in the Coastal Processes Stage 1 & 2 Report. Accelerated 'catch up' erosion is likely when hard defences fail along the frontage which would impact properties, infrastructure and assets behind.

With the Do Nothing approach there is an immediate flood risk to properties and assets in the flood cell behind the defences in units IW23 and IW24. There are two ways in which flooding could occur; through overflowing and breaching. If water levels exceed the crest level of the defences it would lead to flooding to the low lying land behind. This mechanism of flooding could occur in the present day, but the risk is expected to increase in the future as sea levels rise. It is also anticipated that with no maintenance the defences in this location will fail and breach in the future. If this occurs the low lying area behind the defences could be inundated more frequently on a regular basis if sea water flows through the breached defences during lower tide water levels.

5.2 Do Minimum

The Do Minimum scenario essentially represents the existing 'status quo'. Under this scenario, small scale reactive maintenance and 'patch repair' work, as well as activities to maintain Health and Safety compliance will be undertaken. This will help increase the residual life of assets and delay the point at which they are expected to fail. This scenario also does not allow for any adaptation to sea level rise or other climate change responses (i.e. by crest raising) and therefore the flood risk will increase in the future as a function of sea level rise.

This scenario does not allow for scheduled or capital maintenance or refurbishment, rebuild, or any replacement of assets. It has been assumed through 'Do Minimum' activities, the residual life of assets based on a 'Do Nothing' Scenario (Chapter 3), can be extended by a modest amount, with hard defences such as seawalls remaining functional for an extra 10 years and timber structures, such as many of the groynes, lasting an extra 5 years. The onset of erosion behind defences will therefore be delayed compared to the 'Do nothing Scenario with the extent of delay depending on the defence type in question.

6. References

Environment Agency (2006) Managing Flood Risk: Condition Assessment Manual; Doc Ref: 166_03_SD01, October (2006)

AECOM 2017a. Sandown Coastal Processes – Stage 1 & 2 Report.

7. Addendum – Embankment Road and Yarbridge

7.1 Introduction

Following the completion of the defence condition assessment and report, the study area for the appraisal was extended to include Embankment Road, located between Bembridge and St. Helens on the Isle of Wight.

Embankment Road is an embankment of variable width and height and was constructed at the end of the 19th century. The embankment is important to the Sandown study as it protects the Eastern Yar river catchment from tidal flooding up to a 1:25 year standard of protection (Eastern Yar Strategy, Option Appraisal Report, 2010). Without the embankment in place, the Eastern Yar valley would be tidally inundated on a regular basis which could flood the Sandown area 'through the backdoor' from the north-east direction.

For tidal events greater than a 1:25 year return period, parts of Embankment Road will be inundated by the still water level or overtopped by waves. The potential for flooding to extend to and influence properties at Sandown, south and west of Yarbridge depends on the magnitude of the event and the volume of water entering the Eastern Yar valley.

The embankment was originally constructed for a railway route, reclaiming the land behind it to create Brading Marshes. The Marshes are now a designated SSSI and form part of the Solent and Southampton Water Ramsar and SPA. Bembridge Lagoons SAC is also located behind within the SSSI extent behind the embankment. The current environmental designation of Brading Marshes in particular is based on a freshwater habitat with limited amounts of saline water flooding. In addition to protecting properties within the Eastern Yar Valley, including up to Sandown, Embankment Road is valuable because it protects these sensitive freshwater environments from tidal inundation.

The embankment is approximately 10m wide at its narrowest point and approximately 1.5km long. The seaward face of the embankment includes some localised protection works such as sandbags, stone and concrete block work. There are many critical utilities and services located within the embankment, such as gas pipes, telephone and electric cables. In addition the embankment forms one of two transport links to the village of Bembridge.

Figure 7-1 shows a map of the Embankment Road defence.

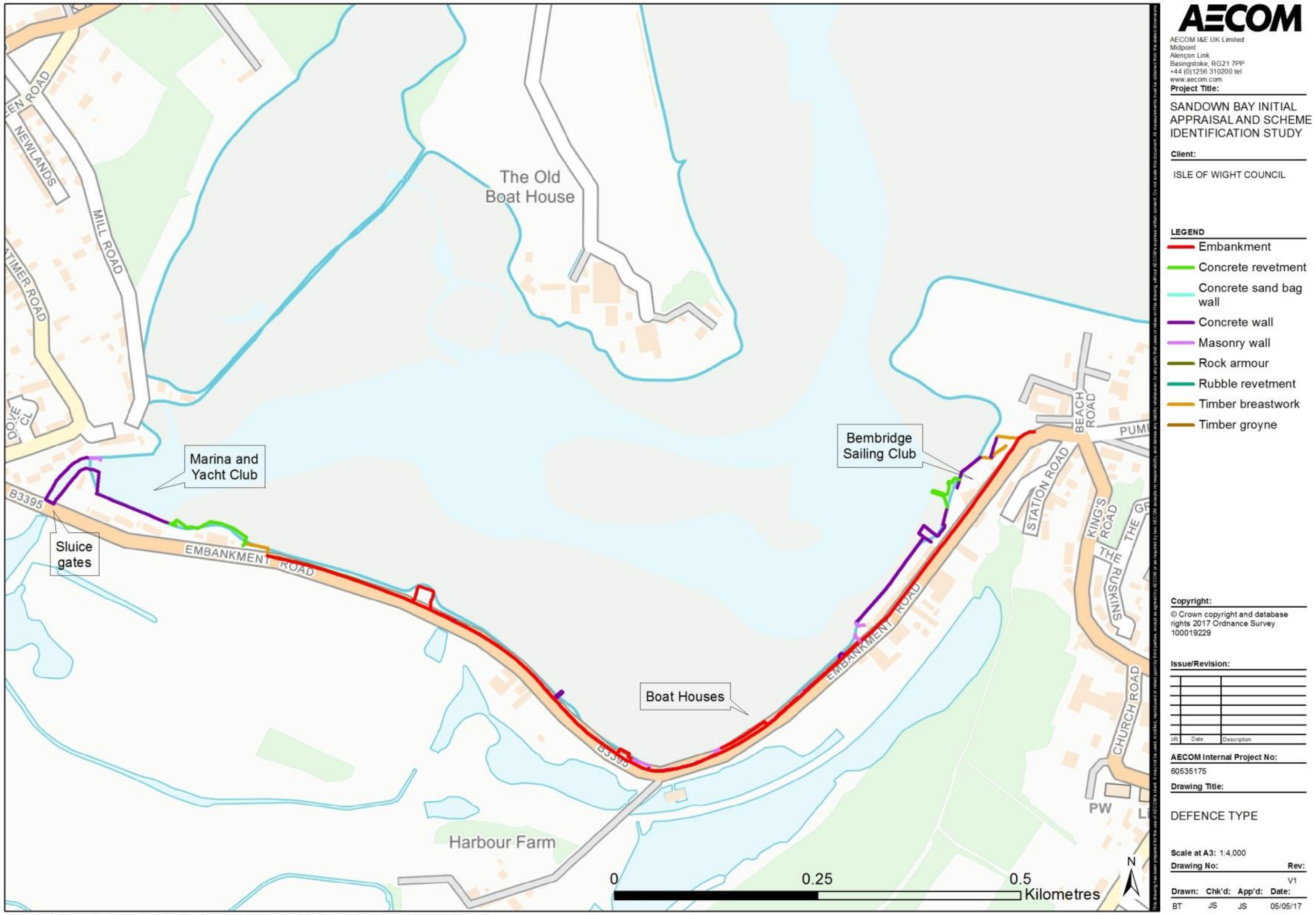

Figure 7-1. Summary figure of Embankment Road defence

7.2 Condition assessment

The project team undertook a site visit on 3rd May 2017 to visually inspect the condition of the Embankment Road defence. The findings of the inspection have verified previous findings studies and visual assessments that have been carried out in the past, for example as part of the Eastern Yar Strategy.

The visual condition assessment of Embankment Road was carried out following the same principles as the asset condition survey carried out along the initial study frontage described in this report. A photographic record of key assets and features was captured and the condition of the defence was assessed in accordance with the Environment Agency Condition Assessment Manual (2006).

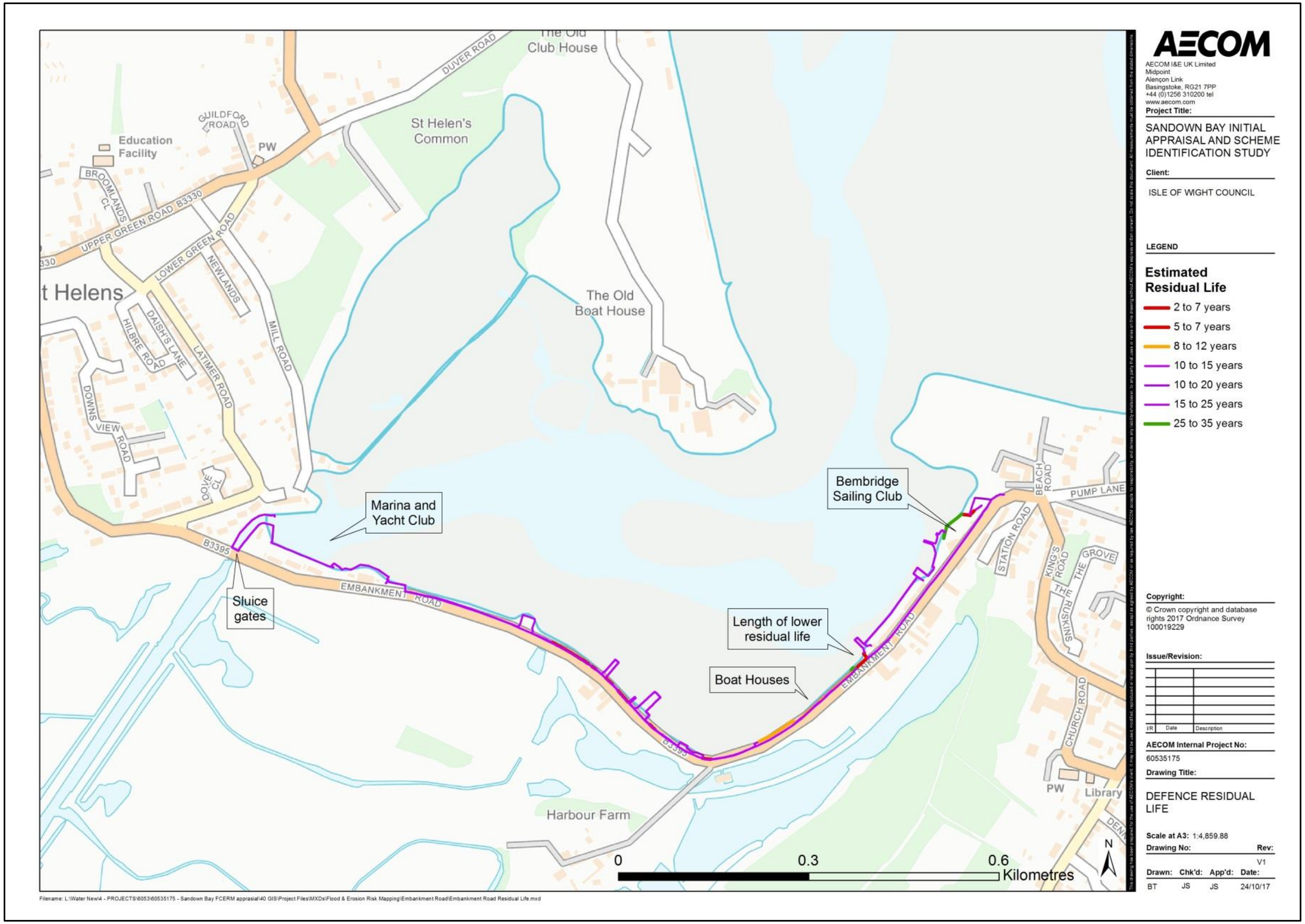

Figure 7-2. Estimated residual life of Embankment Road defences

7.3 Defence crest heights

The defence crest levels along the embankment have been obtained from the analysis undertaken in the Eastern Yar Strategy which used LiDAR data of the area. In the Strategy the levels provided by the LiDAR were verified by a ground trothing topographic survey. The average difference between the survey values and LiDAR was ±0.1m.

Figure 7-3 shows the defence crest level along Embankment Road. The figure has been obtained from the Eastern Yar Strategy documents (2010). The crest level along the embankment varies, with a clear low spot in the defence in the vicinity of Bembridge Sluice. Another low spot is located between chainages 900-1100m (distance from St. Helens) at the southern corner of Bembridge Harbour (where the boat houses are located). The low spots in the defence are at the present day 1:25 year SoP.

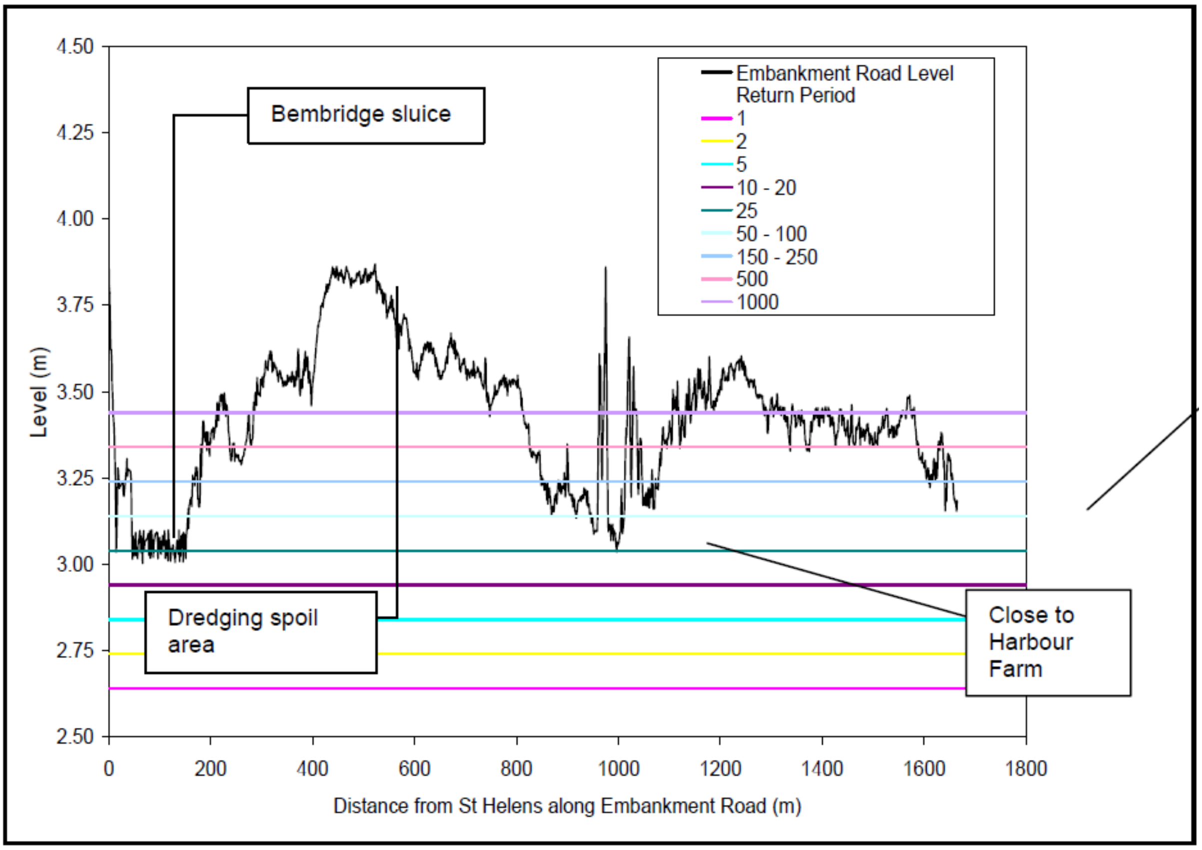

Figure 7-3. Defence crest levels (from LiDAR data) along Embankment Road relative to present day extreme water levels (figure obtained from the Eastern Yar Strategy Options Appraisal report, 2010).

7.4 Asset condition

The tables in this section provide an overview of the defence condition and residual life in each section of the Embankment Road defence.

In summary:

- The carriageway along the crest of Embankment Road is showing no signs of distress, and has recently had a new tarmac surface in places.
- For large sections of the embankment the footpath has recently been resurfaced but there are no signs of inherent stability problems
- The condition of the crest and back slope of the embankment is good and often well vegetated.
- The condition of the front slope of the embankment is good although often undefended. It is in locally poor condition in places (with apparent rotation and slumping in places).
- The front slope of the embankment is mainly composed of an earth / rubble mixture. However, in some locations there are short sections of different defence types in-front of the embankment, such as concrete wall or timber breastwork or varying conditions.

SMP Unit:	IW15	**Survey Date:**	May 2017	
IoW SMP2 Policy:	**Short term (to 2025)**	**Medium term (2026 – 2055)**	**Long term (2056 - 2105)**	
	Hold the Line	Hold the Line	Hold the Line	
Coastal Defence Condition				
Defence Description:	Earth embankment with various short sections of other defence types adjacent to the structure, including concrete walls, concrete bag work, rubble revetment, concrete revetment, masonry wall, slipways and timber breastwork		**Defence Length:**	1.5km
History:	Embankment constructed in late 19th century, originally as a railway embankment. The carriageway on top of the road forms the main transport link between the settlements of St. Helens and Bembridge and one of two links to Bembridge. There are many critical services located within the embankment, such as gas pipes, telephone and electric cables.			
Foreshore Type:	Sandy / mud foreshore. Sandy deposits located at the eastern end of the embankment at the entrance to Bembridge Harbour. Boat houses and connecting services located on the foreshore at the southern corner of Bembridge Harbour.			
Exposure:	Generally the embankment is sheltered, being located within Bembridge Harbour. However, a small stretch of the embankment towards its eastern end (to the south west of Bembridge Sailing Club) could potentially be exposed during storms with a dominant wave direction from the north.			
Ownership:	Environment Agency, Private, Unknown			
Condition Grade:	Embankment – Good, but locally poor Various short sections of other defences – Varied, generally good to fair			
Residual Life:	Embankment – 25 years (very sheltered harbour environment), although locally 5-10 years Various short sections of other defences – Varied, typically 10-25 years			
Crest height (m ODN)	**Min:** 3.0m **Max:** 3.85m			
Description				

Earth / rubble embankment with adjacent defences and slipways. Min crest level of +3.0m ODN corresponding to a present day 1:25year SoP. Embankment generally in a good condition, and owing to the sheltered environment the structure is estimated to have a residual life of approximately 25 years. Some locally poor areas where the front slope of the embankment is seen to be rotating forward, although this was only observed on a 5-10m length of the embankment between Bembridge Sailing Club and the Boat Houses. No sign of distress to the pavement or carriageway on top of the embankment.

Numerous sections of defence adjacent to the embankment, including concrete walls, concrete bag work, rubble revetment, concrete revetment, masonry walls and timber breastwork. These defences are located at Bembridge sailing club, to the south of this in front of the industrial storage sheds, adjacent to the boat houses (private defences), at Bembridge Marina and Yacht club and at the Eastern Yar water level control sluice gates. There are also a number of slipways located along the embankment. The condition of these defences varies, generally good to fair.

(Photographs overleaf()

Photographs




7.5 Do Nothing and Do Minimum scenarios

Under the Do Nothing scenario the embankment along the frontage will fail after the end of its service life and will be subject to erosion. This will lead to loss of the roadway and a breach of the defence allowing tidal water to regularly inundate the land behind.

Under the Do Minimum scenario reactive patch and repair maintenance will be continued which will help increase the residual life of the embankment and delay the point at which it fails. This scenario also does not allow for any adaptation to sea level rise or other climate change responses (i.e. by crest raising) and therefore the flood risk will increase in the future as a function of sea level rise.

7.6 Yarbridge

During the site visit the AECOM project team also visited the bridge crossing at Yarbridge, located in the Eastern Yar valley between Embankment Road and Sandown.

The bridge crossing across the Eastern Yar was visited as it is a potential location where a water level control structure could be constructed in order to separate the flood cell between Sandown and Embankment Road. The use of a water control structure in this location will be investigated in more detail during the option appraisal stage of the study.

During the visit the dimensions of the channel were collected and photographs were taken. In summary, the crossing is approximately 6-7m wide. Photographs of the site are provided in Figure 7-4 and Figure 7-5.

Figure 7-4.Photograph of the bridge crossing across the Eastern Yar at Yarbridge. Photograph looking south

Figure 7-5. Photograph of the bridge crossing across the Eastern Yar at Yarbridge. Photograph looking north.

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Preliminary Environmental Report

Sandown Bay Initial Appraisal and Scheme Identification Study

Isle of Wight Council

60535175
March 2018

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Revision History

Revision	Revision date	Details
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V2	15/03/17	Final Draft Issued to Client
V3	07/06/17	Final Issue
V4	07/08/17	Final Issue (updated in response to further client comments)
V5	22/01/18	Updated to include summary of preferred options
V6	09/03/18	Final (updated to respond to comments on preferred options)
V7	11/05/18	Final. Issued by IWC (client)

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Contents

1. Introduction

This preliminary environmental report has been produced to define the existing baseline environmental conditions of the 5.8km coastal frontage from Yaverland to Shanklin (hereafter referred to as the 'Sandown Bay study area'), the Eastern Yar valley floodplain and the 1.5km frontage along Embankment Road in Bembridge (hereafter referred to as the 'Embankment Road study area'). It also presents a summary of the preferred options, their potential environmental impacts and next steps to be considered in terms of delivering these preferred options as schemes

This desk based study included within this report has utilised available sources of information, including the Multi agency Geographic Information for the Countryside (MAGIC)[1], the Environment Agency's online mapping tools[2,3], the British Geological Society's online mapping tool[4], Historic England online mapping tool[5] and Natural England's Designated Sites View[6], and has been informed by The Second Isle of Wight Shoreline Management Plan (hereafter referred to as the 'SMP2')[7] and its associated appendices that were produced by Isle of Wight Council (IWC) and Royal Haskoning in 2011.

2. The Second Isle of Wight Shoreline Management Plan

The entire 167km coastline of the Isle of Wight is covered by the SMP2, which provides a high level assessment of the risks associated with coastal evolution and presents a policy framework to address the identified risks. The SMP2 promotes management policies for the Isle of Wight coastline that achieve long-term objectives without committing to unsustainable coastal defences. For each of the management units defined within the SMP2, one of the following shoreline management policies has been identified:

- No active intervention;
- Hold the existing defence line;
- Managed realignment; and
- Advance the existing defence line.

3. The Sandown Bay Initial Appraisal and Scheme Investigation Study Areas

3.1 The Sandown Bay Study Area

The Sandown Bay study area includes (from north to south) the settlements/towns of Yaverland, Sandown, Lake and Shanklin. The coast is cliff-lined in the south and more low-lying in the north, with development at both the cliff top and cliff foot. The frontage is predominantly lined by seafront esplanade roads, footpaths, and sandy beaches. Much of the Sandown Bay study area is vulnerable to erosion, with substantial numbers of properties in areas where erosion or flooding is anticipated to occur should the existing coastal defences fail.

The majority of the frontage consists of a series of sea walls, revetments and groynes that have been subject to renewal and extension for more than a century. The existing sea wall fronting the steep sandstone cliffs extends from Sandown to Shanklin, protecting the towns

[1] MAGIC, http://www.magic.gov.uk/MagicMap.aspx
[2] Environment Agency, *What's in Your Backyard?,* http://apps.environment-agency.gov.uk/wiyby/default.aspx
[3] Environment Agency, *Long term flood risk information*, https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=RiversOrSea
[4] British Geological Survey, http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[5] Historic England, *The Heritage List*, https://historicengland.org.uk/listing/the-list/
[6] Natural England, *Designated Sites View*, https://designatedsites.naturalengland.org.uk/SiteSearch.aspx
[7] IWC and Royal Haskoning, 2010, *Isle of Wight Shoreline Management Plan 2*, http://www.coastalwight.gov.uk/smp/

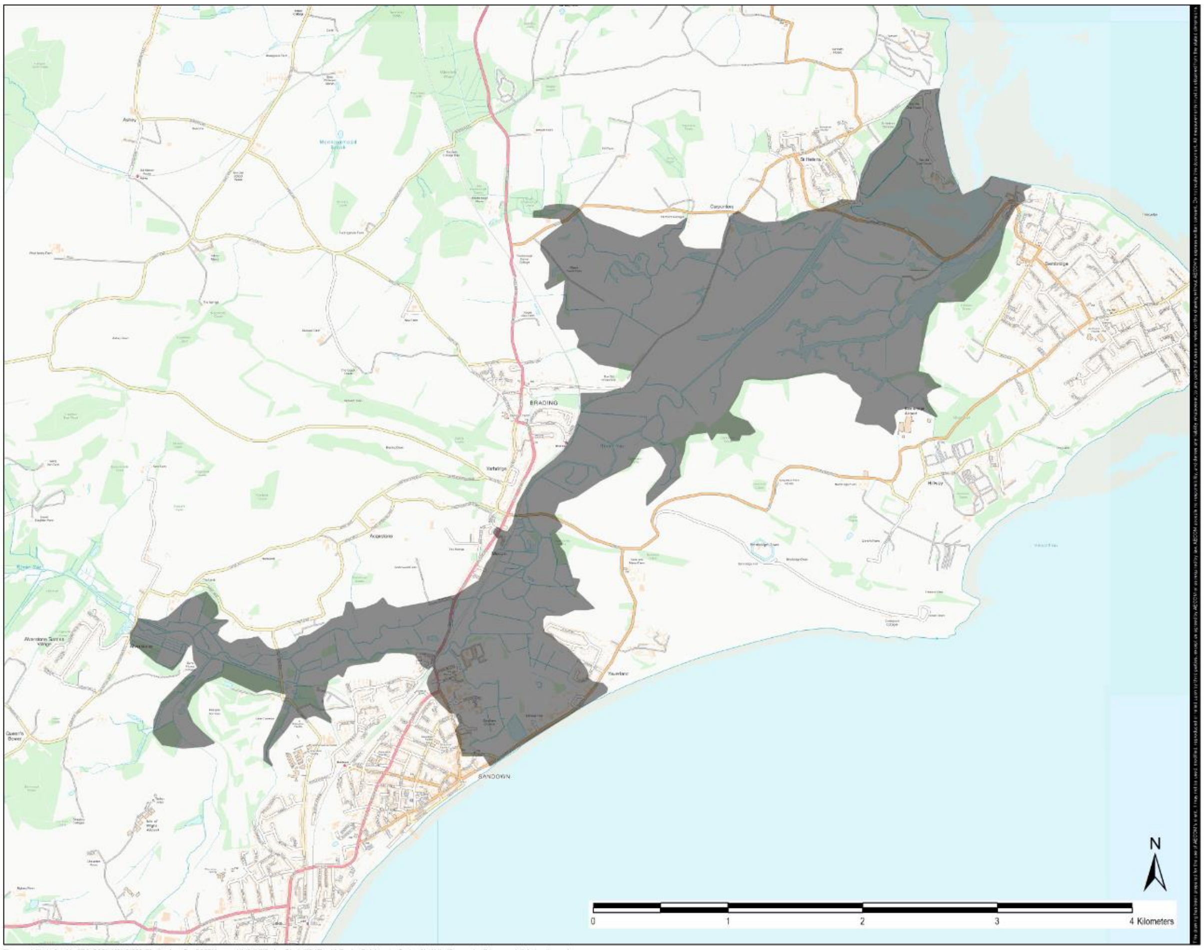
of Sandown, Lake and Shanklin. Whilst it is recognised that the current coastal defences have been successful in retaining substantial quantities of sand, as they deteriorate they will retain less sand and increase risks to the seawall. The extensive groyne field is described to be in poor to very poor condition and without timely renewal, substantial asset losses are anticipated in the future.

This report has used an initial 2km desk study survey area around this frontage to identify assets that could be affected by any future proposals. This desk study survey area encompasses the 100 year coastal erosion line as decisions on coastal defence options within the Sandown Bay study area will be important in protecting environmental designations and assets from coastal erosion.

3.2 The Eastern Yar Valley Floodplain

The Eastern Yar valley floodplain is located behind the existing seawall defences at Yaverland and extends north east towards Bembridge as shown in Plate 1. Environmental designations and assets within the Eastern Yar valley floodplain are considerations for the Sandown Bay Initial Appraisal and Scheme Identification Study, as decisions on coastal defence options within the Sandown Bay study area and the Embankment Road study area will be important in protecting them from tidal flooding.

Plate 1 – The Eastern Yar Valley Floodplain



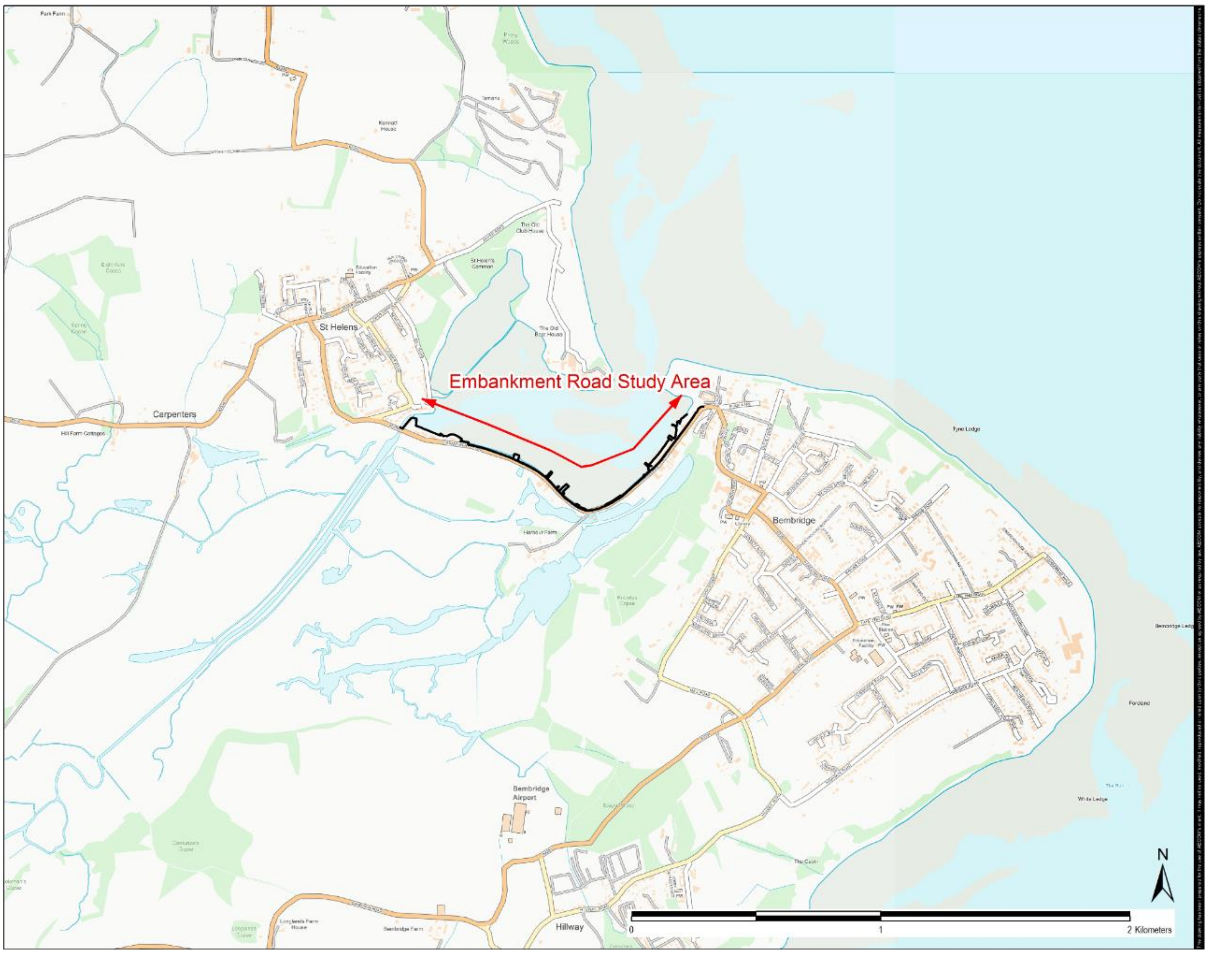
Filename: L:\Water New\4 - PROJECTS\6053\60535175 - Sandown Bay FCERM apprasial\40 GIS\Project Files\MXDs\Flood & Erosion Risk Mapping\Eastern Yar Valley\Proposed or Recommended designation.mxd

3.3 The Embankment Road Study Area

In addition to the works proposed within the Sandown Bay study area, it is necessary to provide additional protection along Embankment Road, Bembridge, because of the inter-connectivity of the two study areas associated with the Eastern Yar valley floodplain. The

Embankment Road study area encompasses the frontage adjacent to the stretch of the B3395 as shown in Plate 2. The frontage itself consists of marina facilities, cafes and restaurants, residential properties and mixture of sea wall, embankment and areas of no formal defence.

Plate 2 – The Embankment Road Study Area



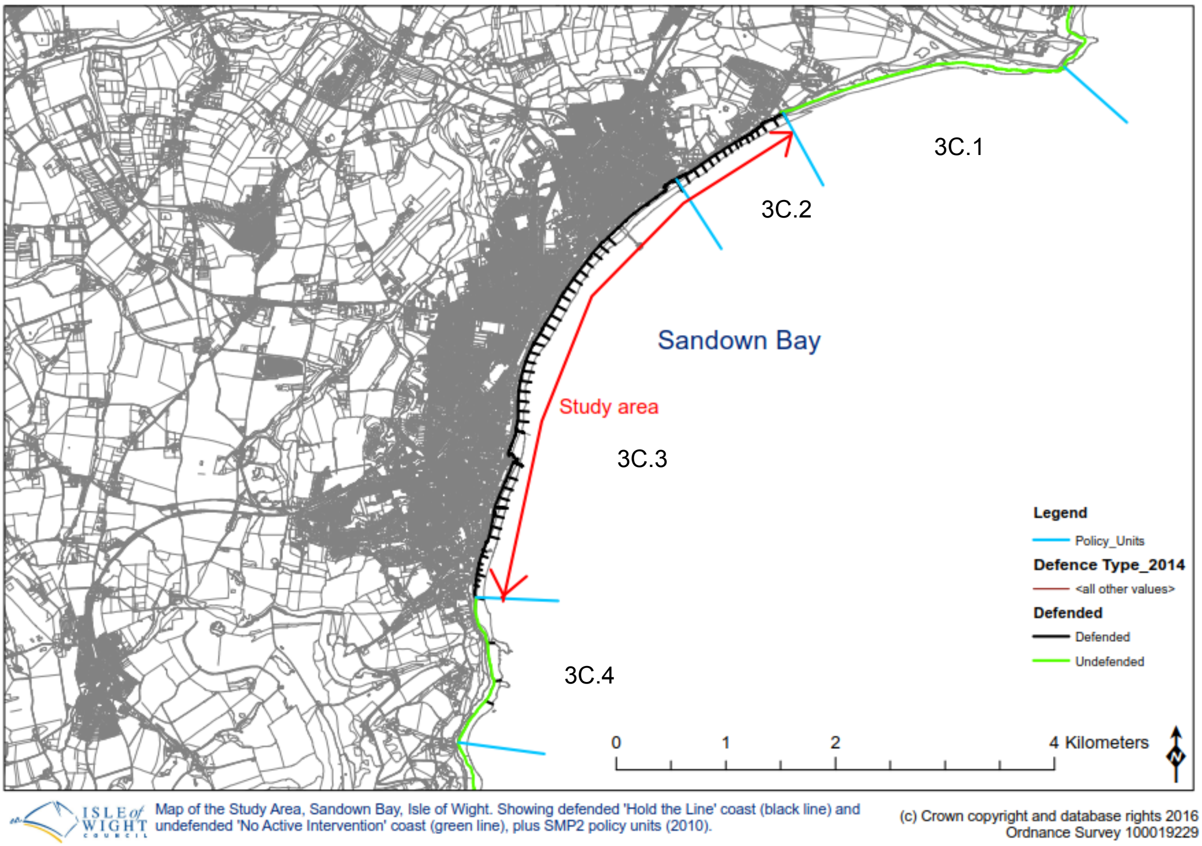
At present a 2km desk study survey area has been used as a buffer around the frontages of the Embankment Road study area and the Sandown Bay study area to identify environmental assets or designations that might be affected by any future scheme. It is possible that there may be other setback options to consider as part of any future environmental options appraisal. If these options fall outside of or are likely to have a potential impact on environmental features outside of the existing desk study survey areas, then it will be necessary to reconsider the baseline in the context of these options as part of any future environmental options appraisal.

3.4 Policy Development Area

The Sandown Bay study area frontage falls within Policy Development Zone (PDZ) 3 defined within the SMP2, but does not cover its full extent. PDZ 3 comprises three management areas (3A, 3B and 3C) and a total of 16 policy units from Priory Bay to Luccombe, each with their own management policy. The Sandown Bay study area encompasses two of these policy units within management area 3C as shown in Plate 3:

- Policy Unit 3C.2 - Yaverland and Eastern Yar Valley; and
- Policy Unit 3C.3 - Sandown to Shanklin.

Plate 3: The Sandown Bay Study Area



There is no approved Coastal Flood and Erosion Risk Management Strategy in place for these two policy units, therefore this Sandown Bay Initial Appraisal and Scheme Identification Study is being undertaken. However, as detailed within the SMP2 it is proposed they will both implement a 'hold the existing defence line' policy. Therefore, a preferred option needs to be defined in order to meet this management objective. The 'hold the existing defence line' policy has been selected "*to sustain the important economic and tourism value of the frontage of Sandown, Lake and Shanklin*."

The SMP2 provides the following information on what a 'hold the existing defence line' policy might entail:

"The intent of this policy is to maintain defence protection to important assets or interests at the coast. This does not necessarily mean that the existing defences would be maintained in exactly the same form as they are at present. There may be a need to adjust the local alignment in the future or to replace, or add, structures. In this way, constructing cross shore or shore linked structures, such as groynes or breakwaters, may be the approach adopted in the future under this policy, in specific cases. The proposed policy therefore sets the intent to maintain defence of the important features in an appropriate manner."

To the north and south of the Sandown Bay study area, the coastlines are undefended, with SMP2 policies of no active intervention. The sediment supply from the undefended cliffs immediately to the south of the Sandown Bay study area is an important consideration in the Sandown Bay Initial Appraisal and Scheme Identification Study.

4. Previous Environmental Studies

A series of environmental studies covering the 167km coastline of the Isle of Wight were completed as part of the SMP2. These studies and reports were:

- A summary of the Natural and Built Environment Baseline[8];
- A Strategic Environmental Assessment[9] (SEA);
- A Water Framework Directive (WFD) assessment[10];
- A Habitats Regulations Assessment[11] (HRA); and
- Habitats Directive: Appendix 20[12].

For the purpose of this report, a summary of the key findings of each of these documents is presented below and will be discussed in further detail in the relevant sections of this report. The full versions of these documents are available to view on http://www.coastalwight.gov.uk/smp/appendices.htm.

4.1 Natural and Built Environment Baseline

The Natural and Built Environmental Baseline was produced to provide a description of the natural, historic and built environments of the Isle of Wight to inform the SMP2. The Natural and Built Environment Baseline report uses 'IW' units[13] to gather information for the policy units defined in the SMP2. This current report makes reference to these 'IW' units where relevant.

The information provided within this report covers the current and future land use, any landscape characters or nature conservation designations and the historic environment of the whole IOW coastline, which includes the Sandown Bay study area. The relevant information from the Natural and Built Environmental Baseline will be discussed within the subsequent sections of this report.

4.2 Strategic Environmental Assessment

The SEA Environmental Report was produced to consider all of the PDZs established within the SMP to ensure that the recommendations of the final SMP2 were environmentally sustainable, to identify any opportunities for potential environmental enhancement and to comply with The Environmental Assessment of Plans and Programmes Regulations 2004 (SI no.1663). The SEA identifies that within PU3C.2 and PU3C.3 the 'hold the existing defence line' policy will have no significant adverse effects in terms of the following environmental topics over a 100 year period:

- Population and Communities;
- Land Use, Infrastructure and Material Assets;
- Biodiversity, Habitats and Species;
- Landscape;

[8] IWC and Royal Haskoning, 2010, Isle of Wight SMP2 Appendix D - Natural and Built Environment Baseline (Thematic Review)
[9] IWC and Royal Haskoning, 2010, Isle of Wight SMP2 Appendix F - Strategic Environmental Assessment Environmental Report
[10] IWC and Royal Haskoning, 2010, Isle of Wight SMP2 Appendix J - Water Framework Directive Assessment
[11] IWC and Royal Haskoning, 2010, Isle of Wight SMP2 Appendix I - Habitats Regulations Assessment (Stage 3: Appropriate Assessment Report)
[12] IWC and Royal Haskoning, 2010, Isle of Wight SMP2 Appendix L - Habitats Directive : Appendix 20 (Stage 4: Information to the Secretary of State/National Assembly for Wales according to Regulations 62(5) and 64(2) of the Habitats Regulations)
[13] IW Units were the policy units along the IOW coastline that were established as an information base prior to SMP2.

- Geology and Soils;
- Water; and
- Cultural Heritage.

Where the SEA Environmental Report does describe potential adverse impacts on receptors relevant to these topics, these receptors are discussed in the relevant sections of this report.

4.3 Water Framework Directive Assessment

The WFD assessment produced as part of the SMP2 establishes a framework for protecting inland surface water, transitional waters, coastal waters and groundwaters. It is important to note that the assessment considered the management area 3C as a whole (four policy units), in combination with three policy units from management unit 3B and so is not directly comparable to the Sandown Bay study area.

The WFD assessment concludes that the proposed management policies for these seven policy units are unlikely to have an effect on the likelihood of meeting the environmental objectives of the WFD. The findings of the WFD assessment are discussed further in Section 6 of this report.

4.4 Habitats Regulation Assessment

The HRA was produced as part of the SMP2 to identify if the proposed management policies would adversely affect the integrity of a European site (Special Protection Area (SPA), Special Area of Conservation (SAC) or Ramsar Site) within or surrounding the PDZs.

It is considered that the subtidal rocky reefs within the Sandown Bay study area could be affected by any changes in sediment supply or coastal processes. However, as the cliffs either side of the Sandown Bay study area will be implementing a ‘no active intervention’ policy, sediment supply and coastal process are unlikely to significantly change. This is because, by allowing cliffs to erode naturally, sufficient sediment will be supplied to the Sandown Bay study area. The HRA does not identify any adverse effects on the integrity of the South Wight Maritime SAC associated with the ‘hold the existing defence line’ policy within the Sandown Bay study area.

The HRA determined that the Isle of Wight SMP2 as a whole would have an adverse effect on the integrity of two European nature conservation designated sites (the Solent & Southampton Water SPA and Ramsar site) owing to the loss of 31 hectares of costal grazing marsh caused by the policy at Yarmouth Mill and Thorley (Policy Unit 6C.5). As a result Stage 4 of the Habitats Regulations Assessment (included as Appendix L of SMP2) was required to be submitted to the Secretary of State according to Regulations 62 (5) and 64 (2) of the Habitats Regulations 2010. It set out whether there were any alternative or preventative measures to those resulting in the adverse effect to determine if the SMP2 should be permitted for Imperative Reasons of Overriding Public Interest (IROPI). It also recorded the compensatory habitat for delivery as part of the EA’s Southern Regional Habitat Creation Programme (RHCP).

4.5 Eastern Yar Flood and Erosion Risk Management Strategy

The Eastern Yar Flood and Erosion Risk Management Strategy was produced in 2010 and sets out the plan to manage flood and erosion risk along the coastline of the Isle of Wight. The strategy area includes the Eastern Yar River, Bembridge Harbour, St Helens and the coast along the front of the Duver peninsula.

The existing Yaverland seawall protects the Eastern Yar valley floodplain from tidal inundation. If no active intervention were to be taken forward as a policy within the Sandown Bay study area, all assets that fall within this floodplain would be at risk from tidal flooding.

Therefore, schemes which ‘hold the existing line’ at Yaverland will be important in protecting these assets from tidal flooding. The assets within the Eastern Yar valley floodplain are specifically identified in the relevant sections of this report.

5. Ecology

The desk study identified 16 statutory and 37 non-statutory sites designated for nature conservation within 2km of the Sandown Bay study area (Figure 1), within the Eastern Yar valley floodplain (Figure 3) and 2km of the Embankment Road study area (Figure 5). There is also one recommended Marine Conservation Zone (rMCZ) and one potential Special Protection Area (pSPA) which are shown in the context of the three study areas on Figures 2, 4 and 6.

5.1 Statutory Designated Sites within the Sandown Bay Study Area

The Sandown Bay study area is located within 2km of the following statutory designated sites for nature conservation:

- South Wight Maritime SAC;
- Solent and Southampton Water SPA;
- Solent and Southampton Water Ramsar;
- Bonchurch Landslips Site of Special Scientific Interest (SSSI);
- Brading Marshes to St Helen’s Ledges SSSI;
- Bembridge Down SSSI;
- Lake Allotments SSSI;
- America Wood SSSI;
- Greatwood and Cliff Copses SSSI;
- Ventnor Downs SSSI;
- Alverstone Mead Local Nature Reserve (LNR); and
- Sibden and Batts Copse LNR.

Statutory designated sites for nature conservation that are located within the Eastern Yar valley floodplain and the Embankment Road study area are discussed within Sections 5.4 and 5.5 respectively.

5.1.1 South Wight Maritime SAC

The South Wight Maritime SAC covers an area of approximately 19,866 ha off the eastern, southern and western coast of the Isle of Wight from Bembridge to Totland. It comprises six types of marine habitat but is predominantly classified as areas of sea inlets. This site has been selected as part of the Nature 2000 site network “*on account of its variety of reef types and associated communities. These features support a diverse range of species in both the sub tidal and intertidal.... The site also contains the only known location of subtidal chalk caves in the UK*”[14], which host many rare algal species along with a range of mollusc species. The internationally important interest features of the SAC are identified as ‘reefs’, ‘vegetated sea cliffs’ and ‘submerged or partially submerged sea caves’. For most of the length of the Sandown Bay study area, the SAC boundary is coincident with the line of Mean Low Water boundary and is thus generally 50-100m seawards of the current coastal defence line (with the exception of most of the existing groynes which extend into this designation).

[14] DEFRA - http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0030061

However, there may be features for which the SAC is designated, located beyond the Mean Low Water boundary that could be impacted by changes in any coastal sediment regime.

For the eastern-most 100m of the Sandown Bay study area frontage the SAC covers the sandy intertidal zone, such that the landwards boundary of the SAC in this area forms the seawards boundary of the car park off Yaverland Road. Despite the SAC boundary being further landwards on this section of frontage, aerial photography does not suggest that any designated SAC interest features are actually present within this part of the SAC. The boundary between Yaverland Road car park and the SAC appears to consist of a sloping concrete wall, with no vegetated cliffs, reefs or sea caves.

5.1.2 Solent and Southampton Water SPA

The Solent and Southampton Water SPA is located 1.6km to the north east of the Sandown Bay study area. The site comprises a series of estuaries and coastal habitats important for breeding gulls, terns and wintering waterfowl[15].

5.1.3 Solent and Southampton Water Ramsar

The Solent and Southampton Water Ramsar is located 1.6km to the north east of the Sandown Bay study area. The site comprises estuaries and adjacent coastal habitats including intertidal flats, saline lagoons, shingle beaches, saltmarsh, reedbeds, damp woodland and grazing marsh. These habitats support internationally important numbers of wintering waterfowl, breeding gull, tern populations and an assemblage of rare invertebrates and species[16].

5.1.4 Bonchurch Landslips SSSI

The Bonchurch Landslips SSSI covers an area of approximately 28.2ha and is located approximately 1.6km to the south of the site near Luccombe Village. "*The site is of great interest for its complex mass-movement features, including the Undercliff itself and the coastal landslips and mud flows beneath it*". "*The lower slopes of the landslips support a complex mosaic of species-rich acidic and calcareous plant communities on unstable clays and sands*"[17].

5.1.5 Brading Marshes to St Helen's Ledges SSSI

The Brading Marshes to St Helen's Ledges SSSI covers an area of approximately 488.5ha and is located 1.6km to the north east of the Sandown Bay study area. The site "*includes a range of costal habitats… Brading Marshes comprises an extensive area of neutral and acid grassland, saline and freshwater lagoons and pools, botanically rich ditches, reedbeds, and areas of ancient woodland peripheral habitats… St Helen's Ledges, together with the Bembridge Ledges SSSI to the south, provide the best example of rocky shore fauna and flora on the south coast, east of Pool Harbour in Dorset."*[18] The site "*forms an important component of the Solent estuarine system which has been identified as an internationally important site for overwintering wildfowl and waders*" and has been identified to have high research potential.

5.1.6 Bembridge Down SSSI

The Bembridge Down SSSI covers an area of approximately 130.8ha and is partially (0.7%, the western-most extent of SSSI management units 6 and 8) located within the eastern extent of the Sandown Bay study area at Yaverland, geographically coincident with the aforementioned eastern-most 100m extent of the SAC adjacent to Yaverland Road car park.

[15] Natural England - http://publications.naturalengland.org.uk/publication/6567218288525312
[16] DEFRA - http://jncc.defra.gov.uk/pdf/RIS/UK11063.pdf
[17] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/1004312.pdf
[18] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/2000221.pdf

The site extends up the eastern coast of the Isle of Wight beyond the Sandown Bay study area to East Cliff in Bembridge. The SSSI "*comprises extensive areas of intertidal sand, rock and shingle and a series of actively eroding cliffs*"[19]. These cliffs support a variety of plant communities and "*the presence of successional vegetation types is of considerable scientific interest*". Within the Sandown Bay study area the only designated habitat that appears to be present according to aerial photography is intertidal sand. Eroding cliff habitat appears to be present immediately to the east of the Sandown Bay study area, in the vicinity of the sailing club. In front of these eroding cliffs is the beach which experiences fluctuating sand levels seasonally and following storm events. The intertidal rock platform is sometimes also exposed in this location and at other times is covered with more sand. This area may have been included in the SSSI for primarily geological reasons; according to the SSSI citation *'The Yaverland - Red Cliff site provides a complete section through the Wealden Group, Gault and Upper Greensand, together with the basal part of the Chalk'.*

5.1.7 Lake Allotments SSSI

The Lake Allotments SSSI covers an area of approximately 0.2ha and is located approximately 800m behind the Sandown Bay study area in the settlement of Lake. The site "*is of national importance as it contains the last known wild population of Martin's ramping-fumitory Fumaria martini in Britain*"[20]. The site also supports assemblages of other members of the fumitory family.

5.1.8 America Wood SSSI

The America Wood SSSI covers an area of approximately 10.9ha and is located approximately 1.7km behind the Sandown Bay study area in the area of Ninham. The site "*includes an area of neutral grassland on parts of the alluvial terrace*"[21] of a small, northward flowing stream. "*The wood has the characteristics of ancient wood-pasture and is the best known example of this woodland found in the Isle of Wight*".

5.1.9 Greatwood and Cliff Copses SSSI

The Greatwood and Cliff Copses SSSI covers an area of approximately 16.3ha and is located approximately 1.2km behind the southernmost extent of the Sandown Bay study area at Shanklin. The site "*comprises areas of ancient ash, wych-elm and beech woodland*"[22].The unusual occurrence of wych-elm "*on flushed soils over Upper Greensand is of considerable ecological interest whilst the stand itself is the best example found on the*" Isle of Wight.

5.1.10 Ventnor Downs SSSI

The Ventnor Downs SSSI covers an area of approximately 162.6ha and is located approximately 1.5km behind the southernmost extent of the Sandown Bay study area at Shanklin. The site a chalk ridge capped with angular flint gravel that supports extensive tracts of gorse with intervening areas of heathland and acid grassland. The site also comprises areas of woodland, mature woodland and ancient woodland[23].

5.1.11 Alverstone Mead LNR

The Alverstone Mead LNR is located approximately 1.9km behind the Sandown Bay study area to the south west of the village of Alverstone. The site comprises an old floodplain of

[19] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/1000806.pdf
[20] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/1002155.pdf
[21] Natural England - http://www.sssi.naturalengland.org.uk/citation/citation_photo/1000687.pdf
[22] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/1000653.pdf
[23] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/1000773.pdf

the eastern Yar river with low-lying grasslands, hay meadows, ditches, open water and woodland[24].

5.1.12 Sibden and Batts Copse LNR

The Sibden and Batts Copse LNR is located approximately 800m behind the Sandown Bay study area in the settlement of Shanklin. The site comprises mixed woodland, scrub, bracken-dominated acid grassland and amenity grassland[25].

5.2 Non-Statutory Designated Sites within the Sandown Bay Study Area

There are also the following 26 non-statutory designated sites for nature conservation within 2km of the Sandown Bay study area :

- Bembridge Down SINC;
- Marshcombe Copse SINC;
- Centurion's Copse SINC;
- Centurion's Copse: Longlands Copse SINC;
- Morton Marsh SINC;
- Brading Down SINC;
- Sandown Levels SINC;
- Sandown Golf Course SINC;
- Sandown Golf Course: Scotchell's Brook SINC;
- Alverstone Marshes East: Alverstone Mead SINC;
- Ninham/Barton Withybeds: Ninham withybed SINC;
- Lake Cliffs North SINC;
- Lake Cliffs Middle SINC;
- Lake Cliffs South SINC;
- Hungerberry Copse SINC;
- Luccombe Chine: Shanklin Chine SINC;
- Luccombe Chine SINC
- Luccombe Chine: Luccombe Common SINC;
- Luccombe Chine: Yellow Ledge and Horse Ledge SINC;
- Hilliard's Cemetery SINC;
- Sibden Hill: Batts Copse SINC;
- Sibden Hill SINC;
- Landguard Manor Farm Copse SINC;
- Landguard Manor Farm Copse: Meadow SINC;
- St Martin's Down SINC; and
- Lynch Copse SINC.

[24] Natural England - http://www.lnr.naturalengland.org.uk/Special/lnr/lnr_details.asp?C=0&N=&ID=1304
[25] Natural England - http://www.lnr.naturalengland.org.uk/Special/lnr/lnr_details.asp?C=0&N=&ID=404

Non-statutory designated sites for nature conservation that are located within the Eastern Yar valley floodplain and Embankment Road study area are discussed within Sections 5.4 and 5.5 respectively.

5.3 Proposed or Recommended Sites within the Sandown Bay Study Area

The following sites are currently not designated, but are either proposed or recommended sites to be designated for their nature conservation value:

- Solent and Dorset Coast potential Special Protection Area (pSPA); and
- Bembridge recommended Marine Conservation Zone (rMCZ).

The location of these sites in relation to the Sandown Bay study area is shown in Figure 2.

5.3.1 Solent and Dorset Coast pSPA

The potential SPA would cover the entire Solent and will extend through the eastern section of the Sandown Bay study area, from Yaverland to just south of the Sandown Pier. It has been proposed for designation to capture waters that are of particular importance to the common tern, sandwich tern and little tern which breed in parts of the Solent and which forage through plunge diving into open waters. The proposed designation covers sub-tidal areas not currently encompassed in existing SPAs. Therefore, in the location of the Sandown Bay study area the boundary of the proposed designation is consistent with the Mean High Water boundary.

This site is considered to be a material consideration in any assessment to be undertaken as Natural England has undertaken public consultation on the proposed site. Therefore, the pSPA will need to be considered in the Sandown Bay Initial Appraisal and Scheme Identification Study.

5.3.2 Bembridge rMCZ

The Bembridge rMCZ site will span the entire frontage of the Sandown Bay study area, encompassing both the intertidal and subtidal area. In Natural England's advice to Defra on recommended Marine Conservation Zones to be considered for consultation in 2015: Annex 9. Site Specific Advice[26], the rMCZ site is described to overlap three-quarters of the South Wight Maritime SAC. The site is recommended as a MCZ for containing a range of exceptionally diverse habitat and species that are not protected by the South Wight Maritime SAC. "*These habitats and species include the reef-building Ross worm (Sabellaria spinulosa), native oyster (Ostrea edulis) and seagrass beds."*

At the time of writing, Natural England has not begun any public consultation on this recommended site. Until any public consultation is undertaken, this site is not considered to be a material consideration in ecological assessments. However, it could become a material consideration in the future and so as a precaution it is to be considered within the Sandown Bay Initial Appraisal and Scheme Identification Study.

5.4 Eastern Yar Valley Floodplain

5.4.1 Statutory Designated Sites

The following statutory designated sites for nature conservation have been identified to be specifically located within the Eastern Yar valley floodplain:

- Solent and Southampton Water SPA;
- Solent and Southampton Water Ramsar;

[26] Natural England's advice to Defra on recommended Marine Conservation Zones to be considered for consultation in 2015: Annex 9. Site Specific Advice, December 2014

- Solent and Isle of Wight Lagoons SAC;
- Brading Marshes to St Helen's Ledges SSSI; and
- Alverstone Mead LNR.

Solent and Southampton Water SPA

The Solent and Southampton Water SPA is located within the boundary of the Eastern Yar valley floodplain. The features of this site ae discussed within section 5.1.2 of this report.

Solent and Southampton Water Ramsar

The Solent and Southampton Water Ramsar is located within the boundary of the Eastern Yar valley floodplain. The features of this site ae discussed within section 5.1.3 of this report.

Solent and Isle of Wight Lagoons SAC

The Solent and Isle of Wight Lagoons SAC is located within the boundary of the Eastern Yar valley floodplain. The site encompasses a series of coastal lagoons, including percolation, isolated and sluice lagoons. The lagoons show a range of salinities and substrates, which support a diverse fauna, including the nationally rare foxtail stonewort *Lamprothamnium papulosum*, the nationally scarce lagoon sand shrimp *Gammarus insensibilis*, and the nationally scarce starlet sea anemone *Nematostella vectensis*[27].

Brading Marshes to St Helen's Ledges SSSI

The Brading Marshes to St Helen's Ledges SSSI is located within the boundary of the Eastern Yar valley floodplain. The features of this site are discussed within section 5.1.5 of this report.

Alverstone Mead LNR

The Alverstone Mead LNR is located within the boundary of the Eastern Yar valley floodplain and lies to the south west of the village of Alverstone. The features of this site are discussed within section 5.1.11 of this report.

5.4.2 Non-Statutory Designated Sites

There are also the following eight non-statutory designated sites for nature conservation specifically located within the Eastern Yar valley floodplain:

- Brading Marshes North SINC;
- Steyne Wood SINC;
- Sandown Levels SINC;
- Mashcombe Copse SINC;
- Morton Marsh SINC;
- Alverstone Marshes East: Alverstone Mead SINC;
- Sandown Golf Course: Scotchell's Brook SINC; and
- Sandown Golf Course SINC.

[27] DERFA - http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0017073

5.4.3 Proposed or Recommended Sites

The following sites are currently not designated, but are either proposed or recommended sites to be designated for their nature conservation value and fall within or adjacent to the Eastern Yar valley floodplain:

- Solent and Dorset Coast potential Special Protection Area (pSPA). The extent and the reason for the proposal are discussed within section 5.3.1; and
- Bembridge recommended Marine Conservation Zone (rMCZ). The extent and the reason for the proposal are discussed within section 5.3.2.

The location of these sites in relation to the Eastern Yar valley floodplain is shown in Figure 4.

5.5 Embankment Road Study Area

5.5.1 Statutory Designated Sites

The following statutory designated sites for nature conservation have been identified to be located within 2km of the Embankment Road study area:

- Solent and Southampton Water SPA;
- Solent and Southampton Water Ramsar;
- Solent and Isle of Wight Lagoons SAC;
- South Wight Maritime SAC;
- Brading Marshes to St Helen's Ledges SSSI;
- Whitecliff Bay and Bembridge Ledges SSSI;
- Bembridge School and Cliffs SSSI; and
- Priory Woods SSSI.

Solent and Southampton Water SPA

The Solent and Southampton Water SPA is located immediately adjacent to east and the west of Embankment Road. The features of this site are discussed within section 5.1.2 of this report.

Solent and Southampton Water Ramsar

The Solent and Southampton Water SPA is located immediately adjacent to the east and the west of Embankment Road. The features of this site are discussed within section 5.1.3 of this report.

Solent and Isle of Wight Lagoons SAC;

The Solent and Isle of Wight Lagoons SAC is located immediately adjacent to the south of Embankment Road. The features of this site are discussed within section 5.4.1 of this report.

South Wight Maritime SAC

The South Wight Maritime SAC is located approximately 315m to the west of Embankment Road. The features of this site are discussed within section 5.1.1 of this report.

Brading Marshes to St Helen's Ledges SSSI

The Brading Marshes to St Helen's Ledges SSSI is located immediately adjacent to the east and the west of Embankment Road. The features of this site are discussed within section 5.1.5 of this report.

Whitecliff Bay and Bembridge Ledges SSSI

The Whitecliff Bay and Bembridge Ledges SSSI is located approximately 315m to the east of Embankment Road. The site comprises extensive areas of intertidal sand, rock and shingle and includes a series of actively eroding cliffs. The site is geologically important because of the famous and well exposed rock sequence and because of the important fossil mammal faunas and fossil plan floras which occur at certain horizons[28].

Bembridge School and Cliffs SSSI

The Bembridge School and Cliffs SSSI is located approximately 1.4km to the south of Embankment Road. The site consists of fossiliferous deposits known as the Steyne Wood Clays and is of national importance for the exposed Quaternary succession[29].

Priory Woods SSSI

The Priory Woods SSSI is located approximately 1.5km to the north of Embankment Road. The scientific interest in the site lies in the gravels which are generally poorly exposed and further research is required in order to develop a better understanding of their origins and adding to knowledge of early humans in the area[30].

5.5.2 Non-Statutory Designated Sites

There are also the following 12 non-statutory designated sites for nature conservation located within 2km of the Embankment Road study area:

- Longlands Copse SINC;
- Spring Copse SINC;
- Eight Acre Copse SINC;
- Hill Farm Copse SINC;
- Brading Marshes North SINC;
- St Luke's Cemetery, Bembridge SINC;
- Breachs Copse SINC;
- Bembridge School Lawn SINC;
- Centurion's Copse SINC;
- Steyne Wood SINC;
- Priory Woods SINC; and
- Nodes Point Meadow SINC.

[28] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/1000806.pdf
[29] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/2000390.pdf
[30] Natural England - https://necmsi.esdm.co.uk/PDFsForWeb/Citation/2000346.pdf

5.5.3 Proposed or Recommended Sites

The following sites are currently not designated, but are either proposed or recommended sites to be designated for their nature conservation value and fall within 2km of the Embankment Road study area:

- Solent and Dorset Coast potential Special Protection Area (pSPA). The extent and the reason for the proposal are discussed within section 5.3.1; and
- Bembridge recommended Marine Conservation Zone (rMCZ). The extent and the reason for the proposal are discussed within section 5.3.2.

The location of these sites in relation to the Embankment Road study area is shown in Figure 6.

5.6 Natural England Comments

Natural England have confirmed that future studies on the effects of any coastal defences will need to consider the direct and indirect effects on the South Wight Maritime SAC and the Solent and Dorset Coast pSPA. In email correspondence, they suggest that it would also be worth considering the adjacent SSSIs given that their designation depends on the unstable nature of the slopes/cliffs[31].

Natural England provided information on the South Wight Maritime Improvement Plan[32], which gives an overview of the issues (both current and predicted) affecting the condition of the South Wight Maritime SAC and outlines the priority measures required to improve the conditions of the features. The report suggests that Natural England need to determine if the extent of the SAC is adequate and appropriate (allowing dynamic hydrological, geomorphological and ecological process to be able to occur unhindered). Under the identified issue of inappropriate coastal management, both the Bonchurch Landslips SSSI and Bembridge Down SSSI (located at either end of the Sandown Bay study area) are also discussed.

5.7 Summary and the Need for Further Ecological Assessment

Of the sites designated for their nature conservation, it is the Solent and Southampton Water SPA and Ramsar, South Wight Maritime SAC, Solent and Isle of Wight Lagoons SAC, Bembridge Down SSSI, Bonchurch Landslips SSSI and Brading Marshes to St Helen's Ledges SSSI that are likely to be the most important considerations in terms of the options assessment to be undertaken as part of the Sandown Bay Initial Appraisal and Scheme Identification Study.

Previous environmental assessments have not considered the likely effects of the 'hold the existing defence line' on the Solent and Dorset Coast pSPA or the Bembridge rMCZ. These should be considered within the Sandown Bay Initial Appraisal and Scheme Identification Study and will likely need considering in any future environmental assessments.

6. Water Resources

6.1 Overview

The Environment Agency's online mapping tool[33] identifies that the Sandown Bay study area is primarily located within Flood Zone 1[34]. However, there are sections of the desk study survey area behind the frontage such as Sandown Grounds at Yaverland, which are located

[31] Email correspondence with Natural England dated 14/03/2017 and 17/03/2017.
[32] Natural England, Site Improvement Plan, South Wight Maritime, Improvement Programme for England's Natura 2000 Sites (IPENS), available on http://publications.naturalengland.org.uk/publication/6628806274056192
[33] EA, What's in your backyard mapping tool, available on http://apps.environment-agency.gov.uk/wiyby/
[34] Flood Zone 1 covers land defined as having a less than 1 in 1,000 annual probability of river or sea flooding.

within Flood Zone 3[35] as they are within the Eastern Yar valley floodplain. The site is not located within a source protection zone and is not located within 1km of any licensed ground or surface water abstractions.

6.2 Sandown Bay Study Area

The following surface water features have been identified in proximity to the Sandown Bay study area:

- The River Yar is located approximately 900m behind the Sandown Bay study area in the Sandown area;
- A surface waterbody (lake/pond) is located approximately 60m behind the Sandown Bay study area between Sandown and Yaverland;
- A surface waterbody (pond) is located approximately 350m behind the Sandown Bay study area just north of Lake; and
- Tributaries of the River Yar are located approximately 950m behind the Sandown Bay study area in the Shanklin area.

In terms of geology, the British Geological Survey Geology of Britain Map[36] and the Environment Agency's online mapping tool (groundwater layer)[37] identify that the Sandown Bay study area is primarily underlain by the Wealden Group, which is a series of mudstone, siltstone and sandstone defined as a Secondary A Aquifer. The Sandown area is also underlain by alluvium superficial deposits of clay, sand and silt.

The Yaverland area is underlain by Gault Formation and Upper Greensand Formation, which is a series of mudstone, sandstone and limestone and White Chalk, both defined as Principal Aquifers. No superficial deposits are identified within the Yaverland area.

The rest of the Sandown Bay study area to the south of Sandown, covering both Lake and Shanklin is underlain by the Lower Greensand Group, comprising sandstone and mudstone and defined as a Principal Aquifer. No superficial deposits are identified within the rest of the Sandown Bay study area.

The Sandown Bay study area is adjacent to the Isle of Wight Lower Greensand (G1) groundwater body. The Sandown Bay study area would lie on the very edge of this unit and so it is not expected that it would be impacted by the proposed coastal defence works.

6.3 Eastern Yar Valley Floodplain

The following surface water features have been identified within the Eastern Yar Valley Floodplain:

- The Eastern Yar River and associated tributaries;
- Bembridge Harbour Coastal Lagoons; and
- Surface water bodies within the vicinity of the Eastern Yar River.

In terms of geology, the British Geological Survey Geology of Britain Map[38] and the Environment Agency's online mapping tool (groundwater layer)[39] identify that the Eastern Yar

[35] Flood Zone 3 covers land defined as having a 1 in 100 or greater annual probability of river flooding; or land having a 1 in 200 or greater annual probability of sea flooding.
[36] British Geological Survey, http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[37] EA, http://maps.environment-agency.gov.uk/wiyby/wiybyController?topic=groundwater&layerGroups=default&lang=_e&ep=map&scale=5&x=531500&y=181500#x=461245&y=84118&lg=4,3,&scale=7
[38] British Geological Survey, http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[39] EA, http://maps.environment-agency.gov.uk/wiyby/wiybyController?topic=groundwater&layerGroups=default&lang=_e&ep=map&scale=5&x=531500&y=181500#x=461245&y=84118&lg=4,3,&scale=7

Valley Floodplain is underlain by Bembridge Marls Member, comprising calcareous mud. The Eastern Yar Valley Floodplain is also underlain by two classified superficial deposits. These are Raised Marine Deposits, a Secondary (undifferentiated) aquifer comprising sand and gravel in the east towards Embankment Road and by Alluvium, a Principal Aquifer comprising clay, silt, sand and gravel in the west towards Yaverland.

According to the SMP2 WFD assessment, the Eastern Yar Valley Floodplain encompasses four groundwater bodies. These are the Isle of Wight Central Downs Chalk, the Solent Group, the Isle of Wight Lower Greensand and 'Other' groundwater bodies.

6.4 Embankment Road Study Area

The following surface water features have been identified in proximity to the Embankment Road study area:

- The Eastern Yar River and associated tributaries located immediately behind the Embankment Road study area at its northern extent;
- Extensive inter-tidal mudflats located immediately in front of the Embankment Road study area;
- Bembridge Harbour Coastal Lagoons, located immediately behind the Embankment Road study area; and
- Surface water bodies within the vicinity of the Eastern Yar River.

In terms of geology, the British Geological Survey Geology of Britain Map[40] and the Environment Agency's online mapping tool (groundwater layer)[41] identify that the Embankment Road study area is underlain by is underlain by Bembridge Marls Member, comprising calcareous mud. The area landward of Embankment Road is underlain by Raised Marine Deposits, a Secondary (undifferentiated) aquifer comprising sand and gravel and the area sea-ward of Embankment Road is underlain by Beach and Tidal Flat Deposits, a Secondary (undifferentiated) aquifer comprising clay, silt, sand and gravel.

The Embankment Road study area is located adjacent to the Isle of Wight Lower Greensand and the Solent Group groundwater bodies.

6.5 Summary of SEA findings

The SEA undertaken as part of the SMP2 has identified that there would be temporary and minor impacts on water quality within the coastal environment during construction works associated with upgrading the coastal defences. As a result the SEA recommends that water quality monitoring should be undertaken during any upgrade works as required.

6.6 Summary of WFD assessment findings

As previously stated the WFD assessment undertaken as part of the SMP2 does not focus solely on the policy units which the Sandown Bay Initial Appraisal and Scheme Investigation study area falls within. Therefore, the reported effects below consider PDZ 3 (Eastern Yar) as a whole.

6.6.1 Isle of Wight East TraC water body

As a result of the policies and sea level rise there is *"potential for there to be coastal squeeze and thus loss of the rocky intertidal ledges, as well as the extent of the seagrass beds being affected with increasing depths of the surrounding subtidal areas. The benthic*

[40] British Geological Survey, http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[41] EA, http://maps.environment-agency.gov.uk/wiyby/wiybyController?topic=groundwater&layerGroups=default&lang=_e&ep=map&scale=5&x=531500&y=181500#x=461245&y=84118&lg=4,3,&scale=7

invertebrate, fish, macroalgae and angiosperm (seagrass) biological quality elements could therefore be affected in the short to medium term until the coastline adjusts to more natural coastal processes and soft coastal management strategies. However, it is unlikely that this will affect the overall potential to meet Good Ecological Potential for the Isle of Wight East TraC water body by 2015"[42].

Whilst any 'hold the existing defence line' scheme may cause a loss of the sandy intertidal area as a result of sea level rise, the subtidal clay exposures and the mudstone reefs are considered to remain unaffected. Therefore, it is unlikely that there will be deterioration in the Ecological Potential of the Isle of Wight East TraC water body as a result of the PDZ 3 management policies.

6.6.2 Isle of Wight East coastal water body

The WFD assessment does not consider the policy units of the Sandown Bay study area when discussing the impacts on this waterbody. Therefore, it is considered that the policies of the SMP for the Sandown Bay study area are unlikely to affect the overall potential to meet good ecological potential for the Isle of Wight East coastal water body.

6.6.3 Eastern Yar transitional water body

The WFD assessment states that "*freshwater habitat is also at risk if the line of defence along Embankment Road is not maintained*", but suggests that a hold the line policy will continue to adversely affect fish migration. Therefore, a hold the line policy has the potential to prevent the water body from attaining Good Ecological Status.

6.6.4 Bembridge Harbour Lagoons transitional Water body

The WFD assessment states that a hold the line policy is unlikely to cause deterioration in the ecological potential of the Bembridge Harbour Lagoons transitional water body.

6.6.5 Old Mill Ponds transitional water body

The WFD assessment does not consider the policy unit of the Embankment Road study area when discussing the impacts on this waterbody. Therefore, it is assumed that the policy of the SMP2 for the Embankment Road study area is unlikely to affect the overall potential to cause deterioration in the ecological potential of the Old Mill Ponds transitional water body.

7. Cultural Heritage

7.1 Overview

As discussed in Section 4.2, the SEA undertaken as part of the SMP2 did not predict any significant adverse effects on cultural heritage. The following section presents a summary of the designated and non-designated heritage assets that are located within 2km of the Sandown Bay study area, within the Eastern Yar valley floodplain and within 2km of the Embankment Road study area. These assets have been identified using Historic England's 'The List'[43], and Annex 1 of the Natural and Built Environment Baseline[44] discussed in Section 4.1 of this report. These sources should be referred to for more detailed information.

There are no World Heritage Sites or registered parks and gardens. However, the following assets have been identified:

- Seven Scheduled Ancient Monuments;

[42] IWC and Royal Haskoning, 2010, Isle of Wight SMP2 Appendix J - Water Framework Directive Assessment
[43] Historic England, The List, available on https://historicengland.org.uk/listing/the-list/map-search
[44] Annex 1 available on http://www.coastalwight.gov.uk/smp/appendices.htm

- 131 listed buildings;
- Five Conservation Areas;
- 170 non-designated monument records; and
- 42 non-designated marine features of interest.

The locations of the identified designated assets in relation to the Sandown Bay study area are shown in Figure 7 and those in relation to the Eastern Yar valley floodplain and Embankment Road study area are shown in Figures 8 and 9 respectively.

The following section of this report has been informed by the Natural and Built Environmental Baseline report and summarises the heritage features of interest that have been identified within defined sections along the frontage of the Sandown Bay study area.

7.2 Heritage Features within Defined Sections of the Sandown Bay Study Area

The following heritage assets have been identified to be located within 2km of the Sandown Bay study area and are shown on Figure 7:

- Two Conservation Areas;
- Five Scheduled Ancient Monuments;
- Three Grade I listed buildings;
- One Grade II* listed building;
- 79 Grade II listed buildings;
- Eight locally listed buildings;
- 65 non-designated monument records; and
- Ten non-designated marine features of interest.

7.2.1 Yaverland Car Park (IW22)

Within this section of the Sandown Bay study area the following non-designated assets have been identified:

- Two non-designated monument records (IWHER 2968 and IWHER 2987); and
- One non-designated marine feature of interest (IWHER 1319258).

There is also one Scheduled Monument (*Yaverland Battery*) immediately to the north of this section within IW21, which is located approximately 15m from the eroding clifftop (which has a no active intervention policy). This is listed on the Heritage at Risk Register.

7.2.2 Yaverland Zoo to The Grand Hotel (IW23)

Within this section of the Sandown Bay study area the following non-designated assets have been identified:

- Six non-designated monument records (IWHER 849, IWHER 2808, IWHER 2963, IWHER 2984, IWHER 2985 and IWHER 2986).

7.2.3 Culver Parade (IW24)

Within this section of the Sandown Bay study area the following designated and non-designated assets have been identified:

- One Conservation Area (Sandown Conservation Area);

- One grade II listed building (*Power Station in The Pavilion on Sandown Miniature Golf Course*);
- Nine non-designated monument records (IWHER 851, IWHER 4644, IWHER 2981, IWHER 2960, IWHER 4100, IWHER 2979, IWHER 2978, IWHER 2962 and IWHER 2720); and
- One non-designated marine feature of interest (IWHER 850).

7.2.4 Sandown Esplanade (IW25)

Within this section of the Sandown Bay study area the following designated and non-designated assets have been identified:

- One Conservation Area (Sandown Conservation Area);
- Two grade II listed buildings (*Church of St John* and *Town Hall*); and
- Three non-designated monument records (IWHER 812, IWHER 2945 and IWHER 3465).

7.2.5 Lake Cliffs (IW26)

Within this section of the Sandown Bay study area the following designated and non-designated assets have been identified:

- One Conservation Area (Sandown Conservation Area);
- One Scheduled Monument (Sandown Barrack Battery);
- Four grade II listed buildings (*Drinking Fountain with trough for Horses And Dogs, Church of The Good Shepherd, Merrie Gardens Farmhouse* and *Landguard*);
- 30 non-designated monument records (IWHER 2816, IWHER 707, IWHER 3054, IWHER 3063, IWHER 3064, IWHER3065, IWHER 3066, IWHER 3067, IWHER 3068, IWHER 3069, IWHER 3070, IWHER 3071, IWHER 3072, IWHER 3073, IWHER 3152, IWHER 3153, IWHER 3154, IWHER 3155, IWHER 3074, IWHER 3075, IWHER 3076, IWHER 3077, IWHER 3078, IWHER 3079, IWHER 4001, IWHER 814, IWHER 1298, IWHER 1573, IWHER 782 and IWHER 5873); and
- Three non-designated marine features of interest (MIW 6245 4774, NMR 1240721 and NMR 895964).

7.2.6 Shanklin Esplanade (IW27)

Within this section of the Sandown Bay study area the following designated and non-designated assets have been identified:

- One Conservation Area (Shanklin Conservation Area);
- 14 grade II listed buildings (*Shanklin Railway Station, Church of St Paul's Including Parish Room, Netherfield Netherfield And Rosemary Rosemary, Keats Inn, Clock Tower And Drinking Fountain, The Vicarage, Church of St Saviour's on the Cliff Including Church Hall, Eastcliff, The Shanklin Theatre and Former Town Hall, Daish's Hotel, Vernon Cottage, Chine Lodge, Hot Brine Bath* and *Fisherman's Cottage Public House*);
- One locally listed building (Shanklin Chine);
- 15 non-designated monument records (IWHER 2721, IWHER 2773, IWHER 2807, IWHER 2817, IWHER 2818, IWHER 2819, IWHER 2888, IWHER 2901, IWHER 3355, IWHER 3458, IWHER 3459, IWHER 3460, IWHER 3461, IWHER 3596 and IWHER 3958); and
- One non-designated marine feature of interest (NMR 895299).

The IWC Archaeology and Historic Environment Service have also suggested there are undesignated heritage assets within this section of the study area, including the lift, the late 19th century shelters and WWII structures (including those relating to PLUTO).

7.2.7 Luccombe Road, Shanklin (IW28)

Within this section of the Sandown Bay study area the following designated and non-designated assets have been identified:

- One Conservation Area (Shanklin Conservation Area);
- 12 Grade II listed buildings (*Rylstone House Hotel, Chine House, Crab Inn, Old Church Parish Room, Vine Cottage, Pencil Cottage, The Old Thatch, Glenbrook Hotel Including Henry's Kitchen, Chalet Café, Home Farm, Jessamine Cottage* and *The Grange*);
- One locally listed park and garden (*Rylestone Gardens*, *Shanklin*);and
- Two non-designated monument records (IWHER 3456 and IWHER 3597).

7.3 Heritage Features within the Eastern Yar Valley Floodplain

The following heritage assets have been identified to be specifically located within the Eastern Yar valley floodplain and are shown on Figure 8:

- Four Conservation Areas (Sandown Conservation Area, Bembridge Conservation Area, St Helens Conservation Area, St Helens (The Duver) Conservation Area); and
- Eight grade II listed buildings (*Pluto Power Station In The Pavilion On Sandown Miniature Golf Course*, *Brading Railway Station Signal Box, Brading Railway Station Main Building on East Platform, Brading Railway Station Footbridge, Brading Railway Station Main Building*, *Alverstone Bridge*, *Drinking Fountain At Entrance to Spithead Hotel* and *St Helen's Old Church Tower*)

7.4 Heritage Features within the Embankment Road Study Area

The following heritage assets have been identified to be located within2km of the Embankment Road study area and are shown on Figure 9:

- Three Conservation Areas (St Helens Conservation Area, St Helens (The Duver) Conservation Area and Bembridge Conservation Area);
- Two Scheduled Ancient Monuments (Steyne Wood Battery and St Helen's Fort);
- One Grade I listed building (*Bembridge Windmill*)
- 42 Grade II listed buildings;
- Eight locally listed buildings;
- 105 non-designated monument records; and
- 32 non-designated marine features of interest.

7.4.1 Bembridge Harbour (IW15)

Within this section of the Embankment Road study area, the following designated and non-designated assets have been identified:

- One Conservation Area (Bembridge Conservation Area);
- One Grade II listed building (*Drinking Fountain*);
- 44 non-designated monument records (IWHER 2596, IWHER 2717, IWHER 2324, IWHER 2675, IWHER 2752, IWHER 1170, IWHER 2915, IWHER 2754, IWHER 2943,

IWHER 3534, IWHER 3535, IWHER 3536, IWHER 3537, IWHER 3538, IWHER 3539, IWHER 3450, IWHER 3541, IWHER 3542, IWHER 3543, IWHER 3544, IWHER 3545, IWHER 3546, IWHER 3547, IWHER 3548, IWHER 3549, IWHER 3550, IWHER 3318, IWHER 3319, IWHER 3551, IWHER 3552, IWHER 3553, IWHER 3341, IWHER 2780, IWHER 3385, IWHER 3309, IWHER 3308, IWHER 3246, IWHER 3528, IWHER 1179, IWHER 2932, IWHER 3264, IWHER 3529, IWHER 3530, IWHER 3280);

7.5 Comments from Historic England and IWC

Historic England[45] suggest that future environmental studies should consider the implications (adverse or beneficial) of any proposed coastal defence works to heritage assets, both in terms of significance and access. It is also noted that Historic England drew attention to the non-designated assets, including locally listed buildings and any archaeological finds within the Sandown Bay study area (identified on the Historic Environmental Record (HER) for the Island), which should also be considered in future studies. Further correspondence with the IWC[46] Conservation Officer suggested that any proposals should not detract from the setting of any identified Scheduled Monuments within the Sandown Bay study area.

7.6 Summary and the Need for Further Cultural Heritage Assessment

Of the assets identified in the previous section, it is the Sandown and Shanklin Conservation Areas, the Sandown Barrack Battery Scheduled Monument and the listed buildings (such as the grade II listed *Clock Tower and Drinking Fountain*, *Fisherman's Cottage Public House* and *Hot Brine Bath*) located closest to the coastline within Shanklin that are likely to be the most important considerations in terms of the options assessment to be undertaken as part of the Sandown Bay Initial Appraisal and Scheme Identification Study. It is these assets closest to any potential schemes that are also most likely to be impacted and require consideration in future environmental assessments to ensure that any scheme is designed to avoid potential setting effects. However, it should be noted that by implementing a 'hold the existing line' policy the physical existence of assets will be protected from erosion and flooding and therefore beneficial effects should also be considered.

8. Ground Conditions/Contaminated Land

To identify potential sources of contamination within and surrounding the Sandown Bay study area, the Eastern Yar valley floodplain, and Embankment Road study area a review of the Environment Agency landfill map[47] was undertaken.

8.1 The Sandown Bay Study Area

This search identified one active landfill and a number of historic landfills within 2km of the Sandown Bay study area:

- The active Apsecastle Wood Pit Landfill, located 2.15km behind the Sandown Bay study area at Shanklin;
- The Waste storage at Sandown Waste Water Treatment Works, located approximately 650m behind the Sandown Bay study area at Yaverland;
- Land adjacent to waste storage at Sandown Waste Water Treatment Works, located approximately 580m behind the Sandown Bay study area at Yaverland;
- Jeals Pit, located approximately 790m behind the Sandown Bay study area at Sandown;

[45] Email correspondence with Historic England dated 13/03/2017.
[46] Email correspondence with IWC dated 16/03/2017
[47] EA, http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=357683&y=355134&scale=1&layerGroups=default&ep=map&textonly=off&lang=_e&topic=waste

- Land at Downsview, located approximately 980m behind the Sandown Bay study area at Sandown;
- Perowne Way, located approximately 740m behind the Sandown Bay study area at Sandown;
- Track, located approximately 1.7km behind the Sandown Bay study area at Sandown;
- Blackpan Farm, located approximately 1.07km behind the Sandown Bay study area at Lake;
- Cheverton Shute Lake, located approximately 1.29km behind the Sandown Bay study area at Lake;
- Ninham Withybed, located approximately 1.35km behind the Sandown Bay study area between Lake and Shanklin;
- Landguard Caravan Park, located approximately 820m behind the Sandown Bay study area between Lake and Shanklin;
- Shanklin Old Tip, located approximately 580m behind the Sandown Bay study area at Shanklin; and
- Land off Josephs Way, located approximately 1km behind the Sandown Bay study area at Shanklin.

8.2 The Eastern Yar Valley Floodplain

The following historic landfill sites have been identified to be located within the Eastern Yar valley floodplain:

- Embankment Road;
- The Waste Storage at Sandown Waste Water Treatment Works;
- Land adjacent to Waste Storage at Sandown Waste Water Treatment Works;
- Track; and
- Yaverland Old Tip

Whilst no active landfills are located within the Eastern Yar valley floodplain, Lower Knighton Farm is located approximately 600m to the north west of the floodplain boundary.

8.3 The Embankment Road Study Area

The following historic landfill sites have been identified to be located within 2km of the Embankment Road study area:

- Embankment Road, located immediately adjacent to the south of the Embankment Road study area;
- Pilots House Sites, located immediately adjacent to the east of the Embankment Road study area; and
- Hungerfields Refuse Tip, located approximately 1.7km to the north of the Embankment Road study area.

8.4 Comments from the IWC Environmental Health Protection Officer

The IWC's environmental health protection officer has identified that in terms of contaminated land there is not *"anything of direct concern that would affect the actual replacement of sea defences"*[48] within the Sandown Bay study area. This view is supported

[48] Email correspondence from IWC Environmental Health Protection Officer dated 21/12/2016 and 09/01/2016

by the findings of the SEA discussed in Section 4.2 of this report, which suggested that no change was expected to geology or soils as a result of a 'hold the existing defence line' policy.

9. Landscape and Visual

9.1 Overview

The following section presents a summary of the landscape within each section of the Sandown Bay study area, as well as in the Eastern Yar floodplain and Embankment Road study area.

The majority of the Sandown Bay study area frontage is described as 'settlement' and parts of the Sandown Bay study area are backed by areas classified as the 'Landscape Improvement Zone' landscape character type. The information presented in this section was identified from a review of the Natural and Built Environmental Baseline report discussed in Section 4.1 of this report.

The Sandown Bay frontage is lined by popular seafront esplanade roads and footpaths, and characterised by wide sandy beaches. As shown in Figure 3, areas adjacent to the Sandown Bay study area at both its northern and southern extents are designated as Areas of Outstanding Natural Beauty (AONB). To the north of the Sandown Bay study area the Isle of Wight AONB extends inland and behind the settlement of Sandown.

9.2 The Sandown Bay Study Area Unit Specific Descriptions

The sections below define the key landscape features present along the coastline of the Sandown Bay study area and identify any specific landscape character types.

9.2.1 Yaverland Car Park (IW22)

This section of the Sandown Bay study area is not located within or adjacent to the 'Landscape Improvement Zone' and is classified as 'settlement'. This frontage consists of a car park, café and a sandy beach below the sea wall that is described as having intermitted exposures of Wessex Formation clays and sandstones.

9.2.2 Yaverland Zoo to The Grand Hotel (IW23)

This section of the Sandown Bay study area is adjacent to the 'Landscape Improvement Zone' and is classified as 'settlement'. The frontage is described as relatively low lying and is fronted by a sandy foreshore.

9.2.3 Culver Parade (IW24)

This section of the Sandown Bay study area is adjacent to the 'Landscape Improvement Zone' and is classified as 'settlement'. The frontage is described as a low lying coastal frontage (valley floodplain) protected by flood defences. The section also features visitor attractions (including a geological/dinosaur museum) and a recreation ground located just beyond the flood defences.

9.2.4 Sandown Esplanade (IW25)

This section of the Sandown Bay study area is not located within or adjacent to the 'Landscape Improvement Zone' and is classified as 'settlement'. This frontage comprises a beach and a densely developed esplanade fronted by hotels and relatively low lying residential buildings, with rising ground behind. This section also includes the Sandown Pier.

9.2.5 Lake Cliffs (IW26)

This section of the Sandown Bay study area is not located within or adjacent to the ‘Landscape Improvement Zone’ and is classified as ‘settlement’. This frontage comprises near vertical greensand cliffs fronted by a promenade, with development lining the cliff top and scattered buildings at the cliff toe.

9.2.6 Shanklin Esplanade (IW27)

This section of the Sandown Bay study area is not located within or adjacent to the ‘Landscape Improvement Zone’ and is classified as ‘settlement’. The frontage comprises a sandy beach, various tourist attractions, hotels, shops and cafes, along a wide strip in front of the former sea cliff.

9.2.7 Luccombe Road, Shanklin (IW28)

This section of the Sandown Bay study area is not located within or adjacent to the ‘Landscape Improvement Zone’ and is classified as ‘settlement’. The frontage comprises 30m high sandstone and clay cliffs vegetated by woodland, scrub, bracken and grassland, with properties along the cliff top.

9.3 Eastern Yar Valley Floodplain

It is worth noting that the Eastern Yar valley floodplain partially extends into the Isle of Wight AONB around the settlements of Alverstone and Yarbridge.

9.4 The Embankment Road Study Area

The Embankment Road study area is not located within the Isle of Wight AONB and is classified as ‘Harbours and Creeks’ landscape character type. A series of coastal lagoons have formed behind the seawall at Bembridge harbour, with intertidal mudflats, sandflats, seagrass bed and shingle all present within the surrounding area.

9.5 Comments from The National Trust

The National Trust confirmed that the Sandown Bay study area itself is not located within the Isle of Wight AONB and stated that any proposed coastal defence works within the Sandown Bay study area are unlikely to have any significant effect on, or change, existing coastal sediment patterns because the areas are already defended[49]. The National Trust also stated that they had no concerns regarding the area either side of the Sandown Bay study area, as long as the amount of defended sea front does not change.

10. Option Appraisal and Scheme Identification

An Option Appraisal and Scheme Identification Report prepared by AECOM (2017) outlines the process of identifying the preferred options for managing the flood and erosion risk along the study area. The report also identifies the preferred options along the study area based on economic, environmental and stakeholder considerations.

An environmental appraisal of the long list of options was undertaken as part of the Option Appraisal and Scheme Identification Report. The environmental appraisal considered options in isolation and utilised a Red, Amber and Green system to classify indicative (unmitigated) impacts associated with the implementation of each individual measure. A summary of the findings of the appraisal are presented in Table 10.1 and full details of the assessment can be found within Appendix A of this report.

[49] Email Correspondence from The National Trust dated 5/03/2017

Table 10.1 - Summary of the Environmental Appraisal of Longlist Measures

Unit(s)	Measure	Indicative impact (unmitigated)	Comments
Embankment Road – IW15	Reactive patch and repair		Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment		Temporary designation / ecological and landscape impacts (disruption) during works
	Gabions		Potential for intertidal landtake and landscape impacts
	Setback floodwall		Potential change to water percolation impact on some features and landscape impacts, but also providing protection from inundation to substantial freshwater designated habitat.
	Revetment		Potential for intertidal landtake and landscape impacts
	Seawall		Potential for intertidal landtake and landscape impacts
	Road raising		Landscape impacts and temporary disruption to ecology during works
	Water level control (Yarbridge)		Potential risk to heritage features / landfill sites from flooding. Potential risk to landfill sites from erosion of Embankment Road. Potential change in habitats
	Temporary defences		Potential for temporary impacts on ecology / conservation areas
Yaverland to Sandown – IW22-25	Reactive patch and repair		Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment (of existing seawalls / revetments)		Temporary designation / ecological and landscape impacts (disruption) during works
	Capital refurbishment (groynes)		Temporary landscape impacts. No extension seawards but potential for increase in footprint laterally (longshore)
	Beach recycling		Temporary ecological impacts during works. Sediment movement impacts
	Beach nourishment		Large quantities of new sediment could impact ecological sites downdrift
	Gabions		Unlikely to require landtake from intertidal area but could impact proposed or recommended designated sites and landscape
	Groyne improvement (lengthening)		Temporary disturbance of intertidal and potential for permanent intertidal/subtidal landtake. Changing sediment movement patterns.
	Groyne construction		Temporary disturbance of intertidal and potential for permanent intertidal/subtidal landtake. Changing sediment movement patterns.
	Revetment		Potential for intertidal landtake and landscape impacts
	Seawall		Unlikely to require landtake from intertidal area (if built as close as possible to the current structure) but could impact proposed or recommended designated sites and landscape
	Crest raising / wave return		Permanent landscape impacts and temporary impacts during construction
	Setback floodwall		Permanent landscape impacts and temporary impacts during construction
	Road raising		Temporary adverse effects during construction
Lake and Shanklin (IW26-28)	Reactive patch and repair		Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment (of existing seawalls / revetments)		Temporary designation / ecological and landscape impacts (disruption) during works
	Capital refurbishment (groynes)		Temporary landscape impacts. No extension seawards but potential for increase in footprint laterally (longshore)
	Beach recycling		Temporary ecological impacts (disruption) during works and potential for sediment movement impacts

Unit(s)	Measure	Indicative impact (unmitigated)	Comments
	Beach nourishment		Large quantities of new sediment could impact ecological sites downdrift
	Gabions		Unlikely to require landtake from intertidal area but could impact proposed or recommended designated sites and landscape
	Groyne improvement (lengthening)		Temporary disturbance of intertidal and potential for permanent intertidal landtake. Changing sediment movement patterns.
	Groyne construction		Temporary disturbance of intertidal and potential for permanent intertidal landtake. Changing sediment movement patterns.
	Revetment		Potential for intertidal landtake and landscape impacts
	Seawall		Unlikely to require landtake from intertidal area (if built as close as possible to the current structure) but could impact proposed or recommended designated sites and landscape
	Crest raising / wave return		Permanent landscape impacts and temporary impacts during construction
	Setback floodwall		Permanent landscape impacts and temporary impacts during construction
	Cliff stabilisation		Permanent landscape impacts and temporary impacts during construction

11. The Preferred Options

11.1 Summary of the Preferred Options

Table 11.1 presents a summary of the preferred option for each management unit within the study area, identifies the proposed measures required to deliver the preferred option and states the timeframes over which they are proposed to be implemented.

Table 11.1: Summary of Preferred Options

<table>
<tr><th>Unit</th><th>Description of Preferred Option</th><th>Measures</th></tr>
<tr><td>IW15 (Embankment Road)</td><td>Maintain then improve approach to a 75yr Standard of Protection</td><td>No preferred measures have yet been identified by the study (alternatives being considered include raising Embankment Road; maintaining Embankment Road plus implementing the Yarbridge control structure; or implementing the Yarbridge control structure and creating intertidal habitat between Embankment Road and Yarbridge.</td></tr>
<tr><td>IW22 (Yaverland Car Park)</td><td rowspan="3">Maintain then sustain a 75yr Standard of Protection (from 2055-60) and additionally undertake groyne refurbishment works to help sustain beach levels</td><td>2027: Resurface revetments and refurbish timber groynes
2055-2060: Crest raising, resurface revetments and refurbish timber groynes
2085-2090: Encase revetment and refurbish timber groynes</td></tr>
<tr><td>IW23 (Isle of Wight Zoo)</td><td>2027: Resurface seawall and refurbish masonry groynes
2055-2060: Crest raising, resurface seawall and refurbish masonry groynes
2085-2090: Encase seawall and refurbish masonry groynes</td></tr>
<tr><td>IW24 (Culver Parade)</td><td>2027: Resurface seawall, refurbish timber groynes and refurbish masonry groynes
2045-2050: Refurbish timber groynes
2055-2060: Crest raising and resurface seawall
2060-2070: Refurbish timber groynes
2065-70: Refurbish masonry groynes
2085-2090: Encase seawall and refurbish timber groynes</td></tr>
<tr><td>IW25 (Sandown Esplanade)</td><td>Maintain then sustain a 75yr Standard of Protection (from 2055-60) and additionally undertake groyne refurbishment works to help sustain beach levels</td><td>2027: Refurbish 1 no. timber groyne
2028-2032: Resurface seawall
2040-2050: Refurbish 1 no. timber groyne
2045-2050: Resurface seawall
2055-60: Crest raising
2065-2070: Encase seawall and refurbish 1 no. timber groyne
2085-2090: Refurbish 1 no. timber groyne</td></tr>
<tr><td>IW26 (Lake Cliffs)</td><td>Maintain</td><td>Immediate: Refurbish timber groynes
2027-2032: Refurbish revetment and seawall
2030-2035: Refurbish timber groynes
2045-2050: Refurbish revetment and seawall
2050-2055: Refurbish timber groynes
2065-2070: Encase revetment and seawall
2070-2075: Refurbish timber groynes
2090-2095: Refurbish timber groynes
2110-2117: Refurbish timber groynes
Refurbish Small Hope groyne at end of service life</td></tr>
<tr><td>IW27 (Shanklin Esplanade)</td><td>Sustain / Improve the performance of the defences</td><td>Immediate: Refurbish IW27/02 seawall
2027: Refurbish timber groynes
2027-2032: Refurbish remaining seawall, concrete groynes and breastwork in unit
2045-2050: Refurbish IW27/02 seawall, refurbish remaining seawall and breastwork in unit and refurbish timber groynes
2065-2070: Encase IW27/02 seawall and encase remaining seawall and breastwork in unit, and refurbish concrete groynes
2085-2090: Refurbish timber groynes</td></tr>
</table>

Unit	Description of Preferred Option	Measures
		2105-2110: Refurbish timber groynes Crest raising in two intervals (to be confirmed during future appraisal)
IW28 (Luccombe Cliffs)	**Two options of 'Do Minimum' or 'Maintain' have been identified and shortlisted, discussed in section 12.8 below. Policy to be reviewed further at next SMP update**	

11.2 Descriptions of Measures

The following section provides a brief description of each of the selected measures and identifies some initial assumptions.

11.2.1 Resurface Revetment

This measure allows for a proactive repair of the existing revetment to ensure that the structure retains its erosion and flood defence functions. These repair works are likely to take the form of concrete spraying of the existing structures.

This repair measure is likely to have a short construction period (typically a few weeks depending on the length required), which would be undertaken at periods of low tide and would require limited workforce and/or plant. It is envisaged that construction landtake would be minimal and that there would be no additional permanent landtake as a result of the completed repair works.

11.2.2 Encasing Revetment

This measure allows for a large scale refurbishment of the existing revetment to ensure that the structure retains its erosion and flood defence functions. This refurbishment is likely to involve toe protection works to the revetment, piling works and excavation of the beach which will require plant to be present. The encasement would create an additional layer in front of the existing structures to provide additional strength and performance.

This refurbishment measure is likely to require a prolonged construction period of several months and would require additional land take for plant/machinery during construction. No estimation of numbers can be provided at this stage, but it is considered that this plant would be operational on the beach or promenade. In addition, once finished, the encased structure is likely to have a permanent land take of 0.5 - 1m in front of the existing structure, although this would be minimised and as close to the present structures and defence footprint as possible.

11.2.3 Refurbishment of Timber Groynes

This measure allows for a proactive repair of the existing timber groynes to ensure that they retain their erosion defence function. This refurbishment may involve replacing timber planks, joints and in some cases could include the replacement of piles (likely to be later on in the scheme appraisal period if the pile condition deteriorates). No existing structures are to be raised or extended as part of these works.

This repair measure is likely to have a short construction period (up to several weeks depending on number of groynes and amount of material that needs replacing), would be undertaken at periods of low tide and require limited workforce and/or plant to facilitate the works. The exception to this is if piles need replacing which would require extensive plant on the beach. It is envisaged that construction landtake would be minimal and that there would be no additional permanent landtake as a result of the repair works.

11.2.4 Refurbishment of Masonry Groynes

This measure allows for a proactive repair of the existing masonry groynes to ensure that they retain their function as an erosion defence. This refurbishment is likely to take the form of concrete spraying of the surfaces of the existing structures or replacement of concrete / masonry blocks. No existing structures are to be raised or extended as part of these works.

This repair measure is likely to have a short construction period (weeks), would be undertaken at periods of low tide and requires limited workforce and/or plant to be completed. It is envisaged that there would be no additional landtake as a result of the repair works.

11.2.5 Refurbishment of the Masonry Wall

This measure allows for a proactive repair of the existing masonry wall to ensure that the wall retains its erosion and flood defence function. This refurbishment is likely to take the form of widespread block replacement in priority areas of the wall before the wall has actually failed.

Depending on the extent of the refurbishment works, these repair works could have a short to medium term construction period (from a few weeks to several months depending on the length and height required), would be undertaken at periods of low tide and require a limited to medium sized workforce and/or plant to be completed. It is envisaged that construction landtake would be minimal and that there would be no additional permanent landtake as a result of the repair works

11.2.6 Refurbishment of Seawall

This measure allows for a proactive repair of the existing seawall to ensure that the seawall retains its erosion and flood defence function. This refurbishment is likely to take the form of patch repair work to any gaps within the face of the seawall followed by concrete spraying of the structure.

These repair works are likely to have a short construction period (typically a few weeks depending on the length required), would be undertaken at periods of low tide and require limited workforce and/or plant to be completed. It is envisaged that construction landtake would be minimal and that there would be no additional permanent landtake as a result of the repair works.

11.2.7 Encasement of Seawall

This measure allows for a large scale refurbishment of the existing seawall to ensure that it retains its erosion and flood defence function. This refurbishment is likely to involve toe protection works to the sea wall, piling works and excavation of the beach. Therefore, plant/machinery and a larger workforce would be required. The encasement would create an additional layer in front of the existing structures to provide additional strength and performance.

This refurbishment measure is likely to require a prolonged construction period of several months and would require additional land take for the construction plant/machinery during construction. No estimation of numbers can be provided at this stage, but it is considered that this plant will be operational on the beach or promenade. In addition, once finished, the encased structure is likely to have a permanent land take of 0.5 - 1m greater than that of the existing structure, although this would be minimised and as close to the present structures and defence footprint as possible.

11.2.8 Crest Raising

This measure involves raising the crest level of the existing seawall by raising the height of the capping beam or by constructing a new vertical capping beam at the top of the existing defence.

These works would require plant/machinery to be completed and would be undertaken over a prolonged construction period. It is assumed that these works would be undertaken from the road side or promenade rather than from the beach and that the raised structure would not result in any additional permanent landtake requirements.

11.2.9 Reactive Patch and Repair

This measure allows for the reactive repair or small scale maintenance of the existing defences to ensure health and safety compliance and does not allow for large scale refurbishment or replacement of existing defences.

It is assumed that these works would be small scale and would often be undertaken over the course of a number of days and would require limited construction land take. No additional permanent landtake would be required as part of this measure.

12. Potential Environmental Impacts and Considerations

This section provides a discussion of potential environmental impacts associated with the implementation of the preferred options within each of the management units of the study area. The details provided within this section do not represent an assessment of the impacts, but identify potential environmental receptors and topic areas where impacts may arise.

12.1 Embankment Road (IW15)

The choice of a preferred option for this section is driven largely by environmental factors and at this stage, further consultation is required with Environment Agency and Natural England to determine an appropriate management approach. Consequently, the options appraisal in the study has stopped short of recommending a single preferred approach to deliver a preferred Maintain then Improve option (to a 75yr SoP, which is preferred, to achieve the same SoP as at Yaverland units 22-24). Whilst a decision will not be made within this study, any future decision will be guided by legislative requirements (i.e. Habitats Regulations and Water Framework Directive) as well as objectives and priorities around the existing freshwater habitat and the potential to create intertidal habitat and/or compensatory freshwater habitat.

Should the option to maintain Embankment Road be selected, then Armourlock / gabions may be a method employed in places along the Embankment. These could have permanent adverse impacts on the Solent and Southampton Water SPA and Ramsar site and Brading Marshes to St Helen's Ledges SSSI associated with permanent landtake. The maintenance of Embankment Road could also lead to coastal squeeze and the loss of intertidal habitat, although the impact of the Hold The Line policy at this location was taken account of in the compensatory requirements identified as part of the SMP level assessment in 2010. There would also likely be temporary effects associated with the disturbance of habitat by construction plant and machinery. The new structures could also impact on the setting of the nearby Bembridge Conservation Area. Temporary views of construction works and noise and vibration from plant and machinery are likely to be experienced by residential receptors along Embankment Road.

Road raising (as recommended by the Eastern Yar Flood and Erosion Management Strategy, 2010) could result in permanent changes to the local landscape and has the potential to alter the setting of the Bembridge Conservation Area. Temporary views of construction works and noise and vibration from plant and machinery are likely to be experienced by residential receptors along Embankment Road. As the works are to be undertaken to the road, it is likely that these will also require traffic management measures.

The option of implementing a water control structure at Yarbridge instead of raising Embankment Road could have a range of notable impacts, dependent on if it was combined with either:

- maintenance of Embankment Road at its present height and the continued prevention of tidal inundation through Embankment Road (i.e. delaying increasing overtopping risk of tidal flooding into the mainly freshwater habitats until later in the 100 year appraisal period);
- or changing operation of the tidal control structures in Embankment Road to allow inundation of the former tidal floodplain between Embankment Road and Yarbridge, resulting in the creation of intertidal habitat (OM4s) but the loss of mainly freshwater habitat, which would require compensation..

The affected area would fall within the Solent and Southampton Water SPA and Ramsar site, Brading Marshes to St Helen's Ledges SSSI and the Solent & Isle of Wight SAC, and so this option would require careful consideration. A transition to intertidal habitat behind Embankment Road could lead to loss of 291Ha of SPA (which is also Ramsar site, and a small part of which is also SAC) and an additional 26.5Ha of SSSI (in their current form). There may also be up to 75-85ha of additional undesignated potential freshwater habitat which could be affected (based on theoretical consideration of the extent of the floodplain). However, the environmental designations could potentially be re-designated based on the habitat that is produced.

12.2 Yaverland Car Park (IW22)

12.2.1 Works Proposed in 2027

The proposals to resurface the existing revetment and refurbish the timber groynes within management unit IW22 in 2027 are likely to have limited environmental impacts during construction. Provided care is taken during the construction works and there is no permanent landtake, it is envisaged that these works are unlikely to have any permanent environmental impacts once they are complete.

Given the location, scale and nature of the repair work proposed, the Isle of Wight AONB, The Yaverland Battery= Scheduled Monument and Grade II listed North Cottage Thatch Cottage are unlikely to experience any setting or settlement impacts during the proposed construction works.

It is considered that residential properties located along Yaverland Road (B3395) are unlikely to experience any long term visual effects associated with the proposed works. However, residential receptors could be susceptible to views of the construction works resulting in temporary adverse effects. It is considered that any construction noise and vibration impacts would be temporary and would only be experienced during daylight hours. There may be potential noise and vibration impacts to consider further should piling be required as part of the refurbishment of the timber groynes.

The construction works are located within the footprint of the Bembridge Down SSSI, South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. However, both the refurbishment of the revetment and the timber groynes are likely to require limited plant/machinery and would be undertaken over a period of a few weeks and therefore, in the absence of detailed site information, it is considered sensitive habitats are likely to remain relatively undisturbed. It is understood that no permanent landtake is required. Any noise and vibration impacts on ecologically sensitive receptors during construction are likely to be temporary, and if piling is required it should be timed to avoid any sensitive months of the year for ecologically sensitive receptors. Appropriate best practice control measures should be applied when undertaking the concrete spraying of the revetment.

12.2.2 Future Works

It is considered that the potential impacts and receptor groups described above would remain largely the same for the repair works proposed in 2055-2060 and 2085-2090. However, given the length of the intervening time period these measures would need to be considered again in the future in respect of the prevailing environmental conditions at the time of the proposed works.

If the piles of timber groynes are to be replaced as part of refurbishment works, there could be disruption to the beach and intertidal habitat and species within the footprint of the Bembridge Down SSSI, South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ associated with piling activities and the movement of plant and machinery during the works.

Based on the existing environmental conditions, proposals to deliver crest raising in 2055 – 2060 have the potential to result in temporary and permanent environmental impacts. As this measure will involve increasing the height of the existing seawall there are likely to be some temporary and permanent visual impacts. It is assumed that the construction works will be undertaken from the road side or promenade. Therefore, whilst there could be some noise and vibration impacts, the beach and intertidal habitat within the footprint of the Bembridge Down SSSI, South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ are likely to remain relatively undisturbed during the construction works and there would be no permanent landtake.

Proposals to encase the existing revetment in 2085-2090 could result in temporary and permanent environmental impacts. The permanent impacts are associated with minimised additional permanent landtake from within the footprint of the Bembridge Down SSSI, South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. Temporary effects on these designations could arise from disturbance of the habitat by construction plant and machinery and from noise and vibration during the construction works (which could include piling). Encasing the existing structure and increasing its footprint could also result in temporary and permanent visual impacts. Residential receptors along Yaverland Road (B3395) would also likely experience amenity impacts during the construction works and users of the promenade could be obstructed by the presence of the works along the frontage during construction.

12.3 Isle of Wight Zoo (IW23)

12.3.1 Works Proposed in 2027

The proposals to repair the seawall and refurbish masonry groynes within management unit IW23 in 2027 are likely to have limited temporary and permanent environmental impacts.

The baseline study identified that no features of historic value, interest or importance are in close enough proximity to the works to be likely to experience any impacts.

Residential properties located along Yaverland Road (B3395) are unlikely to experience any permanent visual effects associated with the refurbishment of the groynes. However, proposals to resurface the seawall could have some limited and localised visual impacts. Additionally, residential receptors could be susceptible to views of the construction works resulting in temporary adverse effects. It is considered that any construction noise and vibration impacts would be temporary and would only be experienced during daylight hours.

The maintenance works would take place within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ, however, they are unlikely to result in any substantial disruption. Both the refurbishment of the seawall and groynes are likely to require limited plant/machinery and would be undertaken over a period of a few weeks and therefore, in the absence of detailed site information, it is considered sensitive habitats are likely to remain relatively undisturbed. It is understood that no permanent landtake is required. Any noise and vibration impacts on ecologically sensitive receptors during construction are likely to be temporary. Appropriate best practice control measures should be applied when undertaking the concrete spraying of the seawall and masonry groynes.

12.3.2 Future Works

It is considered that the potential impacts and receptor groups described above would remain largely the same for the repair works in 2055-2060 and 2085-2090. However, given the length of the intervening time period these measures would need to be considered again in the future in respect of the prevailing environmental conditions at the time of the proposed works.

If the foundations of any masonry groynes are to be replaced as part of refurbishment works, there could be disruption to the beach and intertidal habitat within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ associated with construction activities and the movement of plant and machinery. These works could result in noise and vibration impacts on ecologically sensitive receptors within these designations during the works.

Based on the existing environmental conditions, proposals to deliver crest raising in 2055-2060 have the potential to result in temporary and permanent environmental impacts. As this measure will involve increasing the height of the existing seawall there are likely to be some temporary and permanent visual impacts. It is assumed that the construction works will be undertaken from the road side or promenade. Therefore, whilst there could be some noise and vibration impacts, the beach and intertidal habitat within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ are likely to remain relatively undisturbed during the construction works and there would be no permanent landtake.

Proposals to encase the existing seawall in 2085-2090 could result in temporary and permanent environmental impacts. The permanent impacts are associated with minimised potential additional permanent landtake from within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ. Temporary effects on these designations could arise from disturbance of the habitat by construction plant and machinery and from noise and vibration during the construction works (which could include piling). Encasing the existing structure and increasing its footprint could also result in temporary and permanent visual impacts. Residential receptors along Yaverland Road (B3395) would also likely experience amenity impacts during construction works and users of the promenade could be obstructed by the presence of the works along the frontage during construction.

12.4 Culver Parade (IW24)

12.4.1 Works Proposed in 2027

The proposals to repair the seawall and refurbish the timber and masonry groynes within management unit IW24 in 2027 are likely to have limited temporary and permanent environmental impacts, provided care is taken during the construction works and there is no permanent landtake associated with the works.

There could be potential permanent setting impacts associated the patching and concrete spraying of the seawall within proximity to the Sandown Conservation Area. . No features of historic value or importance are likely to be impacted by the implementation of the preferred option.

Residential properties located along Culver Parade (B3395) are unlikely to experience any permanent visual effects associated with the refurbishment of the groynes. However, proposals to resurface the seawall could have some limited and localised visual impacts.

Additionally, residential receptors could be susceptible to views of the construction works resulting in temporary adverse effects. It is considered that any construction noise and vibration impacts would be temporary and would only be experienced during daylight hours. There may be potential noise and vibration impacts to consider further should piling be required as part of the refurbishment of the timber groynes.

The maintenance works would take place within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ, however, they are unlikely to result in any substantial disruption. Both the refurbishment of the seawall and groynes are likely to require limited plant/machinery and would be undertaken over the period of a few weeks and therefore, in the absence of detailed site information, it is considered sensitive habitats are likely to remain relatively undisturbed. It is understood that no permanent landtake is required. Any noise and vibration impacts on ecologically sensitive receptors during construction are likely to be temporary, and if piling is required it should be timed to avoid any sensitive months of the year for ecologically sensitive receptors. Appropriate best practice control measures should be applied when undertaking the concrete spraying of the seawall and masonry groynes.

12.4.2 Future Works

It is considered that the potential impacts and receptor groups described above would remain largely the same for the repair works in 2045-2050, 2055-2060, 2060-2070 and 2085-2090. However, given the length of the intervening time period these measures would need to be considered again in the future in respect of the prevailing environmental conditions at the time of the proposed works.

If piles / foundations of timber and masonry groynes are to be replaced as part of refurbishment works, there could be disruption to the beach and intertidal habitat within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ associated with piling activities and the movement of plant and machinery. These works could result in noise and vibration impacts on ecologically sensitive receptors within these designations during the works.

Based on the existing environmental conditions, proposals to deliver crest raising in 2055-2060 have the potential to result in temporary and permanent environmental impacts. As this measure will involve increasing the height of the existing seawall there are likely to be some temporary and permanent visual impacts. It is assumed that the construction works will be undertaken from the road side or promenade. Therefore, whilst there could be some noise and vibration impacts, the beach and intertidal habitat within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ are likely to remain relatively undisturbed during the construction works and there would be no permanent landtake.

Proposals to encase the existing revetment in 2085-2090 could result in temporary and permanent environmental impacts. The permanent impacts are associated with minimised potential additional permanent landtake from within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ. Temporary effects on these designations could arise from disturbance of the habitat by construction plant and machinery and from noise and vibration during the construction works (which could include piling). Encasing the existing structure and increasing its footprint could also result in temporary and permanent visual impacts. Residential receptors along Culver Parade (B3395) would also likely experience amenity impacts during construction works and users of the promenade could be obstructed by the presence of the works along the frontage during construction.

12.5 Sandown Esplanade (IW25)

12.5.1 Works Proposed in 2027-2032

The proposals to refurbish one timber groyne within management unit IW25 in 2027 and to resurface the seawall in 2028-2032 are likely to have limited temporary and permanent environmental impacts, provided care is taken during the construction works and there is no permanent landtake associated with the works.

The entire management unit is located within the Sandown Conservation Area. It is possible that the repair works to the seawall, which include concrete spraying, could have a permanent impact on the Sandown Conservation Area which may require further consideration. However, the refurbishment of the groyne is unlikely to result in any permanent changes to the setting of the Conservation Area.

Residential properties along Pier Street and Esplanade are unlikely to experience any permanent visual effects associated with the refurbishment of the groynes. However, proposals to resurface the seawall could have some limited and localised visual impacts. It is considered that any noise and vibration changes would be temporary and would be experienced during daylight hours. There may be potential noise and vibration impacts to consider further should piling be required as part of the refurbishment of the timber groyne.

The maintenance works would take place within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ, however, they are unlikely to result in any substantial disruption. Both the refurbishment of the timber groyne and the seawall are likely to require limited plant/machinery and would be undertaken over the period of a few weeks and therefore, in the absence of detailed site information, it is considered sensitive habitats are likely to remain relatively undisturbed. It is understood that no permanent landtake is required. Any noise and vibration impacts on ecologically sensitive receptors during construction are likely to be temporary, and if piling is required it should be timed to avoid any sensitive months of the year for ecologically sensitive receptors. Appropriate best practice control measures should be applied when undertaking the concrete spraying of the seawall.

12.5.2 Future Works

It is considered that the potential impacts and receptor groups described above would remain largely the same for the repair works in 2040-2050, 2065-2070 and 2085-2090. However, given the length of the intervening time period these measures would need to be considered again in the future in respect of the prevailing environmental conditions at the time of the proposed works.

If piles of the timber groyne are to be replaced as part of the refurbishment works, there could be disruption to the beach and intertidal habitat within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ associated with piling activities and the movement of plant and machinery. These works could result in noise and vibration impacts on ecologically sensitive receptors within these designations during the works.

Based on the existing environmental conditions, proposals to deliver crest raising in 2055-2060 have the potential to result in temporary and permanent environmental impacts. As this measure will involve increasing the height of the existing seawall there are likely to be some temporary and permanent visual impacts along the Esplanade and Pier Street. It is assumed that the construction works will be undertaken from the road side or promenade. Therefore, whilst there could be some noise and vibration impacts, the beach and intertidal habitat within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ are likely to remain relatively undisturbed during the construction works and there would be no permanent landtake.

Proposals to encase the existing seawall in 2085-2090 could result in temporary and permanent environmental impacts. The permanent impacts are associated with minimised potential additional permanent landtake from within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ. Temporary effects on these designations could arise from disturbance of the habitat by construction plant and machinery and from noise and vibration during the construction works (which could include piling). Encasing the existing structure and increasing its footprint could also impact the setting of the Sandown Conservation Area and result in temporary and permanent visual impacts. Residential receptors along Pier Street and Esplanade would also likely experience amenity impacts during construction works and users of the promenade could be obstructed by the presence of the works along the frontage during construction.

12.6 Lake Cliffs (IW26)

12.6.1 Works Proposed Immediately to 2032

Within management unit IW26, the preferred option is to maintain, and therefore only refurbishment works are proposed. These works include the proposed refurbishment of the existing timber groynes and the revetment and seawall.

The immediate action to refurbish the timber groynes is likely to have limited environmental impacts, provided care is taken during the construction works and there is no permanent landtake associated with the works. It is considered that these works are unlikely to have any permanent impacts on the Sandown Barrack Battery Scheduled Monument, which is located on the cliff top in this unit. However, given the number of groynes located within close proximity to the scheduled monument, it is possible that the construction works could result in temporary setting impacts upon the designation.

Residential properties located along Grange Road, Talbot Road, Cliff Road, Currie Road, Ranelagh Road, Cliff Gardens, Sandown Road (A3055), Howard Road, North Cliff Gardens, Culver Road and Beatrice Avenue are unlikely to experience any permanent visual effects associated with the proposed works given the height of the cliffs. However, proposals to resurface the revetment and seawall could have some limited and localised visual impacts. Additionally, residential receptors could be susceptible to views of the construction works resulting in temporary adverse effects. It is considered that any construction noise and vibration impacts would be temporary and would only be experienced during daylight hours. There may be potential noise and vibration impacts to consider further should piling be required as part of the refurbishment of the timber groynes.

The maintenance works would take place within the footprint of the Solent and Dorset Coast pSPA in the very northern part of the unit and in the Bembridge rMCZ along the unit, with some of the larger groynes extending into the footprint of the South Wight Maritime SAC. Both the refurbishment of the timber groynes, revetment and the seawall are likely to require limited plant/machinery and would be undertaken over the period of a few weeks and therefore, in the absence of detailed site information, it is considered sensitive habitats are likely to remain relatively undisturbed. It is understood that no permanent landtake is required. Any noise and vibration impacts on ecologically sensitive receptors during construction are likely to be temporary, and if piling is required it should be timed to avoid any sensitive months of the year for ecologically sensitive receptors. Appropriate best practice control measures should be applied when undertaking the concrete spraying of the revetment or seawall.

12.6.2 Future Works

It is considered that the potential impacts and receptor groups described above would remain largely the same for the repair works at 15 year intervals. However, given the length of the intervening time period these measures would need to be considered again in the future in respect of the prevailing environmental conditions at the time of the proposed works.

If piles of timber groynes are to be replaced as part of the refurbishment works, there could be disruption to the beach and intertidal habitat within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ, associated with piling activities and the movement of plant and machinery. These works could result in noise and vibration impacts on ecologically sensitive receptors within these designations during the works.

12.7 Shanklin Esplanade (IW27)

12.7.1 Works Proposed Immediately - 2027

The proposals to immediately refurbish the seawall in the northern section of management unit IW27 and to refurbish the timber groynes in 2027 are likely to have limited temporary and permanent environmental impacts, provided care is taken during the construction works and there is no permanent landtake associated with the works.

The entire management unit is located within the Shanklin Conservation Area. The proposed works to the seawall, which include concrete spraying (dependent on the method/scheme chosen to be taken forward), could change the appearance of the seawall within the conservation area, which is likely to require further consideration. There could also be a permanent impact on the setting of the Grade II listed Clock Tower and Drinking Fountain, the Grade II listed Fisherman's Cottage Public House and the Grade II listed Hot Brine Bath to consider. The repair works to the groynes are unlikely to result in any permanent changes to the setting of the Conservation Area or the listed buildings.

Residential properties located along Hope Road Approach, Esplanade, Delphi Road, Beatrice Avenue and Hope Road are unlikely to experience any permanent visual effects associated with the proposed works. However, the works could have some limited and localised visual impacts. It is considered that any construction noise and vibration impacts would be temporary and would only be experienced during daylight hours. There may be potential noise and vibration impacts to consider further should piling be required as part of the refurbishment of the timber groynes.

The proposed works would take place within the footprint of the Bembridge rMCZ with some of the larger groynes extending into the footprint of the South Wight Maritime SAC. Both the refurbishment of the timber groynes and the seawall are likely to require limited plant/machinery and would be undertaken over the period of a few weeks and therefore, in the absence of detailed site information, it is considered sensitive habitats are likely to remain relatively undisturbed. It is understood that no permanent landtake is required. Any noise and vibration impacts on ecologically sensitive receptors during construction are likely to be temporary, and if piling is required it should be timed to avoid any sensitive months of the year for ecologically sensitive receptors. Appropriate best practice control measures should be applied when undertaking the concrete spraying of the seawall.

12.7.2 Future Works

It is considered that the potential impacts and receptor groups described above would remain largely the same for the repair works in 2040-2050, 2065-2070 and 2085-2090. However, given the length of the intervening time period these measures would need to be considered again in the future in respect of the prevailing environmental conditions at the time of the proposed works.

If piles or foundations of timber and masonry groynes are to be replaced as part of the future refurbishment works, there could be disruption to the beach and intertidal habitat within the footprint of the South Wight SAC and Bembridge rMCZ associated with piling activities and the movement of plant and machinery. These works could result in noise and vibration impacts on ecologically sensitive receptors within these designations during the works.

Proposals to encase the existing seawall in 2065-2070 could result in temporary and permanent environmental impacts. The permanent impacts are associated with minimised potential additional permanent landtake from within the footprint of the Bembridge rMCZ. Temporary effects on these designations could arise from disturbance of the habitat by construction plant and machinery and from noise and vibration during the construction works (which could include piling). Encasing the existing structure and increasing its footprint could also impact the setting of the Shanklin Conservation Area and result in temporary and permanent visual impacts. Residential receptors along Hope Road Approach, Esplanade, Delphi Road, Beatrice Avenue and Hope Road could also experience amenity impacts during construction works and users of the promenade could be obstructed by the presence of the works along the frontage during construction.

12.8 Luccombe Cliffs (IW28)

Since a preferred option is still to be identified at this stage, it is suggested that the options are reviewed in further detail from an environmental perspective during the preparation of the next SMP update. However, at this stage the potential effects of proposals to 'Do minimum' and 'Maintain' within this unit are presented below.

12.8.1 Do Minimum

This option would maintain the existing defences through refurbishment until the end of their residual life. At the end of the residual life of the existing defences, they would not be replaced and this option would, therefore, likely lead to erosion and cliff retreat.

Refurbishment

The refurbishment of the existing timber groynes and revetment is likely to have limited environmental impacts, provided care is taken during the construction works and there is no permanent landtake associated with the works.

The maintenance works would take place within the footprint of the Luccombe Chine SINC and Bembridge rMCZ and lie within close proximity to South Wight Maritime SAC. The refurbishment of the groynes and revetment are likely to require limited plant/machinery and would be undertaken over the period of a few weeks and therefore, in the absence of detailed site information, it is considered sensitive habitats are likely to remain relatively undisturbed. It is understood that no permanent landtake is required. Any noise and vibration impacts on ecologically sensitive receptors during construction are likely to be temporary, and if piling is required it should be timed to avoid any sensitive months of the year for ecologically sensitive receptors.

It is considered that the repair works to the groynes and revetment are unlikely to result in any permanent changes to the setting of Shanklin Conservation Area which is located in close proximity to the management unit.

Residential and commercial properties located along Esplanade, Everton Lane, Chine Avenue, Popham Road and Luccombe Road are unlikely to experience any permanent visual effects associated with the proposed refurbishment works. However, pedestrians and other recreational receptors could be susceptible to views of the construction works resulting in temporary adverse effects. It is considered that any construction noise and vibration impacts would be temporary and would only be experienced during daylight hours.

For this scenario it is considered unlikely that piles of the timber groynes are to be replaced as part of the refurbishment works. However, if they are there could be disruption to the beach and intertidal habitat within the footprint of the Bembridge rMCZ associated with piling activities and the movement of plant and machinery. These works could result in noise and vibration impacts on ecologically sensitive receptors within these designations during the works.

Cliff Retreat

Following the failure of the existing defences, any erosion and subsequent cliff retreat is likely to present a risk to residential and commercial properties located behind the existing defences. The process also has the potential to impact on Luccombe Chine SINC, with the potential for existing habitats to be lost. It is also considered that cliff retreat has the potential to result in permanent adverse effects on the views from residential and commercial properties as well as on pedestrians and other reactional receptors within the area. Cliff retreat could impact on the setting of the Shanklin Conservation Area and on views from the Isle of Wight AONB.

12.8.2 Maintain

This option would seek to maintain the timber defences in their current form for 100 years through a reactive approach, which is likely to involve the refurbishment of the existing defences beyond their residual life.

The potential environmental effects during refurbishment are considered to be the same as those described in section 12.8.1 under the ‘Do Minimum’ scenario. However, the likelihood of the need to replace the piles of the timber groynes when compared to the ‘Do Minimum’ scenario is increased. Therefore, there is a greater potential to impact on the beach and intertidal habitat within the footprint of the Bembridge rMCZ.

12.9 Other Environmental Considerations for all Management Units

12.9.1 Contaminated Land

As stated earlier in this report, IWC’s environmental health protection officer has stated that in terms of contaminated land there is not *“anything of direct concern that would affect the actual replacement of sea defences”*[50] along the seafront of the Sandown Bay study area.

However, as identified in section 8 of this Report, there are a number of historic landfill sites (potential sources of contamination) present within the study area. In particular, at Embankment Road, there are historic landfills located immediately adjacent to the proposed works and also within the Eastern Yar Valley floodplain. Any construction works which involve below ground excavation or piling, by their nature also have the potential to allow for the vertical migration of contaminants should they exist. However, for any effect to occur, three conditions are required to be satisfied:

- The presence of a receptor which may be harmed (e.g. the water environment, humans, buildings, fauna or flora) (the 'receptor');
- The presence of substances (potential contaminants / pollutants) that may cause harm ('source' of pollution); and
- The existence of a linkage between the source and the receptor (the 'pathway').

Therefore, the presence of a potential source of contamination will not always result in an adverse effect. This will need further consideration as further design details are known for each preferred option.

[50] Email correspondence from IWC Environmental Health Protection Officer dated 21/12/2016 and 09/01/2016

12.9.2 Water Resources

Consideration should be given to those waterbodies with WFD status, as identified in section 6 of this Report, prior to any of the preferred options being taken forward. This is further discussed in Section 13.2.2 below.

13. Next Steps

13.1 The Need for Consent and Environmental Impact Assessment

Given that some of the measures required to deliver the preferred options within the study area are to be undertaken as soon as possible, it is appropriate to consider the appropriate route to consent for these measures. The following section presents the summary of a high level exercise undertaken to consider how it may be determined whether planning permission is likely to be required for the measures which are detailed earlier within Section 11 of this Report.

13.1.1 Need for Consent

It is first necessary to understand if the proposed measures would be considered as ‘development’. Section 55 of the Town and Country Planning Act 1990 defines ‘development’ as:

“the carrying out of building, engineering, mining or other operations in, on, over or under land, or the making of any material change in the use of any buildings or other land”. Part 2 (a) of Section 55 states that “*The following operations or uses of land shall not be taken for the purposes of this Act to involve development of the land—*

(a) the carrying out for the maintenance, improvement or other alteration of any building of works which -

(i) affect only the interior of the building, or

(ii) do not materially affect the external appearance of the building”

A high level exercise should be undertaken to identify the proposed measures which would likely be classed as ‘development’ under the definition above. Where a measure is considered to be ‘development’, it is then appropriate to identify who the determining authority(s) would be. Any development above the mean low water mark would be subject to planning permission from the local planning authority, which in this case would be Isle of Wight Council, unless permitted development rights apply. Any development below the mean high water mark would be likely to require consent from the Marine Management Organisation (MMO).

Normally, a planning permission is required to be commenced within 3 years of the date it is granted. Therefore, any planning applications required to deliver each of the preferred options should be prepared and submitted at an appropriate time.

13.1.2 Need for Environmental Impact Assessment

It is also necessary to consider the need for Environmental Impact Assessment (EIA) under the appropriate EIA Regulations. Where planning applications are to be submitted to the local planning authority the latest revision of the Town and Country Planning (Environmental Impact Assessment) Regulations should be utilised. Where an application is to be submitted to the MMO, the latest revision of the Marine Works (Environmental Impact Assessment) Regulations should be used. In the case of any immediate works that may be taken forward, both of these EIA Regulations were last updated in 2017.

Both of the 2017 EIA Regulations include two lists of different types of development projects. The first list is Schedule 1, which identifies all types of projects for which EIA is mandatory. The second list is Schedule 2, which identifies the types of projects for which EIA may be required if the project in question is considered likely to give rise to significant environmental effects. The 2017 EIA Regulations define coastal defence works as Schedule 2 development under "*coastal work to combat erosion and maritime works capable of altering the coast through the construction of, for example, dykes, moles, jetties and other sea defence works, excluding the maintenance and reconstruction of such works*". Therefore, where any schemes are to be taken forward, it will be necessary to determine whether the proposed development is likely to result in any significant environmental effects and if it therefore constitutes EIA development. It could be advisable to submit an EIA screening opinion request to the relevant determining authority at the appropriate time.

13.2 Recommended Next Steps

It is recommended that a technical consenting note is produced detailing the proposed consenting route for each of the preferred options which are to be implemented immediately. This should also outline the potential scope of documents to be submitted with any required planning applications and the likely need for EIA, Habitats Regulations Assessment (HRA) and Water Framework Directive (WFD) Assessment.

It is also recommended that this approach is followed for all subsequent measures to be taken forward in the future. Given the period of time between the preparation of this Report and the implementation of some of the measures to deliver the preferred options, it is proposed that this exercise is undertaken within 3 years of their planned delivery date to minimise the risk that consenting matters result in delay to the construction programme.

13.2.1 Habitat Regulation Assessment

The Conservation of Habitats and Species Regulations 2017 require a competent authority, before deciding to undertake or give consent or permission to a particular project which *"a) is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects), and (b) is not directly connected with or necessary to the management of that site"* to carry out an appropriate assessment of the implications of the project on the European site(s) in question.

Those European sites of nature conservation value that are identified within this Report are as follows:

- South Wight Maritime SAC;
- Solent and Southampton Water SPA;
- Solent and Southampton Water Ramsar; and
- Solent and Dorset Coast pSPA.

The first task in terms of HRA would be to undertake a Likely Significant Effects (LSE) test. This is an initial assessment to decide whether the full subsequent stage known as 'appropriate assessment' is required. The aim of the LSE test it to identify if, either alone or in combination with other relevant projects and plans, the project is likely to result in a significant effect upon European sites. If it is deemed that there is potential for significant effects then an 'appropriate assessment' would need to be undertaken.

13.2.2 Water Framework Directive Assessment

The WFD aims to protect and enhance the quality of the water environment across all European Union member states. A WFD assessment is a requirement for all projects that have the potential to impact on current or predicted WFD status; they are required to assess their compliance against the WFD objectives of the potentially affected water bodies. The competent authority must consider the potential of a project to:

- Cause a deterioration of a water body from its current status or potential; and/ or
- Prevent future attainment of good status or potential where not already achieved.

13.2.3 Baseline Environmental Surveys

If any baseline environmental surveys are likely to be required in support of any consents, then these should also be discussed within the technical consenting note. For instance, it may be appropriate for some of the proposed works to undertake an ecological Phase 1 Habitat Survey prior to the works taking place. This survey would identify the habitats present and would be able to provide information on the likelihood of the presence of protected or notable species and the requirement for further targeted species surveys.

Appendix A Environmental Appraisal of Longlist Options

Sandown Bay Initial Appraisal and Scheme Identification Study – High Level Environmental Appraisal of the Longlist Options

Classifications

Red – Potentially substantial adverse environmental impacts

Amber – Environmental benefits and enhancements but also adverse environmental impacts, or unlikely to result in a substantial change to the current environmental baseline

Green – Environmental benefits and enhancements and no detrimental impacts

Please also refer to the Environmental Baseline Report (2017) for this study, for full supporting information.

Note: These areas all have Hold The Line policies set at SMP level (2011). Therefore impacts of coastal squeeze etc. were taken into account of at a high-level in the SMP approval and RHCP process.

IW 15 – Embankment Road

Assumptions - Defences will be proposed along the full extent of the study area. It is assumed that the gabions, revetment and seawall options presented will be frontline and installed in front of the existing defences and that they would therefore encroach into the intertidal area. However, it is assumed that that defences would be designed to limit the amount of encroachment. It is assumed that the setback flood wall would be built along the existing road and that it would not encroach and involve landtake from the designations that lie behind the road in this study area.

Option (Method)	Environmental Score	Comments on scoring
Reactive patch and repair	Amber	This option provides initial protection from coastal erosion but no additional protection against flooding. Therefore, properties and parts of the Bembridge Conservation Area within the study area could remain at risk of flooding as overtopping risk increases. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. Impacts will worsen once existing structures reach the end of their life. There is the potential for temporary adverse impacts due to disruption to the Solent and Southampton Water SPA and Ramsar and Bembridge rMCZ should any of the maintenance activities be undertaken within the intertidal zone. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could be experienced during the periods of maintenance.
Capital Refurbishment	Amber	This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties and parts of the Bembridge Conservation Area within the study area could remain at risk of flooding. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. There is the potential for temporary adverse impacts due to disruption to the Solent and Southampton Water SPA and Ramsar and Bembridge rMCZ should any of the maintenance activities be undertaken within the intertidal zone. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could be experienced during the periods of maintenance.
Gabions	Red	This option provides protection from coastal erosion but no additional protection against flooding. Some properties and parts of the Bembridge Conservation Area within the study area could remain at risk of flooding. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the designated sites present in this area. It could lead to coastal squeeze and loss of intertidal habitat within the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Setback Floodwall	Red	This option provides an increased standard of protection to properties within the study area. This option could provide protection from flooding to a small part of the Bembridge Conservation Area and associated listed buildings, depending on how far the flood wall is setback at its eastern end. Construction activities could potentially take place within the footprint of both the 'Embankment Road' and 'Pilots House Site' historic landfill sites, but once constructed would protect both sites from erosion and flooding. This option could prevent water percolation and have permanent adverse impacts on the Solent & Isle of Wight Lagoons SAC. However, it would also provide protection from saltwater inundation to substantial freshwater designated habitats . It is assumed that the setback floodwall could be located on the existing embankment (e.g. at the back of the road) and would not encroach into the Solent and Southampton Water SPA and Ramsar site, Bembridge rMCZ and the Solent & Isle of Wight Lagoons SAC designations that lie behind the road in this location. By contrast, as new setback embankment (which was scoped out) would encroach into the designated areas and would require landtake from the designated sites..

Option (Method)	Environmental Score	Comments on scoring
		This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Revetment		This option provides protection from coastal erosion and is likely to provide some additional protection against flooding. However, some properties and parts of the Bembridge Conservation Area within the study area could still remain at risk of flooding. The 'Embankment Road' and 'Pilots House Site' historic landfill sites would also remain at risk from future flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the designated sites present in this area. It could lead to coastal squeeze and loss of intertidal habitat within the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Seawall		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings and the Bembridge Conservation Area and Eastern Yar valley from coastal erosion and flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the designated sites present in this area. It could lead to coastal squeeze and loss of intertidal habitat within the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Bembridge Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Road Raising		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings and the Bembridge Conservation Area from coastal erosion and flooding. This option is likely to result in some changes to the local landscape and has the potential to result in some adverse effects on the setting of the Bembridge Conservation Area. There is the potential for temporary adverse effects in relation to disturbance to the Solent and Southampton Water SPA and Ramsar site and Bembridge rMCZ during construction, but any adverse effects are likely to be temporary.
Water Level controls (at Yarbridge)		This option will provide a cut-off point to surface waters within the Eastern Yar valley floodplain, protecting residential properties in the Sandown area. However, this option does not mitigate flood risk at Embankment Road and could result in the inundation of land behind Embankment Road when operational. Therefore, this option could result in structural damage to listed buildings that are located within the floodplain at Brading Station. It could also result in the inundation of 'Yar Bridge', 'Yaverland Old Tip', 'Embankment Road' and 'Pilots House Site' historic landfill sites. 'Embankment Road' and 'Pilots House Site' historic landfill sites would also be at risk from coastal erosion. Inundation of the floodplain could lead to the creation of new habitats, but this would need to be considered against the potential loss of the existing habitats within this area which is designated as the Solent and Southampton Water SPA and Ramsar site, Brading Marshes to St Helen's Ledges SSSI and the Solent & Isle of Wight SAC.
Temporary Defences and Property Level Protection		The option provides additional flood protection to properties within the study area, but it cannot provide a high standard of protection. Both the 'Embankment Road' and 'Pilots House Site' historic landfill sites would remain at risk from flooding. This option would provide some protection from flooding to listed buildings and parts of the Bembridge Conservation Area but could result in temporary adverse setting impacts when the temporary defences are in place. The Property Level Protection measures may also have some permanent adverse setting impacts, particularly if installed within the Conservation Area or to any of the listed buildings. Given the nature of this option, it will not impact on the ecologically designated sites within the study area and will have limited potential for impacts on the existing local landscape.

IW 22-25 –Yaverland to Culver Parade, Sandown

Assumptions - Defences will be proposed along the full extent of the study area. It is assumed that the only options which will extend into the intertidal area are the groyne improvement and groyne construction options, and new revetment..

Option (Method)	Environmental Score	Comments on scoring
Reactive patch and repair		This option provides initial protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding as overtopping risk increases. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. Impacts would worsen once existing structures reach the end of their life. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Solent and Dorset Coast pSPA and Bembridge rMCZ. If any of the maintenance activities be undertaken within the intertidal zone, there could also be disruption to the South Wight Maritime SAC. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could also be experienced during the periods of maintenance.
Capital Refurbishment of seawall / revetments		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Solent and Dorset Coast pSPA and Bembridge rMCZ.
Capital Refurbishment of groynes		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option will not involve lengthening of the groynes into the sub-tidal areas. For timber groynes the refurbishment will be within the existing footprint of the defence. For masonry groynes additional concrete used to refurbish the defence could potentially be applied either side of the structure minimally increasing the footprint (longshore) but will not extend the structure seawards. Consequently, there is the potential for temporary adverse impacts due to disruption to the Solent and Dorset Coast pSPA and Bembridge rMCZ. If any of the maintenance activities are undertaken within the intertidal and especially the subtidal zone (especially in the north of this frontage), there could also be disruption to the South Wight Maritime SAC. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Beach Recycling		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ during the beach recycling process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The movement of sediment within the existing frontage could have impacts on local features within the South Wight Maritime SAC and also have impacts further down the coast at Bembridge Down SSSI (also SAC) as a result of changes in sediment movements. Potential for impacts at both the collection and distribution sites within Sandown Bay (designated sites, including the South Wight SAC and Bembridge Down SSSI).

Option (Method)	Environmental Score	Comments on scoring
Beach Nourishment		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Solent and Dorset Coast pSPA and Bembridge rMCZ during the beach nourishment process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The provision of large quantities of new sediment could also have impacts on designated features within the Bay and further down the coast at Bembridge Down SSSI and Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements.
Gabions		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ, but is unlikely to require landtake from the intertidal area. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument.
Groyne Improvement		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat (e.g. due to groyne lengthening). The extension to existing groynes could also have impacts further down the coast at Bembridge Down SSSI and the Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Groyne Construction		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat. The provision of new groynes could also have impacts further down the coast at Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Revetment		This option provides protection from coastal erosion and is likely to provide some additional protection against flooding. However, some properties within the study area could still be at risk of flooding. This option will continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not entirely from flooding.

Option (Method)	Environmental Score	Comments on scoring
		Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Solent and Dorset Coast pSPA and Bembridge rMCZ. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument.
Seawall		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Solent and Dorset Coast pSPA and Bembridge rMCZ, but is unlikely to require landtake from the intertidal area if built as close as possible to the current structures. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC, Solent and Dorset Coast pSPA and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction.
Crest Raising / wave return		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area as a result of the introduction of extension of existing structures within and in close proximity to the Conservation Area and Scheduled Monument. There is the potential for temporary adverse effects in relation to disturbance to the Solent and Dorset Coast pSPA and Bembridge rMCZ during construction.
Setback Floodwall		This option provides an increased standard of protection to properties within the study area. However, whilst this option will provide protection from erosion and flooding to large parts of the Sandown Conservation Area, associated listed buildings and Sandown Barrack Battery Scheduled Monument, not all parts would be protected depending on how far the flood wall is setback. It is assumed that the setback floodwall would not encroach into any designated sites within the area. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Sandown Conservation Area and Sandown Barrack Battery Scheduled Monument as a result of the introduction of new structures within and in close proximity to the Conservation Area and Scheduled Monument.
Road Raising		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some changes to the local landscape and has the potential to result in some adverse effects on the setting of the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument. There is the potential for temporary adverse effects in relation to disturbance to the Solent and Dorset Coast pSPA and Bembridge rMCZ during construction.

IW 26 – 28 – Lake cliffs, Shanklin Esplanade and Luccombe cliffs

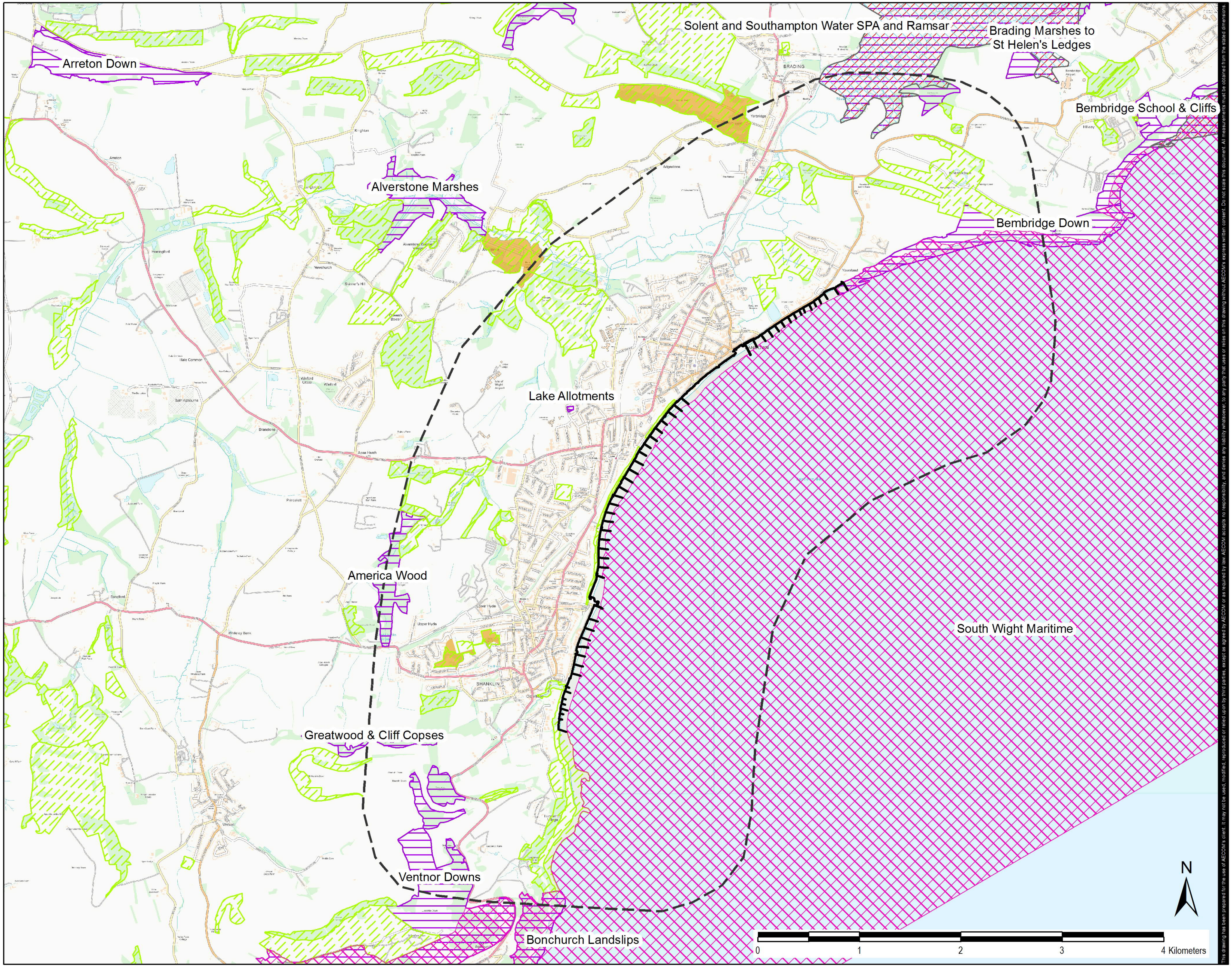
Assumptions - Defences will be proposed along the full extent of the study area. It is assumed that the options presented will be frontline and installed within the intertidal area, unless stated that the option is set back or on the road.

Option (Method)	Environmental Score	Comments on scoring
Reactive patch and repair		This option provides initial protection from coastal erosion but no additional protection against flooding/overtopping. Therefore, properties within the study area could be at risk of flooding (overtopping). This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion. Impacts will worsen once existing structures reach the end of their life. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Bembridge rMCZ. If any of the maintenance activities be undertaken within the intertidal zone, there could also be disruption to the adjacent South Wight Maritime SAC. However, due to the limited nature of the works, this option is unlikely to result in any permanent changes to the local landscape or the setting of any historic features within the study area. Some temporary adverse impacts could also be experienced during the periods of maintenance.
Capital Refurbishment of seawalls / revetments		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse impacts due to disruption to the Bembridge rMCZ.
Capital Refurbishment of groynes		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Sandown Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option will not involve lengthening of the groynes into the sub-tidal areas. For timber groynes the refurbishment will be within the existing footprint of the defence. For masonry groynes additional concrete used to refurbish the defence could potentially be applied either side of the structure minimally increasing the footprint (longshore) but will not extend the structure seawards. Consequently, there is the potential for temporary adverse impacts due to disruption to the Bembridge rMCZ. If any of the maintenance activities will be undertaken within the intertidal and subtidal zone, there could also be disruption to the South Wight Maritime SAC (generally below the LWM). This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Beach Recycling		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Bembridge rMCZ during the beach recycling process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The movement of sediment within the existing frontage could have impacts on local features within the South Wight Maritime SAC (including near Hope beach) and also have impacts further down the coast at Bembridge Down SSSI (also SAC) as a result of changes in sediment movements. Potential for impacts at both the collection and distribution sites within Sandown Bay (designated sites, including the South Wight SAC and Bembridge Down SSSI).

Option (Method)	Environmental Score	Comments on scoring
Beach Nourishment		This option provides protection from coastal erosion but no additional protection against flooding. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option. There is the potential for temporary adverse effects in relation to construction works within the footprint of the Bembridge rMCZ during the beach nourishment process. Construction could also give rise to temporary adverse effects in relation to disturbance to the intertidal area and the South Wight Maritime SAC. The provision of large quantities of new sediment could also have impacts on designated features within the Bay (including near Hope beach) and further down the coast at Bembridge Down SSSI Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements.
Gabions		This option provides protection from coastal erosion but no additional protection against flooding and. Therefore, properties within the study area could be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Bembridge rMCZ, but is unlikely to require landtake from the intertidal area. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Groyne improvement		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat (e.g. due to groyne lengthening). The extension to existing groynes could also have impacts further down the coast at Bembridge Down SSSI and the Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Groyne construction		This option provides protection from coastal erosion but no additional protection against flooding. Therefore properties within the study area could remain at risk of flooding. This option will also continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not flooding. This option could result in temporary disturbance of the intertidal habitat and in some locations the South Wight Maritime SAC and Bembridge rMCZ. There could also be further permanent landtake from the intertidal and subtidal habitat. Providing new groynes could also have impacts further down the coast at Bembridge Down SSSI and the Whitecliff Bay & Bembridge Ledges SSSI as a result of changes in sediment movements. This option is unlikely to result in any permanent changes to the setting of any historic features within the study area. There will be temporary minor adverse impacts on the local landscape during construction, but there is unlikely to be any permanent visual effects as a result of this option.
Revetment		This option provides protection from coastal erosion and is likely to provide some additional protection against flooding. However, some properties within the study area could still be at risk of flooding. This option will continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument from coastal erosion, but not entirely from flooding. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Bembridge rMCZ (& pSPA in part of unit 26). It could lead to coastal

Option (Method)	Environmental Score	Comments on scoring
		squeeze and loss of intertidal habitat within the South Wight Maritime SAC and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Seawall		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on the Bembridge rMCZ (& pSPA in part of unit 26), but is unlikely to require landtake from the intertidal area, if built as close as possible to the current structure. It could lead to coastal squeeze and loss of intertidal habitat within the South Wight Maritime SAC and Bembridge rMCZ. There will also be temporary adverse impacts caused by disturbance during construction.
Crest Raising / wave return		This option provides an increased standard of protection to properties within the study area. This option will also continue to provide protection to listed buildings, the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of extensions to existing structures within and in close proximity to the Conservation Area. There is the potential for temporary adverse effects in relation to disturbance to the Bembridge rMCZ during construction.
Setback Floodwall		This option provides an increased standard of protection to properties within the study area. However, whilst this option will provide protection from erosion and flooding to large parts of the Shanklin Conservation Area, the Sandown Barrack Battery Scheduled Monument and listed buildings, not all parts would be protected depending on how far the flood wall is setback. Depending on the extent of the landtake required, this option would likely have permanent adverse impacts on non-statutory designated sites for nature conservation located behind the frontage. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area.
Cliff Stabilisation		This option reduces risk from cliff falls but would not on its own (without toe protection) provide protection from coastal erosion and additional protection against flooding. Therefore, properties within the study area could be at risk of erosion and flooding, including overtopping. This option will continue to provide some protection to listed buildings, parts of the Shanklin Conservation Area and the Sandown Barrack Battery Scheduled Monument.. This option is likely to result in some permanent changes to the local landscape and has the potential to result in adverse effects on the setting of the Shanklin Conservation Area as a result of the introduction of new structures within and in close proximity to the Conservation Area, although some cliff stabilisation measures have already been undertaken in the area and are minimally intrusive . Slowing down the rate of cliff retreat, without toe protection, could in the future lead to coastal squeeze and loss of intertidal habitat within the Bembridge rMCZ and South Wight Maritime SAC . There will also be temporary adverse impacts caused by disturbance during construction.

Appendix B Figures



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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- Desk Study Survey Area
- The Sandown Bay Study Area
- Ramsar Sites
- Special Protection Area
- Special Area of Conservation
- Site of Importance for Nature Conservation
- Site of Special Scientific Interest
- Local Nature Reserves

Issue/Revision:

I/R	Date	Description

AECOM Internal Project No:

60535175

Drawing Title:

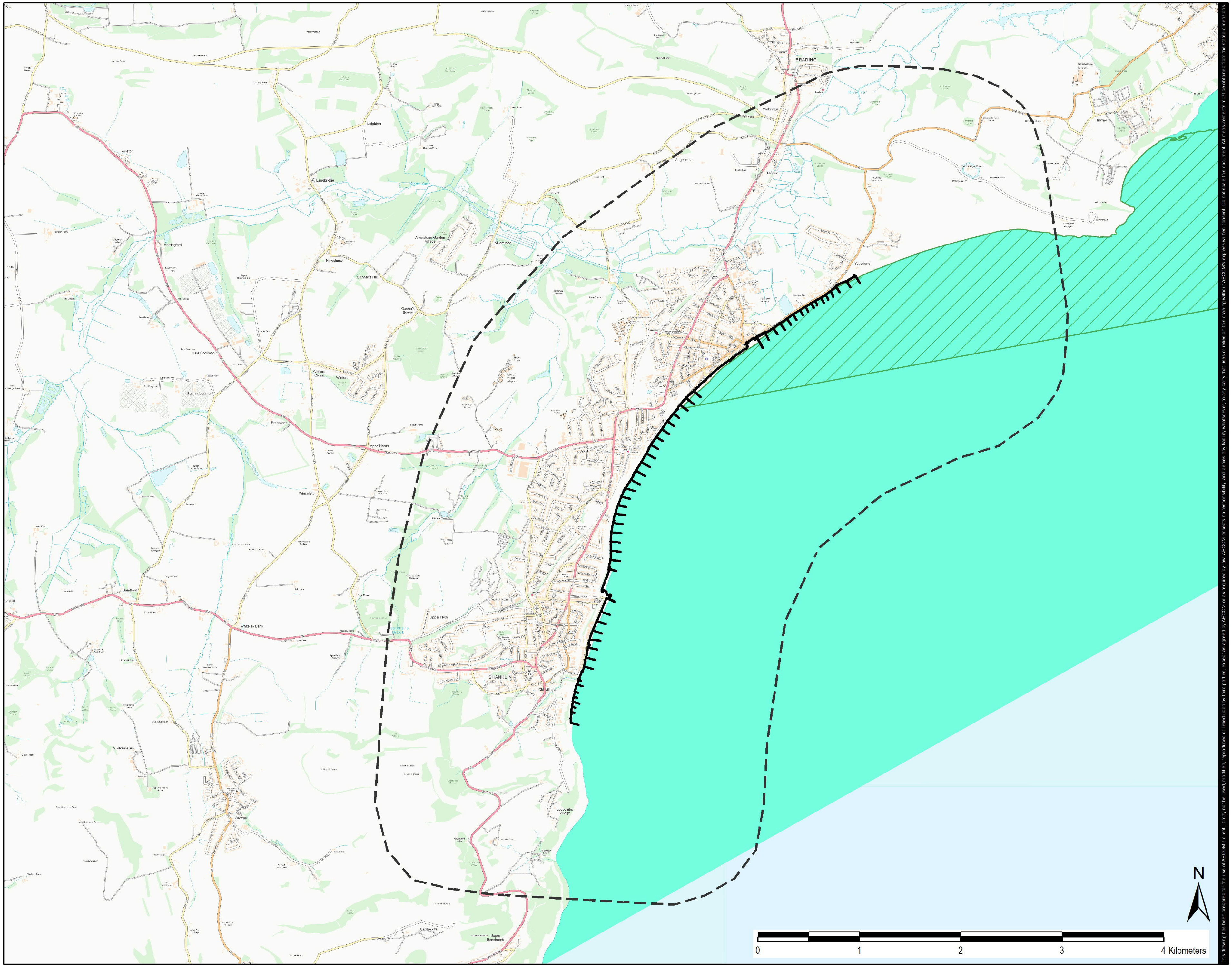
FIGURE 1:
SANDOWN BAY
STATUTORY AND NON-STATUTORY SITES DESIGNATED FOR NATURE CONSERVATION WITHIN 2KM

Scale at A3: 1:34,000

Drawing No: **Rev:** V1

Drawn:	Chk'd:	App'd:	Date:
BO	BT	JS	06/06/17

Filename: L:\Water New\4 - PROJECTS\6053\60535175 - Sandown Bay FCERM apprasial\40 GIS\Project Files\MXDs\Flood & Erosion Risk Mapping\Sandown Bay\Statutory and Non-Statutory Sites Designated for Nature Conservation within 2km.mxd



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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- The Sandown Bay Study Area
- Desk Study Survey Area
- Proposed Special Protection Area
- Recommended Marine Conservation Zones

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Issue/Revision:

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AECOM Internal Project No:

60535175

Drawing Title:

FIGURE 4:
SANDOWN BAY
PROPOSED OR RECOMMENDED ECOLOGICAL DESIGNATIONS

Scale at A3: 1:34,000

Drawing No:

Rev: V1

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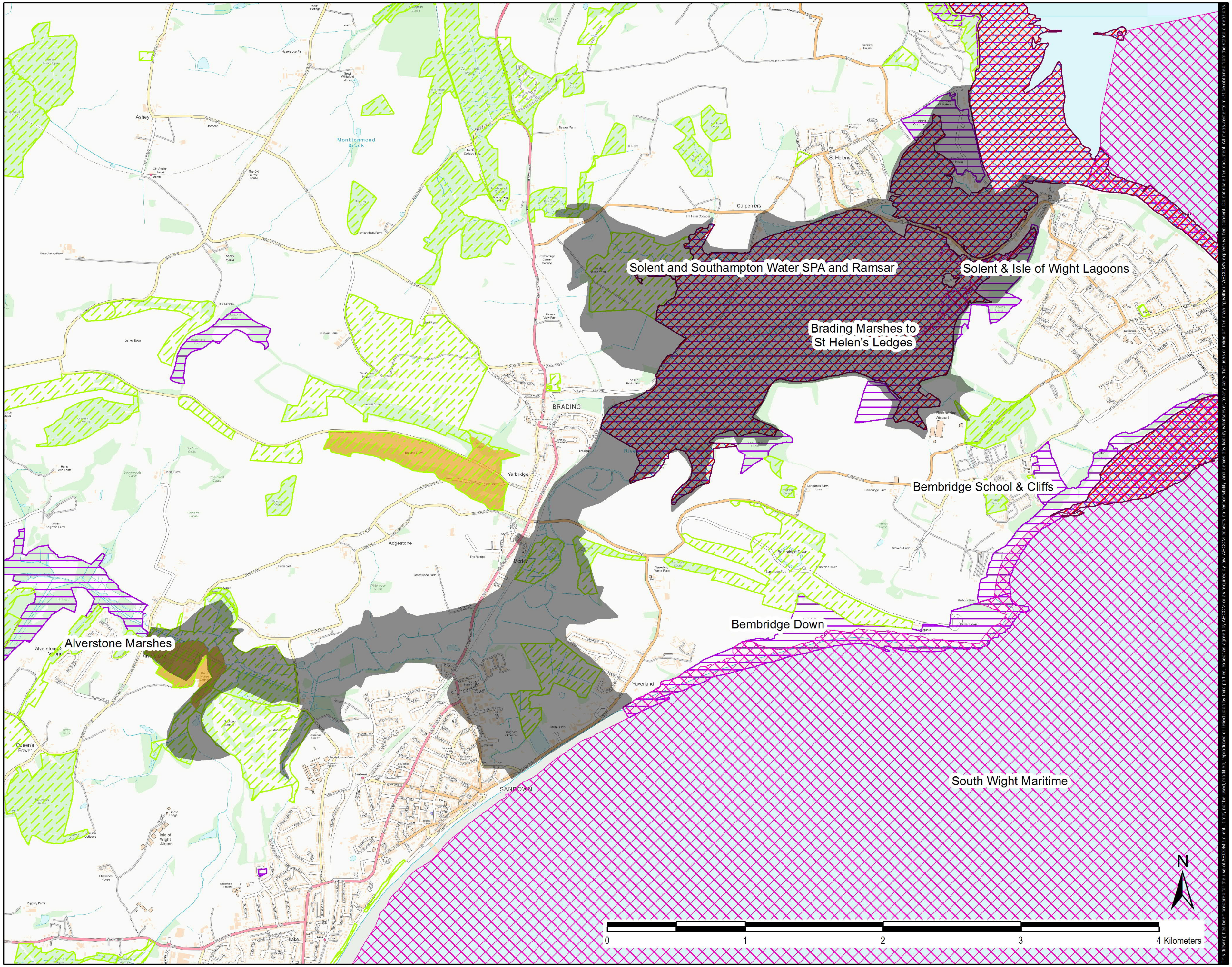
BO	BT	JS	05/06/17

Filename: L:\Water New\4 - PROJECTS\6053\60535175 - Sandown Bay FCERM apprasial\40 GIS\Project Files\MXDs\Flood & Erosion Risk Mapping\Sandown Bay\Proposed or Recommended designation.mxd



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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- Eastern Yar Valley Floodplain
- Special Protection Area
- Ramsar Sites
- Special Area of Conservation
- Site of Importance for Nature Conservation
- Site of Special Scientific Interest
- Local Nature Reserves

FLOODING EXTENT, 200 ARI OVERTOPPING WITH FUTURE PREDICTIONS (2115)

Copyright:

Issue/Revision:

I/R	Date	Description

AECOM Internal Project No:

60535175

Drawing Title:

FIGURE 3:
EASTERN YAR VALLEY FLOODPLAIN STATUTORY AND NON-STATUTORY SITES DESIGNATED FOR NATURE CONSERVATION WITHIN 2KM

Scale at A3: 1:25,000

Drawing No:	Rev:
	V1

Drawn:	Chk'd:	App'd:	Date:
BO	BT	JS	05/06/17

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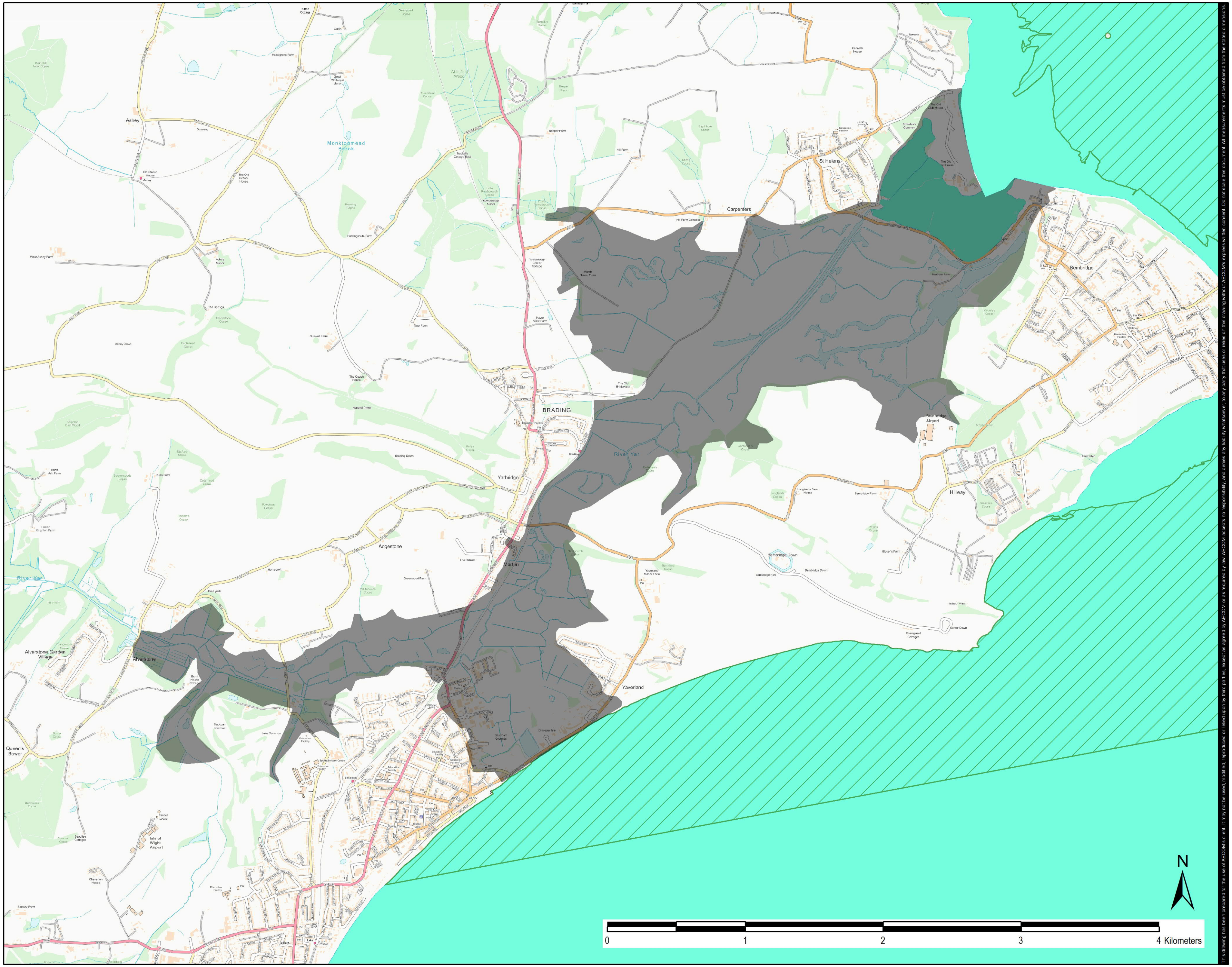

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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- Eastern Yar Valley Floodplain
- Proposed Special Protection Area
- Recommended Marine Conservation Zones

FLOODING EXTENT, 200 ARI OVERTOPPING WITH FUTURE PREDICTIONS (2115)

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AECOM Internal Project No:

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Drawing Title:

FIGURE 4:
EASTERN YAR VALLEY FLOODPLAIN PROPOSED OR RECOMMENDED ECOLOGICAL DESIGNATIONS

Scale at A3: 1:25,000

Drawing No: **Rev:** V1

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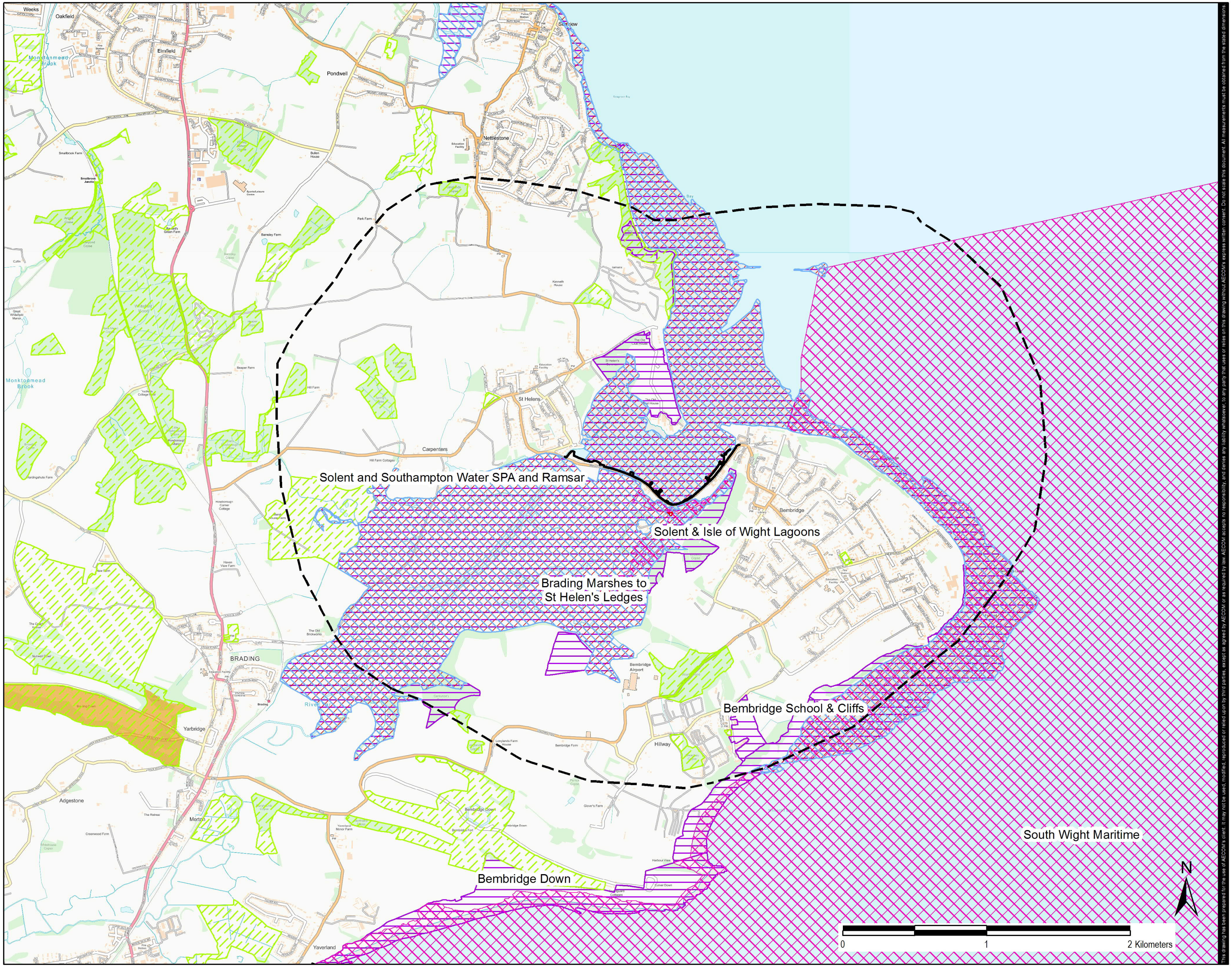

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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- Desk Study Survey
- The Embankment Road Study Area
- Ramsar Sites
- Special Protection
- Special Area of Conservation
- Site of Importance for Nature Conservation
- Site of Special Scientific Interest
- Local Nature Reserves

Issue/Revision:

I/R	Date	Description

AECOM Internal Project No:

60535175

Drawing Title:

FIGURE 5:
EMBANKMENT ROAD STATUTORY AND NON-STATUTORY SITES DESIGNATED FOR NATURE CONSERVATION WITHIN 2KM

Scale at A3: 1:24,000

Drawing No:			Rev:
			V1
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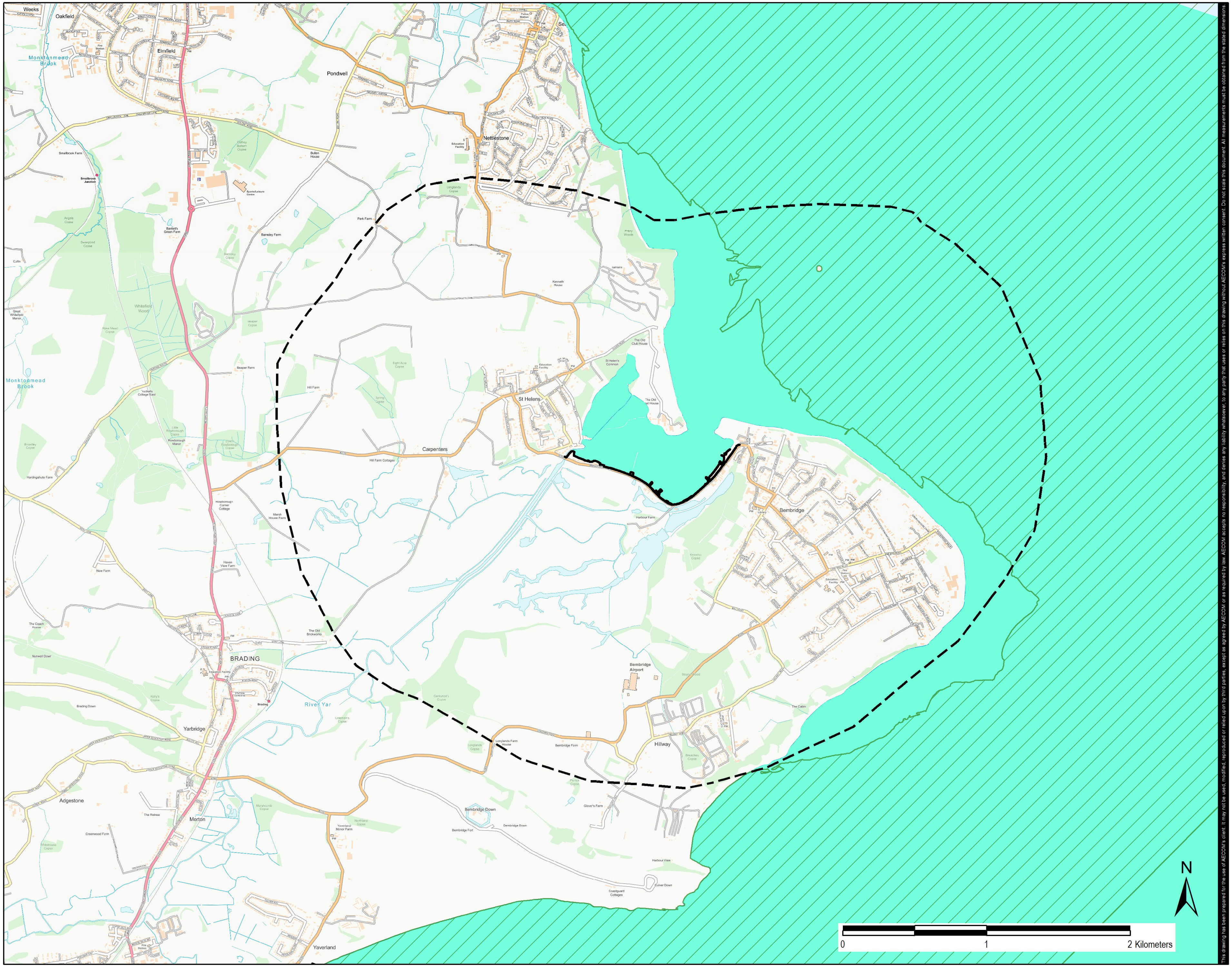
BO	BT	JS	06/06/17

Filename: L:\Water New\4 - PROJECTS\6053\60535175 - Sandown Bay FCERM apprasial\40 GIS\Project Files\MXDs\Flood & Erosion Risk Mapping\Embankment Road\Statutory and Non-Statutory Sites Designated for Nature Conservation within 2km.mxd



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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- Desk Study Survey Area
- The Embankment Road Study Area
- Proposed Special Protection Area
- Recommended Marine Conservation Zones

Copyright:

Issue/Revision:

I/R	Date	Description

AECOM Internal Project No:

60535175

Drawing Title:

FIGURE 6:
EMBANKMENT ROAD
PROPOSED OR RECOMMENDED ECOLOGICAL DESIGNATIONS

Scale at A3: 1:24,000

Drawing No:			Rev:
			V1
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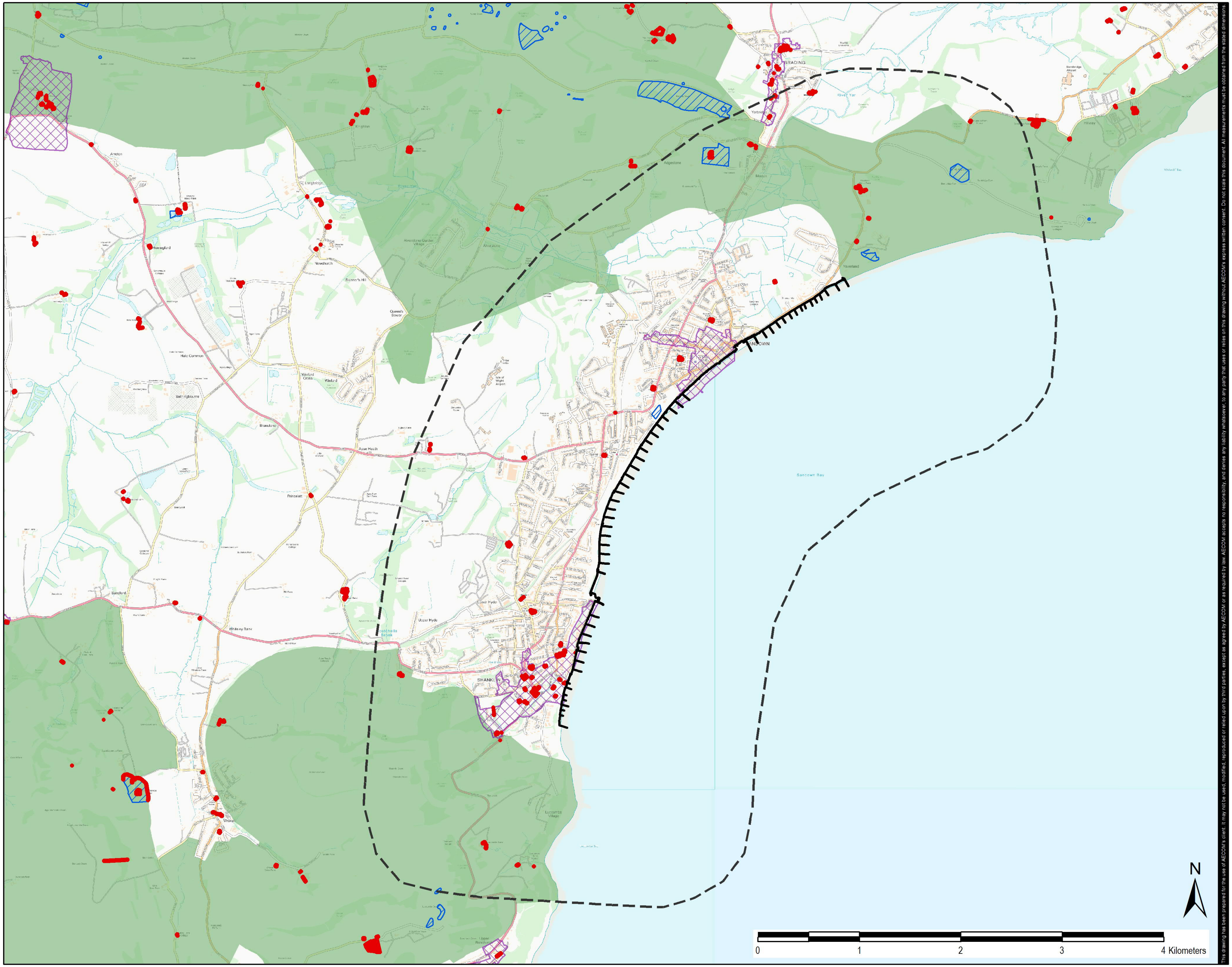
BO	BT	JS	05/06/17

Filename: L:\Water New\4 - PROJECTS\6053\60535175 - Sandown Bay FCERM apprasial\40 GIS\Project Files\MXDs\Flood & Erosion Risk Mapping\Embankment Road\Proposed or Recommended designation.mxd



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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- The Sandown Bay Study Area
- Desk Study Survey Area
- Conservation Area
- Listed Buildings
- Scheduled Monuments
- Area of Outstanding Natural Beauty

Issue/Revision:

I/R	Date	Description

AECOM Internal Project No:

60535175

Drawing Title:

FIGURE 7.
SANDOWN BAY
HERITAGE AND LANDSCAPE DESIGNATIONS

Scale at A3: 1:34,000

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			V1
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BO	BT	JS	02/06/17

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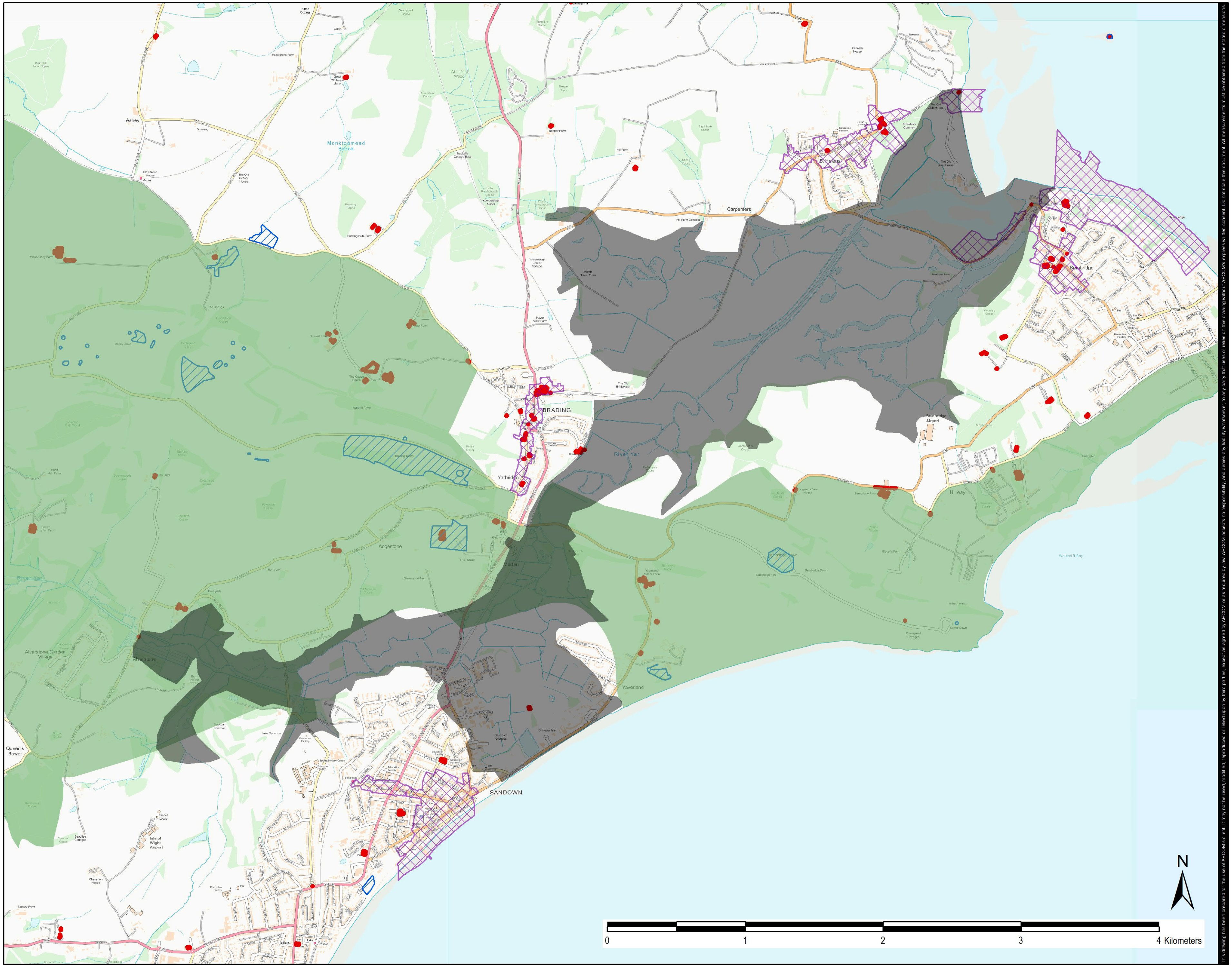

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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- Eastern Yar Valley Floodplain
- Area of Outstanding Natural Beauty
- Scheduled
- Conservation
- Listed Buildings

FLOODING EXTENT, 200 ARI OVERTOPPING WITH FUTURE PREDICTIONS (2115)

Issue/Revision:

I/R	Date	Description

AECOM Internal Project No:

60535175

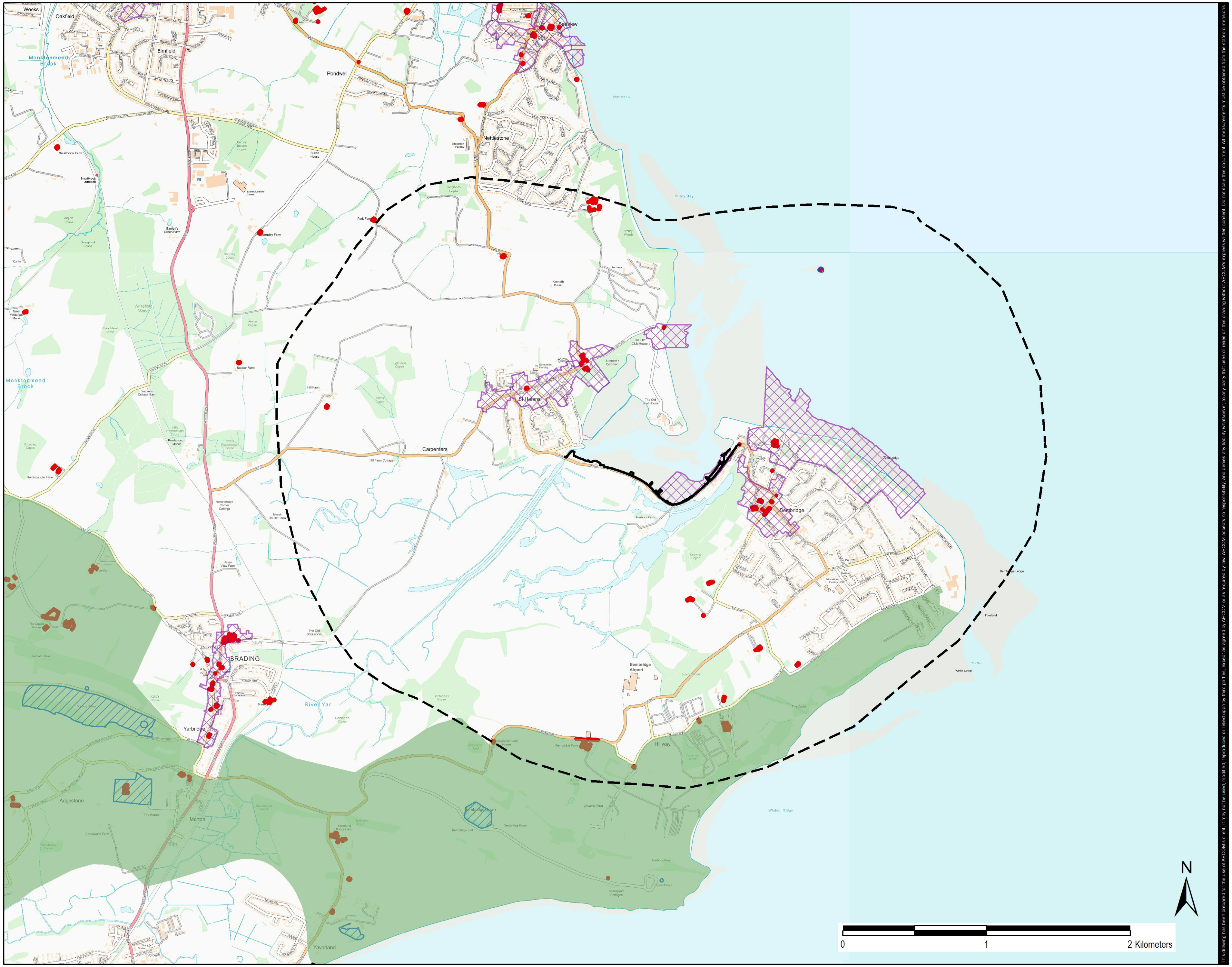
Drawing Title:

FIGURE 8:
EASTERN YAR VALLEY FLOODPLAIN HERITAGE AND LANDSCAPE DESIGNATIONS

Scale at A3: 1:25,000

Drawing No:			Rev:
			V1
Drawn:	**Chk'd:**	**App'd:**	**Date:**
BO	BT	JS	02/06/17

Filename: L:\Water New\4 - PROJECTS\6053\60535175 - Sandown Bay FCERM apprasial\40 GIS\Project Files\MXDs\Flood & Erosion Risk Mapping\Eastern Yar Valley\Historic and Landscape Designations.mxd



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Project Title:

SANDOWN BAY INITIAL APPRAISAL AND SCHEME IDENTIFICATION STUDY

Client:

ISLE OF WIGHT COUNCIL

LEGEND

- Desk Study Survey Area
- The Embankment Road Study Area
- Area of Outstanding Natural Beauty
- Scheduled Monuments
- Conservation Area
- Listed Buildings

Copyright:

Issue/Revision:

I/R	Date	Description

AECOM Internal Project No:

60535175

Drawing Title:

FIGURE 9.
EMBANKMENT ROAD HERITAGE AND LANDSCAPE DESIGNATIONS

Scale at A3: 1:24,000

Drawing No:	Rev:
	V1

Drawn:	Chk'd:	App'd:	Date:
BO	BT	JS	02/06/17

Filename: L:\Water New\4 - PROJECTS\6053\60535175 - Sandown Bay FCERM apprasial\40 GIS\Project Files\MXDs\Flood & Erosion Risk Mapping\Embankment Road\Historic and Landscape Designations.mxd




Sandown Bay Initial Appraisal and Scheme Identification Study

Preferred options & recommended schemes

Summary Briefing Report

Isle of Wight Council

60535175 / OP002

2019

Isle of Wight Council
Seaclose Offices
Fairlee Road
Newport
Isle of Wight
PO30 2QS

Executive Summary

The coastal communities of Sandown, Lake, Shanklin and those bordering the low-lying areas in the Eastern Yar valley, are at risk from coastal erosion and sea flooding. A combination of seawalls, groynes and embankments throughout the Bay and along Embankment Road in Bembridge currently protect a wide range of residential and commercial properties, road and rail infrastructure and environmentally important assets in the area. These coastal defences are ageing, some are in poor condition, and risks will continue to increase over the next 100 years. By 2117, £431 million of assets are at risk (in cash terms), including 661 properties at risk of erosion and 722 properties at risk of sea flooding (2117 1 in 200 year event). In addition, there is also important indirect risk through loss of facilities and infrastructure in the area.

This study has examined alternatives of how the coastal defences in the area could be replaced or improved in the future, what standards of protection could be provided, how much it is likely to cost, and who would need to pay. It has also identified and proposes priority coastal defence schemes for the area.

Cost-effective proposals have been sought which reduce risks, minimise impacts on the high-quality natural and historic environments of the area, and can help sustain the local community and the visitor economy.

To implement the current 'Hold the Line' Policies set by the Shoreline Management Plan (2011) for the defended coastlines in Sandown Bay and Embankment Road, Bembridge, a range of options and methods have been evaluated in eight different units. The following approaches are proposed, looking ahead over the next 100 years. Full details of the type and timings of the proposed methods can be found in the accompanying Options Report.

For Yaverland, Sandown, Shanklin and also Lake, capital refurbishments of the existing defences are proposed. The most cost-effective way to do this is to expand the use of the concrete resurfacing technique used previously on the face of the seawall along Culver Parade in Sandown, until such time as more substantial concrete encasements of the seawalls is needed (later in the appraisal period). Initial capital refurbishments are generally required from 10-15 years time onwards, although in Shanklin an earlier refurbishment is recommended. An earlier concrete encasement is also a feasible option at higher cost if preferred and funding is made available.

Along Lake Cliffs it is proposed is to maintain the defences at their current height throughout the 100 year appraisal period. From Yaverland to Sandown, the approach proposed is to first maintain but then later raise the height of the defences, by adding crest-raising in the medium term (from 2055). Along most of Shanklin Esplanade, maintaining and improving the defences is also proposed. An initial scheme is recommended for this area (discussed further below), and dependent on the method chosen, potential crest-raising of the defences could be included to seek efficiencies. In locations where raising of defences is proposed, the aspiration to raise the defences to achieve a future 1 in 75 year standard of protection is recommended, although the costs of protecting to an alternative higher 1 in 200 year standard of protection have also been considered.

If the groynes are also repaired and refurbished, this could help maintain beach levels and extend the length of time between which periodic refurbishments of the seawall will be needed. The costs for approaches including groyne refurbishments have also been estimated and compared and this approach is recommended (subject to the required funding being secured).

The main flood cell in the area extends along the Eastern Yar Valley between Embankment Road and Yaverland and it only requires inundation / overtopping of one frontage for flooding to occur throughout the flood cell. Therefore it is important that sea defences are coordinated at both ends of the low-lying Eastern Yar valley near Yaverland and Bembridge Harbour. Options to improve the defences at Embankment Road or at an alternative location near Yarbridge have been identified, although significant areas of freshwater habitats are also at risk in this area.

It is important to note that not all the funding required to maintain, replace and improve coastal defences (using the approaches outlined above) can be obtained from national government, under the present system. New coastal and flood defence schemes are prioritised nationally, based on the outcomes they produce, competing for allocations of national 'Grant in Aid' funding. Most schemes also require local 'partnership funding' contributions, which could be sought from anyone benefitting from a scheme.

In Sandown Bay and at Embankment Road, a combination of national and local funding contributions will therefore be required, if risks are going to continue to be reduced, and a continuous defence line and esplanade be maintained along the seafronts. The proportions of national and local funding that will be required vary in different parts of the Study Area, depending on the number and timing of properties and assets at risk. In some areas, significant national funding contributions are likely, in other areas, very little or no national funding contributions are anticipated.

In addition to the approaches outlined above, a range of alternative methods of replacing or improving the current defences have also been considered, and their suitability and additional costs evaluated. If additional funding was secured, some of these more expensive types of works could also be considered.

The improved level of detail in this study (compared to the high level Shoreline Management Plan) has revealed the economic case to implement the 'Hold the Line' policy is not as strong in some areas of the study area as others. The implications of this and residual risks are also discussed in the reports. A range of factors were considered when the Shoreline Management Plan set the current policies in 2011, and will inform future reviews, in accordance with the latest appraisal guidance and evidence.

Initially, two capital schemes for Shanklin Esplanade and then Yaverland/Sandown area have been identified as a priority and are recommended in this report. The funding required for alternative management approaches at these locations is highlighted, based on different design ideas and the numbers of years each coastal defence scheme would last. These schemes are potentially eligible for contributions of national 'Grant in Aid' funding, the proportion of which is dependent on which method is preferred.

The views of stakeholders have informed the study, and further consultation with stakeholders and the local community will help to determine which methods and schemes go forward in the future, especially if new local funding contributions could be identified and secured.

After this study, the next stages will be for applications for funding to be made, local funding contributions to be sought, and the chosen priority scheme(s) to be developed and designed in detail over the next few years.

The study also recognises the important role that continued maintenance plays in reducing risks and extending the life of existing coastal defences, whilst understanding the significant financial challenges in replacing the structures at the end of their service lives. Currently, repairs are prioritised based on risk, and the existing defences will continue to be maintained where the asset owners (including the Isle of Wight Council and Environment Agency) decide to commit resources.

1. Introduction

1.1 Background

AECOM Infrastructure and Environment UK Limited has been appointed by Isle of Wight Council to undertake an initial appraisal and scheme identification study for Sandown Bay and Embankment Road.

This study appraises management options to identify and recommend future schemes for the frontage which faces significant risks. Along this eroding coastline the existing defences are deteriorating and properties and assets along the frontage are at risk from erosion and flooding.

The existing defences are a combination of seawalls and groynes, originally designed to provide back stop protection and beach control. The defences are deteriorating and in some locations the groynes are in a very poor condition. There is a prominent erosion risk and the flood risk is expected to develop in the future so without timely renewal, significant asset losses can be expected in the future.

In Sandown Bay and the adjacent low-lying Eastern Yar valley, over the next 100 years there are 661 properties at risk of coastal erosion, plus an additional 722 properties at risk of tidal flooding (of which two thirds of which are residential). Damages over the next 100 years are anticipated to be £105 million in PV terms or £435 million in cash terms.

1.2 Purpose of this report

This summary document provides a concise overview of the study findings and presents the proposed preferred options and initial schemes required to manage the flood and erosion risks along the study frontage. This includes proposals to reduce flood risk to over 600 properties and reduce erosion risk to over 600 properties. For more detailed information and discussion see the Option Appraisal and Scheme Identification Report (and supporting technical appendices).

1.3 Overview of the study area

The study area comprises a 5.8km frontage at Sandown Bay and also includes the Eastern Yar Valley and Embankment Road at Bembridge, Isle of Wight (Figure 1-1). Sandown Bay is located on the east coast of the Island whilst Embankment Road is located behind Bembridge Harbour on the north-east coast of the Island.

The Sandown Bay frontage extends from Yaverland to Shanklin, comprising seven study units IW21-IW28 (Figure 1-1). The Shoreline Management Plan (SMP) policy for this area is to ‘Hold the Line’ as the entire length of the Sandown frontage is vulnerable to erosion. The defences along the frontage comprise a combination of seawalls and groynes which help trap littoral sediment and maintain beach levels. These defences currently mitigate the erosion risk but are ageing and in variable condition. In some locations, such as within IW26 & parts of IW27 (Lake to Shanklin) there are some areas where beach levels have fallen over the past decade, although there is variation in the beach level trends within the Bay including localised areas of erosion, no significant change and accretion in different groyne bays. Further information is provided in the Coastal Processes Baseline Report. Without timely renewal of the deteriorating defences, significant asset losses are anticipated in the future.

The Sandown to Shanklin frontage is also a popular tourist and amenity area with the long sandy beach, esplanade, and key assets a key attraction for visitors. In the north of the area between Yaverland and Sandown the hinterland behind the frontage is low lying. In the south of the area at Lake and Shanklin the promenade is backed by steep ferruginous sandstone cliffs approximately 35m high. Cliff falls occur regularly in this area with the potential to endanger life below, damage beach huts/cafes, restrict property access, and occasionally damage more substantial property and regularly cut off footpath access along the cliff top and cliff foot.

The seawalls along the frontage benefit from the functioning of the groynes through retaining beach material to help protect the wall foundations. The undefended cliffs at Luccombe to the south of the Shanklin frontage provide a source and continual supply of beach feeding materials to the down drift frontages to their north.

The Embankment Road frontage extends 1.5km along Embankment Road, between Bembridge and St. Helens, comprising study unit IW15. The embankment was originally constructed for a railway route, reclaiming the land behind it to create Brading Marshes. The marshes are now a designated SSSI and form part of the Solent and Southampton Water Ramsar and SPA. The embankment is approximately 10m wide at its narrowest point. At the other end of the floodplain the defences of Yaverland to Sandown also protect the valley from tidal inundation. There are significant numbers of properties and assets at risk from tidal flooding within the Eastern Yar floodplain, especially on the outskirts of Sandown. It is therefore necessary to consider both areas within the study because they are linked from a flood risk perspective. The economic benefits of reducing the flood risk can therefore only be obtained by protecting the flood cell from both ends; at both Sandown and Embankment Road.

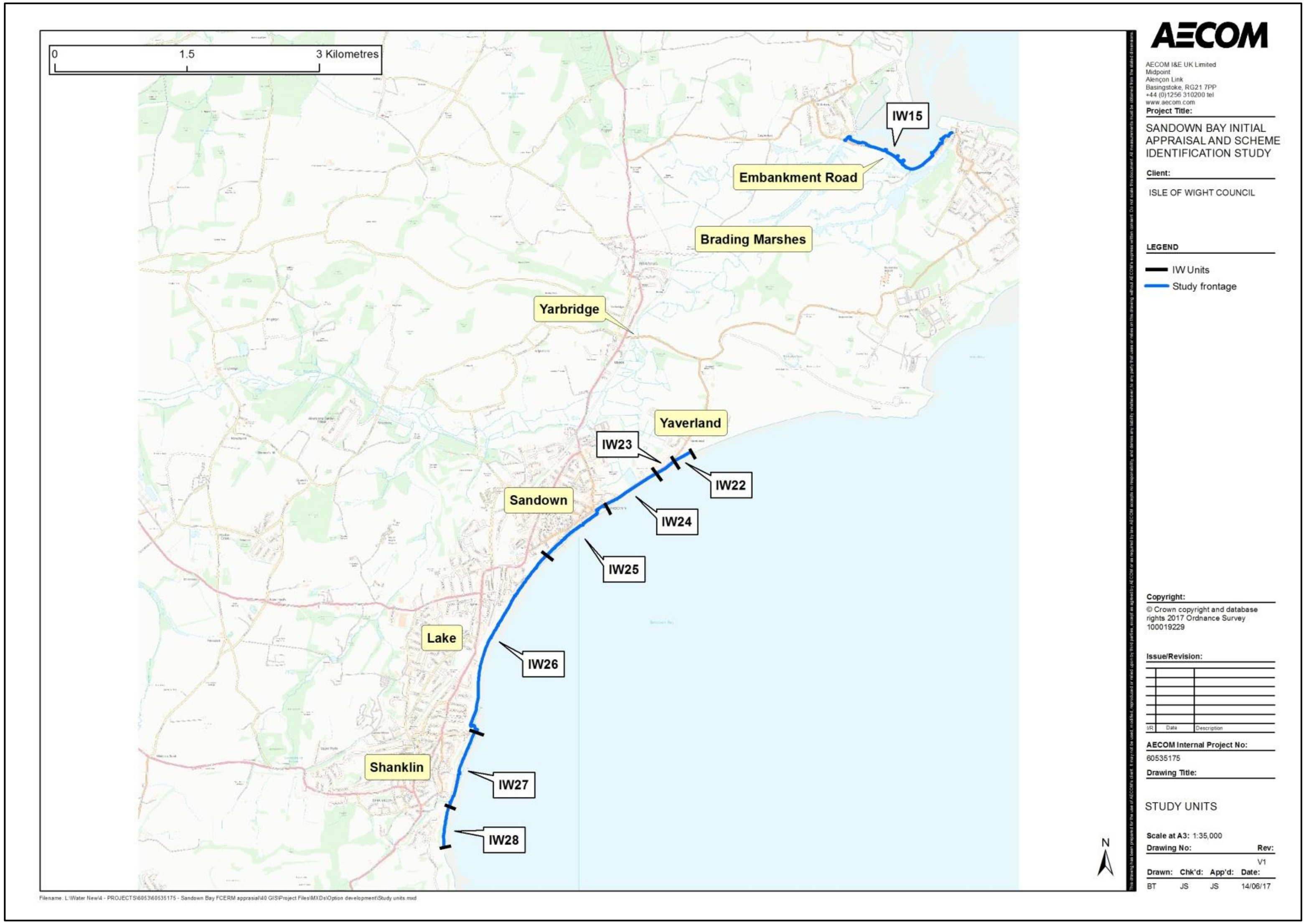

Figure 1-1. Location of study units

Table 1-1. Study unit summary

Units	IW15	IW22 to IW25	IW26 to IW28
Location	Embankment Road	Yaverland & Sandown	Lake & Shanklin
Geographic extent	Environment Agency control structure on Embankment Road to intersection with Beach Road	Yaverland beach car park to western end of Pier Street	Pier Street to Luccombe Road
SMP Policy Unit	3A.4	3C.2 (IW 22,23,24) 3C.3 -part (IW 25)	3C.3
SMP Policy	Hold the Line	Hold the Line	Hold the Line
Characteristics	- Earth embankment with highway - Coastal access - Residential and commercial land use - Flood risk becoming more significant over time. - Sheltered environment. Short section of embankment exposed to storm waves from the north and therefore an erosion risk. - Environmentally designated area of Brading Marshes located behind the defence	- Concrete seawall / revetment with concrete / timber groynes, generally in fair condition with areas of good condition. - Exposed open coastline - Coastal promenade and highway - Wide sandy beach in-front of the defences - Low lying land behind - Residential and commercial land use. - Regeneration opportunities - Flood risk becoming more prominent over time - Erosion risk	- Concrete seawall / revetment with concrete / timber groynes, generally in fair to good condition although some large areas in poor and very poor condition (sections of seawall and timber groynes). - Exposed open coastline - Coastal promenade - Wide sandy beach in-front of the defences - Backed by steep cliffs (which are unstable). Little or no flood risk. - Erosion risk is prominent if the defences fail with many properties located along the cliff top.

2. Potential management measures

In order to deliver potential management options for the coastline (i.e. maintain, sustain, improve protection etc.) a number of management measures and interventions may be required, either separately or in conjunction with one another. These may also need to be phased or sequenced in time to deliver the different management options.

2.1 Initial screening of potential measures

2.1.1 Approach

To ensure all of the potential measures and methods were available for the development and appraisal of options it was important to cast the net as wide as possible at this initial stage to capture all potential measures which could have been considered.

A high level multivariate appraisal of the long list management measures was undertaken to screen out any unfeasible measures (on technical, environmental, health and safety, legal grounds etc.) and to justify removal of any impractical or 'non-starter' measures. This was carried out to ensure that unviable measures were not taken forward any further in the development or more detailed appraisal of the options.

The appraisal was informed by the following:

1. Supporting data and assessments – a review of a wide range of relevant data and completion of the baseline studies provided the understanding of the frontage and issues, constraints and opportunities. This information provided the facts from which to inform the study and screen out non-viable measures.
2. Visual site inspections – several site walkovers were carried out along the study frontage. The walkovers aided the teams' understanding and helped inform the decisions on viability of different measures along the frontage.
3. Stakeholder engagement – consideration of engagement feedback and aspirations of the community and stakeholders was incorporated into the appraisal.
4. Knowledge of IoW Council asset managers – an options workshop was held to utilise local and detailed knowledge of officers responsible for upkeep of the coastal management assets.

2.1.2 Measures screened 'in'

Figure 2-1 and Figure **2**-**2** present the long list 'measures' for each area that were taken forward in the development and appraisal of options.

These include techniques for minor repairs, capital refurbishment of the existing seawalls and embankments, a range of alternative new defence types, crest-raising or setback floodwalls on top of the existing defences, and alternative approaches such as beach nourishment. Groyne refurbishments and groyne construction have also been considered.

Some measures will protect against erosion, others protect against flooding, and some both. Each measure will typically last for a different number of years. For example, a cheaper refurbishment/resurfacing of an existing seawall would be designed to last 20 years, whereas a more expensive new seawall could last for 50 or 100 years. Alternatively, beach recycling would require an ongoing allocation of funding to repeat it regularly. The possible measures can also provide different 'Standards of Protection' (SoP) against flooding, dependent on the height of the structure and the limits of its design, and this is also factored into the costs.

This study has examined options over the next 100 years, using combinations of these measures, seeking efficient and effective approaches, typically requiring both an initial investment and then longer-term costs.

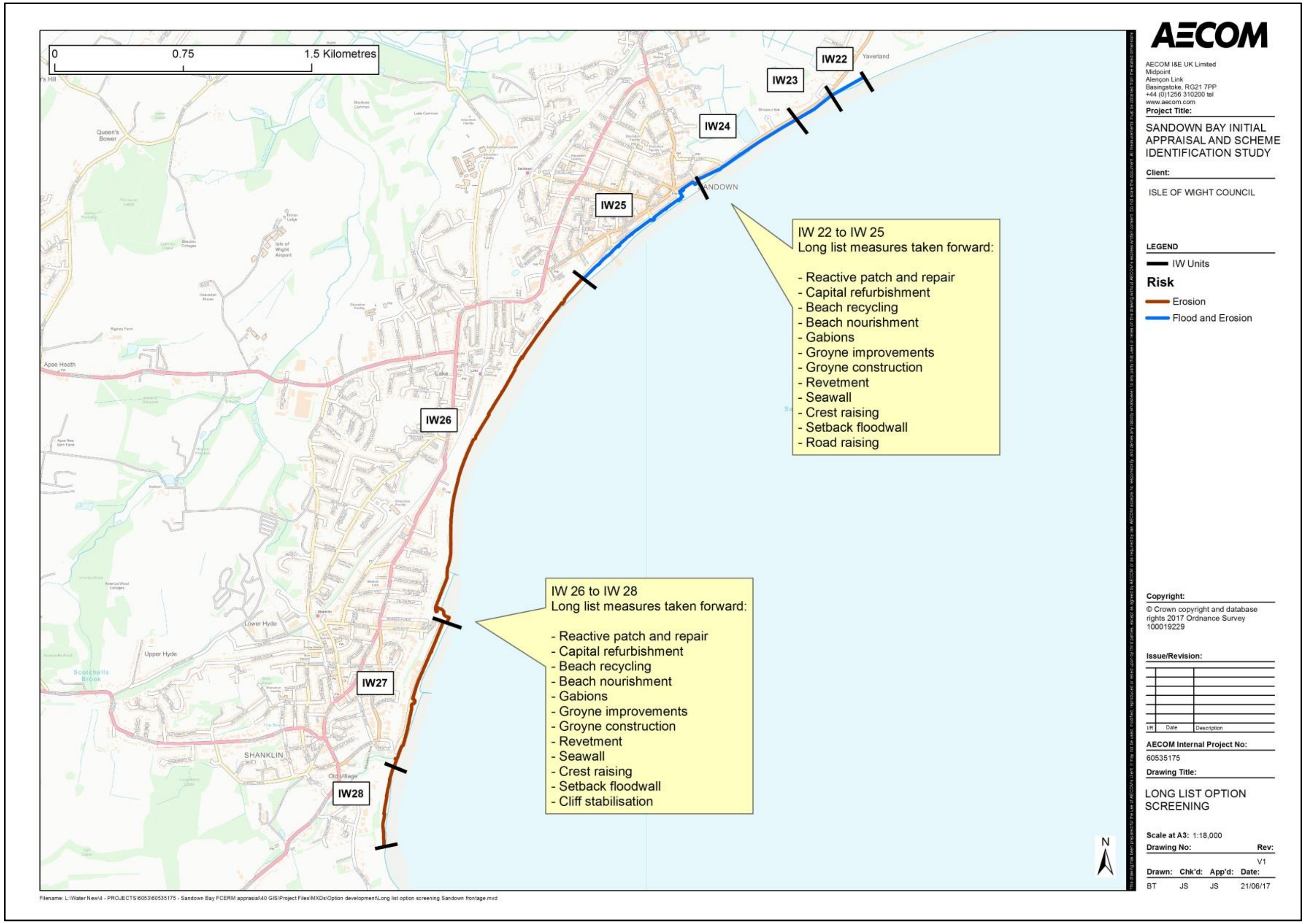

Figure 2-1. Long list measures taken forward for the Sandown frontage.

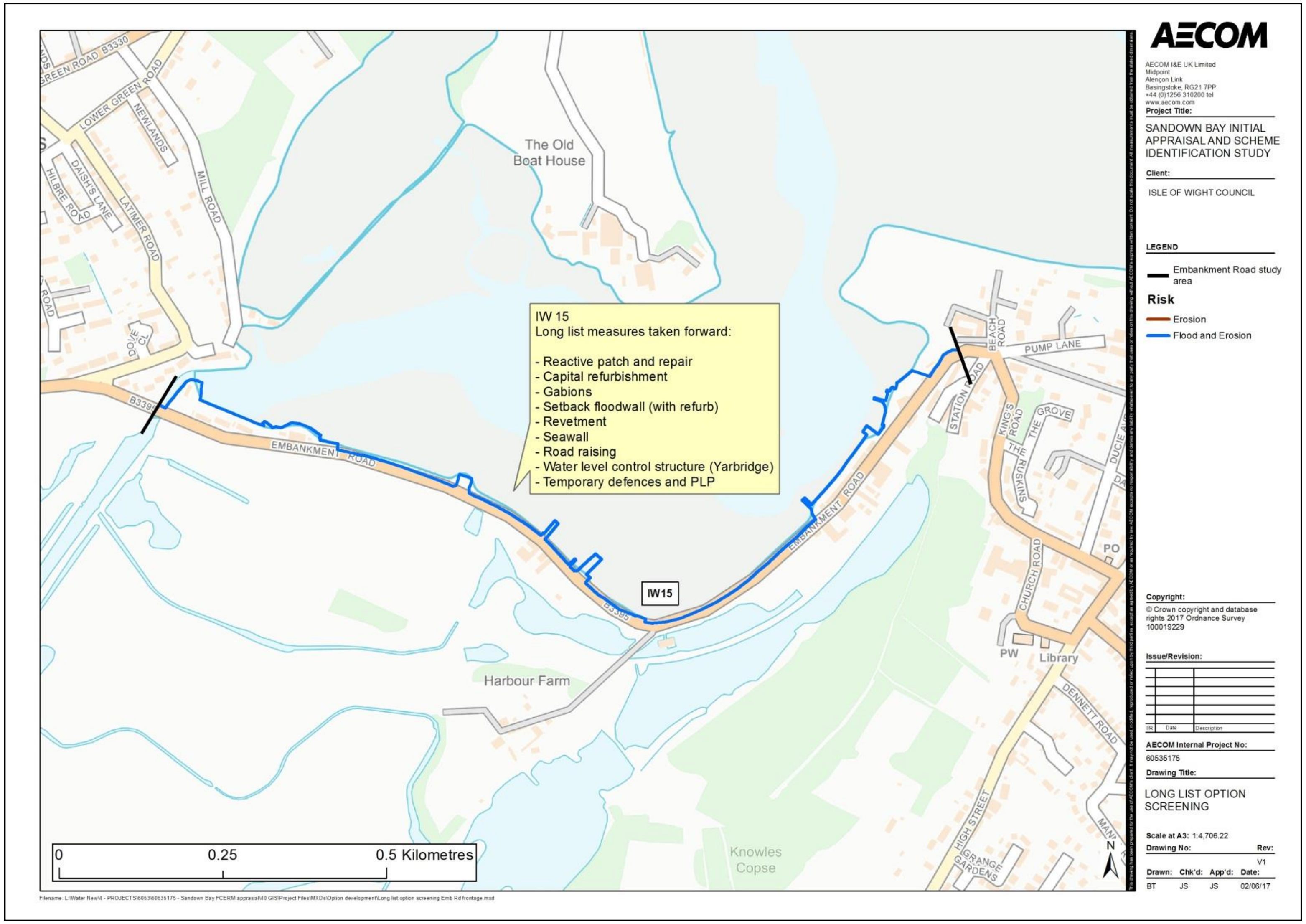

Figure 2-2. Long list measures taken forward for the Embankment Road frontage

2.1.3 Screened out measures

A number of measures were screened out for reasons of technical feasibility, environmental impacts, high cost etc., summarised briefly below. Further information is available in the Options report.

Offshore breakwater (or harbour) was screened out for reasons of high cost, significant environmental footprint, potential impacts in the highly designated offshore sites, sediment supply interruption (potential sediment starving downdrift), and the residual risks remaining as it would only address erosion and not fully address flood risk.

A large-scale setback embankment or flood structure was screened out for reasons of technical feasibility, residual risk and potentially high costs due to the large size, height, and length of a new structure required in the low land levels in the Eastern Yar valley at Yaverland or Embankment Road. Such an option would also not address erosion risk and the remainder of the seafront wall and new flood structures would require refurbishments and maintenance costs. Other reasons for screening out were potential loss of assets in front of the setback structure, such as roads and infrastructure, also sediment disruption, and multiple environmental designations immediately behind Embankment Road.

Temporary flood defences and property level protection (PLP) were screened out due to technical feasibility, as the scale of breach risk in the study area (due to depth and frequency of sea flooding in the valley) would mean this measure was insufficient, and elsewhere wave overtopping and a high degree of exposure along the seafront means these measures are not as effective as they are for still water levels. Localised use of PLP could be considered in support of other leading options.

Other measures screened out included beach nourishment at Embankment Road as it is not suitable, technically feasible and would have environmental impacts, and cliff regrading in The Bay which would result in loss of cliff top properties.

3. Management options

3.1 Description of options

3.1.1 Do Nothing

The ‘Do Nothing’ scenario is a hypothetical ‘walk away’ scenario which is used as a baseline against which to appraise various ‘Do Something’ management options.

Under the Do Nothing scenario the existing defences are abandoned in terms of maintenance or repair, and no remedial or additional protection works are carried out. In addition, adaptation to sea level rise or other climate change responses are not addressed.

Under this scenario the existing defences along the frontage will fail at the end of their service life and the land behind will be subject to erosion. The erosion risk under the Do Nothing scenario is far reaching and this has already been established and is represented by the No Active Intervention (NAI) erosion lines. These are presented in the Coastal Processes Stage 1 & 2 Report. Accelerated ‘catch up’ erosion is likely when hard defences fail along the frontage which would impact properties, infrastructure and assets behind.

Flood risk would increase significantly over time affecting properties and assets in the flood cell behind the defences in units IW15 (Embankment Road), IW22, IW23 and IW24 (Sandown to Yaverland). In these locations there is the potential for wave overtopping and tidal inundation over the defences; this water then spills into the low lying land behind. Under the Do Nothing scenario it is anticipated that the defences in this location will also fail and breach in the future. If this occurs the low lying area behind the defences could be inundated frequently through the breached defences (even during normal astronomical high tides).

Figure 3-1 shows the flood extent in the Sandown area following a breach for the following tides; mean high water (MHW) in 2057, mean high water springs (MHWS) in 2057, MHW in 2117 and MHWS in 2117. Mean high water typically occurs twice per day and therefore following a breach at some point the future a large area would be flooded on a daily basis, including the strategic A-road and railway line, properties at risk would be uninhabitable, utilities would be affected, including the wastewater treatment works for the Isle of Wight, and the seafront B-road would be severed. The depth of flooding following a breach varies with the land level behind the existing defences. For MHW in 2057 it ranges up to approximately 1m for the eastern edge of Sandown (just to the east of Avenue Road).

The Do Nothing scenario could present a number of risks such as increasing risks of public liability injury claims due to unsafe defences, degrading promenades and associated structures, a loss of rental income and business claims as a result of potential promenade or beach closures. There are also likely to be indirect impacts on tourism, recreation and regeneration opportunities in the study area.

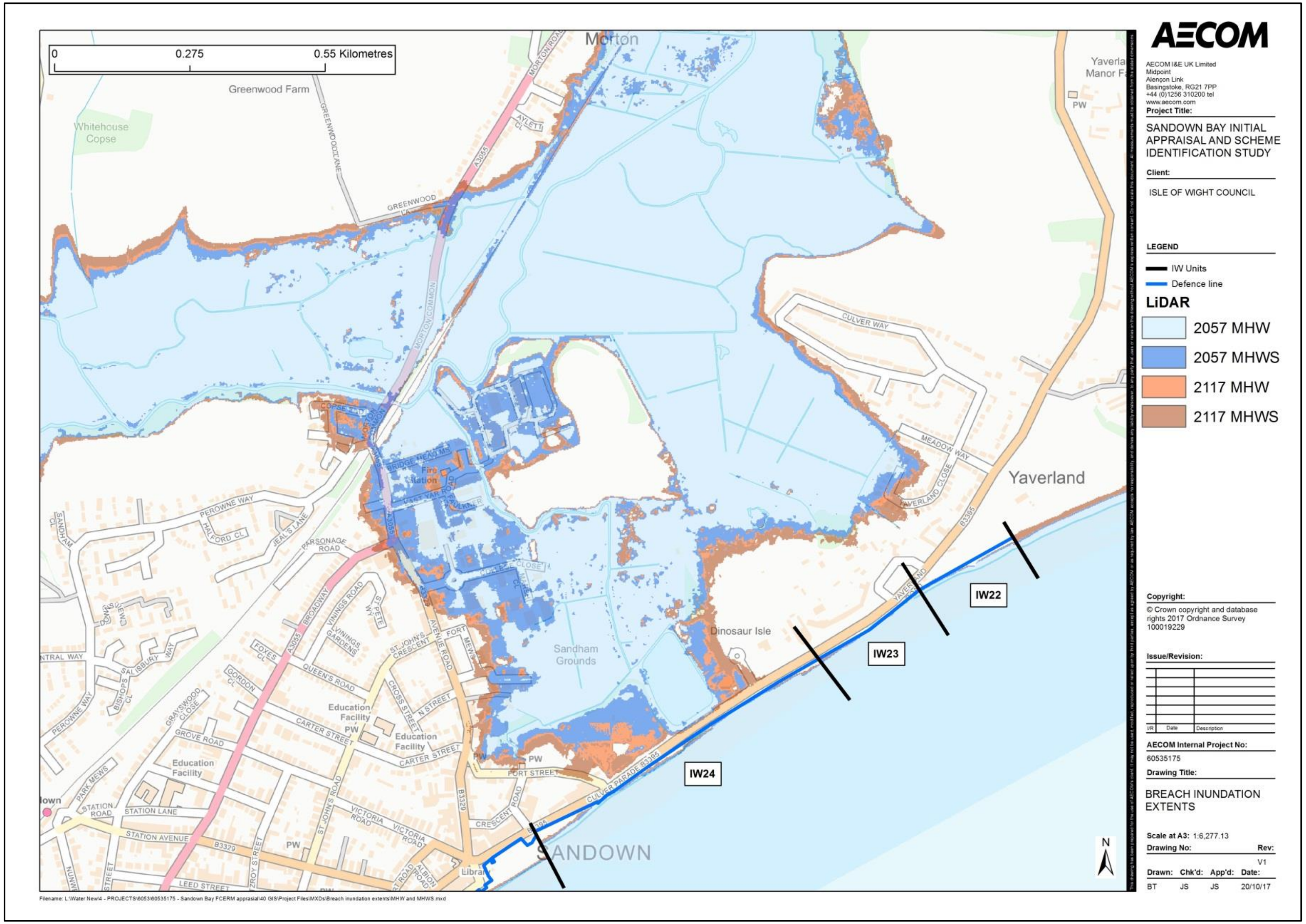

Figure 3-1. Extent of inundation for daily / monthly tides in 2057 and 2117 following a breach (MHW and MHWS tides shown for 2057 and 2117).

3.1.2 Do Minimum

The Do Minimum management option essentially represents the existing ‘status quo’. Under this approach, small scale reactive maintenance and ‘patch repair’ work, as well as activities to maintain Health and Safety compliance will be undertaken, as at present. This will help increase the residual life of assets and delay the point at which they are expected to fail. Do Minimum does not allow for any adaptation to sea level rise or other climate change responses (i.e. by crest raising) and therefore the flood risk will increase in the future as a function of sea level rise.

This approach does not allow for scheduled or capital maintenance or refurbishment, rebuild, or any replacement of assets. It has been assumed through ‘Do Minimum’ activities, the service life of assets compared to a ‘Do Nothing’ Scenario can be extended by a modest amount. This scenario therefore includes a low / basic allowance for maintenance, that is suitable for the Do Minimum scenario. The benefit of this scenario stems from the delayed onset of erosion behind defences, and the delayed breach risk at Yaverland compared to the ‘Do nothing Scenario, with the extent of delay depending on the defence type in question.

3.1.3 Maintain

The maintain option typically involves scheduled maintenance of the existing defences and would likely follow an asset maintenance plan; this is likely to require and include capital refurbishment works. A maintain option represents a proactive approach to maintenance and refurbishment, typically working with existing defence assets rather than building new. It will require increased investment compared to the existing ‘status quo’ as climate change and sea level increases pressure on the aging assets. The maintain option includes an allowance for the cost of ongoing modest maintenance to the current structures until such times when capital refurbishments are required during the 100 year appraisal period.

The maintain option will ensure that the line of the existing defences is kept in place at its current height for the duration of the appraisal period (i.e. the next 100 years) and therefore it will provide erosion benefits and prevent a breach. However, the maintain scenario does not allow for any adaptation to sea level rise or other climate change responses (i.e. by crest raising) and therefore the wave overtopping and flood risk will increase in the future as a function of sea level rise.

In some areas the defences are in a poor condition and investment will be required sooner rather than later to implement this option. An example is at Shanklin seawall, where the existing defences are deteriorating (see Figure 3-2 below).

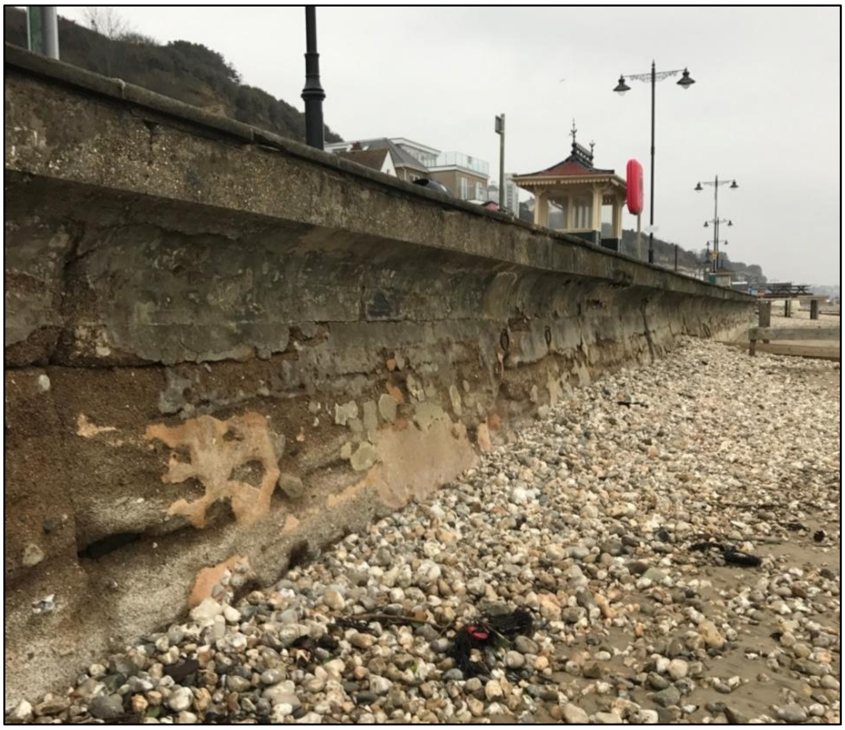

Figure 3-2. IW27 seawall in poor condition (southern end of the esplanade)

3.1.4 Sustain

The sustain option typically applies to flood defences where it involves raising the crest level (or width) of the defences over time to keep pace with sea level rise. For example the crest level may be raised to ensure that a required standard of protection is sustained for the duration of the appraisal period.

The sustain option could be implemented by constructing new defences or by refurbishing and raising the existing defences. The sustain option involves an increased investment compared to the maintain option.

By maintaining the position of the defences and sustaining standard of protection (SoP) this option provides both erosion and flood risk benefits in the future.

3.1.5 Improve

The improve option involves actively improving the standard of protection against flooding and erosion. For example, this could be carried out through implementation of new defences or through raising the crest level of the existing defences to improve the standard of protection, accommodating future sea level rise.

It is likely that new defences would be required to implement the improve option and the improve option will usually require the greatest investment of the management options; however, this option will deliver greatest benefits.

By maintaining the position of the defences and improving the standard of protection this option provides both erosion and flood risk benefits, immediately and also in the future.

3.1.6 Environmental protection

Coastal defences can impact the environment by preventing natural change, but in some circumstances they can also provide protection to other important environmental habitats.

Environmental protection is often carried out alongside another of the management options (i.e. maintain, sustain or improve) to provide additional environmental benefit. The scope for environmental mitigation varies depending on the environmental receptors (including the features, habitats and sensitivities) in the area.

For this study the main environmental mitigation is for the protected habitats of Brading Marshes, situated behind Embankment Road. By continuing to protect the habitats in this area it would provide mitigation because these habitats would otherwise be lost to coastal erosion / flooding if the existing defences were to breach.

4. Development and appraisal of options (short list)

This chapter summarises the development and the appraisal of shortlist options (Table 4-1) which included economic, social and environmental aspects.

For details of the methods and works proposed to implement each of these alternative options, and their timings, please see Chapter 6 of the full Options Report. The preferred options are then discussed in Chapter 5 of this Summary Report.

4.1 Short list of options

The short list of management options is presented Table 4-1. In areas where there are strong environmental drivers for future management (IW15), bespoke options were developed to capture the local issues and opportunities. In addition, for some areas variations or combinations of the high level management options have been used to create a hybrid approach to suit the timing of future risk.

4.1.1 Option development - developing shortlist options at the local level

Each short listed option (Table 4-1) can be implemented by using one, or a selection, of the long list measures taken forward from Chapter 2.

There are potentially thousands of different measure combinations and timings which could be used to implement each management option. Therefore a pragmatic rationalisation was required to facilitate the development of option combinations. It was agreed between the project team that in the first instance the technically feasible lowest cost or 'lower investment' combination of measures would be identified. These measure combinations provide the risk management authorities with a baseline from which to assess FCERM GiA funding availability. However, in addition to this, alternative more costly measure combinations have also been explored in some instances as these could potentially provide further benefits to the area. For example, higher investment options which may include works to refurbish the groynes which would help to sustain beach levels and encourage tourism in the area.

An environmental appraisal of the long list measures was also undertaken at a high level and fed into the appraisal of the short list options.

4.2 Economic Appraisal

An economic appraisal of options was carried out which assessed and compares option costs and benefits to identify the leading economic option and standard of protection. The results are summarised in Table 4-1.

The cost of each option has been identified, using a cost-effective combination of works, and the benefits that would be protected by that option have also been identified (shown in Table 4-1) The 'Cost' of the works includes capital construction costs and maintenance costs. The 'Benefits' include the number of residential and commercial properties protected from erosion, and the number of properties moved to a lower flood risk. Benefits also include risks to infrastructure, loss of visitors to elsewhere, and environmental benefits. The 'Benefit:Cost Ratio' (B:C ratio) compares the cost and benefit of each option.

The costs presented in Table 4-1 are shown in both undiscounted 'cash' and discounted 'present value' terms. Both costs refer to the whole life option costs (capital costs and maintenance costs) for the next 100 years but are presented in different ways. Discounting is technique used in economic appraisals to determine the 'present value' costs and it enables the comparison of the costs (and benefits) that occur at different points in time. Present value costs and benefits are required to establish the B:C ratios.

The costs have also been rounded to the nearest £5k to reflect the strategic level of the costing exercise. As schemes are progressed further in future studies there will be opportunities to refine the cost estimates and provide a greater degree of certainty in cost estimations. For more information on how these costs were developed, refer to Economic Appraisal.

Table 4-1. Summary of short list options, whole life (discounted) costs and benefits over 100 years

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
Yaverland Car Park	IW22	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	35	2,676	76.5
		Maintain 1	Refurbish Revetment	515	8,637	16.8
		Maintain 2	Refurbish Revetment & Refurbish Groynes	580	8,637	14.9
		Sustain 75yr 1	Refurbish Revetment & Crest Raising	525	10,444	19.9
		Sustain 75yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	590	10,444	17.7
		Maintain then Sustain 75yr 1	Refurbish Revetment & Crest Raising	525	8,806	16.8
		Maintain then Sustain 75yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	590	8,806	14.9
		Sustain 200yr 1	Refurbish Revetment & Crest Raising	535	10,489	19.6
		Sustain 200yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	595	10,489	17.6
		Maintain then Sustain 200yr 1	Refurbish Revetment & Crest Raising	530	8,806	16.6
		Maintain then Sustain 200yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	595	8,806	14.8
		Improve 2117 200yr 1	Refurbish Revetment & Crest Raising	570	10,656	18.7
		Improve 2117 200yr 2	Refurbish Revetment, Refurbish Groynes & Crest Raising	635	10,656	16.8
Sandown Zoo	IW23	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	40	975	24.4
		Maintain 1	Refurbish Seawall	500	1,959	3.9
		Maintain 2	Refurbish Seawall & Refurbish Groynes	1,020	1,959	1.9
		Sustain 75yr 1	Refurbish Seawall & Crest Raising	585	1,967	3.4
		Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,095	1,967	1.8
		Maintain then Sustain 75yr 1	Refurbish Seawall & Crest Raising	565	1,967	3.5
		Maintain then Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,085	1,967	1.8
		Sustain 200yr 1	Refurbish Seawall & Crest Raising	595	1,967	3.3
		Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,115	1,967	1.8
		Maintain then Sustain 200yr 1	Refurbish Seawall & Crest Raising	575	1,967	3.4
		Maintain then Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,095	1,967	1.8
		Improve 2117 200yr 1	Refurbish Seawall & Crest Raising	785	1,967	2.5
		Improve 2117 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	1,305	1,967	1.5
Culver Parade	IW24	Do Nothing	No Active Intervention	0	0	/

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
		Do Minimum	Reactive Patch and Repair	110	11,507	104.6
		Maintain 1	Refurbish Seawall	1,345	41,695	31.0
		Maintain 2	Refurbish Seawall & Refurbish Groynes	2,250	41,695	18.5
		Sustain 75yr 1	Refurbish Seawall & Crest Raising	2,185	43,384	19.9
		Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	3,090	43,384	14.0
		Maintain then Sustain 75yr 1	Refurbish Seawall & Crest Raising	1,750	41,867	23.9
		Maintain then Sustain 75yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	2,655	41,867	15.8
		Sustain 200yr 1	Refurbish Seawall & Crest Raising	2,335	43,464	18.6
		Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	3,240	43,464	13.4
		Maintain then Sustain 200yr 1	Refurbish Seawall & Crest Raising	1,780	41,867	23.5
		Maintain then Sustain 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	2,685	41,867	15.6
		Improve 2117 200yr 1	Refurbish Seawall & Crest Raising	2,980	43,913	14.7
		Improve 2117 200yr 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	3,885	43,913	11.3
Sandown Esplanade	IW25	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	170	2,155	12.8
		Maintain 1	Refurbish Seawall	2,025	7,005	3.5
		Maintain 2	Refurbish Seawall & Refurbish Groyne	2,080	7,005	3.4
		Sustain 75yr 1	Refurbish Seawall & Crest Raising	2,925	8,195	2.8
		Sustain 75yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	2,970	8,195	2.8
		Maintain then Sustain 75yr 1	Refurbish Seawall & Crest Raising	2,470	7,849	3.2
		Maintain then Sustain 75yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	2,520	7,849	3.1
		Sustain 200yr 1	Refurbish Seawall & Crest Raising	3,090	8,208	2.7
		Sustain 200yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	3,140	8,208	2.6
		Maintain then Sustain 200yr 1	Refurbish Seawall & Crest Raising	2,515	7,849	3.1
		Maintain then Sustain 200yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	2,565	7,849	3.1
		Improve 2117 200yr 1	Refurbish Seawall & Crest Raising	3,865	8,245	2.1
		Improve 2117 200yr 2	Refurbish Seawall, Refurbish Groyne & Crest Raising	3,920	8,245	2.1
Lake Cliffs	IW26	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	695	2,042	2.9

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
		Maintain	Refurbish Revetment / Seawall & Refurbish Groynes	5,345	5,355	1.0
		Sustain / Improve 1	Refurbish & Raise Revetment / Seawall	7,560	5,606	0.7
		Sustain / Improve 2	Refurbish Revetment / Seawall, Refurbish Groynes & Crest Raising	9,290	5,606	0.6
		Sustain / Improve 3	Refurbish Revetment / Seawall, Construct Concrete Groynes & Crest Raising	10,900	5,606	0.5
		Sustain / Improve 4	Beach Recycling, Refurbish Revetment / Seawall, Refurbish Groynes & Crest Raising	12,110	5,606	0.5
Shanklin Esplanade	IW27	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	800	5,166	6.4
		Maintain	Refurbish Seawall & Refurbish Groynes	3,100	14,071	4.5
		Sustain / Improve 1	Refurbish & Raise Seawall	3,390	17,477	5.2
		Sustain / Improve 2	Refurbish Seawall, Refurbish Groynes & Crest Raising	4,170	17,477	4.2
		Sustain / Improve 3	Refurbish Seawall, Construct Concrete Groyne & Crest Raising	4,515	17,477	3.9
		Sustain / Improve 4	Beach Recycling, Refurbish Seawall, Refurbish Groynes & Crest Raising	5,030	17,477	3.5
Luccombe Road	IW28	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	135	226	1.7
		Maintain	Refurbish Breastwork & Refurbish Groynes	1,165	521	0.4
		Sustain / Improve 1	Construct Timber Revetment & Refurbish Groynes	1,205	536	0.4
		Sustain / Improve 2	Construct Timber Revetment & Construct new Groynes	1,555	536	0.3
		Sustain / Improve 3	Construct Timber Revetment then Seawall. Refurbish Groynes	1,755	536	0.3
Embankment Road*	IW15	Do Nothing	No Active Intervention	0	0	/
		Do Minimum	Reactive Patch and Repair	255	3,737	14.5
		Maintain	Maintenance plan & Armourlock / Gabions	580	14,482	24.9
		Sustain 75yr at Yarbridge	Maintenance plan, Armourlock / Gabions and tide gates	2,745	14,482	5.3
		Sustain 75yr at Emb. Rd	Maintenance Plan & EYS design (setback floodwall)	13,175	15,295	1.2
		Improve 200yr at Yarbridge	Maintenance plan, Armourlock / Gabions and tide gates	2,805	14,482	5.2
		Improve 200yr at Emb. Rd	Maintenance Plan & EYS design (setback floodwall).	13,470	15,542	1.2
		Maintain then Improve 75yr at Emb. Rd	Maintenance plan then EYS design (setback floodwall) later in appraisal period	3,955	15,248	3.9
		Maintain then Improve 200yr at Emb. Rd	Maintenance plan then EYS design (setback floodwall) later in appraisal period	4,035	15,248	3.8
		Maintain then Improve 75yr at Yarbridge	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period	1,160	14,482	12.5
		Maintain then Improve 200yr at Yarbridge	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period	1,175	14,482	12.3

Area	Units	Option	Description of local level measures	PV cost (£k)	PV benefit (£k)	B:C ratio
		Maintain then Improve 75yr at Yarbridge with habitat creation	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period. Operation of EA sluices at Embankment road to create saline habitat.	4,205	13,678	3.3
		Maintain then improve 200yr at Yarbridge with habitat creation	Maintenance plan, Armourlock / Gabions and then tide gates later in appraisal period. Operation of EA sluices at Embankment road to create saline habitat.	4,225	13,678	3.2

4.3 Environmental appraisal

The study area and its surroundings, both onshore and offshore, is highly environmental designated, including international, national and local designations and AONB, reflecting the quality of the natural environment.

To support the assessment an environmental appraisal of the possible methods / long list measures was carried out using a Red, Amber or Green system. For any long list measures taken forward to the short list the evidence from the environmental appraisal was considered. The scale of impacts assessed do not include mitigation which could reduce and limit the environmental consequences, or change potential 'red' assessment to amber etc.

- Red – potentially substantial adverse environmental impacts
- Amber – environmental benefits and enhancements but also adverse environmental impacts, or unlikely to result in a substantial change to the current environmental baseline
- Green – environmental benefits and enhancements and no detrimental impacts

Table 4-2. Summary of environmental assessment

Unit(s)	Measure	Indicative impact (unmitigated)	Comments
Embankment Road – IW15	Reactive patch and repair		Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment		Temporary designation / ecological and landscape impacts (disruption) during works
	Gabions		Potential for intertidal landtake and landscape impacts
	Setback floodwall		Potential change to water percolation impact on some features and landscape impacts, but also providing protection from inundation to substantial freshwater designated habitat.
	Revetment		Potential for intertidal landtake and landscape impacts
	Seawall		Potential for intertidal landtake and landscape impacts
	Road raising		Landscape impacts and temporary disruption to ecology during works
	Tide gates (Yarbridge)		Potential risk to heritage features / landfill sites from flooding. Potential risk to landfill sites from erosion of Embankment Road. Potential change in habitats
	Temporary defences		Potential for temporary impacts on ecology / conservation areas
Yaverland to Sandown – IW22-25	Reactive patch and repair		Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment (of existing seawalls / revetments)		Temporary designation / ecological and landscape impacts (disruption) during works
	Capital refurbishment (groynes)		Temporary landscape impacts. No extension seawards but potential for increase in footprint laterally (longshore)
	Beach recycling		Temporary ecological impacts during works. Sediment movement impacts
	Beach nourishment		Large quantities of new sediment could impact ecological sites downdrift
	Gabions		Unlikely to require landtake from intertidal area but could impact proposed or recommended designated sites and landscape
	Groyne improvement (lengthening)		Temporary disturbance of intertidal and potential for permanent intertidal/subtidal landtake. Changing sediment movement patterns.
	Groyne construction		Temporary disturbance of intertidal and potential for permanent intertidal/subtidal landtake. Changing sediment movement patterns.
	Revetment		Potential for intertidal landtake and landscape impacts

Unit(s)	Measure	Indicative impact (unmitigated)	Comments
	Seawall		Unlikely to require landtake from intertidal area (if built as close as possible to the current structure) but could impact proposed or recommended designated sites and landscape
	Crest raising / wave return		Permanent landscape impacts and temporary impacts during construction
	Setback floodwall		Permanent landscape impacts and temporary impacts during construction
	Road raising		Temporary adverse effects during construction
Lake and Shanklin (IW26-28)	Reactive patch and repair		Temporary designation / ecological and landscape impacts (disruption) during works. Impacts will worsen once existing structures reach the end of their life.
	Capital refurbishment (of existing seawalls / revetments)		Temporary designation / ecological and landscape impacts (disruption) during works
	Capital refurbishment (groynes)		Temporary landscape impacts. No extension seawards but potential for increase in footprint laterally (longshore)
	Beach recycling		Temporary ecological impacts (disruption) during works and potential for sediment movement impacts
	Beach nourishment		Large quantities of new sediment could impact ecological sites downdrift
	Gabions		Unlikely to require landtake from intertidal area but could impact proposed or recommended designated sites and landscape
	Groyne improvement (lengthening)		Temporary disturbance of intertidal and potential for permanent intertidal landtake. Changing sediment movement patterns.
	Groyne construction		Temporary disturbance of intertidal and potential for permanent intertidal landtake. Changing sediment movement patterns.
	Revetment		Potential for intertidal landtake and landscape impacts
	Seawall		Unlikely to require landtake from intertidal area (if built as close as possible to the current structure) but could impact proposed or recommended designated sites and landscape
	Crest raising / wave return		Permanent landscape impacts and temporary impacts during construction
	Setback floodwall		Permanent landscape impacts and temporary impacts during construction
	Cliff stabilisation		Permanent landscape impacts and temporary impacts during construction

The environmental appraisal also identified a number of environmental opportunities along the frontage which could be supported by the various defence measures. Table 4-3 below summarises the opportunities.

Table 4-3. Summary of environmental opportunities along the frontage

Opportunity		Supporting measures
	Public realm enhancements – such as landscape improvements, esplanade information boards, public seating etc.	Hard defences at the back of the beach – for example seawalls, revetments, existing structure refurbishments.
	Beach levels – high beach levels to support tourism, recreation and visual aesthetics of the area	Groyne refurbishments or improvements, beach nourishment and recycling
	Flood and erosion protection – improvements to health, material assets and environmental designations	Refurbished defences, raising of existing defences, floodwalls, seawalls or revetments.
	Species colonisation – e.g. man-made rock-pools / Vertipools	Groyne refurbishments / construction
	Habitat creation / protection – opportunities at Brading Marshes behind Embankment Road, subject to Regional Habitat Creation Programme objectives	Embankment Road or Yarbridge options in unit IW15
	Coastal processes – continuation of erosion of undefended cliffs at southern end of the site leading to natural exposure of sediments (supports species) and sediment input to the littoral system	NAI options for south side of the study site

4.4 Social / Stakeholder appraisal

To support the assessment of options evaluation and consideration of stakeholder aspirations, objectives and feedback was carried out to determine if this influences option choices and if the preferred economic option supports the aspirations for the frontage.

4.4.1 Early stakeholder engagement

The IoW Council facilitated early stakeholder consultation during the initial stages of the study to gather the initial thoughts and aspirations of stakeholders on the constraints and opportunities along the frontage. This included elected representatives, statutory organisations, utilities and a wide range of local organisations, businesses and representatives with an interest in the coastline. This section of the report summarises these findings and relates them to the options which have been identified in the appraisal. The stakeholder feedback has been categorised into the following categories; Environmental, Economic / Commercial, Engineering and Miscellaneous. The Sandown Bay Study has been extended to include consideration of Embankment Road, Bembridge. The outputs of the work throughout the study area will be published for further consideration by stakeholders, leading towards the development of future coastal defence schemes.

Environmental

The 5-miles of beach in Sandown Bay is rare and the importance of it in supporting the community has been highlighted as well as the wide range of environmental designations present throughout the study area, reflecting the quality and importance of the natural environment.

Environmental and heritage designations - a number of stakeholders outlined the key environmental and heritage designations in the study area, including SAC, SPA, Ramsar, SSSI, pSPA, rMCZ, SINCS, three Conservation Areas and numerous heritage features. These have been identified and discussed in the Environmental Appraisal and environmental baseline report.

Man-made rock-pools - as part of a local initiative a number of man-made rock-pools (vertipools) have been created across the frontage. The pools encourage species colonisation in the area. Rock-pools and tiles have been installed within the Sandown Bay groynes to the north of the Sandown Browns mini golf course (at Yaverland) and also on the north side of the concrete groyne at Hope Beach, Shanklin. The leading options outlined in this appraisal will support the ongoing use of the rock-pools along the frontage. Where the pools are already in place, defence works can be timed / designed to cause minimal disruption. Elsewhere, should finances permit, groyne refurbishments could incorporate a rock-pool design into the finish.

Marine dredging - the Marine Management Organisation (MMO) provided a list of the active aggregate licence areas offshore of the frontage and a link to the south coast cumulative impacts study. None of the shortlist options include beach nourishment measures and therefore the options will not be looking to obtain sediment from any of these licence areas. There has also been locally raised concern that offshore aggregate dredging might be an independent cause of beach depletion and an increase in wave heights reaching the frontage. This key concern is acknowledged, and independently-monitored beach level trends over the past twelve years have been examined as part of this study, however, as discussed in the accompanying coastal processes report, at the current time there is no evidence to support a causal link with offshore dredging.

Natural England engagement – a workshop was held with Natural England and the project team and the early options that were emerging from the appraisal were discussed. During this meeting Natural England highlighted their preferences for the management of the frontage and had no initial objections to ‘softer’ engineering approaches such as beach recycling or nourishment, provided the environmental impacts were fully assessed during scheme development. Natural England stated that any future assessment and scheme development at a later stage should consider the following:

- Landtake from designated sites
- Highlight any likely impacts on features to be designated by the rMCZ or pSPA
- Implications for other parts of the coastline / their designated features

Natural England confirmed that they will look provide continued input to the preferred options at Embankment Road but could not confirm their preference for the option during the meeting. However, following the initial consultation the impacts of allowing progressive saline ingress at Embankment Road were communicated by Natural England. The main impact will be to adversely modify the wetland habitat and seasonal vegetation inundation communities from their existing freshwater to a brackish/saline state. The following designated features will be negatively impacted:

- Assemblages of breeding birds – Lowland damp grassland SSSI, Lowland open waters and their margins SSSI
- Ditches
- Lowland mire grassland and rush pasture

- Lowland neutral grassland SSSI
- Lowland wet neutral grassland SSSI
- Lowland wetland including basin fen, valley fen, floodplain fen, water fringe fen, spring/flush fen
- Vascular plant assemblage

From a practical habitat management and ownership perspective, mitigation areas are not available locally, safe stocking for conservation grazing purposes becomes harder to achieve safely, and both Basic Payment Scheme land values and Countryside Stewardship Scheme values will reduce. These impacts are likely to be realised with any options at Embankment Road which do not involve raising of the frontline defences (e.g. Do minimum, maintain or the Yarbridge setback approach).

Economic / commercial

Train passengers - South West Trains provided the number of passengers in Island Line stations. This information was used to update the economic assessment and the valuation of indirect damages / benefits associated with disruption to rail travel through flooding or erosion.

Beach maintenance - a range of beach maintenance activities are currently undertaken along the frontage. For example, every spring the Longshoremen move sediment up the beach from the intertidal in some locations, notably parts of Sandown Esplanade, Small Hope Beach and Shanklin Esplanade. This is done mainly for the amenity benefit of the beach but it could also have a potential benefit of helping to protect the structures at the back of the beach. Other maintenance activities include mechanical beach cleaning in the summer (removing buried glass etc.) and litter picking by hand. For options which include beach recycling it would be important to assess the impact of these maintenance activities on the success of a recycling scheme (to develop the options further at a later stage if required, although this approach is not identified as the most cost-effective to date). Sandown and Shanklin beaches were given Seaside Awards in 2017.

Beach levels – The importance of the beach and healthy beach levels to the key tourism economy of the area was highlighted by stakeholders. This report has carefully sought and costed defence improvements both with and without groyne improvements, to seek options which can help maintain beach levels, as well as continue to prevent erosion and reduce increasing flood risks. This allows the costs and of the different approaches to be considered and future challenges and opportunities to be understood. Annual surveys of beach levels in Sandown Bay are undertaken by the Regional Coastal Monitoring Programme (available at https://www.channelcoast.org/reports/). The shorter-term variability of beach levels (dependent on a combination of storms, tides and wind directions) has also been highlighted by the stakeholders.

Access –Roads, footpaths and Rights of Way – Road access adjacent to the coast to communities and businesses is a key infrastructure asset in the area, as are esplanade footpaths along the waterfront, cliff foot and cliff-top. Ongoing minor maintenance of the defences and cliffs currently helps maintain these assets. The potential of future erosion and flooding to remove these access roads and footpaths has been considered within this study and opportunities to maintain these assets have been sought and costed. Whilst sea defences at the toe of the cliff reduce the rate of erosion of the cliffs, rockfalls and talus slope failures cannot be entirely prevented due to the impacts of weathering, climate change and vegetation on the cliff faces. The rights of way and footpaths along the seafront are also anticipated to be considered as part of the upcoming English Coastal Path initiative, which will highlight their importance, although challenges in funding their future maintenance remain.

Regeneration –There are aspirations to encourage and promote regeneration in The Bay area, and at specific sites along Shanklin Esplanade in particular. Any regeneration proposals would benefit from coastal defences being refurbished to protecting the access road to these sites (and protect the existing properties in the area), and benefit from any additional defence improvements reducing future risks in the area. Regeneration proposals and opportunities will continue to be considered alongside future development of coastal defence schemes in the Shanklin area and in the Bay.

Engineering

Southern Water assets - Southern Water provided a list of assets in the area which may / may not be impacted from flooding or erosion. These significant assets include the Sandown Water Treatment Works serving the Island, Eastern Gardens pumping station between Culver Parade and Sandown Esplanade and Hope Beach pumping station in Shanklin. The do something options outlined in the appraisal will protect these assets from erosion and/or flooding, and they would benefit from continued defence of the frontage. Southern Water has also announced an investment in improving water quality in the Shanklin area.

Key utilities – In addition to the Southern Water information above, Table 4-4 below summarises the key utilities along the Sandown frontage. Note that this list is not exhaustive and future appraisals should investigate utilities further. Schemes which protect these assets could provide indirect benefits to the area (including benefits to the wider communities beyond those immediately at risk) and potential financial contributions may be relevant from utility companies for schemes, although this will need to be explored in more detail during future appraisals.

Table 4-4. Key utilities identified in study area

Area	Key utilities present
Embankment Road (IW15)	- Telephone infrastructure and cables - Gas network located along Embankment - SSE electricity cables
Yaverland to Sandown (IW22-24)	- BT openreach infrastructure at Yaverland village and behind defences (inc. poles, ducts and kiosk) - SSE high voltage and low voltage cables behind defences at Yaverland Road - SW Sandown Water Treatment works, Eastern Garden pumping station
Sandown (IW25)	- BT openreach infrastructure (inc. ducts & poles) behind defences - Gas network located close to frontage near Sandown Pier - SSE high voltage cables adjacent to Sandown Pier. Low voltage cables along Sandown frontage and behind defences, adjacent to pier and in Sandown town.
Lake cliffs (IW26)	- BT openreach infrastructure behind cliff top and adjacent to Hope beach - SSE cables at cliff top and along Cliff Road (High and Low voltage)
Shanklin (IW27-28)	- BT openreach infrastructure (inc. poles, jointbox) behind defences - SSE cables at cliff top - SW Hope Beach pumping station

<u>Miscellaneous</u>

Harbour creation at Luccombe – an idea to create a harbour at Luccombe was proposed by a stakeholder. This suggestion has been taken on board by the project team when examining future alternatives, but regarding funding for this potential scheme idea, this is very uncertain at this stage (i.e. there is not a commitment from stakeholders to provide external contributions for their ideas). Therefore, given that the proposal did not have reasonable potential for funding through government 'flood and coastal defence grant in aid' funding it has not been taken forward in the option development. However, if alternative sources of external funding are obtained, aspirations could be revisited during subsequent design stages following this study.

In addition, this shoreline is currently undefended, and both this study, and the underlying Shoreline Management Plan (2011) policies on which it is based, do not recommend extending defences into undefended areas. It is essential that the erosion and retreat of the cliffs in the Luccombe area continues to supply sediment to the beaches of Sandown Bay. A harbour structure could bring economic benefits but would also interrupt the continuous natural longshore drift sediment supply from south to north along the bay, and impact upon the designated intertidal and subtidal zones.

Removal of the Osborne Groyne –This suggestion was made during the consultation, and the concerns over this structure were taken on board in the Study. A range of options for improving the defences along Shanklin Esplanade have been developed by the study, including changes from the current approach. It is also noted that beach levels updrift (south) of the Osborne Groyne have, over the past twelve years, overall remained stable or slightly accreted, therefore it is possible that removal of the groyne could result in lowered beach levels along the southern half of Shanklin esplanade. The appraisal has revealed it is difficult to fund groyne upgrades and replacements (even more so than repairing seawalls) and funding has not currently been identified to redesign and replace this groyne. However, the recommended preferred option involves refurbishments to Osborne groyne and the timber groynes along Shanklin Esplanade in the future (dependent on funding availability). This will help to keep these structures functioning for as long as possible and potentially have a positive impact on the variable beach levels along the frontage.

Managed Realignment at Yaverland – an aspiration to breach the seawall and redesign the flood defences at Yaverland to allow better access from the lower land behind and potentially aid development in the area has been considered. However, the Eastern Yar valley is very low-lying (with much of the valley only approx. 1m above sea level, so vulnerable to inundation by the sea without the current defences). This longlist option has not been taken forward in this study for a number of reasons, including, the low land levels would mean an arc of new flood wall/embankment to protect the surrounding settlements would be very large and costly, any development in front of the new defence would be increasingly vulnerable to regular tidal inundation, and both the new setback floodwall and the remainder of the seawall preventing erosion would require ongoing maintenance costs. Also, the seafront road would have to be re-routed across a breach on a bridge, or the road moved permanently away from the seafront, and sediment accumulation could affect water flow and water quality in the area. A range of alternative options and their benefits have been considered. Concerns were also raised on the suitability of rock armour as an alternative method of improving the defences, regarding the safety of this method (i.e. gaps between the rock armour boulders) in a popular family tourist area.

Summary

In summary, a range of suggestions and issues informed the option appraisal, and there were no significant constraints identified from the early consultation responses which may significantly alter the choice of the preferred options. However, there are a number of aspects which, if certain options are selected as the preferred option or scheme, will need to be investigated and developed further in subsequent design stages, including seeking local funding opportunities.

4.4.2 Isle of Wight Council option preferences

When undertaking the appraisal process the project team identified some preferences from the Isle of Wight Council for the options along the frontage. Where possible, the options should;

- consider working with existing structures to seek cost-efficient approaches and identify if options are available within the footprint of the existing defences; and
- help to maintain the beach levels along the frontage, including for the purposes of amenity and to encourage recreation / tourism in the area.

The option appraisal process has shown that options which meet these preferences are not necessarily the most cost effective approaches (particularly with regards to beach levels). However, meeting the preferences of the Council is important when selecting the preferred options and where the preferred option is not the leading economic option the case for change has been explored.

5. Preferred Options

5.1 Preferred options

In the following figures the preferred options for each unit are presented, including the timing and type of works proposed. Where years are stated for implementing specific measures these are used as a guideline / estimate and are specified for costing purposes. Funding will need to be secured to take forward these preferred options. Further information on funding is provided below, and Chapter 8 of the full Options Report, which also provides a full commentary on these preferred options.

In reality, if a defence is still in a good condition when the works are specified then they could be delayed. Furthermore, sea level rise projections are inherently uncertain, and therefore crest raising or structures to protect against flooding may be required before, or after, the time periods specified in this report. Continued monitoring of sea levels should be carried out in the future to determine when exactly interventions are required.

Stakeholder engagement was undertaken and fed into the development of these preferred approaches and schemes. The next stages will involve discussions of the proposed preferred options (and proposed future schemes) with a wide range of organisations, representatives and the community.

Figure **5**-**1** shows the proposed preferred option in Yaverland and Culver Parade (units IW22-24). Figure 5-2 shows the proposed preferred option approach at Sandown Esplanade (unit IW25). Figure 5-3 shows the proposed preferred option for Lake Cliffs (unit IW26). Figure 5-4 shows the proposed preferred options for Shanklin Esplanade (units IW27 and 28). Figure **5**-**5** shows the proposed preferred option alternatives for Embankment Road, Bembridge (IW15).

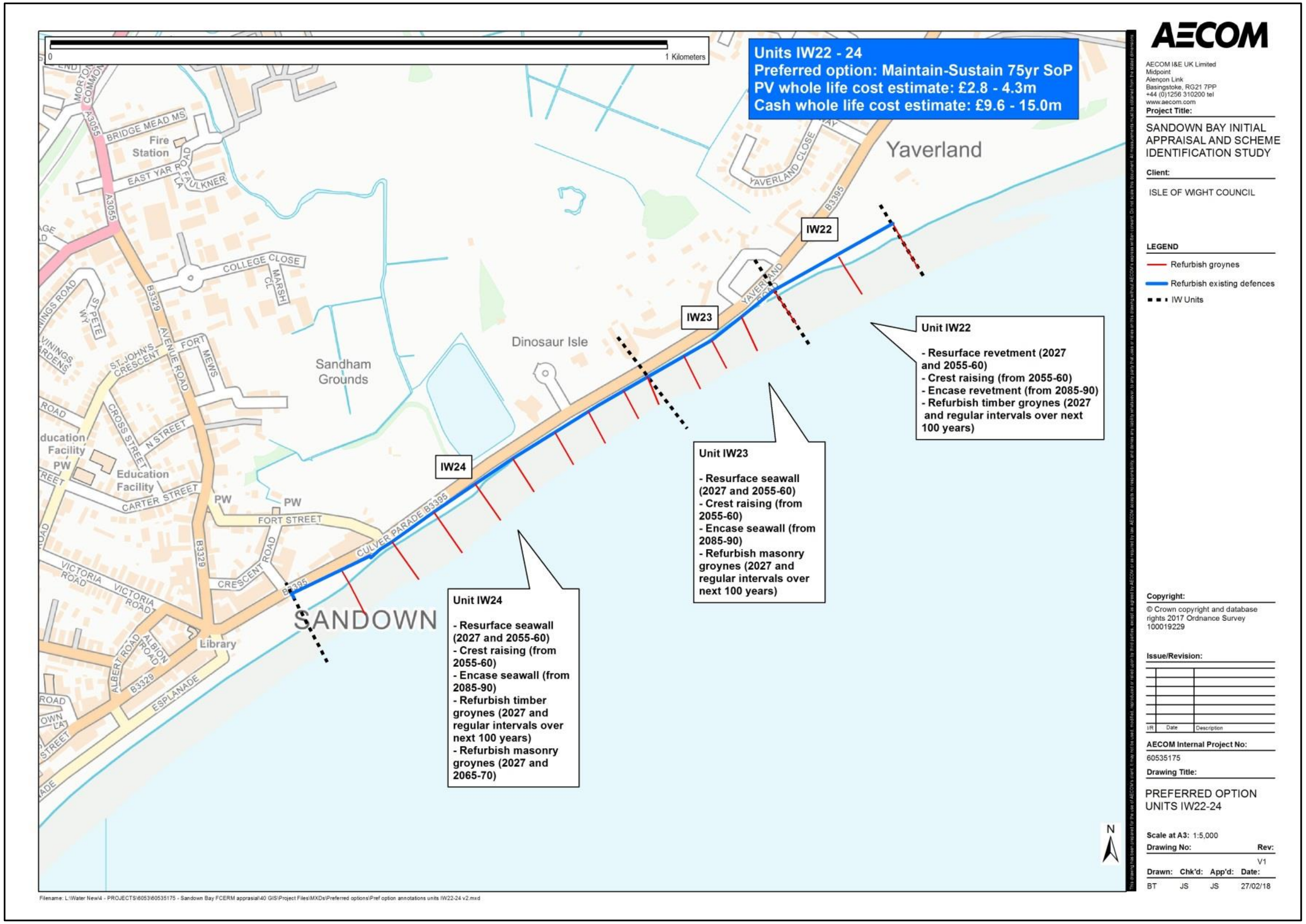

Figure 5-1. The preferred option for units IW22-24 is to 'Maintain then Sustain' the standard of protection to a 1 in 75year standard. Please see the Options Report, Chapter 8 for further details.

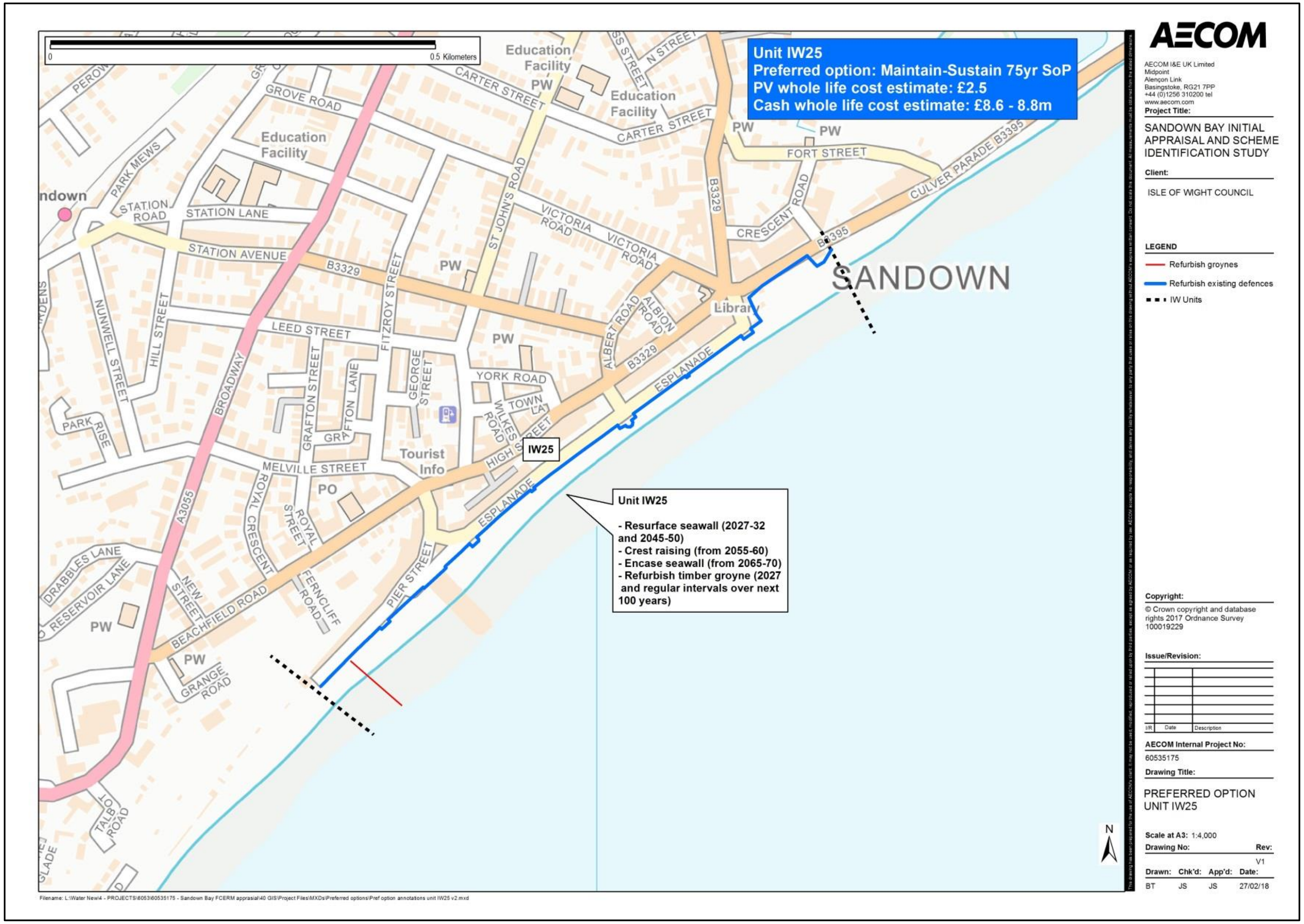

Figure 5-2. The preferred option for unit IW25 is to 'Maintain then Sustain' the standard of protection to a 1 in 75year standard.

Please see the Options Report, Chapter 8 for further details.

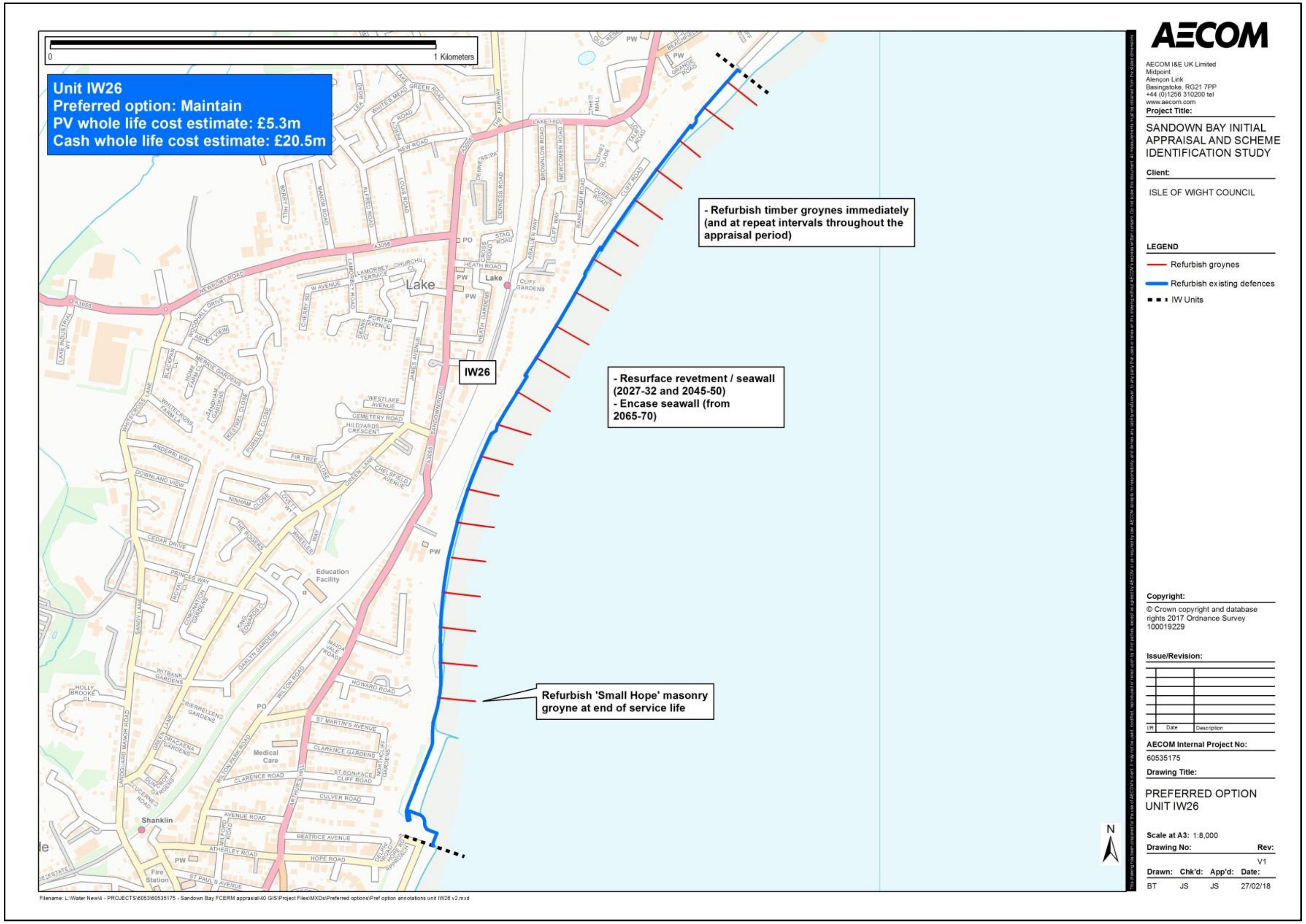

Figure 5-3. The preferred option for unit IW26 is to 'Maintain' the current defences, but not raise them, due to funding constraints. Please see the Options Report, Chapter 8 for further details.

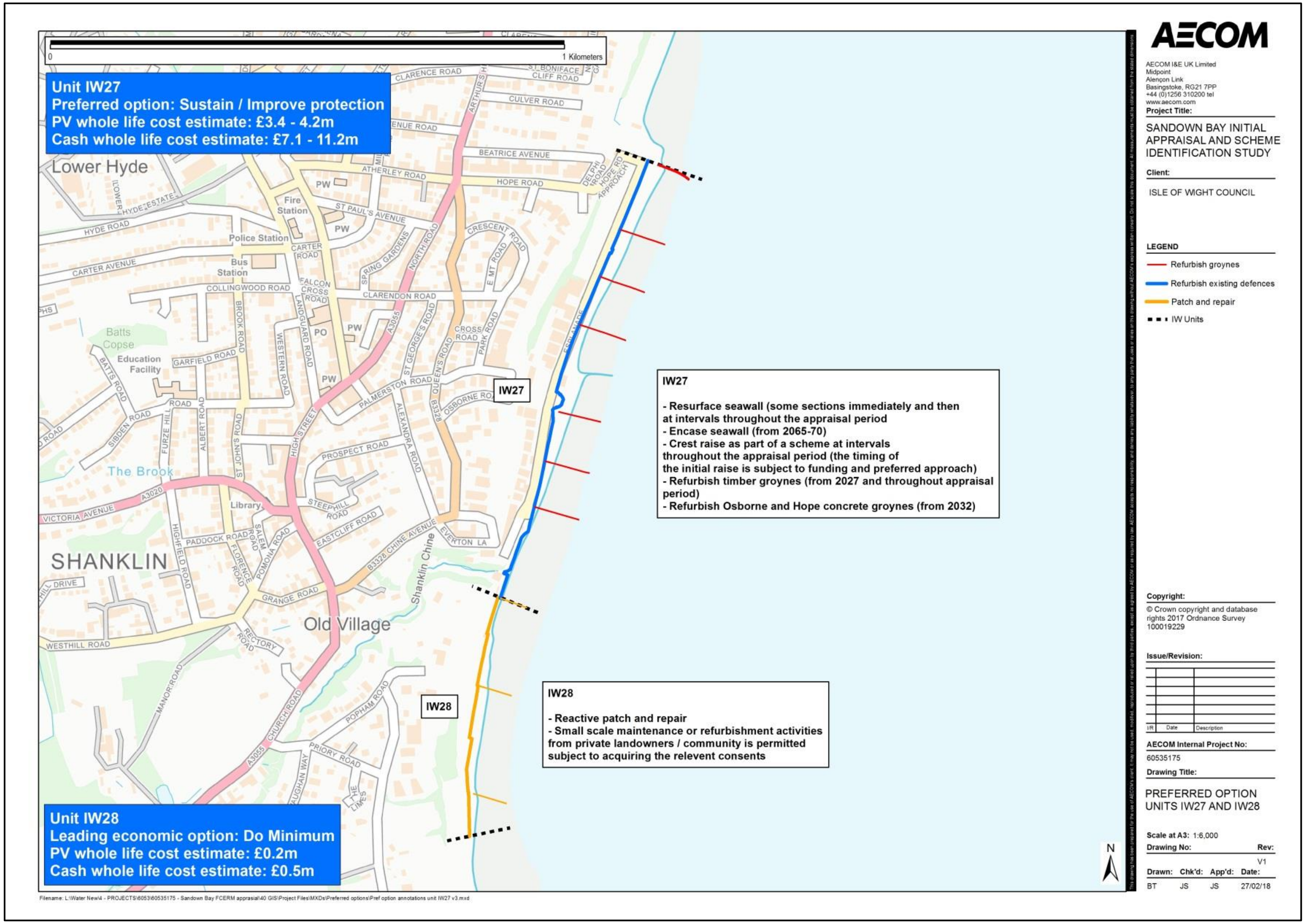

Figure 5-4. The preferred option for unit IW27 is to 'Improve/Sustain' the standard of protection; For unit IW28 the leading economic option is to 'Do Minimum' or the alternative option is to 'Maintain'. Please see the Options Report, Chapter 8 for further details of these alternatives.

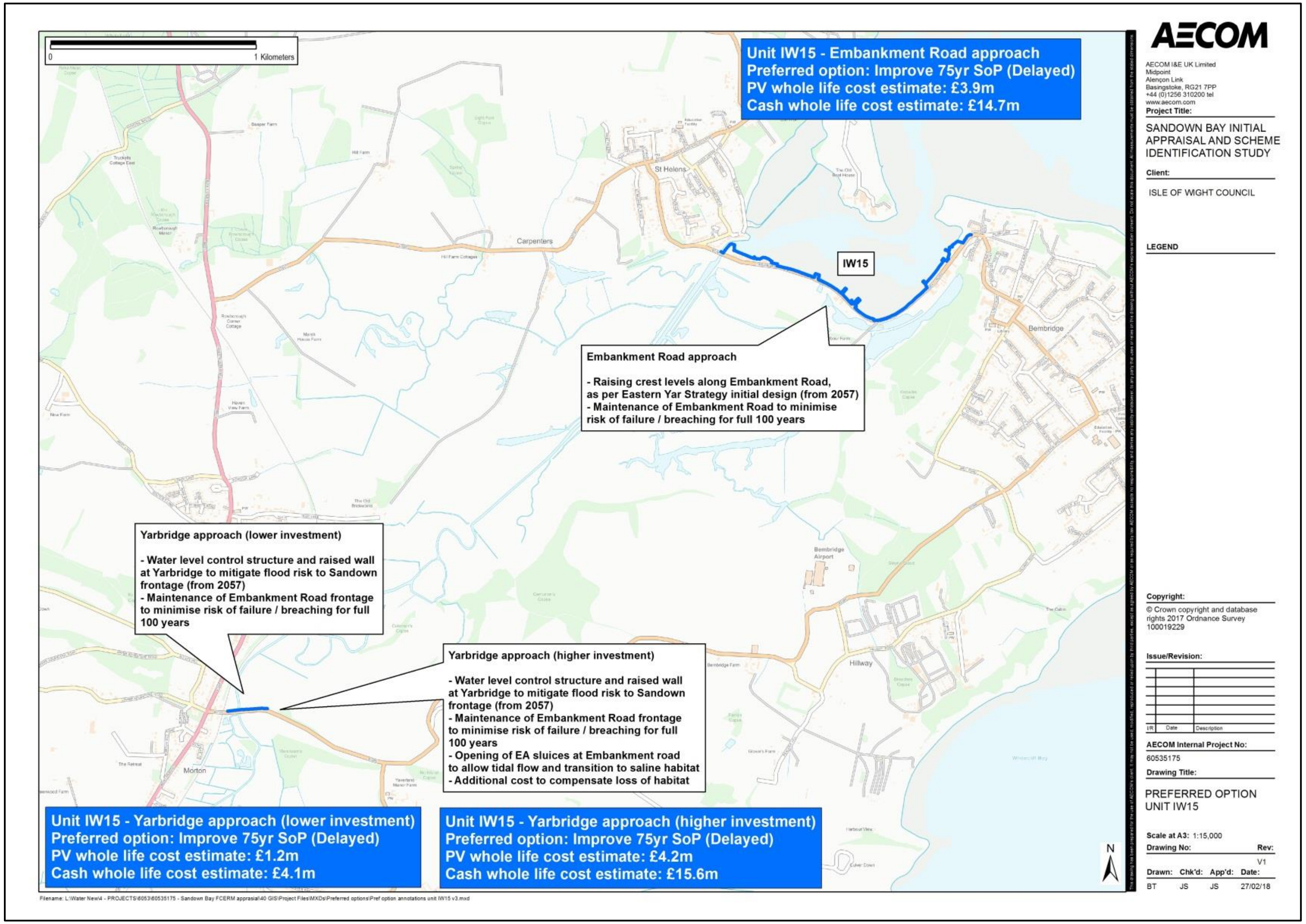

Figure 5-5. The choice of potential approaches in unit IW15 (frontline at Embankment Road, or setback at Yarbridge), , which would deliver the proposed option to 'Maintain then Improve' the standard of protection to a 1 in 75year standard. Please see the Options Report, Chapter 8 for further details of these alternatives, and also a further potential approach including intertidal habitat creation.

6. Priority schemes and funding

The first ‘schemes’ required to deliver the preferred options have been identified, and those with the greatest possibility of securing a higher proportion of national FCERM Grant in Aid (GiA) funding have been identified. These are termed the ‘priority schemes’ and are discussed in more detail in this chapter.

The schemes are eligible for a proportion of GiA, and in situations where the schemes are unlikely to be fully funded then the Isle of Wight Council and Environment Agency will seek the remaining funding for these schemes. Funding contributions can be sought from anyone benefitting from a scheme or from other grants such as Local Levy, Local Enterprise Partnership etc. Striving to deliver broader outcomes and wider benefits for the communities as part of schemes may help unlock additional potential funding streams.

National ‘Grant in Aid’ funding for coastal and flood defence schemes is given to those areas most at risk nationally, so schemes are prioritised through an assessment of outcomes, and local ‘partnership funding’ contributions are required to help fund most schemes. The size of the partnership funding contributions required varies dependent on the outcomes measures delivered by the scheme. Ongoing maintenance costs will generally still require non GiA funding and this is also an important consideration from the perspective of overall affordability.

6.1 Shanklin seawall / groyne refurbishment

The section of wall along the northern half of Shanklin Esplanade (unit IW27/02) is in a poor condition and has a low residual life. The wall was constructed pre 1900 and there are a number of large cracks with the fill material exposed in many locations. The proposed preferred option for this unit (Sustain / Improve performance) recommends an initial refurbishment of this section of defence (using a sprayed concrete technique to extend the life of the existing seawall, as has been used previously along Culver Parade in The Bay).

Elsewhere in unit IW27 (along the southern half of Shanklin Esplanade) the seawall is generally in a fair condition but notable areas are also in poor condition. The timber breastwork at the southern end of the unit is in a fair condition. To deliver the preferred option these sections of defence will also require refurbishment before the end of their service life. For the purpose of costing it was assumed that the initial refurbishments in this unit would be carried out in two stages; the first phase for the wall in unit IW27/02 and then the second phase for the remaining sections of defence from year 2027-32. However, in order to maximise the benefits of the scheme the full length of defence could be refurbished in one go. This would provide a consistent Standard of Protection and ensure that the benefits for the whole unit could be counted (rather than just IW27/02) and for the full service life of the newly refurbished defence. This includes a significant number of properties at risk of erosion including permanent loss of access, discussed further below.

The proposed preferred option for this unit also recommends the refurbishment of the groynes which could help to control beach levels and extend the life of the seawall. The cost of refurbishments to the timber groynes (20% material replacement) and also to the concrete groynes (Hope and Osborne groynes) have been included in the funding calculations (unless otherwise stated). Hope and Osborne groynes typically have a longer service life (15-25yrs) than the timber groynes (8-20 years) and therefore GiA calculations with/without costs to refurbish the concrete groynes have been undertaken.

In order to Sustain / Improve the performance of the defences it could also be necessary to raise the height of the defences at some point over the next 100 years, although without detailed flood modelling in the area it is difficult to establish the requirement for this. Typical defence heights in the unit are 2.8-4.9m with low spots of 2.2m. The purpose of this raising would be to reduce the potential for waves to overtop the defences in the future (due to sea level rise) and affect esplanade properties and infrastructure and eventually interact with the cliff toe which could potentially reactivate the former sea cliff and lead to cliff top erosion. Numerical modelling is not currently available for this unit and it is therefore recommended that to support delivery of the scheme in the future that numerical modelling of the area is undertaken to better determine the need for crest raising and when it may be required. In addition, the numerical modelling will enable the number of properties between the defences and the cliff toe that are potentially at risk from wave overtopping to be quantified and an economic benefit of the scheme (in terms of flood risk) to be established.

For assessing GiA eligibility, Partnership Funding calculations have been undertaken for the initial schemes with / without crest raising (to a 2057 1:75yr SoP). In reality crest raising may not be required until the latter part of the 100 year appraisal period but for comparison purposes the case for including initial raising in the scheme has been included. Crest raising of the defences in this unit increases scheme costs by approximately £800k (cash cost) which significantly impacts the amount of GiA which is available for the scheme.

An alternative approach to deliver the preferred option would be to encase the entire length of the seawall (which includes raising to desired SoP), but not undertake any groyne refurbishments (as the encasement would include strengthening the toe of the seawall). This approach is higher cost for the initial intervention but has a longer estimated service life (50 years compared to 30) and is a lower total investment over the full appraisal period. For comparison purposes this alternative has also been evaluated.

As a further addition a ‘hybrid’ scheme has been considered whereby the section of wall in the worst condition is encased (located between Hope Car Park and Shanklin Rowing Club) and the remaining wall is resurfaced with concrete spraying was explored. With the scheme the timber breastwork and timber groynes would also be refurbished, but concrete groyne works would not be undertaken. Given that only a section of the defences would be encased with this approach the scheme life is limited to 30 years.

Table 6-1 below summarises the PF scores for the different scheme approaches to implement the initial phase of the coastal defence improvements recommended in the proposed preferred option in unit IW27. The shortfall (contribution required) for each option is listed in the column on the right.

If crest raising is included in an early scheme, access points to the beach, steps and slipways would need to be adapted, as part of future detailed scheme design, as would a tie in point of the crest raising to the rising road at the northern end of the esplanade.

Table 6-1. Partnership Funding scores for an initial scheme at Shanklin Esplanade (IW27)

Shanklin seawall / groyne refurbishments									
Approach	**Scheme duration (years)**	**Capital cost***	**Whole life costs (Present value)**	**OM1 benefit (PV)**	**OM3 properties benefiting**	**PF score (raw)**	**Shortfall**	**Likely GiA (should score reach 100%)**	**Indicative maximum GiA (based on outcomes delivered)**
- Refurbish seawall full length (concrete spraying 814m) **- Refurbish timber breastwork (87 m)** **- Crest raise** **- Refurbish groynes (all timber and concrete groynes)**	30	£2,920k	£3,015k	£16,276k	75	66%	£1,005k	£1,915k	£1,975k
- Refurbish seawall full length (concrete spraying 814m) **- Refurbish timber breastwork (87m)** **- Refurbish groynes (all timber and concrete groynes)** **- (no crest raising; to be implemented later in appraisal period)**	30	£2,135k	£2,225k	£16,276k	75	89%	£240k	£1,895k	£1,975k
- Refurbish seawall full length (concrete spraying 814m) **- Refurbish timber breastwork (87m)** **- Refurbish timber groynes only (no refurbishing of concrete groynes)**	30	£1,555k	£1,645k	£16,276k	75	120%	NA	£1,555k	£1,975k

- (<u>no crest raising</u>; to be implemented later in appraisal period									
- Encase part of the seawall (in unit IW27/02 - Hope car park to Shanklin Rowing club, 491m) **- Refurbish remaining seawall and timber breastwork (total 410m)** **- <u>Refurbish timber groynes only</u> (no refurbishing of concrete groynes)**	30	£2,580	£2,670	£16,276k	75	74%	£670k	£1,910k	£1,975k
- Encase seawall full length (including crest raising 814m) **- Replace breastwork with seawall (87m)** **- (<u>no groyne</u> refurbishments)**	50	£3,335k	£3,480k	£16,503k	75	66%	£1,140k	£2,195k	£2,290k

** Note that capital costs include appraisal costs*
***Number of OM3 properties benefiting needs to be further confirmed with EA during each stage of scheme development.*

As shown in Table 6-1 the PF scores for the different approaches to implementing the initial phase of the preferred option fall between 66-120%. The approach with the most favourable score involves refurbishing the full length of the seawall (via resurfacing – spraying) and also the timber groynes. However, it does not include costs for crest raising of the defences at the low spots (e.g. next to Sail/Surf and 'Lazy Wave' establishments) and refurbishing the concrete groynes (Hope groyne and Osborne groyne) and in order to deliver the preferred option to Sustain / Improve performance this may need to be undertaken at a later stage (depending on rates of sea level rise and the onset of risk). Further analysis of the inundation and wave overtopping and how this propagates inland in this unit is recommended at a later stage to investigate whether this approach is suitable for implementation of the preferred option– i.e. is crest raising required immediately or can it be delayed until later on in the appraisal period?

If crest raising were to be undertaken as part of the initial scheme it would decrease the PF score and increase the shortfall from approximately £240k to £1,005k. There are potentially a number of benefits associated with initially crest raising in this unit which have not been included in the economic assessment. For example, there are a row of properties located between the cliff toe and the defence line and these properties could potentially be at risk from flooding in the future should the defences overtop. However, with no numerical modelling in this area the potential flood risk benefits associated with crest raising cannot be accurately quantified. Other potential benefits include avoidance of road disruption along this frontage should it flood during an extreme event. These non-quantified benefits could be assessed in more detail during further scheme development and potentially enhance the OM1 (and OM2) benefits and the case for funding.

The full encasement option has a PF score of 66% and an estimated shortfall just over £1m. The main advantage of this approach is that it has an estimated service life of 50 years and includes crest raising within the measure. However, the approach does not allow for groyne refurbishments and therefore there is greater uncertainty in the beach levels in the future. If encasement is the preferred method for refurbishing the defences along Shanklin Esplanade (in the Conservation Area), refurbishments to the groynes could still be carried out during the lifetime of the scheme, although these would require full local funding.

Alternatively, if some lengths of masonry wall refurbishment like-for-like were preferred (in the Conservation Area), this would add approximately £300 per metre cost (based on an approx. 4m wall height, including early optimism bias), although the cost difference could be higher and depends on the type of masonry wall and the finish that is required. Upgrading all 814m of seawall in this way would add approximately £250k to the contributions likely to be required to fund the scheme (in addition to the shortfall listed in the table above).

Photograph examples of concrete spraying and encasement are provided in Figure 6-1.

Figure 6-1. Photographs showing examples of concrete spraying of a seawall at Minehead (left) and encasement at Cromer (right)

6.2 Yaverland defence / groyne refurbishments (IW22-24)

The preferred option for units IW22 to IW24 initially involves maintaining and refurbishing the defences at the back of the beach and the groynes (masonry and timber groynes, timber groynes with a 20% material replacement). This is the recommended approach until 2055-60 when crest raising would be undertaken to provide a 1:75yr SoP.

The initial refurbishment intervention is not proposed until 2027 for the length of the frontage. For the purpose of assessing the GiA availability it has been assumed that the works for the entire frontage will take place together in 2027 by hypothetically 'jumping forward' in time and resetting the economics discounting at this point (PF calculations are not intended for schemes set in the future so therefore it is necessary to reset the baseline date).

Similar to the financing assessment for unit IW27, an alternative approach to implementing the preferred option without groyne refurbishments has also been assessed. This refurbishment of the seawall only is more cost effective initially, although it would be anticipated to have a shorter lifespan overall, as beach levels would not necessarily be retained to help protect it (without the groyne refurbishments), so the concrete spraying refurbishment would require repeating sooner (20 years rather than 30 years).

Table 6-2 below summarises the PF scores for the different scheme approaches to implement the initial phase of the preferred option in units IW22-24. The method of improving the defences proposed is repeating and extending the concrete spaying of the face of the seawall which has already been undertaken along part of Culver Parade (in 2006). If this method is not preferred, alternative costs for other methods are discussed in Chapter 6 in the main options report and would result in increased costs and shortfalls.

Table 6-2. Partnership Funding scores for an initial scheme in at Yaverland & Culver Parade (units IW22 – 24) (nb. 2027 baseline)

Yaverland defence / groyne refurbishments (2027 baseline)									
Approach	**Scheme duration (years)**	**Capital cost***	**Whole life costs (PV)**	**OM1 benefit (PV)**	**OM3 properties benefiting**	**PF score (raw)**	**Shortfall**	**Likely GiA (should score reach 100%)**	**Indicative maximum GiA (based on outcomes delivered)**
- Refurbish seawalls and revetment (spraying – 1160m) - (no groyne refurbishments)	20	£1,610k	£1,645k	£37,142k	1	126%	£0k	£1,610k	£2,075k
- Refurbish seawalls and revetment (spraying – 1160m) - Refurbish all groynes – 10 timber groynes, 6 masonry/concrete	30	£3,890k	£3,955k	£59,374k	1	84%	£635k	£3,255k	£3,310k

**Note that capital costs include appraisal costs*

As shown in Table 6-2 the PF scores for the different approaches to implementing the initial phase of the proposed preferred option fall between 84-126%. The more favourable score is for the 20-year refurbishment approach which does not include groyne works (126%) (therefore any groyne works during this time would need to be funded locally). The shortfall for the alternative 30-year refurbishment approach which includes groyne works is approximately £0.6m. Should the shortfall be found through contributions, the amount of GiA available for approach including groyne refurbishments would be approximately £3.3m.

Commercial properties will also benefit from continued defence in this area, as well as residential properties.

Repairs and outflanking of the slipway at the northern end of the area (e.g. gabions) will require further consideration at the time of detailed design in the future, dependent on the progress of erosion in the intervening period, with potential interim repairs. Future works should also consider potential implications for the environmental enhancement techniques currently being tested on the groynes near Browns mini golf course.

The approach and future scheme for Unit 15 Embankment Road also requires careful consideration alongside this scheme outlined above, and is discussed further below, including consideration of funding contributions.

The Scheme outlined above is for units 22-24 commencing in approximately ten years time, lasting for 20 or 30 years, dependent on the alternative chosen.

In the medium term (approx. 2055-60) crest-raising and further refurbishments are proposed for this area (units 22-24), and defence improvement is also proposed for unit IW15 (at Embankment Road and/or Yarbridge), With this in mind, potential costs and benefits for a Scheme in 2057 combining defence elements in both units (at both ends of the floodplain) have also been assessed, at a preliminary level, with costs and benefits for those units potentially combined in the medium to long term. Further information is provided below.

6.3 Further works

In addition to the priority schemes outlined above, the following locations have also been identified for further consideration. However, generally these GiA eligibility of these further works is much reduced and a significant part of the funding will be need to be sourced from external contributions.

6.3.1 Lake groynes

A section of groynes in the southern section of unit 26 (Lake cliffs) are currently in a very poor condition, and some areas along this frontage have shown localised fall of beach levels over the past decade of approx.15 to + 30%, although the overall pattern is mixed with other areas in the unit are more stable (re. Figure 4-8 in the Coastal Processes Baseline Report). Repairing/refurbishing the groynes in the worst condition could help retain beach levels and extend the life of the existing seawall and esplanade (potentially delaying the time when seawall refurbishment will be required in the future). This relates to 8 groynes in the south of the unit (in a very poor condition shown in red in Figure 3-2 of the Defence Condition Report), although detailed consideration of potential groyne repairs throughout this unit would identify priorities for localised repairs (another 12 groynes in this unit are also in a poor condition).

It is not anticipated these works could be funded by GiA, therefore they would depend on availability of funding contributions.

Currently structures are inspected and assessed alongside other maintenance needs. Repairs are prioritised and undertaken based on risk, with regard to urgency, budgetary constraints and seasonal working.

Costs of a new groyne are estimated at approx. £1,000 to £3,000 per metre. Example costs for groyne refurbishment elsewhere the country (approximate length of 60m) have estimated 10% material replacement on a groyne at approx. £21k, or 20% replacement at £42k, and £30% replacement at 64k (including 60% optimism bias).

6.3.2 Embankment Road, Bembridge

This study has updated options and costs for potential future works in the area of Embankment Road at the back of Bembridge Harbour, to address tidal flood risks in Eastern Yar valley, including different Standards of Protection (SoP) and alternative locations.

The leading economic options identified for unit IW15 involve constructing Tidal flood gates at Yarbridge from 2057. An alternative to this involves raising Embankment Road. Given that the initial capital investment in this unit may be in 40 years time (although it could be progressed sooner if funding is secured, as the SoP is currently 1:20 to 1:25yrs) it is unlikely that the current partnership funding rules will still be in place. However, despite this, indicative partnership funding scores have been calculated to give a general idea of how forthcoming government funding may be when the future scheme alternatives are constructed (note that there is considerable uncertainty in this approach and the existing funding system may change entirely by this time period).

Scores for a combined scheme at the Embankment Road / Yarbridge frontage (unit IW15) and at Yaverland (units 22-24) in approx. 40 years time have also been considered, assuming the lower investment alternative for the preferred option at Yaverland (note that with this combination it has been assumed that the encasement construction works at Yaverland are brought forward by approx. 8 years to 2057 to tie in with Embankment Road scheme. This timing deviates from the original options developed for Yaverland but is acceptable as an exercise to assess potential funding levels. The encasement would include crest raising, subject to rates of sea level rise).

The scores consider the combined benefits and costs of the schemes across these units at this time (but do not double count benefits). The partnership funding scores assume a 2057 baseline representing a 'jump forward' in time, and are presented in Table 6-3 below.

Whilst this unit is not classified as a priority for an immediate scheme, maintenance requirements on the Embankment should be carefully considered in the short term and it is recommended further work is undertaken as a priority to confirm the preferred timing and funding of future capital works. This is required to ensure a coordinated approach and SoP is achieved with the Priority Scheme identified above for Yaverland. There remains considerable uncertainty in the funding for a scheme in this area and there is the flexibility to undertake improvements to the SoP sooner should funding become available. Both the properties at risk and the environmental habitats at risk are important drivers and factors in this area and should be considered going forward.

Table 6-3. Indicative partnership funding scores for unit IW15, assuming a 2057 baseline

Embankment Road / Yarbridge (2057 baseline)			
Approach	**Approximate scheme duration (years)**	**Whole life costs (PV)**	**Indicative PF score (raw)**
Scheme alternatives based on Unit IW15 costs and benefits alone:			
Embankment Road defence raising to 75yr SoP	60	£13,110k	17%
Yarbridge alternative, 75yr SoP	60	£2,670k	77%
Yarbridge alternative, 75yr SoP with intentional habitat creation	60	£14,200k	146%*
Scheme alternatives based on combined costs and benefits in units IW22-24 and IW15:			
Embankment Road defence raising to 75yr SoP and Yaverland encasement	60	£17,415k (Capital costs: £12.8m Embankment Road £4.2m Yaverland)	32%
Yarbridge alternative, 75yr SoP and Yaverland encasement	60	£6,975k (Capital costs: £2.2m Yarbridge £4.2m Yaverland)	81%
Yarbridge alternative, 75yr SoP with intentional habitat creation and Yaverland encasement	60	£18,505k (Capital costs: £13.7m Yarbridge £4.2m Yaverland)	133%*

**note that these options include OM4s for creation of 400 hectares of intertidal habitat, but would also require freshwater habitat compensation (at a significant cost) and finding the land for this is likely to be extremely challenging due to the size of the compensation required (up to approx. 400ha , including both designated and undesignated habitat, please see the Options Report for further details).*
<u>Please note:</u> Further details on how OM2s can be considered in these2057 Schemes above can be found in the Options Report.

It should be noted (regarding Table 6-3 above) that for the majority of approaches/future schemes to mitigate increasing tidal flood risk to the Eastern Yar valley area, these are likely to require significant local funding contributions, which have not currently been identified based on discussions to date. The indicative scheme costs and Partnership Funding scores listed in the table above provide an indication of the scale of this future funding requirement to aid further discussions with key stakeholders and the community on the future of these vulnerable communities, infrastructure and important habitats.

It should also be noted that the scheme alternative listed in the table above with an indicative score above 100% (involving additional creation of intertidal habitat, consequent loss of freshwater habitat, and resulting freshwater habitat compensatory requirements) would require careful further consideration, and may not be acceptable or feasible due to stakeholder wishes, residual risk and/or whether or not there is an appropriate location(s) at which the necessary compensatory habitat could be provided within the required geographical area. This is likely to be extremely challenging due to the potential size of the compensation required.

Presently, embankment structures at Embankment Road and Culver Parade are reducing the risk of tidal (sea) flooding in this low-lying valley area, and continuing to maintain these structures in the short and medium term (as proposed by this study) provides time for further discussion on the future of this area, to consider of the implications of the new alternatives provided, and to seek funding contributions towards future investments to reduce risk. However, all future decision-making within this vulnerable floodplain area should continue to be made in full accordance with an awareness of the increasing potential future risks.

6.3.3 Maintenance

Existing maintenance plays a key role in reducing risks along the coastal defences and cliffs present in the Sandown Bay and Embankment Road study areas. Coastal defence structures are inspected and assessed alongside other maintenance needs based on risk. Repairs are prioritised and undertaken based on risk, with regard to urgency, budgetary constraints and seasonal working.

The study recognises the important role that continued maintenance plays in extending the life of existing coastal defences, having recognised the significant financial challenges in replacing the structures at the end of their service lives. Existing defences will continue to be maintained where the Isle of Wight Council, Environment Agency and asset owners decide to commit resource.

6.4 Indicative funding availability along the frontage

Mapping showing the indicative funding availability for the proposed preferred options along the frontage has been developed. The maps show the PF scores and GiA percentage for the whole life options and benefits over 100 years, rather than the initial schemes (which are discussed earlier in this chapter). It is a useful tool to illustrate the areas along the frontage where funding is likely to be limited or more widely available. However, it should *not* be used to indicate the funding availability for the initial schemes or for schemes later on in the appraisal period. For each unit the scheme costs and benefits differ, and future costs are discounted in the assessment, as explained below. The mapping has been produced with the following assumptions and limitations:

- PF score and GiA percentage is based on the whole life option costs and benefits over 100 years and is therefore not representative of a score for initial schemes or later schemes.
- The economic discounting (which is required by national guidance, to take account of risk later in the appraisal period rather than immediately) is based on a present day baseline. This means that for schemes not needed until years 10-15 from now and the capital cost are reduced in the assessment because they are discounted). The maps show the costs in ‘present value’ (discounted) terms. The cash costs are higher, and are provided in Chapter 6 and 8 of the main options report.
- The map should be used to compare the potential for funding between options but does not indicate the exact amount of funding which may be available.
- A range of assets are at risk within the Eastern Yar Valley floodplain. These ‘benefits’ (i.e. what would be protected by works) are divided between the units at either end of the floodplain, at Yaverland (units 22-24) and Bembridge Harbour (unit 15). However, in reality, the flood cell will merge between these units to a different extent depending on the magnitude of the event.

The mapping is shown in Figure 6-2 and Figure **6**-**3**.

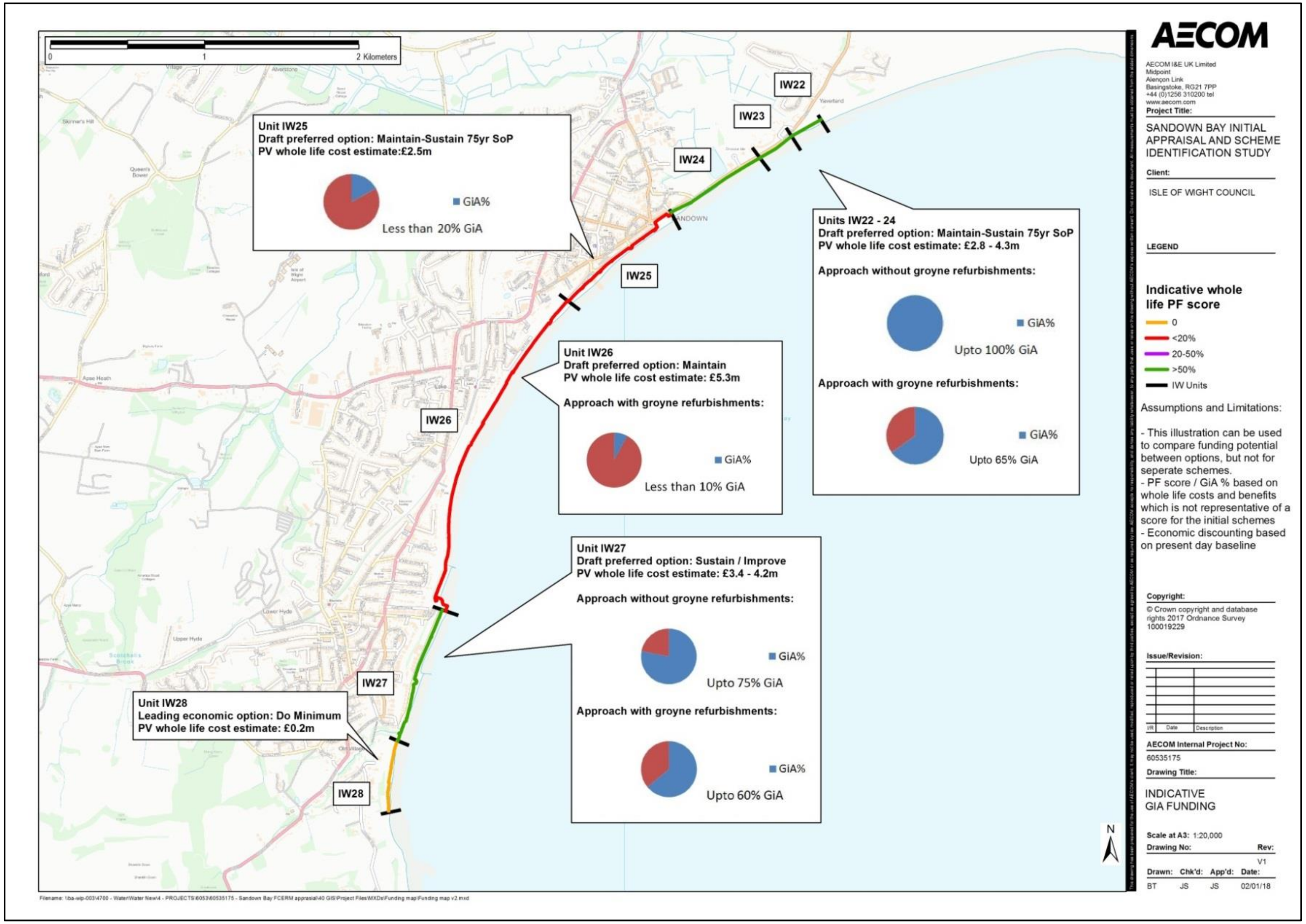

Figure 6-2. Indicative funding map for units IW22-28

(Note: PV refers to present value which takes into account cost discounting for spend over time; Alternative undiscounted 'cash costs' are provided in the maps in Chapter 5).

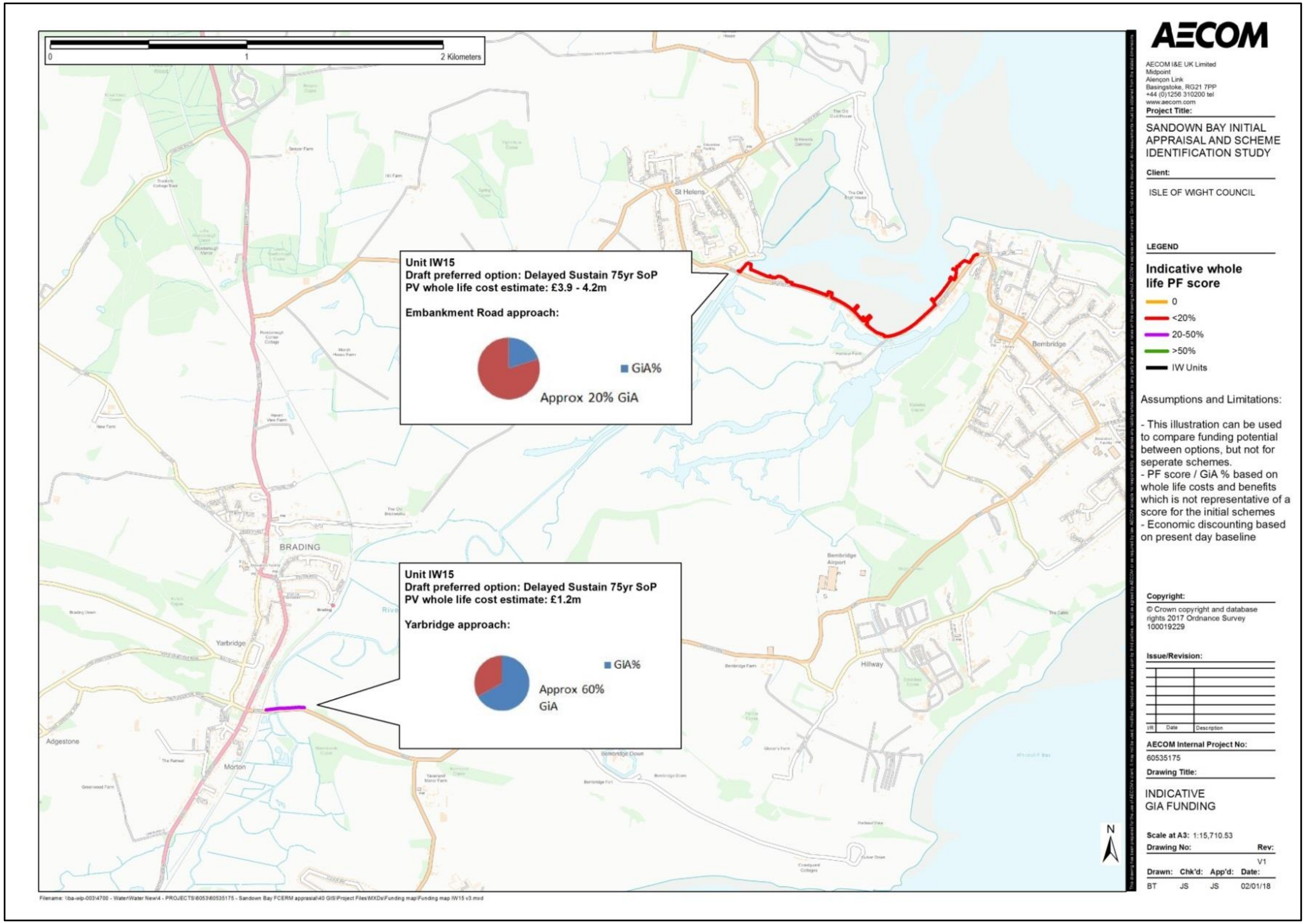

Figure 6-3**. Indicative funding map for alternative approaches unit IW15**

(Note: PV refers to present value which takes into account cost discounting for spend over time; Alternative undiscounted 'cash costs' are provided in the maps in Chapter 5).

AECOM
Midpoint
Alencon Link
Basingstoke
RG21 7PP