Isles of Scilly – Design Services for Off Islands Coastal Erosion Defence and Dune Management

Climate Adaptation Scheme - Preliminary Design - St Agnes

DKR6499-RT002-R03-00

December 2021

Document information

Document permissions	Confidential - client
Project number	DKR6499
Project name	Isles of Scilly – Design Services for Off Islands Coastal Erosion Defence and Dune Management
Report title	Climate Adaptation Scheme - Preliminary Design - St Agnes
Report number	RT002
Release number	R03-00
Report date	07 December 2021
Client	Council of the Isles of Scilly
Client representative	Stephen Swabey
Project manager	Aurora Orsini
Project director	Tim Pullen

Document history

Date	Release	Prepared	Approved	Authorised	Notes
07 Dec 2021	03-00	AGC	AUO	AUO	
18 Aug 2021	02-00	AGC	APO	AGC	
23 Jul 2021	01-00	XX	XX	XX	DRAFT FOR COMMENT

Document authorisation

Prepared	Approved	Authorised
	Aurora Orsini	Aurora Orsini

Executive Summary

This document is a RIBA Stage 3 Design Engineering Report. This report presents the preliminary design for the interventions proposed at different beaches on St. Agnes Island to improve the coastal defences to protect the island and its infrastructure from the threat of climate change.

Three beaches have previously been identified with sites under threat from climate change. HR Wallingford have reviewed the previous proposals at these sites and following a site visit to inspect the existing conditions at each of these beaches, have used wave modelling results from others and have applied our expertise on the impacts of climate change to propose design solutions to protect these beaches.

As appropriate the required water level and wave overtopping protection requirements at the critical sections of each beach have been determined and the sections of the beaches most vulnerable and in need of interventions have been identified and solutions proposed. The previous proposals made in the Outline Business Case (OBC) (Reference 2) were reviewed and these and alternative proposals for each beach have been assessed and recommendations made and preliminary designs developed. These recommendations have considered the critical sections at each beach, it is not intended to provide extensive protection measures around the entirety of the beaches. The recommendations have been developed considering the required technical requirements, the likely costs and construction form to make sure that they are appropriate for the Client's requirements and budget.

During the site visit each beach was assessed in its entirety and in some sites different sections of beach from those identified in the OBC were identified as requiring intervention, and this report sets out the proposed concepts at each site. The proposed protection measures are a combination of revetment and engineered embankments, such as the recommended revetment at Pereglis Beach (site 48 and 49) shown as Figure S.1 and will enhance the level of protection from wave inundation on Bryher. These recommendations will then be progressed to detailed design.

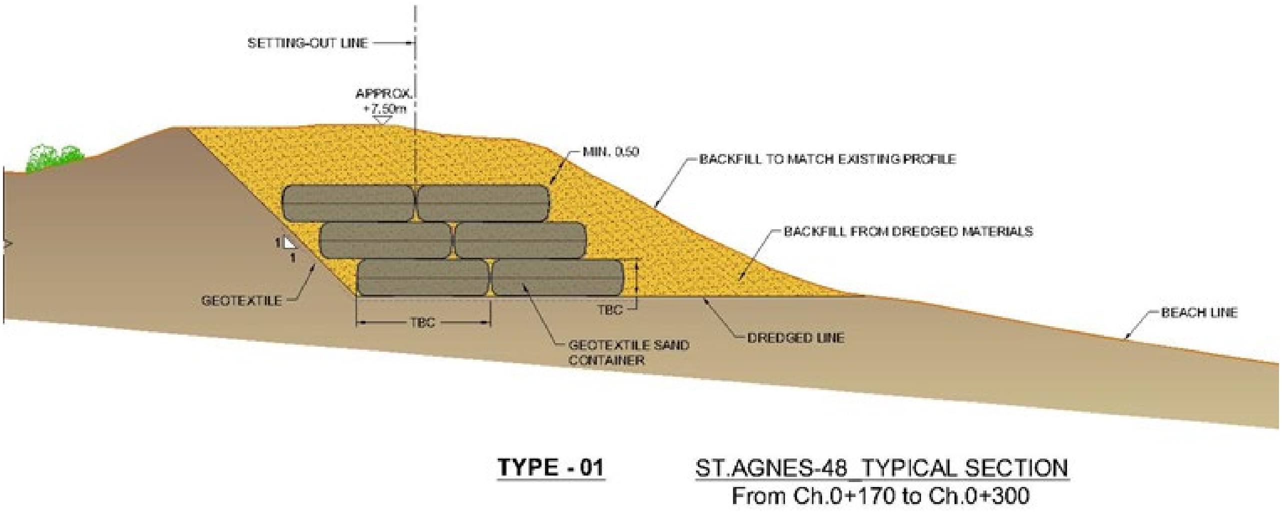


Figure S.1: Proposed revetment at Pereglis Beach

Contents

Figures

Tables

1. Introduction

The Isles of Scilly have received funding from the European Regional Development Fund and the Environment Agency to complete a range of climate change adaptation works in the Scilly Isles of St Agnes, Bryher and St Martins. These include interventions, such as coastal protection works, renourishment of existing beaches and dunes, upgrade or/and construction of new defences, aiming to reduce the impact of coastal erosion and wave overtopping exacerbated by future climate change scenarios.

The Isles of Scilly are one of the areas in Europe most vulnerable to the effects of climate change, sea level rise and consequent increased risk of inundation, overtopping and coastal erosion.

The council of the Isles of Scilly has commissioned HR Wallingford to undertake this work to evaluate the risk at the sites identified as being most vulnerable and develop designs for the coastal works proposed. The present report will describes the approach to the identification, selection, appraisal and development of the schemes to detailed design for the Island of St Agnes.

Conceptual options were suggested and were preliminary appraised as part of previous studies (JBA, 20). These will be qualitatively appraised together with suitable alternatives considered after the site inspection. The preferred schemes will then progress to detailed design.

The presented report is a RIBA Stage 3 Design Engineering Report. It includes design basis, option appraisal and selection of preferred option and development of the preferred option to a suitable level for Planning Application.

1.1. Abbreviations

AOD	Above ordnance datum
BMP	Beach management plan
GI	Ground investigation
OBC	Outline business case
RIBA	Royal Institute of British Architects
RFP	Request for Proposal
SPA	Special Protection Area
SSSI	Site of special scientific interest

2. Scope

The scope of the works includes the following key elements for the sites on St Agnes, as identified in the OBC (Ref. 2 in Table 3.1) and in the RFP (Ref. 1 in Table 3.1):

- Review of documents, data and information
- Review of waves and water levels information
- Site Visit, visual inspection of flood and coastal protection
- Beach stability desk study
- Option appraisal and evaluation, selection of preferred option
- Scheme design RIBA Stage 3
- Scheme Design RIBA Stage 4
- Ground Investigation (GI) Specifications.

The locations of the sites are shown in Figure 2.1 with a more detailed aerial view, identifying the beaches, the location of cross sections at each beach and other identifying features in Figure 2.2. This is also reproduced in Appendix A.

The sites on St. Agnes that have been examined in this scope are:

- Site 48/49 - Pereglis Beach
- Site 50 - Porth Coose
- Site 51 - Porth Killier.

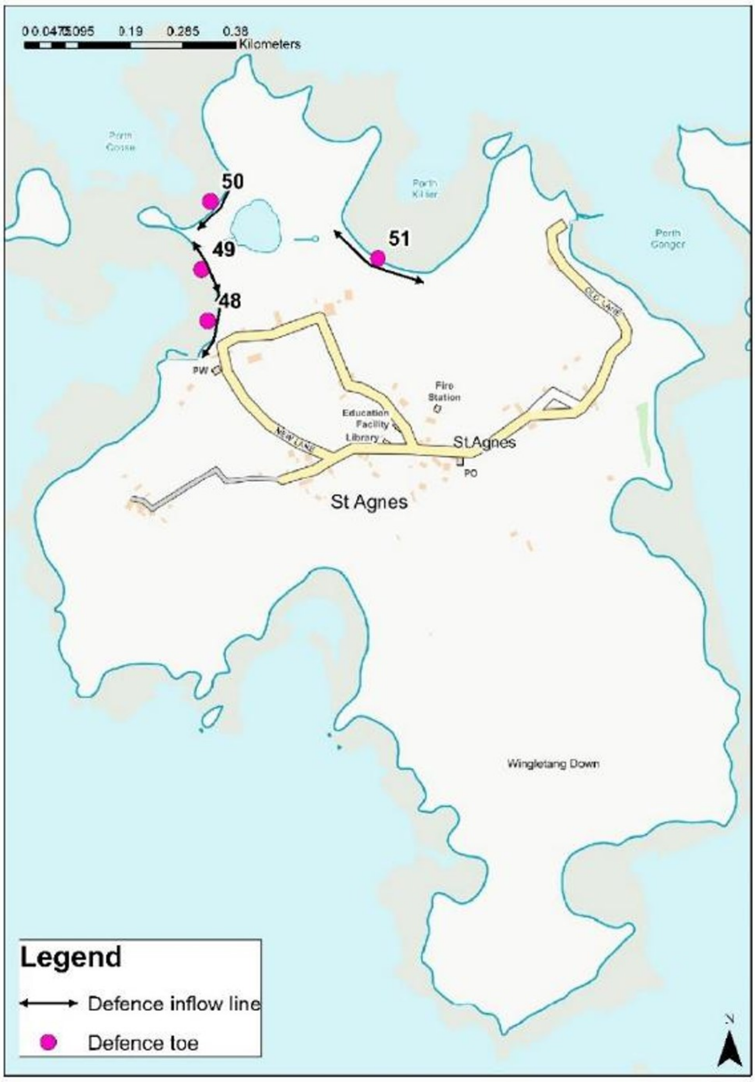


Figure 2.1: Location of sites

Source: Council of Isles of Scilly (OBC, 2020)

Figure 2.2: Location map

Source: DKR6499-001-01

3. Reference documents

Data from the documents/sources described in Table 3.1 below, has been provided by the Council of the Isles of Scilly to be used for the purpose of the design.

Table 3.1: Reference used for the design

Reference Number	Document Title	Published	Provided by
1	Scope of Work- RFP- Annex B_Brief for Off-Island Coastal Defence Works_Final	2021	Council of the Isles of Scilly
2	Adaptive Scillies – Natural Dune Restoration & Flood Resilience – FCERM Outline Business Case	JBA, Arcadis, Council of the Isles of Scilly, April 2020	Council of the Isles of Scilly
3	Isles of Scilly – Coastal Flood Modelling – Final Main Report	JBA, Environment Agency, February 2019(a)	Council of the Isles of Scilly
4	Isles of Scilly – Coastal Flood Modelling- Model development Report	JBA, Environment Agency, February 2019(b)	
5	DKR6499_RT01-Site Visit Notes	HR Wallingford 2021	HR Wallingford

Reference Number	Document Title	Published	Provided by
6	SMP2	2010	Council of the Isles of Scilly
7	SMP2 interim review	2016	Council of the Isles of Scilly

4. Holds

Some HOLDS exist at this preliminary design stage due to insufficient information. The preliminary design can be developed without these data, but these items will need to be addressed before investment decisions and prior to start of construction:

- Detailed Topographic survey (up to low water contour)
- Economic Appraisal, BoQ and detailed costing developed in the OBC
- Ground Investigation Report
- As built drawing Port Killier Seawall.

5. Background

St. Agnes is the southernmost populated island in the Scilly Isles and is very exposed to the wave climate from all directions, even though the islands to the west offer some protection from westerly swells. St Agnes covers an area of 1.8 km^2 and the maximum ground elevation is about 29m AOD.

The area described as Big Pool SSSI and Lower Town (Periglis, Porth Coose, Porth Killier) is vulnerable to erosion and breaching. It is known that sea water inundation of the area poses a threat to the water supply to the Lower Town area. In addition, seawater can affect coastal and fresh water habitats, with migrating birds flocking to the existing fresh water supply.

Flood modelling carried out by JBA (Ref. 3 and Ref. 4, 2019) for the Environment Agency identified that, if left undefended, the water supply would be at risk as well as some properties and buildings to the south of Big Pool. Figure 5.1 shows the location of the most vulnerable sites and the consequences for present day and year 50 (2069 in the JBA report) of a do nothing option.

The isles are particularly vulnerable to the effect of climate change, particularly sea level rise and any increase in wind speed and storminess of the waves.

The subsequent OBC (Ref. 2) in 2020 confirmed that; there was a need to continue working with natural processes while protecting, improving and sustaining the coastal and freshwater habitats. The OBC concluded that this could be achieved by strengthening, improving elevation profiles, raising crest heights, addressing the causes of damage, improving public access and appreciation of the dunes and their coastal defence function. The proposed measures had the aim to manage flood risk (not resist coastal erosion). Where natural dunes exist, the protective measure do not seek to ‘hold the line’ against dune regression, instead they will enable the dunes, as repaired and restored eco-systems, to regress adaptively (as a ‘system’) in a manner that maximises environmental and habitat adaptation.

The recent site visit, however, has found that most of the banks, described in previous studies as dunes, are not actually dunes. The rolling back and natural dynamic response of a dune system, would therefore not necessarily apply here. The dune / banks have been engineered and should be described as embankment structures rather than natural dunes. The increase envisaged in the crest height would therefore need to be engineered and it cannot be done solely with sand nourishment and planting, except for a few localised stretches of the coastal frontages, as discussed below.

It is, however, acknowledged that any intervention needs to consider a natural restoration, where practicable, as part of any solution. Furthermore, it is desired to give the dunes and their eco-systems the capability to better withstand incoming storms, by strengthening their core when possible and recover and reduce the loss of crest height following future extreme storm events and damage.

The OBC stressed the high environmental value and importance of the habitats and the fact that any enhanced protection will need to work with the environmental constraints present in the Island. Figure 5.2 shows a map of the designated sites in the area of required works in St Agnes.

Table 5.1 describes the preferred options as identified in the OBC (Ref.2) and also reported in the RFP (Ref. 1). In Section 9, where considered appropriate, alternative options are also discussed and then are appraised as part of the option appraisal in Section 10.

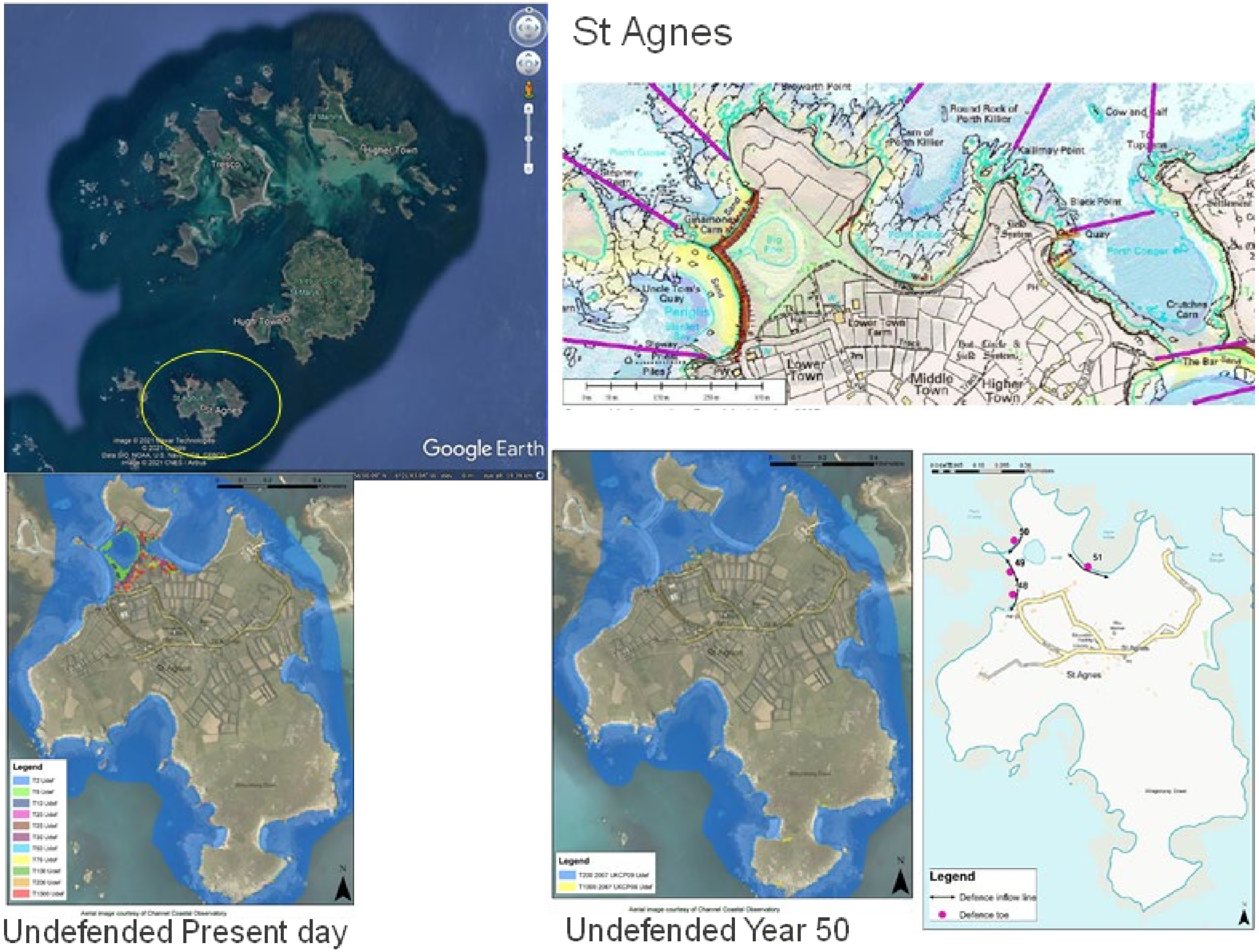


Figure 5.1: Appreciation of the site – St Agnes

Source: Extracted from JBA (2019) Table 3.3

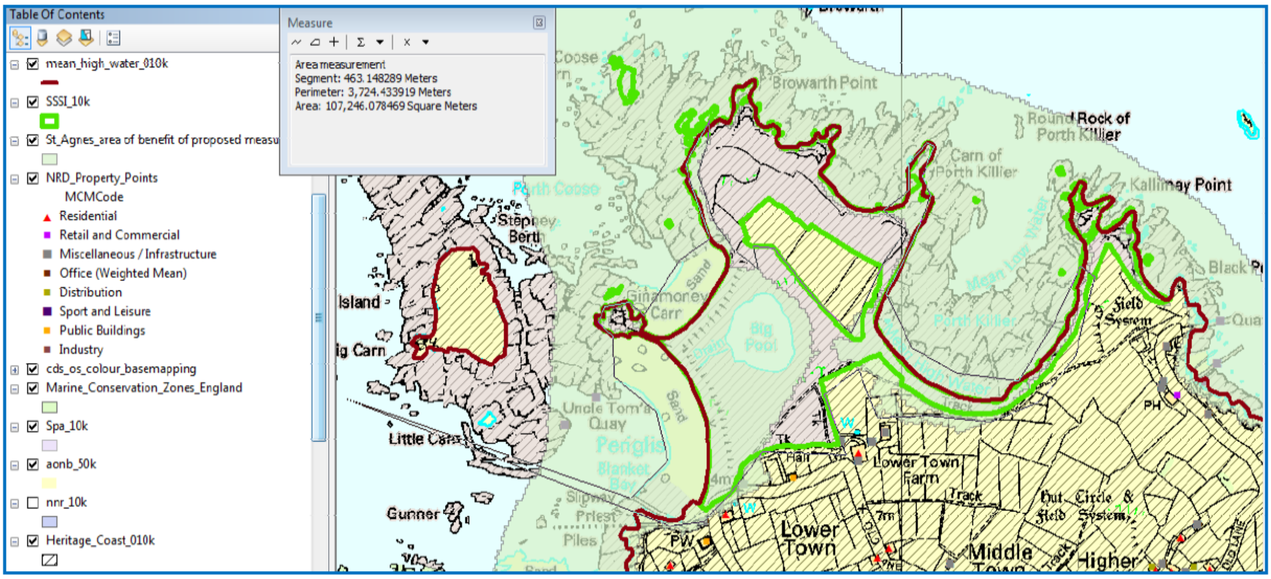


Figure 5.2: Environmental designations in the area of proposed works

Source: Extracted from OBC (2020, Ref. 2)

Table 5.1: OBC Preferred Options

Option	Site	Protecting	Aim	Issue	Activity
1A	51 – Porth Killier	Seawall stability	Prevent erosion and reduce overtopping risk	Seawall erosion	Reduce scouring of toe/foundation of 10m length of retaining sea wall by protecting it with 1.5 m³ of rock armour per linear metre.
2A	51 – Porth Killier	Main road	Prevent erosion and reduce overtopping risk	Ram erosion	Halt ram erosion & overtopping risk at a 5 m section to immediate SE of sea wall by installing localised 2.5 m high rock armour revetment.
3A	51 – Porth Killier	Groundwater recharge area	Reduce overtopping risk	Low section of rock armour	Add 20 m³ of rock armour to existing to raise height and address overtopping risk on NW side of Porth Killier.
4A	50 – Porth Coose 48, 49 – Periglis	Groundwater recharge area	Reduce overtopping risk	Low sections of dune	One option from (1), (2) or (3). (1) Restore 500 m of dunes, locally recharging 125 m of it with imported granite ‘crush’. Naturally & flexibly strengthen, raise and protect low sections with biomatting & by planting and establishing with varied palette of costal dune flora. Achieve a

Option	Site	Protecting	Aim	Issue	Activity
					consistent profile 750 mm above the current low points. (2) Alternatively, protect 220 m length and 8 m width of dunes on Periglis beach with concrete block revetment, while the remainder is treated as (1) above. (3) Alternatively, protect 220 m length and 8 m width of dunes on Periglis beach with Tecco Cell proprietary erosion protection matting, while the remainder is treated as (1) above.
5A	48 – Periglis	Slipway	Repair slipway	Slipway in poor repair	Repair Periglis Slipway (6 m³ concrete) & enhance rock armour at quay & tie-in with beach entrance.
6A	48 – Periglis	Slipway	Prevent flooding through slipway	Slipway flood risk	Add stop log fitting and supply stop logs to slipway.

Source: From RFP – provided by Council of Isles of Scilly

6. St Agnes site notes

A site visit to the Isles of Scilly was conducted between 15th to the 17th of June 2021 to gain field information on the existing defences and the fronting beaches. This information has supported the identification, selection and development of the coastal works required. The findings of the site visit are discussed in DKR6499-RT001 (Ref. 5 above).

The site visit has provided information on the coastal environment and it has given a good appreciation of the boundaries with the designated sites and the condition of the present dune/banks. Also, it provided up to date information on which sections of defence had already been upgraded since 2019, and no longer require further intervention. During the site visit, alternative options were discussed with the Client and these were added to the project option appraisal together with the existing options indicated by the OBC.

The findings of the Site Visit are detailed in the Site Visit Notes (Ref. 5), the description of the alternative options includes the conclusions reached on site.

7. Design basis

7.1. Design life

The design life for the coastal scheme is 25 years.

7.2. Coordinate system

National Grid for plane coordinates.

7.3. Vertical datum

All levels are shown in m OD.

7.4. Data

7.4.1. Topographic and Bathymetric data

The following topographic data was used:

- LiDAR downloaded from: https://environment.data.gov.uk/DefraDataDownload/?Mode=survey:
  - Digital Surface Model (DSM) - this LiDAR data type was chosen for consistency and better understanding when displaying data in Excel plots. Generally a DTM would be preferable but in this case, not available for all years of interest.
  - Years used: 2011, 2014, 2018 and 2020.

During the analysis of the LiDAR data, ‘discrepancies’ were apparent between surveys regarding elevation (‘z’ values). To address this issue, an additional elevation check was carried out using profile data from the Channel Coastal Observatory (CCO). The CCO data provided topographical coastline profiles using the same vertical datum (m ODN) as the LiDAR, therefore a local comparison could be made against the LiDAR datasets. This allowed an informed decision to be made regarding what was a ‘realistic’ elevation for a particular match of survey year. Following on from this, it was decided that the 2011 LiDAR (earliest year) values should be used as the baseline to adjust the other LiDAR survey to, thus making all the datasets nominally comparable. Hard point elevation values (roads surfaces, concrete slipways) were extracted from the same positions in all LiDAR datasets in order to work out an average difference (adjustment) between a baseline year and the other years of interest. The average adjustment values were applied to the 2014/18/20 datasets so these could be brought in line with the 2011 baseline LiDAR.

7.5. Water Levels

7.5.1. Sea and tidal levels

Table 7.1: Tide Tables

Level	Elevation (m CD) -	Elevation (m OD) -
MHWS	5.68	2.77
MHWN	4.35	1.44
MLWN	2.04	-0.87
MLWS	0.73	-2.18
LAT	0.09	-2.82

Source: HR Wallingford

7.5.2. Extreme water levels

Extreme sea levels were based on predictions published in the Environment Agency's Coastal Flood Boundaries report, Environment Agency (2018). These were updated to the present (2021) to account for likely rises on sea levels since 2017, the base date for these levels, University of Colorado (2021), and estimated changes in land levels since this date, Bradley *et. al.* (2008).

Site CFB Chainage	Extreme still water level for the year 2017 per AEP (mODK)										
	50%	20%	10%	5%	4%	3.33%	2%	1.33%	1%	0.5%	0.1%
ESL 0	3.51	3.59	3.64	3.69	3.71	3.72	3.75	3.78	3.80	3.84	3.95

Figure 7.1: Extreme sea level data

Source: JBA (2019)

7.6. Waves

The RFP did not require wave modelling and instructed the tenderers to extract the required input data from "The Isles of Scilly Coastal Flood Modelling" (JBA for the EA, 2019). A preliminary review of this document showed that the report did not provide suitable wave data for detailed design. More information on extreme waves and water levels data were required. The Client requested the data, in electronic copy, from the Environment Agency at the start of the project.

The EA provided a first set of data, which was considered insufficient. A further more extensive set of data was subsequently provided. This was reviewed and design wave conditions were extracted.

As instructed by the Client, HR Wallingford have utilised the data provided from the above mentioned study. HR Wallingford has duly reviewed the information provided and confirms that they appear reasonable. However, without access to the raw data, and repeating the full analysis, we note that HR Wallingford are unable to take responsibility for any existing data quality and quantity provided by others.

The data supplied to HR Wallingford from the JBA modelling study consists of a sub-set of 10,000 years' of modelled extreme conditions, which has been set-up for extreme overtopping conditions. This sub-set of data contains the combinations of wave and sea level parameters that give the largest overtopping rate, although not necessarily the largest wave heights. However, the method adopted to generate these data was developed by HR Wallingford (see for example Gouldby et. al., 2017), and it is considered that a reliable estimate of the extreme wave heights at the site(s) could be determined from the data provided.

Two sets of data were provided:

- Defended
- Defended NPPF 2117.

Where NPFF stands for "National Planning Policy Framework".

It is assumed that:

- "Defended" is the current day (2017) estimate of wave heights and overtopping rates with existing sea defences.
- "Defended NPPF 2117" is the 2117 estimate of wave heights and overtopping rates which includes a 10% increase in offshore wind speed and wave heights, though no adjustment seems to be made to the wave period to maintain the input wave steepness. Sea level rise from 2017 to 2117 is given as 1.037m. This seems to be consistent with guidance given for the higher central allowance for sea level rise as currently given in this link:

https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#sea-level-allowances

The information for the relevant sites at St Agnes were extracted from these datasets. As part of the present study, a SLR allowance has been included in the water level to update the data to present day water levels (@2021) and to calculate water levels in 2046 (25 years life).

7.6.1. Extreme wave heights and water levels

The design return period for St Agnes has been confirmed by the Client as a 1 in 150 year return period. Based on the review of the data as described above and through interpolation between the 2017 and 2117 defended epochs, the following criteria have been selected for the design wave conditions and associated water levels at each of the sites considering the 25 year design life.

Table 7.2: Design waves and water levels

Point	Hs (m)	Tp (s)	Water Level
48	1.69	7.73	4.10
49	1.56	7.50	3.95
50	1.48	7.55	4.00
51	1.23	9.90	3.88

Source: HR Wallingford

7.7. Overtopping assessment

A wave overtopping study was carried out as part of the JBA(2019) study for the EA. This study provided as output the flood extent and recommendations for the increase in crest elevation required along the coastal frontages. In addition, indications were given for flood alerts related to water levels and overtopping discharges.

As part of the present study, overtopping calculations are undertaken to assess the stability of the coastal/flood protection. No flood modelling is performed for the selected options, since this is outside the present scope of work.

The recommendations given in Ref. 2 and Ref.3, based on flood modelling, are considered as part of the assessment. Wave overtopping at the revetments is assessed using the empirical formulations reported in the EurOtop II (2016) manual.

7.8. Materials

7.8.1. Quarry rock properties

A quarry rock density of 2650kg/m^3 is assumed in the design of the rock revetment. This is the lower end of typical values for granite, so is a conservative value to use.

7.8.2. Concrete properties

A minimum concrete density of 2350kg/m^3 is assumed for concrete, for any flood or wave wall incorporated in the design.

7.8.3. Dune/Ridge recharge material

It is assumed that sand and recharge material to match existing ground can be locally sourced from the island.

7.8.4. Geotextile properties

The geotextiles to be used should be designed to meet the following criteria:

- A permeability criterion to ensure the geotextile is permeable enough to allow liquid to pass through relatively unhindered;
- A retention criterion to ensure the geotextile openings are small enough to prevent excessive migration of soil particles ("piping");
- An anti-clogging criterion to ensure the geotextile is porous enough so when soil particles become entrapped in or on the geotextile its permeability will not be adversely affected;
- A survivability criterion to ensure the geotextile survives installation; and,
- A durability criterion to ensure the geotextile is durable enough to withstand the effects of chemicals, UV light and abrasive conditions for the life of the project.

8. Design criteria

8.1. Ultimate limit states

8.1.1. Rock armour

For stability, a return period event of 1:200 year (0.5% probability per annum) is used for the preliminary design. The target damage level at this return period is selected as per the Rock Manual guidelines (CIRIA/CUR/CETMEF (2007)):

- Start of Damage: Sd = 2 – corresponds to "no damage" with approximately less than 5% armour rock displacement.

8.1.2. Overtopping

Guidance on methodologies and maximum allowable overtopping rates along the frontage will follow the recommendations in EurOtop II (2018), though consideration will also be given to acceptable flooding and acceptable damage following the conclusions and recommendations provided in Ref.2 and Ref. 3.

The crest level/configuration of the flood protection will be designed in such a way to limit mean wave overtopping and minimize risk of flooding and damage to the banks. Overtopping discharges obtained along the frontage will be reviewed considering the stability of the structures.

Based on extensive research on the resistance of grass covered slopes under overtopping events, EurOtop II (2018) provides the following suggestions:

- A good closed grass cover without open holes is very resilient to wave overtopping for wave heights H_{m0} < 3m.
- A badly maintained grass cover with open holes and a lot of moss may fail well below q < 5 l/s/m.

These limits are summarised in Table 8.1.

Table 8.1: Design return periods for the quay walls and the maximum allowable overtopping

Hazard type and reason	Mean discharge q (l/s per m)
Grass covered crest and landward slope; maintained and closed grass cover; Hm0 = 1 – 3 m	5
Grass covered crest and landward slope; not maintained grass cover, open spots, moss, bare patches; Hm0 = 0.5 – 3 m	0.1
Grass covered crest and landward slope; Hm0 < 1 m	5-10

Source: EurOtop II (2018)

8.1.3. Geotextile sand containers

It is envisaged that geotextile tubes/containers, referred to a geocontainers in this report, will be used as part of the proposed material. Geotextile sand containers are a low cost, soft and reversible solution for a cost effective shore protection, and have a history of more than 50 years in hydraulic and marine applications. Coastal structures built with geotextile sand containers are obtained by substituting rocks or concrete units with containers made of geotextile and filled with locally available sand.

The hydraulic processes affecting the stability of geotextile sand containers / structures will be assessed using Geosystems. Design rules and applications" by Bezuijen and Vastenburg and the work carried out by Oumeraci et al (2003, 2010) and Recio (2007).

8.2. Serviceability limit states

Sea defence overtopping conditions with a 1 in 1 year joint probability return period will be used as the SLS design criterion. The sea defence will be designed in such a way that it will limit wave overtopping over the public footpath with a target maximum not to exceed q = 1 l/s/m in order to not cause danger to pedestrians who are assumed to be aware of the weather conditions, see Figure 8.1 extract from EurOtop (2018). The limit applicable for all the sites refers to $Hm_0 < 2$m.

No damage criteria are necessary for this serviceability limit state.

Hazard type and reason	Mean discharge q (l/s per m)	Max volume V_{max} (l per m)
People at structures with possible violent overtopping, mostly vertical structures	No access for any predicted overtopping	No access for any predicted overtopping
People at seawall / dike crest. Clear view of the sea.		
H_{m0} = 3 m	0.3	600
H_{m0} = 2 m	1	600
H_{m0} = 1 m	10-20	600
H_{m0} < 0.5 m	No limit	No limit
Cars on seawall / dike crest, or railway close behind crest		
H_{m0} = 3 m	<5	2000
H_{m0} = 2 m	10-20	2000
H_{m0} = 1 m	<75	2000
Highways and roads, fast traffic	Close before debris in spray becomes dangerous	Close before debris in spray becomes dangerous

Figure 8.1: Limits for overtopping for people and vehicles

Source: Extracted from EurOtop II (2018) Table 3.3

8.3. Code and standards

The design of the coastal works has been carried out in accordance with the codes, standards and guidance documents as listed below:

- British Standards, BS6349 suite, Maritime Structures;
- BS EN 1991-1-1:2002. Eurocode 1: Actions on structures - Part 1-1: General actions. BSI;
- BS EN 1997-1:2004 Eurocode 7: Geotechnical design - Part 1: General rules. BSI;
- BS EN 13383 Parts 1 and 2 European Armourstone Specification.

In addition to the standards above, the following international guides for good practice have also been adopted:

- CIRIA; CUR; CETMEF, (2007). The Rock Manual. The Use of Rock in Hydraulic Engineering; (2nd Edition), London;
- CIRIA, (2010). Beach management manual. (2nd Edition), London. PUB C685;
- CIRIA, (2020). Groynes in coastal engineering – Guide to design, monitoring and maintenance of narrow footprint groynes, London;
- EurOTop II (2018).

9. Description of options

9.1. Introduction

The Outlined Business Case (OBC, 2020) evaluated a number of conceptual options, including do nothing and do minimum. The preferred options identified as part of the OBC (Ref.2, 2020) are summarised in Table 3.1, and are as provided in the RFP (Ref. 1).

The site visit confirmed that some coastal features described as dunes in Table 5.1 were not sand dunes but often ridges or banks, not always of natural formation, and made of mixed material, as described below. The Client acknowledged that the word “dunes” had been used with a very broad meaning in the documentation provided.

The OBC (Ref. 2) did not make a differentiation between dunes and ridges / banks. However, a dune would respond dynamically to storms, reshape and reform. Ridges / banks are in many cases man made and engineered, therefore their response will be different from the response of a natural dune system and any reshaping may lead to failure. Below the word “dune”, used in the OBC, should be read therefore as “ridge / bank”.

In the sections that follow, the Preferred options presented in Table 5.1 are described in more detailed and alternative options, proposed as part of this study, and discussed with the Client on site, are also presented.

A layout showing the different sites and the sections reviewed and considered in this design are presented in Appendix A.

9.2. Periglis Beach – Units 48 and 49

As discussed in Section 5, during the winter storms of 2013 - 2014, the crest along Periglis was notched and hence it retreated significantly at the south end. Similarly, also at the centre and north area of the bay, the ridge's crest was lowered; potentially leaving the area behind exposed to high risk of inundation. Bulk bags were positioned to strengthen the bank (see Figure 9.1). The presence of these bulk-bags has helped to protect/reduce the dune/bank from further erosion.

Figure 9.1: Exposed geobags at Periglis Beach

Anecdotal evidence that as well as placement of these bags, there has been some human infill in between and in front of these bags to raise the dune level from sand found on the beach. Subsequently, it is evident that there has been some natural increase in the sand to the front of this area through natural coastal processes, which shows evidence that the bank/ dune has partially recovered The crest elevation is illustrated in the plan and long section shown as Figure 9.2 and Figure 9.3.

The dune / bank has potential for long term stability as self-healing is evident here.

9.2.1. Outline Business Case (OBC) preferred options

Based on the above, the OBC (Ref. 2) proposed one of the following three options to nourish, restore and naturally strengthen the damaged ridge:

- Option 1 (former Option 4a-1): Locally recharging 125 m of the dune / bank with imported granite ‘crush’. Naturally & flexibly strengthen, raise and protect low sections with biomatting and planting with a varied palette of costal dune flora. Achieve a consistent profile 750 mm above the current low points;
- Option 2 ((former Option 4a-2): Protect 220 m length and 8 m width of dune / bank on Periglis beach with concrete block revetment;
- Option 3 (former Option 4a-3): Protect 220 m length and 8 m width of dune / bank on Periglis beach with Tecco Cell proprietary erosion protection matting.

Figure 9.2: Chainages and crest line of Perigilis Beach

Source: Background imagery from ArcGIS Pro

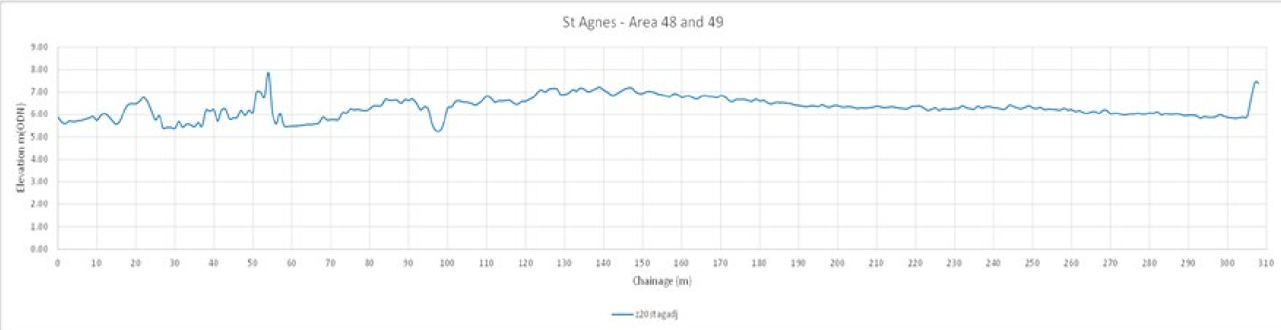


Figure 9.3: Longitudinal section along crest of Periglis Beach

Source: LiDAR

9.2.2. Alternative preferred option

Based on the existing conditions of the dune / bank, and having reviewed the OBC proposals, HR Wallingford is proposing the following option:

- Option 4: Protect Periglis beach using geocontainers and cover with cobble / sand material; along most of the bay.

The proposed solution aims to provide a more robust and permanent approach in terms of protection from coastal erosion, taking inspiration from the results obtained by the emergency works carried out after the 2013-2014 winter storms. This approach will enhance the dune / bank stability, providing at the same time a enhanced core. The approach can be summarised as:

- Part of the existing material at the top of the beach (mix of sand and cobbles) will be excavated, from the seaward face, to allow the positioning of geocontainers in the core of the bank;
- The geocontainers will be placed within the existing footprint. Excavation will be made from the seaward face of the dune/bank;
- The geocontainers will be covered / protected by a mix of local sand and cobbles and topped up by locally excavated material where available. The new reshaped seaward slope will follow the natural slope of the existing dune / bank. **HOLD** – source and volume of material to be confirmed.

The geocontainers will be covered by fill material so will not be exposed directly to the waves and will not be a visual eyesore. The fill will also be protected with a matting to encourage establishment of vegetation and will also provide additional erosion protection.

The crest elevation along the beach will be increased. Figure 9.3 shows a longitudinal elevation extracted along Periglis bay, from which it is evident that the lowest elevation along the bay, north of the slipway, is approximately +5.9mODN. This low area is located between Chainage 270m and Chainage 300m. Conversely, at the southern end of the beach, from Chainage 120m (approximately to the north of the slipway) to Chainage 170m, the crest level is approximately +7.0mODN.

As per OBC's (Ref.1 and Ref.2) recommendations, along the north side of the bay the crest level will be increased to achieve a consistent profile at least 750 mm above the current low points. In order to meet the criteria for wave overtopping discharges, however, it is necessary to raise crest levels to approximately +7.5 mODN. It is recommended that the area by the revetment is closed to the public during extreme events. The crest width will be increased, where required, to reach a minimum of 4m.

In order to achieve the required increase in crest elevation, the existing dune/bank will be topped up and covered using local materials with biodegradable matting to retain the material whilst the grasses and plants establish. The natural plant fibres have the advantage of providing a system of erosion control of the material positioned over the top of the dune / bank, while local flora gets naturally established. In addition, biodegradable matting have relatively low manufacturing and installation costs. Finally, being biodegradable, they are more likely to meet the environmental requirements for St Agnes.

Typical cross-sections are shown in Figure 9.4 and Figure 9.5, for the south and north area, respectively.

It was observed during the site visit that the stop log fitting and stop logs to the slipway have been implemented already, and so therefore no further action is required. It was also observed, that some rock armour is now already present to tie into the slipway. From on site assessment, it was concluded that it is less likely that further work will be required at this location at present.

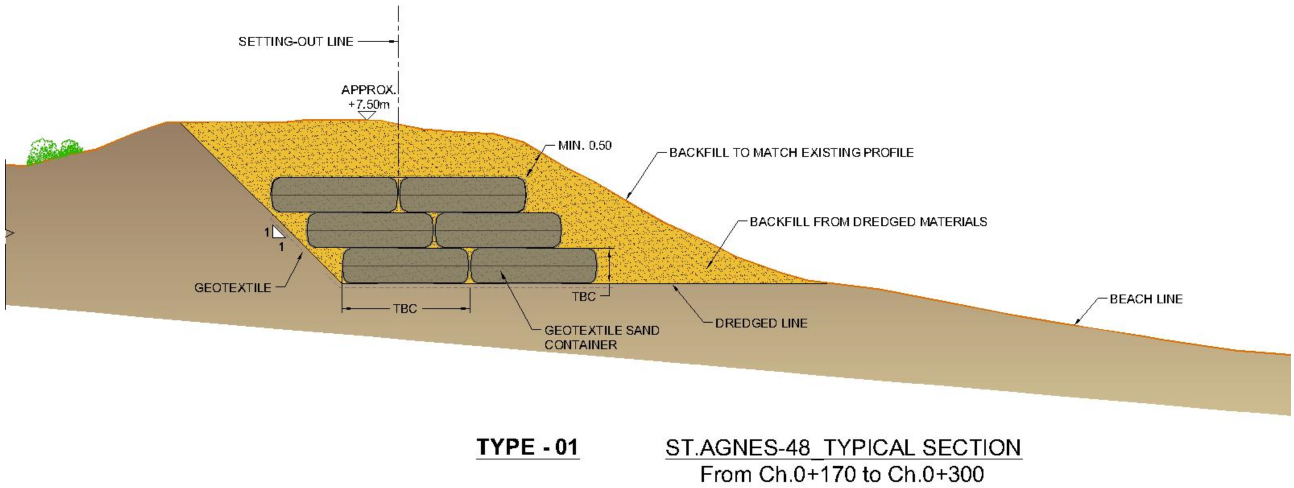


Figure 9.4: Typical cross-section along Periglis Beach (Chainage 120m to 170m)

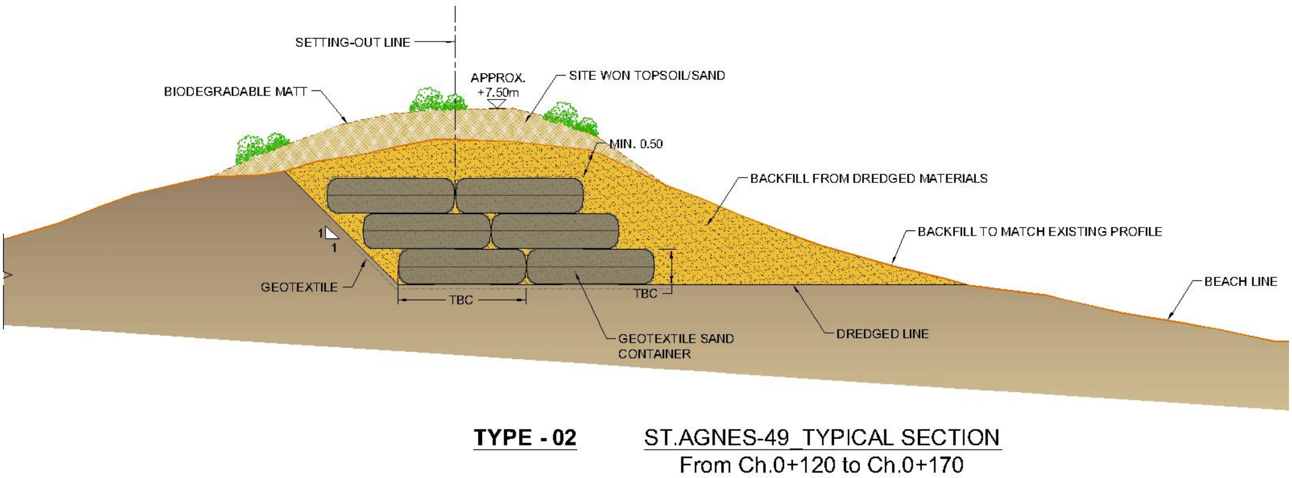


Figure 9.5: Typical cross-section along Periglis Beach (Chainage 170m to 300m)

Plant restoration on dunes

Due to the grassland interest at the site, restoration of the floral features will be undertaken after engagement and agreement with Natural England. Whilst the final method is not currently known, this may consist of one or a combination of:

- locally harvest seed from site for use in re-establishing the flora post works;
- removal of the existing flora and some topsoil/sand to set aside and lay back and secure, once the works are complete;
- sourcing seed as locally as possible to re-seed areas following completion of the works, noting that the seed mix is likely to be different on the forward facing slope as compared to the crest and back.

9.2.3. Efficacy and advantages

- The suggested level of protection (Option 4 - use of geobags) is likely to withstand the impact of future extreme storms events. In particular, the Isles of Scilly has a shortage of natural rock and therefore a geocontainer system offers the advantages of simplicity in placement and constructability, cost effectiveness, and minimal impact on the environment. Moreover, this solution will not affect the footprint of the existing beach area, as the dredged material will be replaced at the natural profile of the beach.
- The bags are usually filled with dry sand of density of around 1600kg/m^3. During filling, a constant supply of water is provide into the container to allow the sand to compact inside so the density of wet sand is about 1900kg/m^3. Information on geocontainers filled with sand is reported in Appendix C. If sand material is not available (likely at this location), it is possible to fill geocontainers with graded local or imported rocks using high performance nets, which can be ecologically advantageous. The supplier will supply the bags and will do on-site training required for the filling, lifting and placing of the bags. Supplier information on rock bags is also included in Appendix C.
- The geocontainer will be used complementary to the dune/bank nourishment to increase its lifetime. Beach monitoring is required during the beach life time and maintenance should be planned to reinstate

the design profile of the dune/bank following severe erosion and potential exposure of the geocontainers. Over its design life the embankment is far more likely to be reshaped by waves than wind-blown reshaping, though it may contribute some sand the area behind the crest.

9.2.4. Constraints and disadvantages

- Disadvantages for the use of geocontainers for coastal defence are related to their design life and need of maintenance if they become exposed during severe storms. The design life of 25yrs can only be assured if the geocontainers remain covered. Therefore, regular beach monitoring following storm events must be undertaken to detect any damage and erosion trends in the banks. An effective beach monitoring program will be required to provide an early warning of potential threats to dune/bank resilience and a beach management and emergency plan (BMEP) will be required to mitigate the risks of further coastal erosion. Any cobbles / large rock protection on the banks / toe will help to mitigate the risk of damage.
- Geocontainers should not be positioned directly on a rough foundation as sharp elements may easily damage the casing of the element. To combat this, a layer of geotextile is usually placed underneath the first layer of bags and behind the structure, as can be seen in Figure 9.4 and Figure 9.5. When designing geocontainers the main considerations / problems are related to the integrity of the units during filling, release and placement impact. When working with this technology, the manufacturer's specifications should be followed. The installation needs an experienced contractor, though manufactures will typically provide site training as needed.
- A local source of recharge sediment for the dunes/banks it to be identified and the permissions to use it needs to be obtained. If no sufficient local material is available, filling material should be imported, possibly from local quarries in Cornwall.

9.3. Porth Coose

9.3.1. Outline Business Case (OBC) preferred option

In a similar manner to Periglis Beach, Porth Coose suffered severe overtopping during the 2013-14 winter storms. As a result of likely high overtopping discharges, the crest and rear side were compromised and lowered the elevation of the revetment, exposing the rear side (containing local infrastructure, important freshwater habitat, wells and aquifer) to significant breach and inundation risks.

Based on the above, the OBC (Ref. 1 and Ref. 2) proposed the following option to nourish, restore and naturally strengthen the damaged revetment:

- Option 1: Restore the revetment with locally recharging 125 m of it with imported granite 'crush'. Naturally & flexibly strengthen, raise and protect low sections with biomatting & by planting and establishing with a varied palette of costal dune flora. Achieve a consistent profile 750 mm above the current low points.

The beach layout and chainages are included as Figure 9.6.

Figure 9.6: Porth Coose layout and chainages

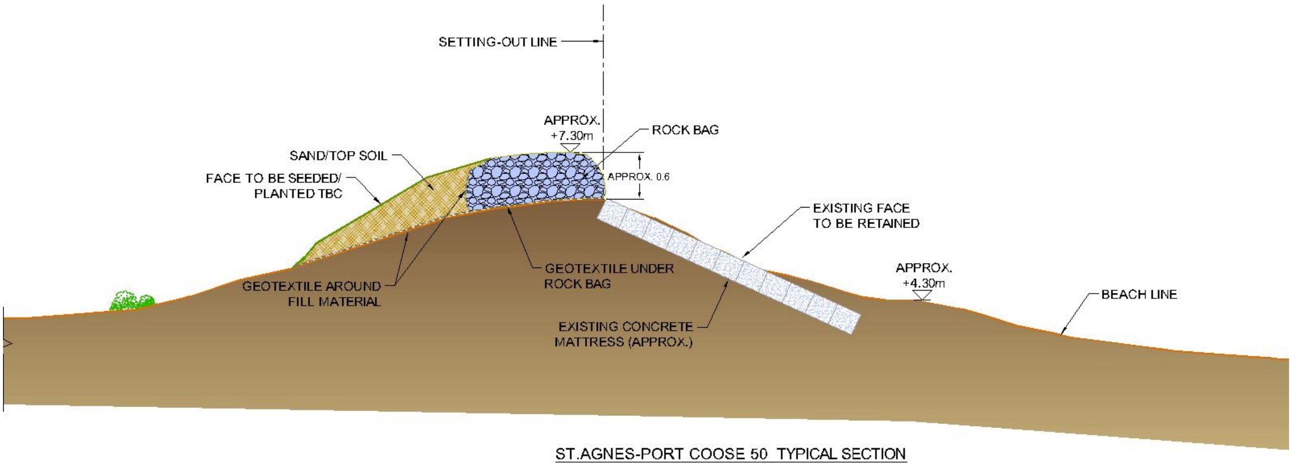
9.3.2. Preferred alternative options

Alternative solutions are proposed below that aim to provide a more robust and wider ridge crest, and at the same time providing protection against erosion at both the seaward and rear-side of the bank.

A – Rock mattress protected crest

This considers a solution which increases the crest elevation, achieved through recharge using local and imported material, with a protective rock mattress directly on the existing crest. The rock mattress would be a rock bag, an example product is contained in Appendix C. The material behind the crest would be placed on a geotextile. This could be made of a high strength geocomposite, 100% polypropylene, with a woven base layer, featuring inseparable loops for soil and gravel retention. Such materials have a life comparable to the life required for the scheme, provided that the recommended maintenance is carried out. Also, they work in combination with a covering layer of soil planted with locally appropriate plants, which will root through the membrane.

The proposed crest should reduce overtopping but it is important to note that the type of solution for behind the bank is not designed to be exposed to waves, therefore it will be important to monitor the bank regularly and maintain or re-establish planted cover if this gets damaged by severe storms. This proposed section is illustrated in Figure 9.7.



ST.AGNES-PORT COOSE 50 TYPICAL SECTION
From Ch.0+000 to Ch.0+140

Figure 9.7: Typical cross-section along Porth Coose Option A

B - Engineered rock protected crest

Another option that has been considered, is to increase and strengthen the crest. This is similar to the option proposed in the OBC but would involve the use of a system that involves the mechanical bonding of an aggregate (crushed rock or gravel), such as Elastocoast® system solution (Polyurethane Bonded Aggregate – PBA) bonded with an environmentally compatible 2-component polyurethane plastic. These types of material have the capacity to withstand overtopping discharges, even in cases of larger overtopping volumes (Bakker et al., 2008). Moreover, this material provides resistance to aggressive marine environments, and it has been determined that there are no negative effects on the aquatic environment (PBA Manual, 2010). It can be further investigated, given that it would provide a longer lasting protection.

PBA revetments are generally applied with a cover layer thickness ranging from 0.10 to 0.50m. However, from a functional point of view, a minimum layer thickness of approximately 2 × D_{n50} is required to ensure complete coverage of the application area, and layers less than 0.10 m thick are hard to achieve.

We are aware that this option may be controversial for this site, due to the environmental sensitivity and the concern on the release of plastic material into the environment due to abrasion. Therefore it has not been fully appraised, but it is a viable alternative option that is worth including for discussion. See Figure 9.8.

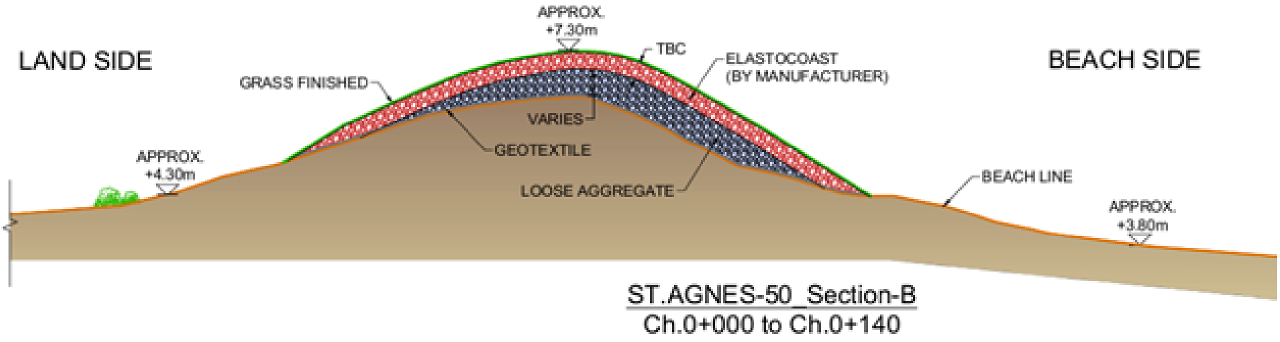


Figure 9.8: Typical cross-section along Porth Coose Option B

Other engineered revetments have been considered, including Teccocell as proposed as an option in the OBC. Teccocell was included in the optional appraisal but was rejected due to concerns about deterioration over the design life and perhaps more importantly the aesthetics of a meshed rock slope.

Option development

For both options the following consideration on the required crest level apply:

- The lowest area of the bay is at +5.6 mODN. Similar to Periglis, it is suggested to increase the crest level to achieve a consistent profile 750 mm above the current low points. This suggests that a minimum crest elevation of approximately +6.4 mODN is required along the bay. However in order to comply with the minimum overtopping criteria (q < 5 l/s/m), the crest elevation should be at approximately +7.3 mODN.
- The option will need to extend for the entire length of the Porth Coose frontage.
- As noted in Section 9.2.2, the restoration of vegetation over the matting is key to stabilising the material over the top of the dunes/banks. The approach to seeding or planting is still to be agreed and will be done in consultation with Natural England.

9.3.3. Efficacy and advantages

The proposed solution retains the existing concrete slope protection so requires no works seaward of the crest. The use of more durable materials behind the crest provides a more robust and long lasting option for the leeward stability.

The seeding/planting of grasses will help to quickly re-establish the habitat and will fix the topsoil/sand to protect the rear of the crest line from any erosion.

9.3.4. Constraints and disadvantages

Although the geomembrane will have at least a 25-year design life, this is subject to the geomembrane being covered and not exposed to UV which will degrade the material. It will be necessary to monitor the bank on a regular basis as part of a BMP, especially after any storm event, and swift establishment of the grasses onto of the dune will be crucial in stabilising the topsoil covering.

The geomembrane is a plastic material. Care will be taken in product selection to ensure that the material is inert but it is not as environmentally friendly as the biomatting proposed in the OBC. Details of the environmental innocuousness of an example product is included in Appendix C for information.

9.4. Porth Killier

This site has been divided into three areas of intervention: the seawall; the eastern-end; and, the western-end. These are treated separately as each of them requires a different engineering intervention. These are illustrated in and the sites and proposed interventions are described in the following sections. The site and the different sections are indicated in Figure 9.9.

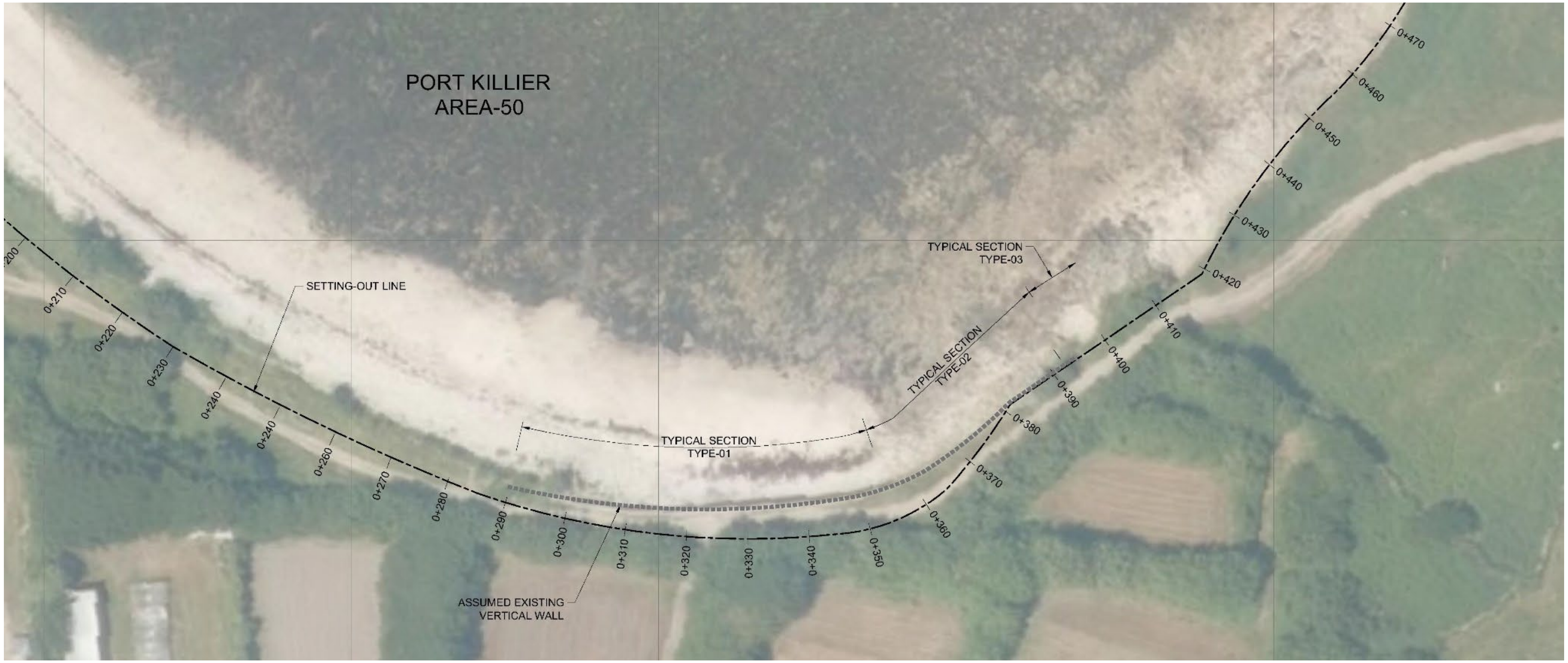


Figure 9.9: Porth Killier layout

9.4.1. Port Killier (Seawall) - Outline Business Case (OBC) preferred options

Along Porth Killier, for an extension of approximately 100m, there is a vertical wall which is currently subject to erosion at the toe (as shown in Figure 9.10).

The client is proposing the following option:

- Reduce scouring of toe / foundation of 10 m length of retaining sea wall by protecting it with 1.5 m^3 of rock armour per linear metre.

Figure 9.10: Scour erosion at the toe of the vertical wall

9.4.2. Alternative option

In line with the client's recommendation, a rock scour protection at the foundation of the seawall is proposed. The toe protection is designed to protect the wall from undermining and failure, and also to reduce overtopping. The overtopping reduction is caused by the seaward extension of the toe, which also functions as a dissipative berm. Therefore a wider toe protection of 0.3 to 1 t rock size with a minimum width of 3 m is recommended (as shown in Figure 9.11).

During the site visit it was noticed that the east side of the wall was more damaged than the west side. In order to minimise the volume of rock required, two separate areas along the vertical wall were identified for different design solutions. The most damaged is from Chainage 390m to 360m, and a 3m toe-berm of 0.3-1 t rock armour toe berm is recommended, see the proposed section in Figure 9.11). Conversely, from

Chainage 360 m to 295 m where less damage has occurred, the rock toe will be characterised by 1.9 m wide 0.3-1 t rocks and 1.1 m of cobbles, as shown in Figure 9.12, and which will tie into the existing rock headland.

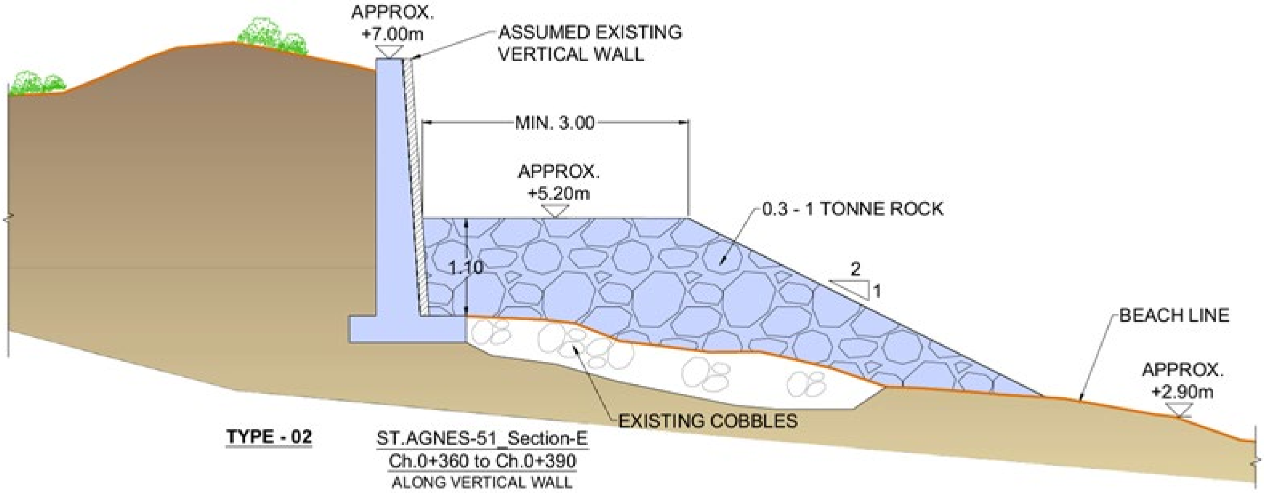


Figure 9.11: Typical cross-section along the east side of the vertical wall (Chainage 390 m to 360 m)

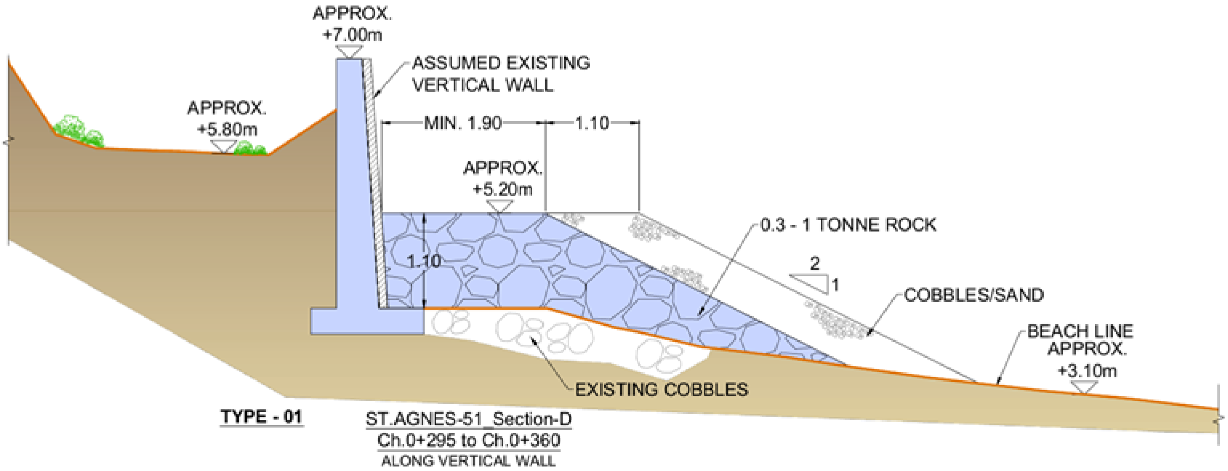


Figure 9.12: Typical cross-section along the west side of the vertical wall (Chainage 360m to 295m)

9.4.3. Efficacy and advantages

There are areas along the wall that are clearly eroded and directly exposed to the wave action. Any storm could potentially undermine the stability of the wall (erosion of the Ram), therefore scour protection is needed. By placing a wide toe protection, there is a double benefit:

1. improving the overall stability of the wall;

2. reducing possible overtopping discharges.

This option has low impact on the local environment, landscape and amenity as the solution will be very similar to the existing situation.

9.4.4. Constraints and disadvantages

The availability of suitable rock material on the island is a constraint and rock will need to be imported if it can't be sourced locally.

9.4.5. Porth Killier (Eastern end) - Outline Business Case (OBC) preferred options

At the eastern-end of the wall, there is a small pocket rocky beach with a localised halt Ram erosion, as can be seen in Figure 9.13. This section is also subject to overtopping events that impact the road at the leeward side. The OBC (Ref 1 and Ref 2) is therefore suggesting to build a localised 2.5 m high rock armour revetment to reduce the on-going erosion.

Figure 9.13: Localised halt ram erosion

For this site, no alternative options have been identified and it proposed to build a rock structure revetment as proposed with 1-3t rock material, as shown in the typical cross-section in Figure 9.14, to reduce the cutback of the ram. The rock revetment, or more likely rock augmentation, would be placed up to the crest of the underside of the ram / outcrop in order to reduce the cut back towards the road. In this case, in order to minimise the volume of rock required, rock armour will be protected by a cobble toe that will make use of existing materials.

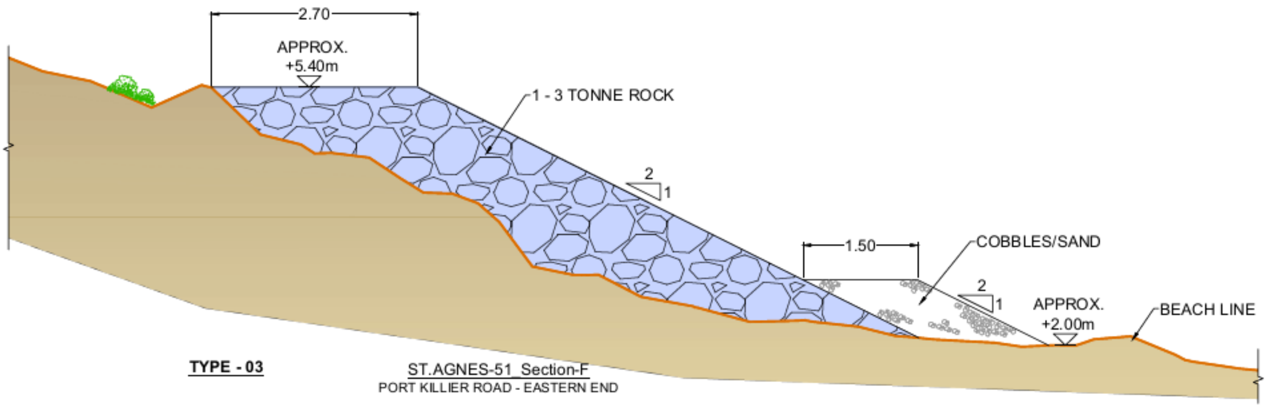


Figure 9.14: Typical cross section for the localised eroded area

9.4.6. Efficacy and advantages

This option has low impact on the local environment, landscape and amenity as will not change the appearance of the beach significantly. The presence of the revetment will improve the stability of the halt-ram but also act as reduction to wave overtopping events.

9.4.7. Constraints and disadvantages

Although the look of the beach will be similar, the footprint of the proposed section is quite large. The same constraints exist as per the seawall protection with the availability of rock an issue that will likely require importing materials.

9.4.8. Porth Killier (Western end) - Outline Business Case (OBC) preferred options

Along all the beach crest in Porth Killier severe overtopping was reported to have previously occurred. At the western side of the bay the OBC (Ref.1 and Ref.2) proposes to add a total of 20 m^3 of rock armour to raise the crest and reduce overtopping risk.

9.4.9. Alternative option

During the site visit it was concluded that this section, although lower that along the beach crest, may not require intervention. Anecdotal evidence based on a discussion with the farmer whilst onsite, suggested that overtopping had not occurred at this location. Additionally, many of the rocks are well covered with lichen, which is further evidence that they rarely, if ever, are exposed to green water discharges. Whilst there is a low point along the crest of the beach at this location, waves approaching here will be subject to significant dispersion around the headland and also obliquities of around 90^0. Coupling this with a relatively high roughness and a degree of permeability, it is unlikely that any intervention here (especially 20m^3 of rock armour) would be of significant benefit and no works are therefore proposed.

10. Appraisal (criteria and evaluation- qualitative) – Preferred option

10.1. Assessment criteria

A description of the option appraisal is given below.

The assessment criteria were developed taking into account the coastal environment where the project is located and the nature of the project. They reflect the appraisal carried out to date, itemising the issues and providing a basis for the evaluation.

The colour associated in the appraisal with each indicator or aspect of a criterion identifies the level of preference of the options. The preference is given considering the relevance and/or the impact of that item on the option. For example, an option that effectively manages coastal erosion and flood risk and provides an adequate level of protection would meet the requirements and therefore it will score highly; in this case a green colour will be associated to it. On the contrary, an option which would be not able to deliver an adequate protection over the life of the project, would not meet the requirement and it will score poorly; in this case a red colour will be associated with it. When an indicator is relevant or has some impact on the option, but the consequence could be mitigated or the impact is moderate or they are acceptable, it will score moderately, and a yellow colour will be associated with it.

When an indicator or overall criterion is not applicable it will score 0 and indicated as NA.

The meaning of the colour associated with a preference is summarised below.

PR	Preferred	An option considered to provide an overall effective solution to the criteria being assessed.
A	Acceptable	An option considered to provide an acceptable solution to the criteria being assessed.
LP	Least preferred	An option which does not provide an acceptable solution to the criteria being assessed.
NA	Not Applicable	This criterion is not applicable for this option.

The identified criteria and relative indicators or aspects are described below:

Performance

- Option provides long term flood protection
- Option provides protection from long term coastal erosion
- Option supports the growth of vegetation and sand stabilization
- Negative impact along the adjacent frontages
- Positive impact along the adjacent frontages
- Option helps to prevent undermining of structures.

Monitoring and maintenance

- Maintenance
- Monitoring.

Constructability

- Construction will occur near water - Tidal Restrictions
- Sourcing material
- Ease of access to site
- Ease of access to beach.

Impact on natural processes

- Allow supply of fresh material to the foreshore of adjacent frontages.

Impact on environment

- Visual impact
- Amenity value / Access to beach
- Impact of construction (noise, dust etc)
- Potential impact on marine designations during construction and once built
- Potential impact on landside designations
- Potential impact on Water Framework Directive (WFD) water body.

Schedule

- Construction Period Duration (Shortest preferred).

Costs

- Capital costs
- Maintenance costs.

The criteria have been assessed against each option and they are presented with their respective preference in Appendix D with an example illustrated in Figure 10.1 below.

Score	Criteria \ Options and Option description	Do Nothing	Do Minimum	1 Granite/biomatting restoration	2 Concrete block protection	3 Tecco Cell protection	4 Geobags protection
	Performance						
2	Option provides long term flood protection			A	A	A	PR
2	Option provides protection from long term coastal erosion			A	A	A	PR
2	Option supports the growth of vegetation and sand stabilization			PR	LP	PR	A
2	Negative impact along the adjacent frontages			A	A	A	A
2	Positive impact along the adjacent frontages			A	A	A	A
2	Option helps to prevent undermining of structures			A	PR	A	PR
	Monitoring and Maintenance						
2	Maintenance			A	PR	A	A
2	Monitoring			A	A	A	A
	Constructability						
2	Construction will occur near water - Tidal Restrictions			A	A	A	A
2	Sourcing material			A	A	A	A
2	Ease of access to site			A	A	A	A
2	Ease of access to beach			A	A	A	A
	Impact on natural processes						
2	Allow supply of fresh material to the foreshore of adjacent frontages			A	A	A	A
	Impact on Environment						
2	Visual impact			A	LP	LP	PR
2	Amenity value / Access to beach			A	LP	LP	PR
2	Impact of construction (noise, dust etc)			A	LP	A	A
2	Poptential impact on marine designations			A	LP	LP	PR
2	Potential impact on landside designations			A	LP	LP	LP
2	Potential impact on WFD water body			A	A	A	A
	Schedule						
2	Construction Period Duration (Shortest preferred)			A	A	A	PR
	Costs						
2	Capital costs			A	LP	A	PR
2	Maintenance costs			A	A	A	A

PR	Preferred	PR	Preferred	2
A	Acceptable	A	Acceptable	1
LP	Least preferred	LP	Least preferred	0
N	No Applicable	N	No Applicable	

Figure 10.1: Option appraisal matrix – Example for Periflis Beach (48-49)

- A score is assigned to each preference as shown below:

LEGEND		
	Preference	score
P	Preferred	3
A	Acceptable	2
LP	Least Preferred	1
NA	Not applicable	0

- The evaluation matrix calculates the subtotal score of the indicators/aspects per each criterion, given as a percentage.
- The subtotal per criterion show how well the options perform in the various criteria.
- The subtotals are calculated as the ratio between the total score for that criterion and the highest possible total score of the criterion. For example, the criterion “Performance” the highest possible subtotal score is 12 and the subtotal achieved from scoring the indicators, for example for Periglis Beach (48 & 49) Option 3 above, is 7, therefore 7/12 given as a % is 58.3%. See Figure 10.2.
- Using a similar approach to the above, the final score aims to show how well the options perform overall. The final score is calculated as the ratio between the sum of all the subtotal scores and the highest possible total score. To use the same example as above, for Option 3 it will be: (58.3+50+50+50+16.7+50+50)/700=46.4%.

Options and Option description	0	0	1	2	3	4
	Do Nothing	Do Minimum	Granite/biomatting restoration	Concrete block protection	Tecco Cell protection	Geobags protection
Performance						
Option provides long term flood protection			1	1	1	2
Option provides protection from long term coastal erosion			1	1	1	2
Option supports the growth of vegetation and sand stabilization			2	0	2	1
Negative impact along the adjacent frontages			1	1	1	1
Positive impact along the adjacent frontages			1	1	1	1
Option helps to prenvent undermining of structures			1	2	1	2
Performance - Average score	**0.0%**	**0.0%**	**58.3%**	**50.0%**	**58.3%**	**75.0%**
Monitoring and Maintenance						
Maintenance			1	2	1	1
Monitoring			1	1	1	1
Monitoring and Maintenance - Average score	**0.0%**	**0.0%**	**50.0%**	**75.0%**	**50.0%**	**50.0%**
Constructability						
Construction will occur near water - Tidal Restrictions			1	1	1	1
Sourcing material			1	1	1	1
Ease of access to site			1	1	1	1
Ease of access to beach			1	1	1	1
Constructability- Average score	**NA**	**0.0%**	**50.0%**	**50.0%**	**50.0%**	**50.0%**
Impact on natural processes						
Allow supply of fresh material to the foreshore of adjacent frontages			1	1	1	1
Impact on natural processes - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**	**50.0%**	**50.0%**
Impact on Environment						
Visual impact			1	0	0	2
Amenity value / Access to beach			1	0	0	2
Impact of construction (noise, dust etc)			1	0	1	1
Poptential impact on marine designations			1	0	0	2
Potential impact on landside designations			1	0	0	0
Potential impact on WFD water body			1	1	1	1
Impact on Environment - Average score	**0.0%**	**0.0%**	**50.0%**	**8.3%**	**16.7%**	**66.7%**
Duration of works						
Construction Period Duration (Shortest preferred)			1	1	1	2
Duration of works - Average score	**NA**	**0.0%**	**50.0%**	**50.0%**	**50.0%**	**100.0%**
Costs						
Capital costs			1	0	1	2
Maintenance costs			1	1	1	1
Costs - Average score	**0.0%**	**0.0%**	**50.0%**	**25.0%**	**50.0%**	**75.0%**
TOTAL %SCORE	**0.0%**	**0.0%**	**51.2%**	**44.0%**	**46.4%**	**66.7%**

Figure 10.2: Option evaluation Matrix from the appraisal shown in Figure 10.1 above

It is proposed that any option which does not meet the key indicator / aspect "Option provides long term flood protection" will not be shortlisted even if it has a high total score. However, the Do-nothing option will still be used for the economic appraisal. At this stage no weight has been applied to the preferences (green, yellow and red). Table 10.1 below gives a summary of the option appraisal and the shortlisted Options.

Table 10.1: Summary of options

Location	No.	Option	Description	Benefits delivered / Risks involved	Short list or rejection
48/49 - Periglis beach		Do Nothing	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
		Do Minimum	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
	1	Granite/ biomatting restoration	Restore the dunes, locally recharging 125 m of it with imported granite 'crush'. Naturally & flexibly strengthen, raise and	Biomatting is a natural material, which will make it compatible with the environmental at the location, though it will	Shortlisted

Location	No.	Option	Description	Benefits delivered / Risks involved	Short list or rejection
			protect low sections with biomatting & by planting and establishing with varied palette of costal dune flora. Achieve a consistent profile 750 mm above the current low points. Repair Periglis slipway (6m³ concrete) & enhance rock armour at quay & tie-in with beach entrance Add stop log fitting and supply stop log to slipway.	not provide a long term solution and is likely to be subject to erosion if directly exposed to wave action. The repair to the slipway and the armour appeared to have been already carried out, from the findings of the site visit.	
	2	Concrete block protection	Protect 220 m length and 8 m width of dunes on Periglis beach with concrete block revetment. Repair Periglis slipway and associated works as per option 1.	Concrete block revetment can be considered as an option. However this option will be more expensive than the use of other solutions as for example geocontainers/geobags. It will also not havea greater visual impact. The repair to the slipway and the armour appeared to have been already carried out, from the findings of the site visit.	Rejected
	3	Tecco Cell protection	Protect 220 m length and 8 m width of dunes on Periglis beach with Tecco Cell proprietary erosion protection matting. Repair Periglis slipway and associated works as per option 1.	This soft engineering solution may be subject to rapid deterioration with poor aesthetic results. The repair to the slipway and the armour appeared to have been already carried out, from the findings of the site visit.	Rejected
	4	Geobags protection	Northern end - geotextile/ Tecco Cell exposed over	This solution will provide more robust results in	Shortlisted/ preferred

Location	No.	Option	Description	Benefits delivered / Risks involved	Short list or rejection
			the ridge/dune. For the seaward face, replacing geobags with more robust geobags buried into the dunes. These will be covered with local cobbles and sand. Repair Periglis slipway and associated works as per option 1.	terms of erosion and will enhance the dune stability at the seaward side of the slope. The geocontainers will provide a hard core of the bank/dune and provide an unerodable line of defence. The bank will still require some level of maintenance for storm event if the geobags get exposed.	
50 - Porth Coose		Do Nothing	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
		Do Minimum	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
	1	Granite/ biomatting restoration	Restore the dunes, locally recharging 125 m of it with imported granite 'crush'. Naturally & flexibly strengthen, raise and protect low sections with biomatting & by planting and establishing with varied palette of costal dune flora. Achieve a consistent profile 750 mm above the current low points.	The option provides a solution which can blend with the environment, though the material may get moved during storms and the already exposed steel wires, evident during the site visit at the crest of the ridge, confirm that erosion of the crest occurs during severe storms. Therefore this solution may require a regular monitoring and maintenance in order to make sure that crest levels are maintained at the elevation required.	Shortlisted
	2	Geomatting and	This is not a sand dune, there is an existing	This solution will increase the crest	Shortlisted/ preferred

Location	No.	Option	Description	Benefits delivered / Risks involved	Short list or rejection
		engineered crest	revetment (embankment with protected seaward side) buried underneath the sand/cobbles. Exposed steel wires were evident during the site visit. Repair the seaward side and increase the crest level of embankment by increasing top and rear side (footprint) using geobags or other geocontainer systems. A board-walk could be placed on the top to protect crest from human erosion. Numerous marine and terrestrial designations present.	elevation and repair the bank while creating an impermeable barrier, which provides a reduction in wave overtopping to Big Pool and protection from coastal erosion. The option offers a more permanent solution and it reduces the requirement for maintenance, though any engineered rock material will need to be evaluated from an environmental point of view, given the high environmental value of the site.	
51 - Porth Killier (Seawall)		Do Nothing	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
		Do Minimum	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
	1	Rock fill	Reduce scouring of toe/foundation of 10m section of retaining sea wall by protecting it with 1.5 m³ of rock armour per linear metre.	The option provides the protection required, though it may be under designed (required greater berm). In addition, any localised solution may move the problem downdrift.	Shortlisted
	2	Toe/Scour protection	Rock toe protection at the foundation of the seawall. The toe protection will be designed to be wider and higher to have a beneficial effect in reducing wave overtopping and it requires	Rebuild toe protection, but possibly higher, bigger rock and a wider berm to help reduce overtopping.	Shortlisted/ preferred

Location	No.	Option	Description	Benefits delivered / Risks involved	Short list or rejection
			to extend along the whole seawall frontage, possibly reducing in width.		
51 - Porth Killier (Road (eastern end))		Do Nothing	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
		Do Minimum	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
	1	Rock armour revetment	Halt ram erosion & overtopping risk at a 5 m section to immediate SE of sea wall by installing localised 2.5 m high rock armour revetment.	The option provides the protection required, though it may be under designed (required higher crest elevation).	Shortlisted
	2	Rock revetment	To reduce the cutback of the ram, a rock revetment will be placed to at least the height of the underside of the ram/outcrop.	Rock revetment top level should be adjusted to match ram and reduce cut back towards road.	Shortlisted/ preferred
51 - Porth Killier (western end)		Do Nothing	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
		Do Minimum	Appraised as part of OBC. This option is not re-appraised as part of the present study.		
	1	Rock fill	Add 20 m³ of rock armour to existing to raise height and address overtopping risk on NW side of Porth Killier.	The option provide a valuable solution, though it may be over designed.	Shortlisted
	2	Do Nothing/ Minimum intervention	Anecdotal evidence and engineering judgment from site visit suggests that it is not a risk, therefore a minimum intervention/re-shaping it is considered.	No material or construction costs necessary.	Shortlisted/ preferred

11. Description of preliminary design of preferred options

11.1. Preferred options

Section 9 has described the proposed options for each site and included typical cross-sections, for all relevant sites in St. Agnes. The option appraisal evaluated the options, using the criteria described above and preferred options were selected as summarised in Table 10.1. Table 11.1 below, provides a summary list of the preferred options.

Table 11.1: List of Preferred Option Drawings

Location	Preferred Option
Periglis Beach	Geocontainer solution
Porth Coose	Geomatting and engineered crest
Port Killier (Seawall) - Ch 295 to 360	Toe protection with rock armour and cobbles/sand
Port Killier (Seawall) - Ch 360 to 390	Toe protection with rock armour
Port Killier (Western end)	No intervention proposed
Port Killier (Eastern end)	Rock revetment

12. BOQ and costs

Bills of Quantity and Estimated cost will be included in the detailed design report.

13. Constructability

The proposed works have been selected considering constructability on St Agnes. The following criteria were considered:

- Materials – locally available rock. However due to material property requirements some import of armourstone may be necessary.
- Rock may require import by barge, suitable landing sites at the beaches should be confirmed.
- Geobags – are usually filled with dry sand. During filling, a constant supply of water is provide into the container to allow the sand to compact inside so the density of wet sand is increased. If sand material is not available, it is possible to fill geocontainers with graded local or imported rocks using high performance nets, which can be ecologically advantageous. The installation needs an experienced contractor, though manufactures will typically provide site training as needed.
- Plant – the requirement of large construction plant is not recommended due to accessibility and cost. All works proposed should be able to be completed be standard JCB type excavators or similar adequate plant.
- Workforce – Although the proposed works are not complex, contractors with marine experience should undertake the works, but much of the workforce could be local manpower and equipment.

14. References

BAKKER, J.J., MOM, R.J.C. and STEENDAM, G.J., (2008). Factual Report: Golfoverslagproeven Zeeuwse dijken. INFRAM, Marknesse, The Netherlands.

Bezuijen and Vastenburg. 2015. Geosystems. Design rules and applications, Routledge, UK.

LOCK, M., (2008). Early colonization of littoral communities on PU coated substrates: a field and laboratory study. ARCADIS, Hoofddorp, The Netherlands.

McConnell, 1998, Revetment Systems against wave attack: A design Manual, HR Wallingford Thomas Telford London.

Oumeraci, H., Hinz, M., Bleck, M., Kortenhaus, A. 2003. Sand-filled geotextile containers for shore protection, COPEDEC VI, Colombo, Sri Lanka.

Oumeraci, H., Recio, J. 2010, Geotextile Sand Containers for shore protection, Invited Chapter in Handbook of Coastal and Ocean Engineering, World Scientific Publishing, Singapore, 553-600.

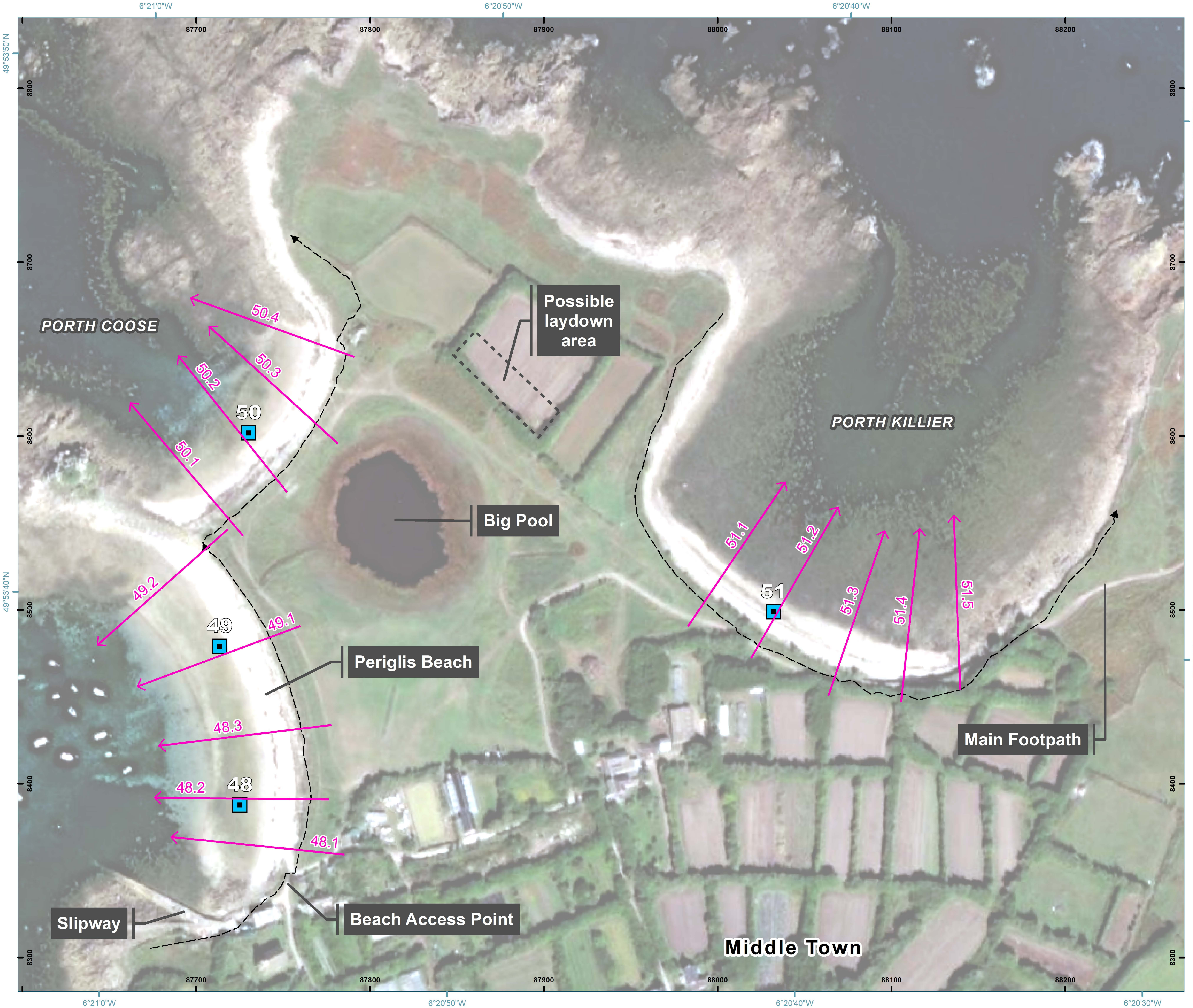
Pilarczyk, 2000. Geosynthetics and Geosystems in Hydraulic and Coastal Engineering, Routledge, UK.

POLYURETHANE BONDED AGGREGATE REVETMENTS DESIGN MANUAL 2010, ARCADIS.

Recio, J. 2007. Hydraulic stability of geotextile sand containers for coastal structures- effect of deformations and stability formulae, *PhD Thesis,* Leichweiss-Institute for Hydraulic Engineering and Water Resources, Braunschweig, Germany.

Appendices

A. Drawings



Background Imagery from ArcGIS Pro. Service Layer Credits: Maxar, Microsoft. Contains Ordnance Survey data © Crown copyright and database right 2021.

BEACH CROSS SECTION PROFILE

CREST ELEVATION PROFILE

DEFENCE ID

Isles of Scilly – Design Services for Off Islands Coastal Erosion

Climate Adaptation Schemen -Preliminary Design - St Agnes

PROFILE LOCATIONS

0 0.05 0.1 KILOMETRES

N

SCALE: 1:2,000 **PAPER SIZE:** A3 (42 x 29.7 cm)

GEODETIC INFORMATION

CRS: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
False Easting: 400,000.0000
False Northing: -100,000.0000
Central Meridian: -2.0000
Scale Factor: 0.9996
Latitude Of Origin: 49.0000

PROJECT REF: DKR6499
DRAWING: DKR6499-001-01-DDE
DATE: 03/08/2021 **DRAWN:** DDE **CHECKED:** TAP

HR Wallingford
Working with water
HR Wallingford, Howbery Park, Wallingford, Oxfordshire OX10 8BA, United Kingdom.
tel +44 (0)1491 835381 fax +44 (0)1491 832233
email info@hrwallingford.com
www.hrwallingford.com

DEFENCE ID

PHOTO LOCATION

Isles of Scilly – Design Services for Off Islands Coastal Erosion

Climate Adaptation Schemen -Preliminary Design - St Agnes

SITE INVESTIGATIONS

0 0.05 0.1
KILOMETRES

N

SCALE: 1:3,000 **PAPER SIZE:** A3 (42 x 29.7 cm)

GEODETIC INFORMATION

CRS: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
False Easting: 400,000.0000
False Northing: -100,000.0000
Central Meridian: -2.0000
Scale Factor: 0.9996
Latitude Of Origin: 49.0000

PROJECT REF: DKR6499
DRAWING: DKR6499-003-01-DDE
DATE: 03/08/2021 **DRAWN:** DDE **CHECKED:** TAP

HR Wallingford
Working with water
HR Wallingford, Howbery Park, Wallingford, Oxfordshire OX10 8BA, United Kingdom.
tel +44 (0)1491 835381 fax +44 (0)1491 832233
email info@hrwallingford.com
www.hrwallingford.com

B. Health, safety and welfare issues

B.1. Health, safety and welfare issues

B.1.1. Construction - Construction (Design and Management Regulations)

Introduction

The Construction (Design and Management) Regulations 2015 (CDM 2015) require a designer to avoid foreseeable risks to those involved in construction and future use of the structure, and in doing so, they should eliminate hazards (so far as is reasonably practicable, taking into account other design considerations) and reduce and control risks associated with those hazards which remain. It is essential that, where required to do so, a principal designer and principal contractor are appointed to fulfil their respective duties under the CDM 2015. It is also essential to highlight and record the impacts of the works on health, safety and welfare which should feed into the Health and Safety File. Further details of the requirements of CDM 2015 can be found on:

http://www.hse.gov.uk/construction/cdm/2015/index.htm

HR Wallingford is a designer on this project under the CDM 2015. In this role we have given due consideration to the statutory duties contained in the CDM 2015 as summarised above. It is also essential that a competent principal designer and principal contractor are selected to undertake any construction work which may ultimately be undertaken.

We assume that the appointed principal designer will notify the client of their responsibilities under CDM 2015 and that the relevant enforcing authority is notified of the project in accordance with regulation 6 of the CDM 2015.

Key marine hazard sources

Coastal and maritime construction can be hazardous because of the hostile and sometimes unpredictable nature of the environment. Guidance documents by Simm & Cruickshank (1998) and Cork & Cruickshank (2005) have examined these issues for the coastal environment. The key sources of hazards are depicted in Figure A.1 below. They derive from:

- The (uncertain) marine environment – wind, waves, currents, water levels;
- The dynamic physical environment – impacts from the above including poor ground conditions;
- Third parties – lack of containment of the site.

The above items influence the works, the equipment, the operatives and third parties.

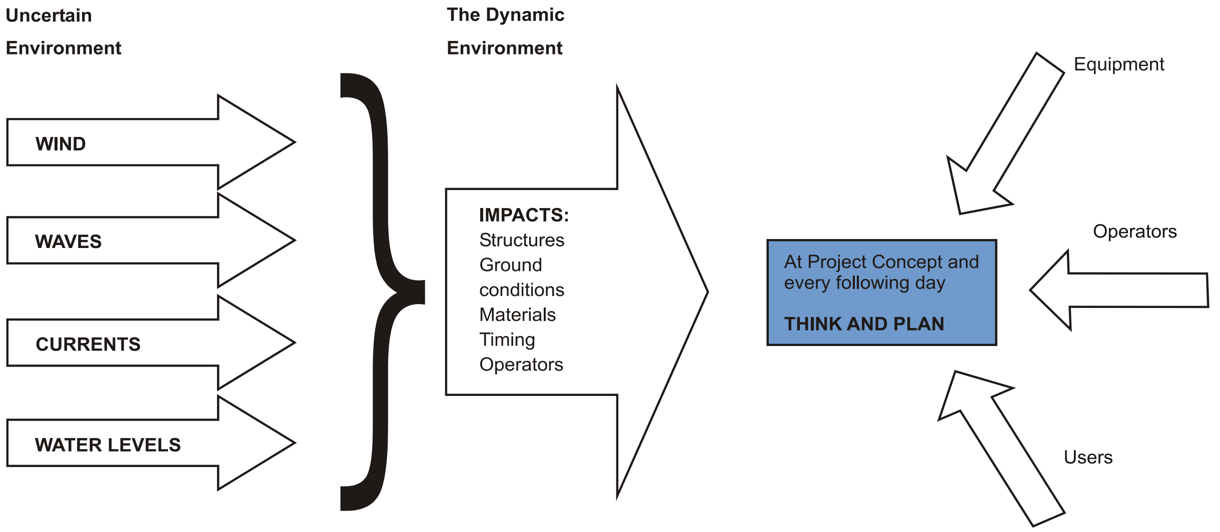


Figure B.1: Key marine hazards

Elimination of hazards

As a designer we have a duty to eliminate or reduce risks to the health and safety of any person in the preparation of that element of the design which we have undertaken for the project. Isles of Scilly – Design Services for Off Islands Coastal Erosion Defence and Dune Management".

In so doing we have assumed that a competent principal contractor will be employed who is experienced in the construction work proposed on this project and will use established good working practices for such engineering projects.

The feasibility design process has preliminarily identified risks and provided a preliminary response strategy; the risk assessment should be reviewed during the next phase of design:

Table B.1: Source of Risk

Source of Risk	Consequences	Risk Owner	Response Strategy
Availability of Surveys (Topographic, Geotechnical and Environmental).	Resulting in delay, costs and potential alteration to methods.	Client	Undertake survey to inform Risk.
Ground Conditions: beach levels can change following storms.	Ground level for excavation and re- profiling operations could change during construction resulting in delays and costs.	Contractor	Undertake subsequent surveys to inform risk Store plant securely outside beach area.
Ground Condition (2): Uncertain ground conditions.	Risk for plant and personnel. Resulting in delay, costs and potential alteration to methods.	Client/Contractor	Undertake survey to inform Risk (Client). Provide routes of safe access to plant and personnel (Contractor).

Source of Risk	Consequences	Risk Owner	Response Strategy
	Additional geotechnical investigation required.		
Beach level changes leading to need for modifications to excavation requirements.	Increase cost and delay to programme.	Contractor	Check latest site surveys have been incorporated into design. Check Design work.
Weather/Tidal work.	Increase cost and delay to programme.	Contractor	Monitoring and Early planning of construction schedule.
Work near water.	Risk to equipment and personnel.	Contractor	Monitoring and Early planning of construction schedule. Store equipment safe away from intertidal area.
Difficulties in the delivery of Material to the Islands.	Increase cost and delay to programme.	Client/Contractor	Identification and development of a schedule of construction which maximize construction during season with milder weather/sea conditions.
Construction Access.	Increase cost and delay to programme.	Client/Contractor	Identification and development of potential temporary access and cost impact mitigated.
Public Access during construction.	Increase cost and delay to programme.	Client/Contractor	Early identification of a construction schedule and consultation with main stakeholders.
Storm / flood risk.	Works commencement delayed.	Client/Contractor	Early identification, and design / plan in place for addition works.
Site Safety.	Accident, harm, injury, death, works stopped, delay and litigation.	Client/Contractor	Work to be undertaken by suitable, qualified and competent personnel. Adequate H&S procedure. Monitor that H&S procedures are correctly followed.
Public Safety during Construction.	Accident, harm, injury, death, works stopped, delay and litigation.	Client/Contractor	Ensure an understanding of the Public use of the beach during construction. Put in place fencing, signage and

Source of Risk	Consequences	Risk Owner	Response Strategy
			exclusion zones. Use of banksmen and avoid busy season for construction if possible. Provide alternative routes where feasible.
Possible presence of services and /or cables buried in the dunes/ridges.	Danger to workforce and public. Increase in Costs and delay.	Client/Contractor	Retrieve a detailed location map of any services located in/along the dunes/banks and in the area of work.

Source: HR Wallingford

This design risk assessment only applies to the design work elements undertaken by HR Wallingford and has assumed that appropriate risk assessments will be undertaken for the detailed design and other parts of the construction works planned. We recommend that HR Wallingford (1998) and HR Wallingford (2004) be considered when assessing construction and public safety risk.

Health and safety file

We recommend that relevant information contained within this report is retained on the Health and Safety File as it sets out the overtopping rates allowed for in the design.

References

HR Wallingford (1998), Construction risk in coastal engineering, Thomas Telford, 2000.

R Wallingford (2004), Construction health and safety in coastal and maritime Engineering, Thomas Telford, 2004.

C. Geocontainers and geosynthetic solutions

D. Option appraisal and evaluation

48 49 Periglis Beach Appraisal

Score	Criteria / Options and Option description	Do Nothing	Do Minimum	1 Granite/biomatting restoration	2 Concrete block protection	3 Tecco Cell protection	4 Geobags protection
	Performance						
2	Option provides long term flood protection			A	A	A	PR
2	Option provides protection from long term coastal erosion			A	A	A	PR
2	Option supports the growth of vegetation and sand stabilization			PR	LP	PR	A
2	Negative impact along the adjacent frontages			A	A	A	A
2	Positive impact along the adjacent frontages			A	A	A	A
2	Option helps to prevent undermining of structures			A	PR	A	PR
	Monitoring and Maintenance						
2	Maintenance			A	PR	A	A
2	Monitoring			A	A	A	A
	Constructability						
2	Construction will occur near water - Tidal Restrictions			A	A	A	A
2	Sourcing material			A	A	A	A
2	Ease of access to site			A	A	A	A
2	Ease of access to beach			A	A	A	A
	Impact on natural processes						
2	Allow supply of fresh material to the foreshore of adjacent frontages			A	A	A	A
	Impact on Environment						
2	Visual impact			A	LP	LP	PR
2	Amenity value / Access to beach			A	LP	LP	PR
2	Impact of construction (noise, dust etc)			A	LP	A	A
2	Poptential impact on marine designations			A	LP	LP	PR
2	Potential impact on landside designations			A	LP	LP	LP
2	Potential impact on WFD water body			A	A	A	A
	Schedule						
2	Construction Period Duration (Shortest preferred)			A	A	A	PR
	Costs						
2	Capital costs			A	LP	A	PR
2	Maintenance costs			A	A	A	A

PR	Preferred
A	Acceptable
LP	Least preferred
N	No Applicable

PR	Preferred	2
A	Acceptable	1
LP	Least preferred	0
N	No Applicable	

48 49 Periglis Beach Evaluation

Options and Option description	0	0	1	2	3	4
	Do Nothing	Do Minimum	Granite/biomatting restoration	Concrete block protection	Tecco Cell protection	Geobags protection
Performance						
Option provides long term flood protection			1	1	1	2
Option provides protection from long term coastal erosion			1	1	1	2
Option supports the growth of vegetation and sand stabilization			2	0	2	1
Negative impact along the adjacent frontages			1	1	1	1
Positive impact along the adjacent frontages			1	1	1	1
Option helps to prenvent undermining of structures			1	2	1	2
Performance - Average score	**0.0%**	**0.0%**	**58.3%**	**50.0%**	**58.3%**	**75.0%**
Monitoring and Maintenance						
Maintenance			1	2	1	1
Monitoring			1	1	1	1
Monitoring and Maintenance - Average score	**0.0%**	**0.0%**	**50.0%**	**75.0%**	**50.0%**	**50.0%**
Constructability						
Construction will occur near water - Tidal Restrictions			1	1	1	1
Sourcing material			1	1	1	1
Ease of access to site			1	1	1	1
Ease of access to beach			1	1	1	1
Constructability- Average score	**NA**	**0.0%**	**50.0%**	**50.0%**	**50.0%**	**50.0%**
Impact on natural processes						
Allow supply of fresh material to the foreshore of adjacent frontages			1	1	1	1
Impact on natural processes - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**	**50.0%**	**50.0%**
Impact on Environment						
Visual impact			1	0	0	2
Amenity value / Access to beach			1	0	0	2
Impact of construction (noise, dust etc)			1	0	1	1
Poptential impact on marine designations			1	0	0	2
Potential impact on landside designations			1	0	0	0
Potential impact on WFD water body			1	1	1	1
Impact on Environment - Average score	**0.0%**	**0.0%**	**50.0%**	**8.3%**	**16.7%**	**66.7%**
Duration of works						
Construction Period Duration (Shortest preferred)			1	1	1	2
Duration of works - Average score	**NA**	**0.0%**	**50.0%**	**50.0%**	**50.0%**	**100.0%**
Costs						
Capital costs			1	0	1	2
Maintenance costs			1	1	1	1
Costs - Average score	**0.0%**	**0.0%**	**50.0%**	**25.0%**	**50.0%**	**75.0%**
TOTAL %SCORE	**0.0%**	**0.0%**	**51.2%**	**44.0%**	**46.4%**	**66.7%**

50 Porth Coose Appraisal

Score	Criteria / Options and Option description	Do Nothing	Do Minimum	1 Granite/biomatting restoration	2 Geomatting and engineered crest
	Performance				
2	Option provides long term flood protection			A	PR
2	Option provides protection from long term coastal erosion			A	PR
2	Option supports the growth of vegetation and sand stabilization			PR	A
2	Negative impact along the adjacent frontages			A	A
2	Positive impact along the adjacent frontages			A	A
2	Option helps to prevent undermining of structures			N	N
	Monitoring and Maintenance				
2	Maintenance			A	PR
2	Monitoring			A	A
	Constructability				
2	Construction will occur near water - Tidal Restrictions			A	A
2	Sourcing material			A	A
2	Ease of access to site			A	A
2	Ease of access to beach			A	A
	Impact on natural processes				
2	Allow supply of fresh material to the foreshore of adjacent frontages			A	A
	Impact on Environment				
2	Visual impact			LP	A
2	Amenity value / Access to beach			LP	A
2	Impact of construction (noise, dust etc)			A	A
2	Poptential impact on marine designations			A	LP
2	Potential impact on landside designations			A	LP
2	Potential impact on WFD water body			A	A
	Schedule				
2	Construction Period Duration (Shortest preferred)			A	PR
	Costs				
2	Capital costs			PR	A
2	Maintenance costs			A	PR

PR	Preferred
A	Acceptable
LP	Least preferred
N	No Applicable

PR	Preferred
A	Acceptable
LP	Least preferred
N	No Applicable

50 Port Coose Evaluation

Options and Option description	0	0	1	2
	Do Nothing	Do Minimum	Granite/biomatting restoration	Geomatting and engineered crest
Performance				
Option provides long term flood protection			1	2
Option provides protection from long term coastal erosion			1	2
Option supports the growth of vegetation and sand stabilization			2	1
Negative impact along the adjacent frontages			1	1
Positive impact along the adjacent frontages			1	1
Option helps to prenvent undermining of structures				
Performance - Average score	**0.0%**	**0.0%**	**50.0%**	**58.3%**
Monitoring and Maintenance				
Maintenance			1	2
Monitoring			1	1
Monitoring and Maintenance - Average score	**0.0%**	**0.0%**	**50.0%**	**75.0%**
Constructability				
Construction will occur near water - Tidal Restrictions			1	1
Sourcing material			1	1
Ease of access to site			1	1
Ease of access to beach			1	1
Constructability- Average score	**NA**	**0.0%**	**50.0%**	**50.0%**
Impact on natural processes				
Allow supply of fresh material to the foreshore of adjacent frontages			1	1
Impact on natural processes - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**
Impact on Environment				
Visual impact			0	1
Amenity value / Access to beach			0	1
Impact of construction (noise, dust etc)			1	1
Poptential impact on marine designations			1	0
Potential impact on landside designations			1	0
Potential impact on WFD water body			1	1
Impact on Environment - Average score	**0.0%**	**0.0%**	**33.3%**	**33.3%**
Duration of works				
Construction Period Duration (Shortest preferred)			1	2
Duration of works - Average score	**NA**	**0.0%**	**50.0%**	**100.0%**
Costs				
Capital costs			2	1
Maintenance costs			1	2
Costs - Average score	**0.0%**	**0.0%**	**75.0%**	**75.0%**
TOTAL %SCORE	**0.0%**	**0.0%**	**51.2%**	**63.1%**

51 Porth Killier Seawall Appraisal

Score	Criteria / Options and Option description	Do Nothing	Do Minimum	1 Rock fill	2 Toe/Scour protection
	Performance				
2	Option provides long term flood protection			N	N
2	Option provides protection from long term coastal erosion			A	PR
2	Option supports the growth of vegetation and sand stabilization			N	N
2	Negative impact along the adjacent frontages			A	A
2	Positive impact along the adjacent frontages			A	A
2	Option helps to prevent undermining of structures			PR	PR
	Monitoring and Maintenance				
2	Maintenance			A	PR
2	Monitoring			PR	PR
	Constructability				
2	Construction will occur near water - Tidal Restrictions			A	A
2	Sourcing material			A	A
2	Ease of access to site			A	A
2	Ease of access to beach			A	A
	Impact on natural processes				
2	Allow supply of fresh material to the foreshore of adjacent frontages			A	A
	Impact on Environment				
2	Visual impact			A	A
2	Amenity value / Access to beach			A	A
2	Impact of construction (noise, dust etc)			A	A
2	Poptential impact on marine designations			A	A
2	Potential impact on landside designations			A	A
2	Potential impact on WFD water body			A	A
	Schedule				
2	Construction Period Duration (Shortest preferred)			A	A
	Costs				
2	Capital costs			A	A
2	Maintenance costs			PR	PR

PR	Preferred	PR	Preferred
A	Acceptable	A	Acceptable
LP	Least preferred	LP	Least preferred
N	No Applicable	N	No Applicable

51 Porth Killier Seawall Evaluation

Options and Option description	0 Do Nothing	0 Do Minimum	1 Rock fill	2 Toe/Scour protection
Performance				
Option provides long term flood protection				
Option provides protection from long term coastal erosion			1	2
Option supports the growth of vegetation and sand stabilization				
Negative impact along the adjacent frontages			1	1
Positive impact along the adjacent frontages			1	1
Option helps to prenvent undermining of structures			2	2
Performance - Average score	**0.0%**	**0.0%**	**41.7%**	**50.0%**
Monitoring and Maintenance				
Maintenance			1	2
Monitoring			2	2
Monitoring and Maintenance - Average score	**0.0%**	**0.0%**	**75.0%**	**100.0%**
Constructability				
Construction will occur near water - Tidal Restrictions			1	1
Sourcing material			1	1
Ease of access to site			1	1
Ease of access to beach			1	1
Constructability- Average score	**NA**	**0.0%**	**50.0%**	**50.0%**
Impact on natural processes				
Allow supply of fresh material to the foreshore of adjacent frontages			1	1
Impact on natural processes - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**
Impact on Environment				
Visual impact			1	1
Amenity value / Access to beach			1	1
Impact of construction (noise, dust etc)			1	1
Poptential impact on marine designations			1	1
Potential impact on landside designations			1	1
Potential impact on WFD water body			1	1
Impact on Environment - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**
Duration of works				
Construction Period Duration (Shortest preferred)			1	1
Duration of works - Average score	**NA**	**0.0%**	**50.0%**	**50.0%**
Costs				
Capital costs			1	1
Maintenance costs			2	2
Costs - Average score	**0.0%**	**0.0%**	**75.0%**	**75.0%**
TOTAL %SCORE	**0.0%**	**0.0%**	**56.0%**	**60.7%**

51 Porth Killier Eastern end Appraisal

Score	Criteria / Options and Option description	1	2	3	4
		Do Nothing	Do Minimum	Rock armour revetment	Rock revetment
	Performance				
2	Option provides long term flood protection			A	PR
2	Option provides protection from long term coastal erosion			A	PR
2	Option supports the growth of vegetation and sand stabilization			N	N
2	Negative impact along the adjacent frontages			A	A
2	Positive impact along the adjacent frontages			A	A
2	Option helps to prevent undermining of structures			PR	PR
	Monitoring and Maintenance				
2	Maintenance			PR	PR
2	Monitoring			PR	PR
	Constructability				
2	Construction will occur near water - Tidal Restrictions			A	A
2	Sourcing material			PR	PR
2	Ease of access to site			A	A
2	Ease of access to beach			A	A
	Impact on natural processes				
2	Allow supply of fresh material to the foreshore of adjacent frontages			A	A
	Impact on Environment				
2	Visual impact			A	A
2	Amenity value / Access to beach			A	A
2	Impact of construction (noise, dust etc)			A	A
2	Poptential impact on marine designations			A	A
2	Potential impact on landside designations			A	A
2	Potential impact on WFD water body			A	A
	Schedule				
2	Construction Period Duration (Shortest preferred)			A	A
	Costs				
2	Capital costs			A	A
2	Maintenance costs			PR	PR

PR	Preferred
A	Acceptable
LP	Least preferred
N	No Applicable

PR	Preferred
A	Acceptable
LP	Least preferred
N	No Applicable

51 Porth Killier Eastern end Evaluation

Options and Option description	1 Do Nothing	2 Do Minimum	3 Rock armour revetment	4 Rock revetment
Performance				
Option provides long term flood protection			1	2
Option provides protection from long term coastal erosion			1	2
Option supports the growth of vegetation and sand stabilization				
Negative impact along the adjacent frontages			1	1
Positive impact along the adjacent frontages			1	1
Option helps to prenvent undermining of structures			2	2
Performance - Average score	**0.0%**	**0.0%**	**50.0%**	**66.7%**
Monitoring and Maintenance				
Maintenance			2	2
Monitoring			2	2
Monitoring and Maintenance - Average score	**0.0%**	**0.0%**	**100.0%**	**100.0%**
Constructability				
Construction will occur near water - Tidal Restrictions			1	1
Sourcing material			2	2
Ease of access to site			1	1
Ease of access to beach			1	1
Constructability- Average score	**NA**	**0.0%**	**62.5%**	**62.5%**
Impact on natural processes				
Allow supply of fresh material to the foreshore of adjacent frontages			1	1
Impact on natural processes - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**
Impact on Environment				
Visual impact			1	1
Amenity value / Access to beach			1	1
Impact of construction (noise, dust etc)			1	1
Poptential impact on marine designations			1	1
Potential impact on landside designations			1	1
Potential impact on WFD water body			1	1
Impact on Environment - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**
Duration of works				
Construction Period Duration (Shortest preferred)			1	1
Duration of works - Average score	**NA**	**0.0%**	**50.0%**	**50.0%**
Costs				
Capital costs			1	1
Maintenance costs			2	2
Costs - Average score	**0.0%**	**0.0%**	**75.0%**	**75.0%**
TOTAL %SCORE	**0.0%**	**0.0%**	**62.5%**	**64.9%**

51 Porth Killier Western end Appraisal

Score	Options and Option description / Criteria	1 Do Nothing	2 Do Minimum	3 Rock fill	4 Do Nothing/ Minimum intervention
	Performance				
2	Option provides long term flood protection			PR	A
2	Option provides protection from long term coastal erosion			PR	A
2	Option supports the growth of vegetation and sand stabilization			LP	PR
2	Negative impact along the adjacent frontages			A	A
2	Positive impact along the adjacent frontages			A	A
2	Option helps to prevent undermining of structures			PR	A
	Monitoring and Maintenance				
2	Maintenance			A	PR
2	Monitoring			A	PR
	Constructability				
2	Construction will occur near water - Tidal Restrictions			A	PR
2	Sourcing material			A	PR
2	Ease of access to site			A	PR
2	Ease of access to beach			A	PR
	Impact on natural processes				
2	Allow supply of fresh material to the foreshore of adjacent frontages			A	A
	Impact on Environment				
2	Visual impact				
2	Amenity value / Access to beach				
2	Impact of construction (noise, dust etc)				
2	Poptential impact on marine designations				
2	Potential impact on landside designations				
2	Potential impact on WFD water body				
	Schedule				
2	Construction Period Duration (Shortest preferred)			A	PR
	Costs				
2	Capital costs			A	PR
2	Maintenance costs			A	PR

PR	Preferred
A	Acceptable
LP	Least preferred
N	No Applicable

PR	Preferred
A	Acceptable
LP	Least preferred
N	No Applicable

51 Porth Killier Western end Evaluation

Options and Option description	1 Do Nothing	2 Do Minimum	3 Rock fill	4 Do Nothing/ Minimum intervention
Performance				
Option provides long term flood protection			2	1
Option provides protection from long term coastal erosion			2	1
Option supports the growth of vegetation and sand stabilization			0	2
Negative impact along the adjacent frontages			1	1
Positive impact along the adjacent frontages			1	1
Option helps to prenvent undermining of structures			2	1
Performance - Average score	**0.0%**	**0.0%**	**66.7%**	**58.3%**
Monitoring and Maintenance				
Maintenance			1	2
Monitoring			1	2
Monitoring and Maintenance - Average score	**0.0%**	**0.0%**	**50.0%**	**100.0%**
Constructability				
Construction will occur near water - Tidal Restrictions			1	2
Sourcing material			1	2
Ease of access to site			1	2
Ease of access to beach			1	2
Constructability- Average score	**NA**	**0.0%**	**50.0%**	**100.0%**
Impact on natural processes				
Allow supply of fresh material to the foreshore of adjacent frontages			1	1
Impact on natural processes - Average score	**0.0%**	**0.0%**	**50.0%**	**50.0%**
Impact on Environment				
Visual impact				
Amenity value / Access to beach				
Impact of construction (noise, dust etc)				
Poptential impact on marine designations				
Potential impact on landside designations				
Potential impact on WFD water body				
Impact on Environment - Average score	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Duration of works				
Construction Period Duration (Shortest preferred)			1	2
Duration of works - Average score	**NA**	**0.0%**	**50.0%**	**100.0%**
Costs				
Capital costs			1	2
Maintenance costs			1	2
Costs - Average score	**0.0%**	**0.0%**	**50.0%**	**100.0%**
TOTAL %SCORE	**0.0%**	**0.0%**	**45.2%**	**72.6%**

HR Wallingford
Working with water

PAS 99 Integrated Management Systems CERTIFIED
IMR 719286

ISO 9001 Quality Management Systems CERTIFIED
FS 516431

ISO 45001 Occupational Health and Safety Management CERTIFIED
OHS 595357

ISO 14001 Environmental Management CERTIFIED
EMS 558310

HR Wallingford is an independent engineering and environmental hydraulics organisation. We deliver practical solutions to the complex water-related challenges faced by our international clients. A dynamic research programme underpins all that we do and keeps us at the leading edge. Our unique mix of know-how, assets and facilities includes state of the art physical modelling laboratories, a full range of numerical modelling tools and, above all, enthusiastic people with world-renowned skills and expertise.

HR Wallingford, Howbery Park, Wallingford, Oxfordshire OX10 8BA, United Kingdom
tel +44 (0)1491 835381 fax +44 (0)1491 832233 email info@hrwallingford.com
www.hrwallingford.com