REPORT

Economic Assessment Report

Kirk Michael - Isle of Man

Client: Flood Management Division - Isle of Man Government

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Executive Summary

Royal HaskoningDHV were commissioned by the Flood Management Division of the Isle of Man Government to carry out a strategic assessment of coastal erosion at Kirk Michael. The study consists of three stages. This report presents the results of Stage 2, the Economic Assessment report, and should be read together with the Stage 1 Strategic Risk Assessment. The aim of this report is to assess the cost of damages caused by coastal erosion at Kirk Michael for a Do Nothing scenario (in which there is no further investment in the provision or maintenance of any defences). The main conclusions drawn from this assessment are presented below.

- The appraisal period covers the next 100 years and looks at best case (50th %ile), best estimate (70th %ile), and worst case (95th %ile) erosion predictions based on a high climate change projection (RCP 8.5). Additionally, the assessment incorporates these scenarios with two safety buffers surrounding the properties: 1) Single Cliff Fall (20 m buffer), 2) 2-year average from the erosion lines.
- The baseline scenario used is the best estimate (70th %ile) with the single cliff fall buffer (20 m)
- Receptors assessed include property, people related damages, agriculture, roads, utilities, and tourism/amenity.
- Most damages are associated with residential properties, with the majority being affected after "Year 40". In total there are 69 residential properties and 3 non-residential at risk using the baseline scenario. Recognising the uncertainty due to climate change, the damages could range between a present value of £1.9M and £4.0M over a 100-year appraisal period, with a best estimate of £3.2M.
- People related damages included "Intangible Mental Health" costs, which amount to approximately £600k over the 100 year appraisal period. "Human Related Intangible Impacts (health)" are not included as these only apply to properties at risk of imminent loss, which is not applicable at Kirk Michael.
- Agricultural land is lost at a rate of approximately 0.5 hectares every 10 years. Under the baseline scenario (not including the safety buffer) a total of 5ha will be lost with a total present value amounting to approximately £20k.
- The following receptors were included, but not assessed quantitatively, either due to limited data being available or because they are not expected to be affected by erosion within the appraisal period:
  - Roads: The main A3 road is not expected to be affected, however, local residential roads are at risk. These primarily serve the properties located directly on them and their loss would cause minimal disruption.
  - Utilities: No utilities are at risk from erosion within the appraisal period, however the sewage works is close under the worst-case scenario.
  - Tourism, Recreation and Amenity: Loss of carparks to the North and South would result in the loss of recreation and amenity value for the local community and visitors, with both being completely lost within the appraisal period. There is limited infrastructural damage with the loss of the Glen Wyllin campsite, and it is assumed that the campsite would adapt, however it could impact the local economy during the TT season causing a direct impact to the individual business.
- Recognising the uncertainty due to climate change, the total damages in the baseline scenario could range between a total present value of £2.4M and £4.4M over a 100-year appraisal period, with a best estimate of £3.6M.
- Based on a number of example projects, representative cost estimates for a traditional engineering scheme were produced. Such a scheme is expected to cost in the range of £8.2M to £22.3M,

depending on the type of solution adopted, the expected lifetime of the structure and the design standard of protection. Compared to the prevented damages (i.e. the benefits of protection), this would give a Benefit-Cost ratio of 0.54 at best (a BCR of 1 or higher indicating a viable scheme), which means that it is unlikely that a traditional engineering solution would be justifiable if implemented in the near future. However, considering that an accelerating number of properties become at risk from Y40 onwards, an alternative scenario is presented in which intervening in Y40 could be viable, because at that point the Present Value benefits would be higher as they would not be reduced so much by discounting. Even then however, the viability is at most marginal.

1 Introduction

The purpose of this report is to outline the methodology used for the economic assessment of the impact of the damages caused by coastal erosion at Kirk Michael and present the results. This economic assessment accompanies the Erosion Risk Assessment undertaken as part of the Kirk Michael Coastal Erosion Study, which included a detailed review of the erosion rates and mechanisms.

The calculation of damages was undertaken in accordance with the Flood and coastal erosion risk management appraisal guidance (FCERM-AG) (Environment Agency, 2022b) using approaches set out by the Multi-Coloured Manual (MCM) 2013 (Penning-Rowsell et al., 2013) and Multi-Coloured Handbook 2023 (Penning-Rowsell et al., 2023).Where required, values have been updated to the 1st Quarter 2023 using the GDP Price Deflator Index, published on 31st March 2023.

The economic assessment considers damages associated with residential and non-residential property, agricultural land, utilities and recreation and amenity. Furthermore, mental health damages and the damages associated with the human related intangible impacts of coastal erosion have been included within the economic assessment.

This economic assessment considers the Do Nothing baseline scenario only (scenario in which there is no investment into the provision or maintenance of any defences) and includes sensitivity analysis on the rate of erosion and the size of safety buffer zone (point at which properties are uninhabited ahead of being directly at risk of erosion) to provide a robust assessment of the potential scale and timing of coastal erosion damages.

1.1 Background

Kirk Michael is considered one of the most active areas of the Isle of Man at risk of coastal erosion, with a significant part of the community located near the cliff edge. In the 2016 National Strategy, the area was defined as a hot spot, and an erosion rate of 1.3 m/yr was reported; recent analysis of monitoring since 2019 suggested an accelerated rate of erosion. The area near the clifftop is defined as a Coastline Management Zone as shown in Figure 1-1.

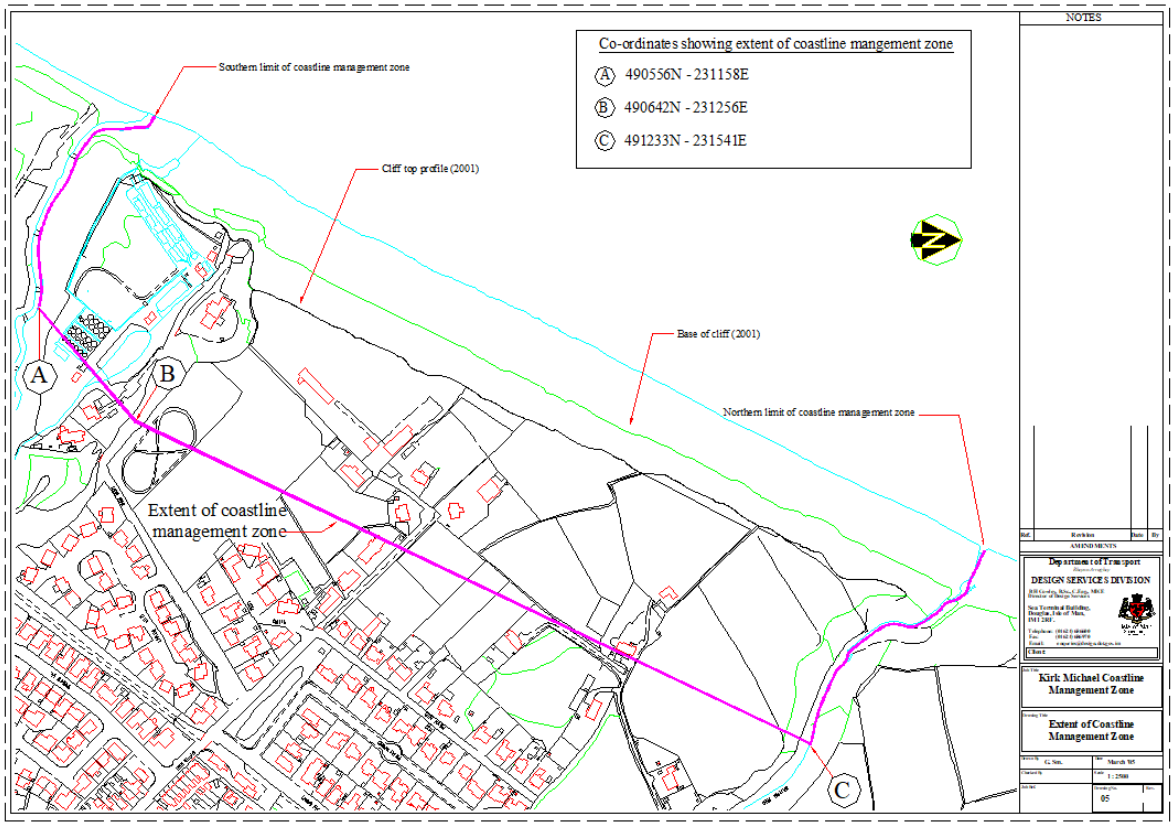

Figure 1-1: Kirk Michael Coastline Management Zone (2016 National Strategy)

In parallel to the Kirk Michael Coastal Erosion Study, the Isle of Man Government is in the process of developing a Shoreline Management Plan, while there is also the intention to update the National Strategy. Over time, these developments will be combined with the findings of this study to support decisions about the sustainable future management of coastal erosion at Kirk Michael.

2 Methodology

2.1 General

As agreed with the client, current methods used in England have been applied for the assessment. Damages have been calculated using the Multi Coloured Manual (MCM) and the Green Book (HM Treasury, 2020). These documents have been used in combination with the latest guidance from the Environment Agency and Defra where appropriate.

Damages have been calculated for a 100 year appraisal period. Discount rates in line with HM Treasury guidance have been applied, with different rates applied to health-related damages as shown in Table 2-1. The base date for the economics in this assessment is Q1 2023.

Table 2-1: HM Treasury Green Book Discount Rates

	Appraisal Years 0-30	Appraisal Years 31-75	Appraisal Years 75-99
Standard discount rate	3.5%	3.0%	2.5%
Health discount rate	1.5%	1.296%	1.071%

2.2 Erosion Lines

Alongside this economic assessment a detailed Erosion Risk Assessment was developed, in which predictions were developed for future coastal erosion. The predictions have been used in the economic assessment to calculate the value of the damages under a Do Nothing scenario. More detail on the Erosion Risk Assessment and the resulting predictions can be found in that particular report, however, a brief overview is included below.

The Do Nothing scenario is the 'walk away' option under which no further maintenance would be carried out at the existing defences at Glen Wyllin, and under which no new defences would be implemented. This would ultimately result in the failure of the existing defences and cliff erosion would continue unhindered. This option is considered in order to provide a baseline against which the benefits of various Do Something options can be assessed at a later date.

The erosion lines were derived by digitising the visible cliff edge from a combination of historical aerial imagery, OS mapping and drone captured imagery. The cliff lines were then intersected with a selected number of shore-perpendicular transects to determine distances over time for each transect. The two distinct timescales over which cliff recession plays a role (individual cliff falls in the short term and gradual consistent recession in the long term) have both been incorporated into this study. The analysis of historical erosion was used to derive a present-day recession rate. The effects of human error and errors in the data have been incorporated by creating upper and lower estimates of this present-day rate.

The acceleration of the present-day erosion rates was calculated based on the 50th, 70th & 95th percentiles in the RCP8.5 climate change scenario. For the purpose of this assessment, three future scenarios were considered:

- The best-estimate present day erosion rate was combined with the 70th %ile acceleration due to climate change to represent the **best estimate** of future coastal erosion at Kirk Michael (in line with Environment Agency Guidance).

- The lower boundary of the present-day erosion rate was combined with the 50th %ile climate change acceleration to represent the lowest likely erosion scenario.
- The upper boundary of the present-day erosion rate was combined with the 95th %ile climate change acceleration to represent the highest likely erosion.

2.3 Safety Buffer Zone

The safety buffer zone is the distance between the cliff edge and properties at which point the property would be at risk from being lost to coastal erosion within one storm. It is therefore the point at which properties would be abandoned and demolished ahead of actually being directly lost to erosion. This is implemented into the economics report as it gives a more realistic representation to when a building would be "out of use". Due to the nature of erosion and cliff collapse at Kirk Michael, two safety buffers have been applied to the property dataset:

- Single Cliff Fall: The nature of the erosion at Kirk Michael is episodical, meaning that it is susceptible to single large cliff collapse events. Events with up to 15m of cliff loss in a single event have been observed at Kirk Michael (see the Erosion Risk Assessment). To represent this, a 20m buffer has been applied to the property dataset.
- 2-year average: The standard approach recommended by Defra within FCERM appraisal for the properties at risk of coastal erosion is to use a buffer which is representative of 2 years of erosion under an average erosion rate (i.e. not taking into account the episodical nature of cliff erosion).

3 Assessment of Damages

3.1 Receptors

A range of receptors have been assessed to determine the likely impacts of coastal erosion. Where data and recognised methodologies are available the impacts have been quantified, where this is not possible the impacts have been assessed qualitatively. The receptors assessed are shown in Table 3-1. The assessment for each receptor category is set out in the sections below.

Table 3-1: Identified receptors at risk of coastal erosion and method of assessment

Quantitative Assessment	Qualitative Assessment
• Property direct damages • Mental health damages • Human related intangible impacts • Agricultural losses	• Roads • Utilities • Tourism, recreation, & amenity

3.2 Property

3.2.1 Properties at Risk

The property dataset used for this assessment has been provided by the Isle of Man Government in the form of a NLPG (National Land Property Gazetteer) point shapefile and accompanying CSV. This has been combined with OS (Ordnance Survey) data to identify the property boundaries.

The erosion lines with safety buffer zones applied have been used to identify the properties at risk from coastal erosion under a Do Nothing scenario over the next 100 years. This has been done for all three of climate change scenarios being considered. The results of the analysis have been set out in Table 3-2, showing the numbers predicted to be lost in each period. Properties are considered as "lost" or "affected" when the safety buffer is reached; this is generally before the point where they would actually be damaged by erosion, however, in practice the properties would be abandoned and/or demolished ahead of actually being directly lost to erosion.

A few key observations about the resulting numbers from the baseline scenario (70th %ile including the Single Cliff Fall safety buffer of 20m):

- The large majority of affected properties is residential. There are only 3 non-residential properties at risk, all affected in the first 20-30 years.
- Before year 40 only 1 residential property is affected. From then onward, a slightly accelerating rate of properties are affected each decade, from 7-8 initially to 12-15 per decade toward the end of the 100 year period.
- The fastest climate change scenario causes approximately 50% more properties to be at risk within the 100 year period than the slowest climate change scenario.
- The larger buffer (20m) causes approximately 10 more properties to be at risk compared to the smaller buffer (2 years).

Table 3-2: Properties at risk of coastal erosion within 100 years within the study area

Safety Buffer Zone	Property Type	Year of Loss										
		10	20	30	40	50	60	70	80	90	100	Total
50%ile Erosion Rates												
Single Cliff Fall (20m)	Residential	0	0	1	3	7	7	11	11	10	13	63
	Non-residential	1	1	1	0	0	0	0	0	0	0	3
	Total	1	1	2	3	7	7	11	11	10	13	66
Standard (2 yr average)	Residential	0	0	1	0	2	6	9	12	12	9	51
	Non-residential	0	1	2	0	0	0	0	0	0	0	3
	Total	0	1	3	0	2	6	9	12	12	9	54
70%ile erosion rates												
Single Cliff Fall (20m)	Residential	0	0	1	3	8	9	12	11	12	13	69
	Non-residential	1	1	1	0	0	0	0	0	0	0	3
	Total	1	1	2	3	8	9	12	11	12	13	72
Standard (2 yr average)	Residential	0	0	1	0	3	8	10	13	12	12	59
	Non-residential	0	1	2	0	0	0	0	0	0	0	3
	Total	0	1	3	0	3	8	10	13	12	12	62
95%ile erosion rates												
Single Cliff Fall (20m)	Residential	0	0	1	6	8	12	15	12	15	12	81
	Non-residential	2	1	0	0	0	0	0	0	0	2	5
	Total	2	1	1	6	8	12	15	12	15	14	86
Standard (2 yr average)	Residential	0	0	1	0	7	9	14	13	15	15	74
	Non-residential	0	1	2	0	0	0	0	0	0	1	4
	Total	0	1	3	0	7	9	14	13	15	16	78

Figure 3.1 below shows the distribution of properties at risk of coastal erosion throughout the 100-year appraisal period for all the scenarios considered.

Figure 3-1: Distribution of properties at risk throughout appraisal period (Red = Residential, Green = Non-residential)

3.2.2 Property Values

Damages related to properties for coastal erosion are taken as the risk-free market value of the property taken at the predicted year of loss. The risk-free valuation removes any potential depreciation of property value due to imminent erosion risk. The market value for the residential properties has been taken from the Isle of Man Housing Market Review 2022 which gives an average market value for the Isle of Man as a whole for houses and flats. These values have been applied to the different house types as shown in Table 3-3.

Table 3-3: Average property prices for Kirk Michael

House Type	IoM Housing Market Report 2022	Value
Detached	House	£386,955
Semi-detached	House	£386,955
Terraced	Flat	£187,002
Flat	Flat	£187,002

These values were sense-checked by gathering information on properties currently for sale in the area on Zoopla and Rightmove. The most recent sales value information provided by the Isle of Man Government has not been used for residential properties due to the majority of the sales being a significant time ago, which therefore will not accurately reflect current risk-free market values. Only residential properties which have been sold since 2020 were used as part of the sense checking process. It was concluded that the values in Table 3-3 are appropriate for the level of this study.

There are only three non-residential properties at risk of erosion within the 100 year appraisal period, even under the more extreme erosion predictions. The market values for non-residential properties have been taken from the most recent sales value information provided by Isle of Man Government. These values are:

- Glen Wyllin Trout Hatchery: £275,000 (25/10/2022)
- Blacksmiths (17 Broogh Wyllin): £200,000 (29/04/2008)
- Cooil Stables: £61,000 (30/10/2003)

Where there is no sales information, for instance for barns, those properties have been valued following the methodology in the MCM using their floor area and the average rateable value for industrial use for England, which is £49.07/m^2 (no Isle of Man specific data was available at the time of writing).

3.2.3 Property Damages

The damages are applied at the predicted year of loss of each property and discounted accordingly using the HM Treasury standard discount rates. The present value (PV) damages due to property losses under the Do Nothing scenario for the different erosion rates and safety buffer zones considered by this assessment are shown in Table 3-4.

Table 3-4: Present value damages under the Do Nothing Scenario for Kirk Michael

Safety Buffer Zone	Property Type	Erosion Rate		
		50%ile	70%ile	95%ile
Single cliff fall (20 m)	Residential	£2,488,213	£2,884,330	£3,663,635
	Non-residential	£284,648	£284,648	£297,801
	Total	**£2,772,861**	**£3,168,978**	**£3,961,436**
Standard (2 yr average)	Residential	£1,745,515	£2,115,990	£2,839,170
	Non-residential	£206,004	£213,214	£226,920
	Total	**£1,951,520**	**£2,329,204**	**£3,066,091**

The table shows that, similar to property numbers, the fastest scenario generates approximately 50% higher damages. The difference between the two buffer approaches is approximately 25%, or £1m.

3.3 Mental Health

Intangible mental health losses due to coastal erosion have been applied to all affected residential properties using the methodology outlined in Advice for Flood and Coastal Erosion Risk Management: Mental Health Costs of Flooding and Erosion (Environment Agency, 2020b) based on the property type and year of loss. The guidance gives a value per adult of £9,546 at a 2018 price date. This has been uplifted to a 2023 base date using the GDP Deflator Index to give a value of £11,201 per adult.

This value is multiplied by the number of adults per property. For this assessment the national averages by property type for England (shown in Table 3-5) were used as given in the guidance in the absence of any Isle of Man specific data.

Table 3-5: National average number of adults per property in England

Property type	Number of adults per property
Average (all categories)	1.85
Detached	2.01
Semi-detached	2.00
Terraced	1.95
Bungalow	1.99
Flat	1.45

The damages are applied at the predicted year of loss of each property and discounted accordingly using the HM Treasury health discount rates. The present value (PV) damages under the Do Nothing scenario for the different erosion rates and safety buffer zones considered by this assessment due to intangible mental health losses are shown in Table 3-6. The table shows that this type of damages is small but significant, at 10-15% of direct property damages.

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Table 3-6: Damages due to intangible mental health losses.

Safety Buffer	Erosion Rate		
	50%ile	70%ile	95%ile
Single cliff fall	£522,578	£398,604	£411,908
Standard (2 yr average)	£411,908	£595,447	£461,984

3.4 Human Related Intangible Impacts

The economic valuation of human related intangible impacts of flooding and coastal erosion in project appraisals is described in Flood and Coastal Defence Project Appraisal Guidance FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities (Defra, 2004).

The supplementary guidance is based on evidence from a research project which included an extensive national survey of recently flooded and 'at-risk' residents. The results of the research concluded that the value of avoiding the health impacts of fluvial flooding is of the order of £200 per year per household (2004 base date).

The research and methodology which underpins the supplementary guidance is predominantly focused on the impacts associated with flooding, however it is reasonable to assume that there are intangible impacts on households threatened with imminent loss of their property to coastal erosion.

Although these may be of a very different nature to that of the constant threat of flooding, as coastal erosion and flood management projects are considered in the same appraisal and prioritisation framework, schemes to combat erosion could be disadvantaged if these potential losses were not recognised.

The long-term equivalent of £200 per household per year capitalised over 50 years using current Treasury rates is some £5,000 (2004 base date). The guidance indicates that where coastal erosion schemes are designed to significantly postpone (by more than 25 years) imminent loss of property (i.e. the property concerned has more than 80% chance of loss in the next 5 years without the scheme), the damage reduction or benefit per property should be enhanced by this capital value.

The value of £5,000 per property has been uplifted using the GDP Price Deflator Index for 2023 to a value of £7,753 per household applied at the year of loss.

There are no residential properties identified as being at risk within the first 5 years of the appraisal period even under the more extreme erosion predictions. Therefore, there are no human related intangible impact damages accumulated under the Do Nothing scenario.

3.5 Agricultural Loses

There are 9 fields which have been identified through the "Field Gazette" layer on the IoM government website which are at direct risk of coastal erosion. Assessing the land from aerial imagery and Google Earth it has been determined that the land mainly consists of grassland. These fields have been digitised and an estimated loss of field per 10 years has been calculated in hectares using the erosion lines. No safety buffer zone is applied to agricultural land.
The value of the agricultural land has been assessed using a study in which a selection of different sources has been used to derive a range of land values which can be applied to this area to provide a higher level of confidence that the magnitude of valuation is realistic.

Following the advice in the Multi-Coloured Handbook 2022, the change in the study area equates to Scenario I: Permanent loss of agricultural land. The guidance states that land permanently lost to agriculture should in most cases be valued at its market value (£11,000/ha - £14,000/ha for grazing land) less £600/ha to reflect the subsidy effect of farm income support. Whilst this guidance is based on England, the approach remains valid for the Isle of Man. Farm subsidies are also available on the Isle of Man, whilst the value may vary compared to England it is acceptable to use this approach for the level of this study.

In addition to the MCM methodology, land values for agricultural land have been sought from various publicly available data sources including specialist agricultural land management organisations and sales websites. There is little data available which is specific to the Isle of Man, therefore average values for England have been sought. The only Isle of Man specific values found are from the Chrystals Estate Agents website, which has been used to get an average value from current listings (October 2023) for agricultural land with no buildings across the Isle of Man. This includes a listing for a parcel of land in the Kirk Michael area. The results of the searches into agricultural land values are shown in Table 3-7. This shows that the current Kirk Michael listing is within the range of national and regional values from other sources and is therefore deemed an acceptable land value to apply to the agricultural land at risk of erosion for this study.

Results from the analysis are presented in Table 3-8 below. It highlights that there is a consistent loss of agricultural land every 10 years, with an average of 0.5 hectares lost over every 10 years across each scenario. The table also shows that agricultural damage is very small compared to property-related damage (less than 1%).

Table 3-7: Summary of findings into search of agricultural land value for Kirk Michael

Source	Scale	£/hectare	Price date year	£/hectare @ 2023 prices
Multi-Coloured Handbook	National Lower	£ 10,400	2018	£ 12,203
	National Upper	£ 13,400	2018	£ 15,723
Savills	National	£ 11,120	2021	£ 12,059
Farmers Weekly	Regional - Cumbria	£ 13,927	2021	£ 15,103
Farmers Weekly	National average	£ 18,541	2021	£ 20,108
Strutt & Parker	Regional - North	£ 12,355	2023	£ 12,355
Strutt & Parker	National	£ 21,004	2023	£ 21,004
Chrystals	**Kirk Michael**	**£ 12,964**	**2023**	**£ 12,964**
Chrystals	Isle of Man average	£ 28,210	2023	£ 28,210

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Table 3-8: Agricultural Land Lost (hectares) to Erosion over a 100 year Appraisal Period

Metric	Erosion Rate	Year of Loss (Hectares)										
		10	20	30	40	50	60	70	80	90	99	Total
Area lost	50th%ile	0.63	0.59	0.57	0.49	0.44	0.47	0.49	0.51	0.45	0.35	**4.99**
	70th%ile	0.66	0.62	0.6	0.51	0.47	0.51	0.53	0.52	0.43	0.36	**5.21**
	95th%ile	0.7	0.67	0.63	0.54	0.54	0.58	0.61	0.52	0.43	0.39	**5.61**
Value	50th%ile	£8,167	£7,649	£7,389	£6,352	£5,704	£6,093	£6,352	£6,611	£5,834	£4,537	**£64,689**
	70th%ile	£8,556	£8,037	£7,778	£6,611	£6,093	£6,611	£6,871	£6,741	£5,574	£4,667	**£67,541**
	95th%ile	£9,075	£8,686	£8,167	£7,000	£7,000	£7,519	£7,908	£6,741	£5,574	£5,056	**£72,726**
Present Value	50th%ile	£5,790	£3,847	£2,631	£1,683	£1,124	£896	£692	£549	£379	£236	**£17,827**
	70th%ile	£6,066	£4,043	£2,769	£1,752	£1,200	£972	£749	£560	£362	£243	**£18,716**
	95th%ile	£6,434	£4,369	£2,907	£1,855	£1,379	£1,105	£862	£560	£362	£263	**£20,096**

3.6 Roads

The main A3 road, which forms part of the Isle of Man TT Road racecourse, is not expected to be affected by coastal erosion within the 100 year appraisal period, even under the most extreme erosion predictions. Whilst there are roads at risk of erosion within the appraisal period, they are local residential roads which primarily serve the properties located directly on them. The loss of these roads would therefore cause minimal disruption as the properties they serve would also be lost to erosion.

3.7 Utilities

There is limited utilities data available for this economic assessment. Within the property dataset there are no utilities that are affected by erosion within the appraisal period, however, the sewage works located directly north of the Michael United Football ground is approximately 20m from the 100 year erosion line in the 95th %ile scenario.

There are likely to be buried services under the local roads which are at risk of erosion. However, these will primarily serve the properties which are also at risk of erosion and therefore there is unlikely to be disruption to the wider community. There are likely to be periodic costs associated with making services safe and continuing supply to the rest of the properties on an affected street as erosion progresses. However, at this stage it is not possible to determine the magnitude of these damages.

3.8 Tourism, Recreation, and Amenity

There are several potential impacts to tourism, recreation, and amenity receptors in Kirk Michael from coastal erosion. Whilst there is not sufficient data available at this stage to quantify potential damages, the impacts have been assessed qualitatively. The impacts include:

- **Kirk Michael (north) and Glen Wyllin (south) Beach parking areas and access roads:** loss of the car parks and the beach access ramp/slipways at the north and south of the study area would result in the loss of recreation and amenity value for the local community and visitors. Access to open "green spaces" is important for physical and mental wellbeing, and health related damages would be incurred under the Do Nothing scenario. This could be mitigated by 'rolling back' the car parks and beach

access at periodic points to ensure access is maintained, though this would incur a cost. The car parks appear to be free to use and therefore there is no loss of revenue damages. Both of these car parks could be completely lost within 100 years.

- **Glen Wyllin campsite:** while there is limited infrastructure, and therefore limited direct damages associated with the campsite, it is an important asset for the local visitor economy, particularly during TT season. Loss of this asset could impact on the local economy; however, it is likely that the campsite could adapt and there is potential for alternative areas around Kirk Michael to offer alternative campsites. The impacts therefore would be to the individual business, with revenue transferring elsewhere within the local area. There are no impacts to the local economy that can be quantified. The area to the west of the charging points and showering blocks leading towards the beach is estimated to be lost within the 100-year appraisal period.

There are several other important community facilities that are located within the study area but are outside of the 100-year erosion zone. These include the Michael United AFC football ground and the Heritage Trail footpath/bridal way (old railway line).

4 Summary of Do Nothing Damages

This section summarises the assessment of damages associated with the Do Nothing option which assumes no coastal management is put in place to prevent further erosion and defences in place are left to fail.

A summary of the damages under the Do Nothing scenario for the different erosion rates and safety buffer zones considered by this assessment are presented below in Table 4-1.

Table 4-1: Summary of Do Nothing Present Value damages at Kirk Michael

Safety Buffer Zone	Damage Receptor	Erosion Rate		
		50%ile	70%ile	95%ile
Single cliff fall (20m)	Property	£2,772,861	£3,168,978	£3,961,436
	Mental Health	£522,578	£398,604	£411,908
	Human Related Intangible Impacts	None	None	None
	Agriculture	£17,827	£18,716	£20,096
	Total	**£3,313,266**	**£3,586,298**	**£4,393,440**
Standard (2 yr average)	Property	£1,951,520	£2,329,204	£3,066,091
	Mental Health	£411,908	£595,447	£461,984
	Human Related Intangible Impacts	None	None	None
	Agriculture	£17,827	£18,716	£20,096
	Total	**£2,381,255**	**£2,943,367**	**£3,548,171**

The best estimate of the damages from coastal erosion at Kirk Michael under the Do Nothing scenario is **£3.6 million**. This is based on the most likely erosion rates under the 70%ile RCP8.5 scenario and the single cliff fall (20m) safety buffer zone, which best represents the mechanism of erosion observed at Kirk Michael.

The sensitivity testing on the rates of erosion and size of safety buffer zone show that the Do Nothing damages could range from **£2.4 million to £4.4 million.** Whilst this range shows an increase of 183% from lowest to highest, the values are in the same order of magnitude. This supports the robustness of the assessment.

The best estimate (70%ile + single cliff fall safety buffer zone) for properties at risk under the Do Nothing scenario for Kirk Michael is **69 residential and 3 non-residential properties** within the 100 appraisal period, with only 4 residential and 3 non-residential properties at risk before year 50 (short to medium term), as shown in Table 4-2.

According to the 2021 Isle of Man Census Report there are 674 households in the parish of Michael. Kirk Michael is the main area of housing within this parish. The 69 residential properties at risk of coastal erosion represent 10% of the housing stock within the parish.

Under the most extreme predictions of erosion (95%ile + single cliff fall safety buffer zone) the number of properties increases by 19%, with an additional 12 residential and 2 non-residential becoming at risk. The 81 residential properties at risk under the worst-case scenario represent 12% of the housing stock in the parish of Michael.

Under the best-case scenario (50%ile + standard 2yr average safety buffer zone) there is a decrease of 25%, with 18 fewer residential and same number of non-residential properties at risk, compared to the best estimate (70%ile + single cliff fall safety buffer zone). The 51 residential properties at risk under the best-case scenario represent 8% of the housing stock in the parish of Michael.

Under all scenarios the number of properties at risk is in the same order of magnitude which supports the robustness of the assessment.

Table 4-2 Summary of properties at risk of coastal erosion in Kirk Michael

Safety Buffer Zone	Damage Receptor	Erosion Rate					
		50%ile 'Best-Case'		70%ile 'Best Estimate'		95%ile 'Worst-Case'	
		Short Term	Total	Short Term	Total	Short Term	Total
Single cliff fall (20m)	Residential	4	63	4	69	7	81
	Non-Residential	3	3	3	3	3	5
	Total	**7**	**66**	**7**	**72**	**10**	**86**
Standard (2 yr average)	Residential	1	51	1	59	1	74
	Non-Residential	3	3	3	3	3	4
	Total	**4**	**54**	**4**	**62**	**4**	**78**

5 Potential Investment Costs

Any future structural intervention to mitigate erosion along the Kirk Michael coastline will require investment. Whether this investment is justifiable, is strongly dependent on the balance between these investments and the benefits that they might deliver, i.e. the return on investment, often calculated in the form of a Benefit-Cost Ratio (BCR; with a BCR of 1 or higher indicating a viable scheme). In this case, the benefits of any scheme would be the prevention of the damages as summarised in section 4, and it is therefore important to also get an indication of the costs. This section presents a range of example projects from across the British Isles, as well as the initial design for Kirk Michael from 2019, in order to provide a cost range in which an intervention at Kirk Michael is likely to fall.

5.1 Preliminary Design for Kirk Michael

In February 2019, Glennerster Consulting were commissioned by the Isle of Man Government to perform a desk-based feasibility study of protecting the coast at Kirk Michael by means of a rock armour revetment (Glennerster, 2019). Two main options were developed as part of this feasibility study; a revetment set forward from the cliff (Figure 5-1) and a revetment at the toe of the cliff (Figure 5-2). Of both options, a "budget" version was considered, but it is noted by Glennerster (2019) that these options are not likely to meet industry standards.). The cost estimates are based on a protected stretch of 775m.

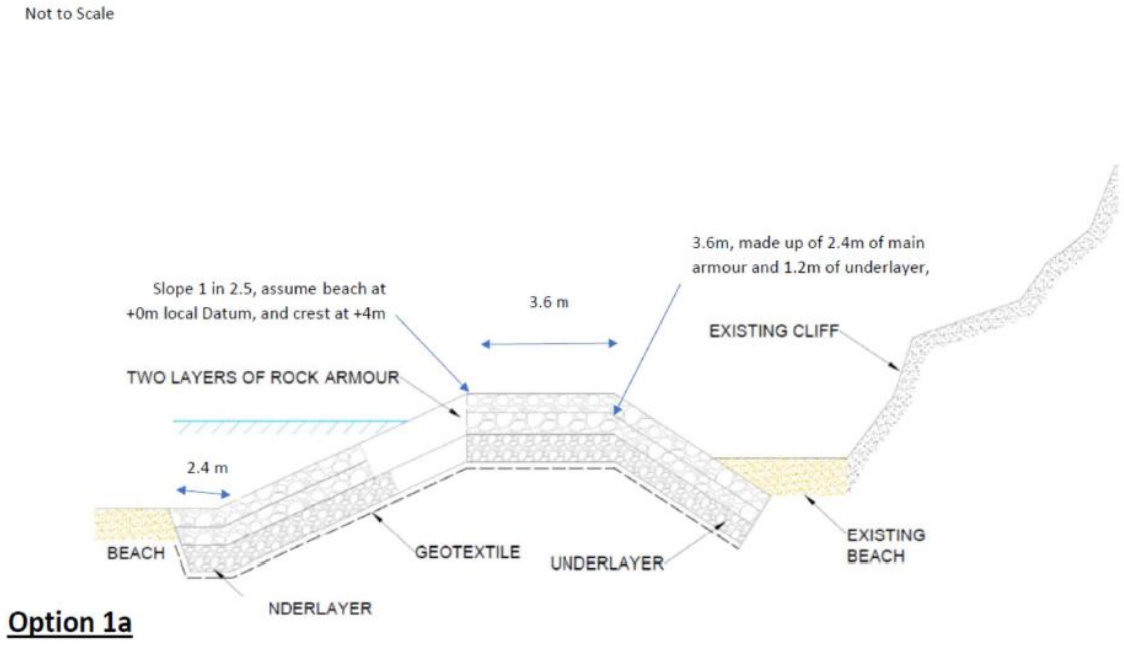

Figure 5-1: Concept drawing of a rock revetment set forward from the cliff. Source: Glennerster (2019).

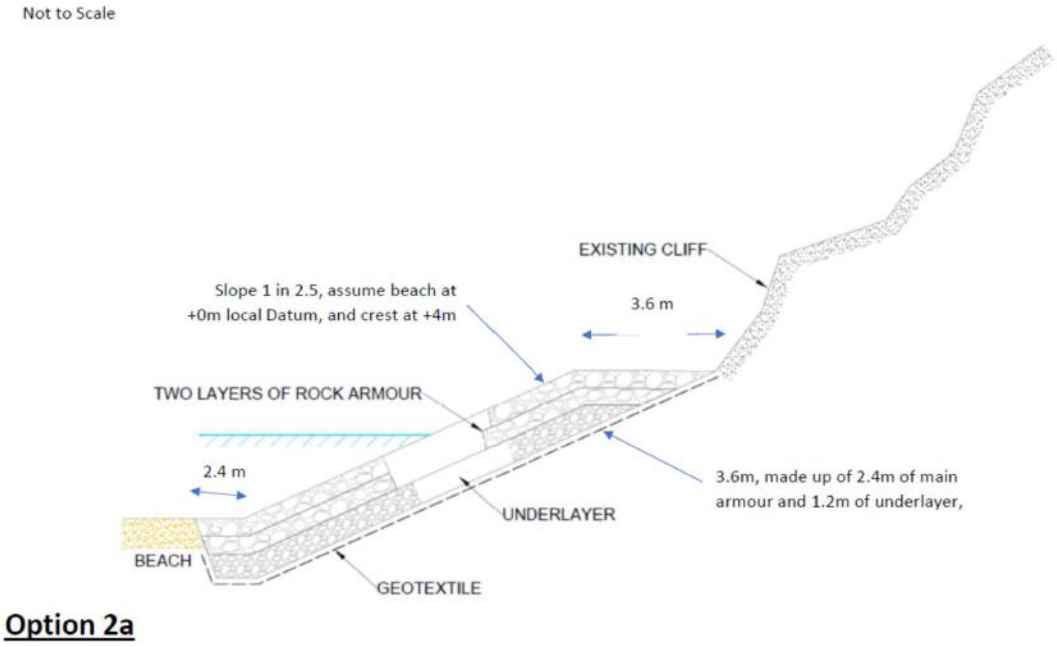

Figure 5-2: Concept drawing of a rock revetment at the toe of the cliff. Source: Glennerster (2019).

The following should be considered regarding the cost estimates presented by Glennerster (2019):

- The geometry of the revetments seems not to have been based on a design wave height and water level; we assume it is an initial concept design based on engineering judgement. Similar considerations hold for the size of the rock armour (3-6 tonne). Both of these factors influence the cost of the revetment significantly, and therefore there is potential for a significant cost variation in the outline / detailed design stages compared to the current estimates, when these parameters are firmed up.
- Preliminaries, design fees and construction supervision fees are included in these estimates.
- The costs were estimated at a 2019 price point. Since then, there has been significant inflation which has also affected the construction industry. There, we have corrected these cost estimates to a 2023 price point to reflect this.
- The estimated costs do not include an optimism bias. Such a bias normally accounts for any unforeseen costs that might come to light during later stages of the design, and it is good practice to include 60% in a high-level feasibility study such as this. Comparing the unit rates per tonne of 3-6T rock from Glennerster (2019), however, with our own recent experiences, these unit rates are suitably conservative to account for that 60% optimism bias.

The corrected cost estimate for either of these options amounts to £10.8M.

In 2019, VolkerStevin presented FMD with a cost estimate for a range of coastal defence schemes around the Island of Man, including rock armour at Kirk Michael. For the scheme at Kirk Michael, a cost is quoted of £5.9M (corrected to a 2023 price point). This is significantly different from Glennerster (2019); the expected amount of rock needed is significantly less, and additionally, these numbers are based on performing a number of projects in sequence, creating an economy of scale. For this reason, we have not used this estimate in our viability analysis (section 5.5), but we mention them here to illustrate that the cost estimates are indicative only at this stage.

5.2 Thorpeness Rock Revetment

In 2021, the village of Thorpeness was under urgent pressure from beach and cliff erosion. The Shoreline Management Plan has a Managed Realignment policy, with a stated intent that local intervention to stop erosion is allowed as long as this does not have unacceptable impacts on coastal processes. RHDHV was commissioned to help East Suffolk Council (ESC) and the Thorpeness Coastal Futures Community Group to select the solution that meets the level of coastal protection sought by the community, whilst considering the impact of the solution on the coastal environment (which is recognised as an Area of Outstanding National Beauty; AONB) and the relationship of the community of Thorpeness with its beach. For that purpose, RHDHV reviewed an existing (but outdated) preferred design option and developed a new outline design. Within this process, existing (failed) defences had to be considered, as well as some temporary works that needed to be integrated into the longer-term option. The scheme would have to be funded mostly by the local community themselves, as there was limited justification for central government funding. The project therefore focussed on supporting the community's investment decision by generating an overview of different options based on a range of standards of protection and design lifetimes, and one of the key decision-making elements was the funding gap between the required investment and the available funds. An important element for the community was having access to the crest of the defence as part of the coastal path. Figure 5-3 presents an overview of several options that were explored for the protection of the cliff face, based on different defence crest levels and the in- and exclusion of a walkway and upstand wall. The envisioned lifetime of this structure was 25 years, with a design standard of 1:50 yrs.

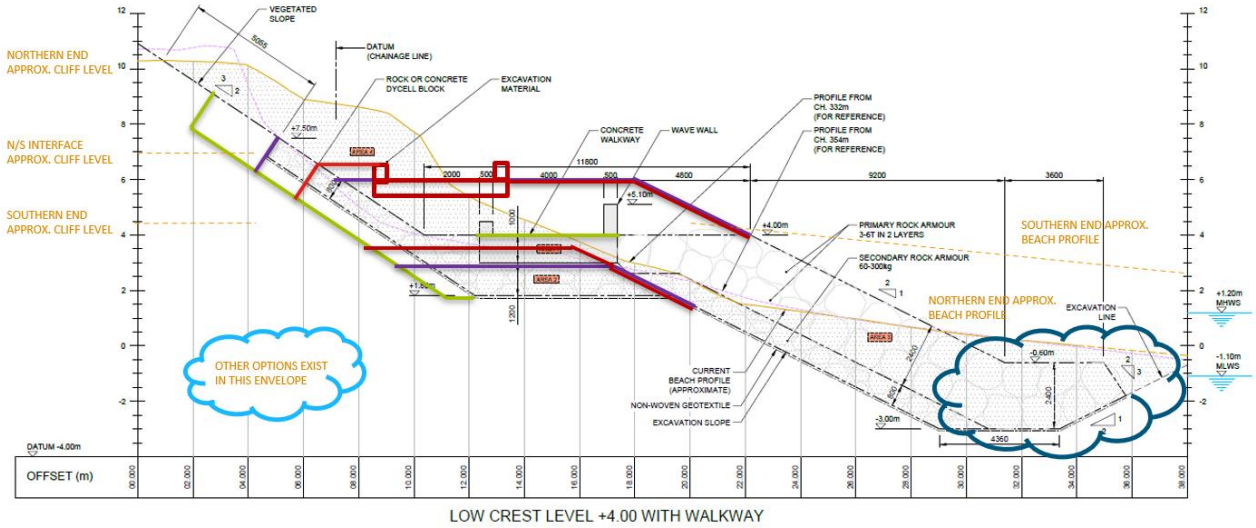

Figure 5-3: Overview of different options for the Thorpeness Cliff Toe protection.

Compared to Kirk Michael, the defences at Thorpeness are of a larger scale than what was proposed for Kirk Michael (see section 5.1). However, estimated rock armour sizes are of a similar order of magnitude, and it is not impossible that a larger scheme would be needed at Kirk Michael, as the feasibility design could not be based explicitly on local design conditions.

The estimated cost of the scheme at Thorpeness (excluding design costs, consenting, surveying costs and construction supervision, but including 60% optimism bias) was in the range of £2.8M to £3.1M for a stretch of 200m revetment, depending on the chosen option, at a 2021 price point. Correcting this to 2023 for 775m of revetment at Kirk Michael, these costs would be in the range of £12.8M to £14.1M.

5.3 Southsea Coastal Defence Scheme

RHDHV are the lead designer for the prestigious £100M, 5km-long Southsea coastal defence scheme in Portsmouth. The scheme is the UK's largest Local Authority led coastal defence scheme and is being delivered as part of an integrated delivery team between Royal HaskoningDHV, Volker Stevin Boskalis Westminster (as lead contractor) and Coastal Partners (as client). The current coastal defences do not offer a sufficient level of protection as they are too low and there have been multiple failures over the past few years putting properties at imminent risk of flooding. The scheme is divided into 6 sub-frontages.

For sub-frontage 3 the scheme consists of promenade and carriageway raising, combined with a primary defence of rock armour, upstand walls and beach recharge, and a secondary defence earth bund. Figure 5-4 to Figure 5-7 provide an overview of the design. This design will provide a 1:200yr standard of protection for the next 100 years. The total cost for this sub-frontage is £37.5M at a 2023 price point (estimated by the contractor based on the detailed design drawings. These costs are not directly applicable to Kirk Michael, as the design not only includes rock armour, but also stepped pre-cast concrete revetments, the beach recharge, complete redevelopment of the promenade, demolition of old defences, temporary relocation of historical monuments and shelters, and outfall works. Furthermore, the project is set in a challenging setting of historical importance and popular with the local population and tourists alike.

Reworking the sub-frontage 3 costing to only include those elements relevant to Kirk Michael (i.e. the rock revetment and contractor costs and fees), taking into account the different lengths of coastline, results in a representative fee of £22.3M.

Figure 5-4: Recent overview of sub-frontage 3.

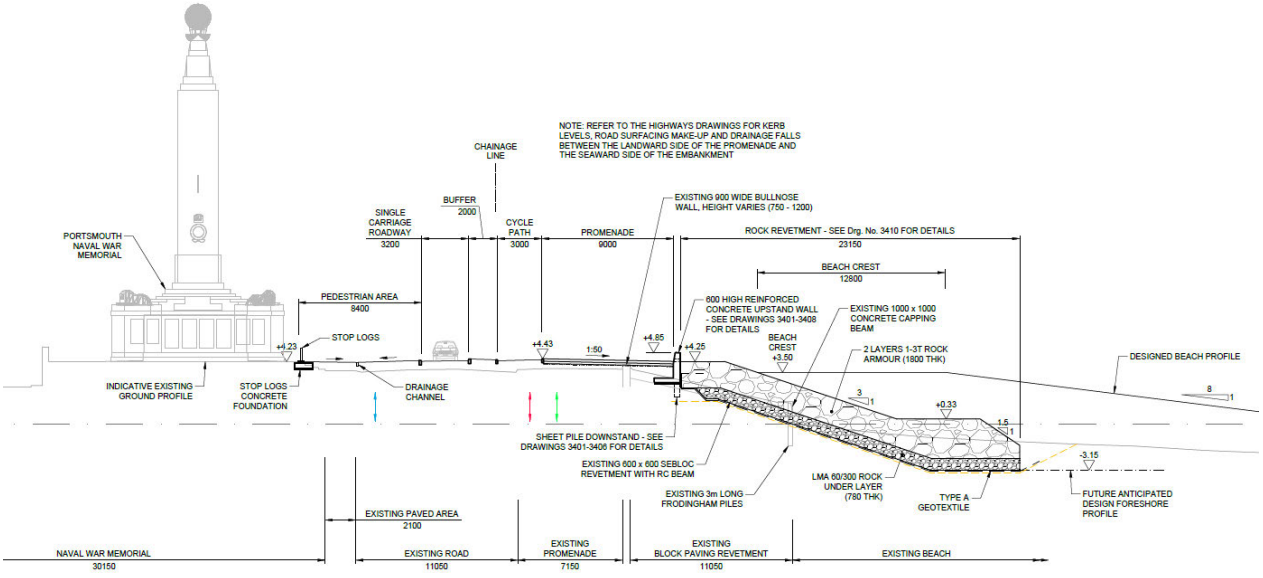

Figure 5-5: Typical cross-section of the rock revetment at sub-frontage 3.

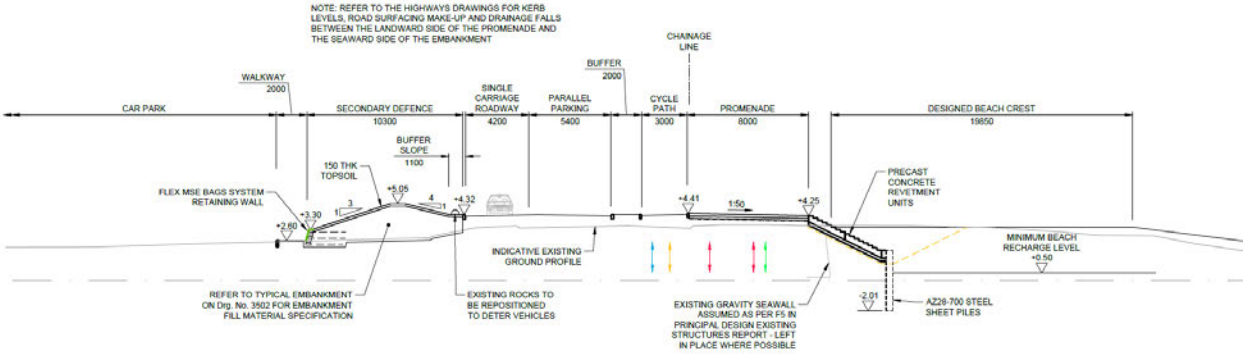

Figure 5-6: Typical cross-section of the stepped pre-cast concrete revetment at sub-frontage 3.

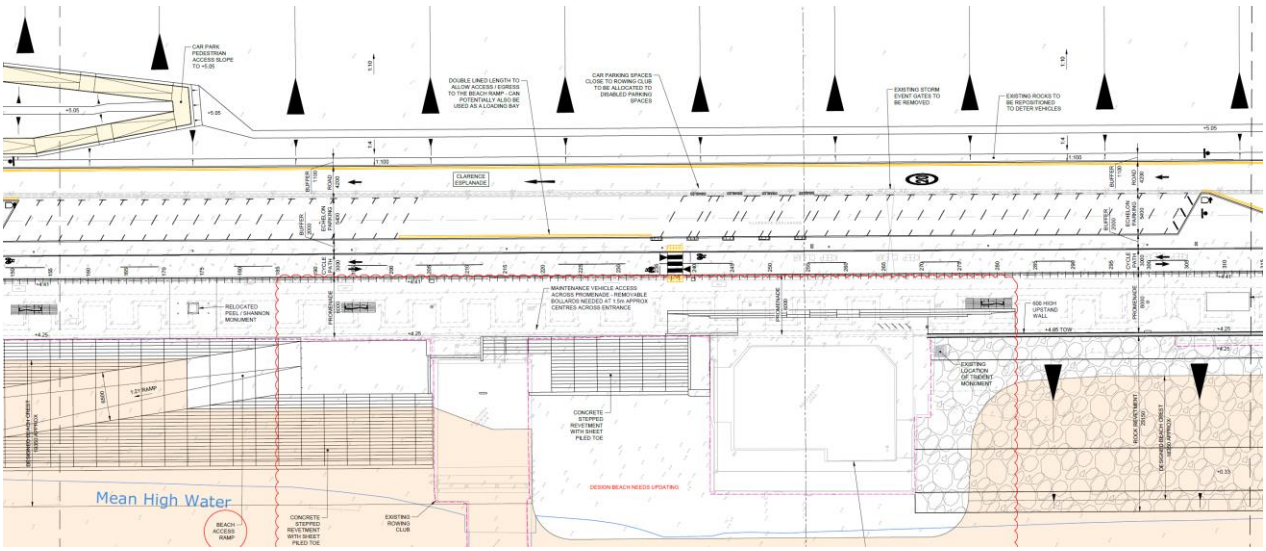

Figure 5-7: Top view of part of sub-frontage 3 (see located at the bottom of the image) at the transition between stepped and rock revetments, indicating the complexity of the project.

5.4 Bacton Sandscaping Scheme

The Bacton Sandscaping Scheme was constructed in 2019 in North Norfolk, England. The scheme protects the nationally critical Bacton Gas Terminal from cliff erosion against a 1:10,000 per year storm and buys time for the downdrift communities to progress their adaptation to coastal change (as maintaining and upgrading the seawall is not justifiable). It is a so-called “mega-nourishment”: 1.8M m^3 of sand was placed on the existing beach, 1M m^3 of which located at the terminal. The expected lifetime of the scheme is 15-20 years, over which it gradually spreads out to sustain the protection at the village and potentially further downdrift as well. The overall cost of the implementation of the scheme in 2019 was in the order of £20M. Figure 5-8 presents a typical cross-section of the scheme at the Terminal, whereas Figure 5-9 presents an impression of the extent of the scheme.

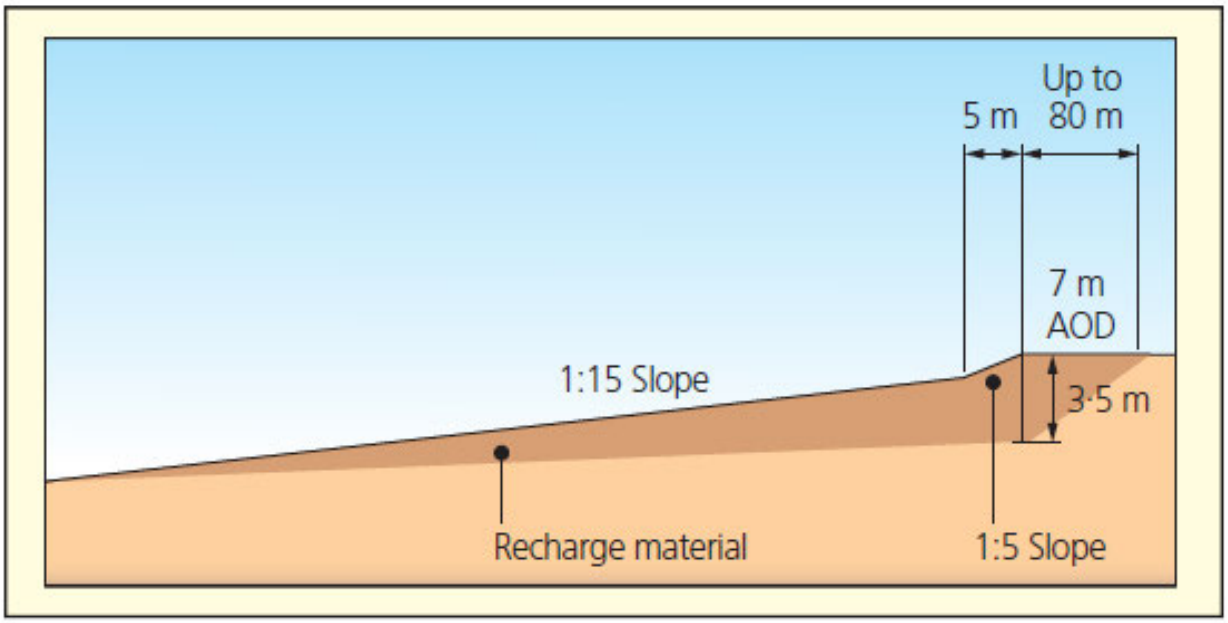

Figure 5-8: Simplified cross section of the final design in front of the Bacton Gas Terminal. From Clipsham et al. (2021).

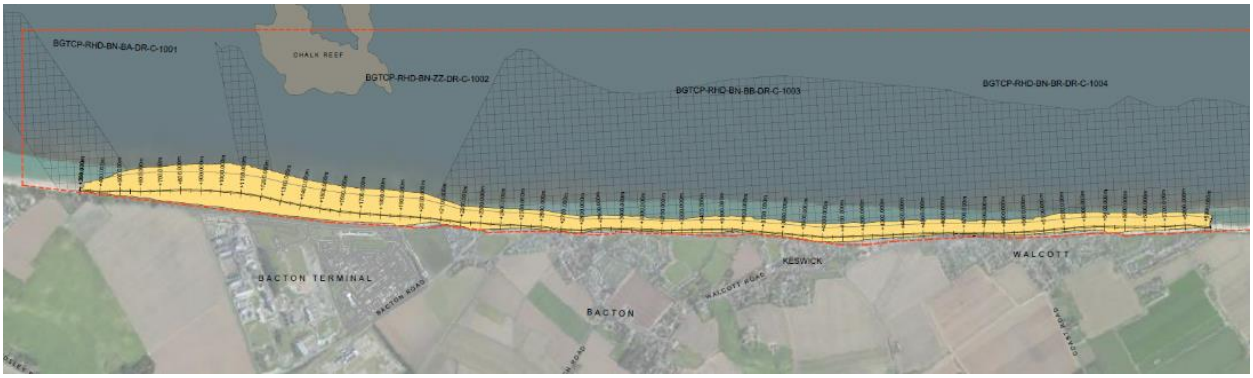

Figure 5-9: Impression of the extent of the Bacton Sandscaping Scheme.

In the absence of any design information, a very initial cost estimate for a nourishment scheme at Kirk Michael can be based on the assumption that a cross-section of a similar order of magnitude to protection of the Gas Terminal at Bacton would be required to protect the cliffs at Kirk Michael. Given that 1M m^3 of sand was placed there over a stretch of approximately 1.3km, this would result in an approximate cost of £8.2M for Kirk Michael (updated to a 2023 price level).

It should be noted that the beach profile at the Terminal was designed to protect against a very severe extreme event (1:10,000 years) over a lifetime of 15-20 years. It is likely that less sand would be required at Kirk Michael; or expressed differently, that a nourishment of this scale could be expected to have a longer functional life. Due to its size, there was a major economy of scale at Bacton; therefore, a smaller scheme would lead to higher unit rates per m^3 sand, driving the price up. In addition, the cost of beach nourishment is heavily determined by sailing distance to the sediment source (there are licensed areas, by The Crown Estate of England, in Liverpool Bay).

5.5 Summary

Table 5-1 provides a summary of the design standards and associated construction costs for the examples in the sections above, corrected to reflect the situation at Kirk Michael. It can reasonably be expected that the cost for a scheme at Kirk Michael will fall in the range of £8M to £25M, depending on the solution that is chosen and the level of protection that is implemented over a chosen lifetime. Table 5-1 also shows the range of the expected damages based on this study; in other words, the benefits justifying the implementation of a structure.

Table 5-1: Comparison of representative costs of a scheme at Kirk Michael based on a range of examples, for both the scenario of implementing a scheme in 2023 and in Y40. BCR = benefits / costs.

Project Example	Type	Defence Standard	Equivalent Cost 2023	Benefits 2023	Benefits Y40	BCR 2023	BCR Y40
Glennerster Feasibility Study	Revetment	Unknown	£10.8M	£2.4M - 4.4M	£6.4M – 12M	0.22 – 0.41	0.59 – 1.11
Thorpeness Cliff Protection	Revetment	1:50yrs 25yr lifetime	£12.8 - 14.1M			0.17 – 0.34	0.45 – 0.94
Southsea Coastal Protection Scheme	Revetment	1:200yrs 100yr lifetime	£22.3M			0.11 – 0.20	0.29 – 0.54
Bacton Sandscaping Scheme	Nourishment	1:10,000yrs 15-20yr lifetime	£8.2M			0.29 – 0.54	0.78 – 1.46

If the scheme were to be delivered in 2023, at best, there is a £3.8M deficit between the cost estimates and the estimated benefits that a scheme would deliver. The Benefit-Cost Ratio for a scheme ranges between 0.11 and 0.54 (with a BCR of 1.0 or higher indicating a viable scheme). It is therefore unlikely that a traditional engineering scheme could be justified at Kirk Michael if implemented as soon as possible.

It should be kept in mind, however, that the timing of the intervention matters for the economic viability of the scheme. The analysis in section 3.2.1 shows that an accelerating number of properties becomes at risk from Y40 onwards. Therefore, a second scenario is shown in Table 5-1 in which it is assumed that an intervention is not implemented until Y40. The benefits would in that case be incurred much sooner after the implementation of the intervention, resulting in less discounting (therefore higher Present Value benefits) than when the intervention was to be implemented in 2023. For this scenario, the discounting of the benefits

has therefore been corrected to reflect the delay of the implementation, and corresponding BCRs have been calculated as well. This shows that in case of a later intervention, a traditional engineering scheme might be feasible at Kirk Michael, but the BCR is still marginal.

6 Next Steps

Next steps for Kirk Michael should be determined within the wider setting of the area. The emerging National Strategy Review and envisaged Shoreline Management Plan should play a role in supporting decisions; Kirk Michael could be used as a pilot to help steer the Isle of Man's strategic approach.

The economic assessment as presented in this report should form the basis of the economics assessment for Kirk Michael within the SMP Development project; it considers a Do Nothing scenario, which at Kirk Michael is equivalent to both the No Active Intervention (NAI) and With Present Management (WPM) baselines. When setting the policy for the Kirk Michael frontage, it is important that the option is not only viable (i.e. the benefits outweigh the investment – a BCR > 1) but also affordable (based on the likelihood that funding can actually be made available if it is determined that a policy is viable). This will prevent setting expectations through the chosen SMP Policy (e.g. designating this as a HTL frontage) which, when it comes to implementing the SMP policy, cannot be met, which is likely to frustrate future management of the coastline. This was recommended in the Shoreline Management Plan refresh's supplementary guidance as produced for England and Wales and currently being rolled out with the Coastal Groups there.

When it comes to option development, if the agreed SMP policy includes any form of structural intervention, then, in addition to the Do Nothing baseline, the options should include consideration of the Do Minimum and a range of 'Do Something' options which should include a 'Do Maximum' option. Consideration of adaptation approaches should be included as well as traditional engineering approaches. Given the relatively low Do Nothing damages of £3.6M the economically justifiable costs of any options will be limited, as was indicated in section 5.5. This is also why the timing of interventions will need to be carefully considered. The longer interventions can be delayed, the better the benefit-cost ratio will be due to the effect of reduced discounting of the benefits. It was highlighted in section 5.5 that delaying intervention until Y40 could result in a viable scheme, although marginally (based on the indicative cost estimations). A longer delay would also have the benefit of leaving multiple options open for longer, i.e. not closing off options that may turn out to be preferable in the longer term, based on better understanding of the future (erosion rates, but also socio-economic and technical aspects).

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