

TECHNICAL NOTE

JBA Project Code	2020s0838
Contract	Mumbles Coastal Protection Scheme
Client	Amey Consulting
Day, Date and Time	16 March 2021
Author	Katie Corbett
Reviewer / Sign-off	Anne-Marie Moon
Subject	Mumbles Coastal Processes Review

1 Introduction

The proposed Mumbles Coastal Protection Scheme is intended to upgrade approximately 1.2 km of the existing defences located in Mumbles Bay, near Swansea, South Wales. The scheme seeks to reduce the threat of coastal flooding in Mumbles.

A review of the coastal process in Mumbles was undertaken by Arup on behalf of ABPmer in March 2017¹. This technical note is a review of the information provided in the 2017 report, aiming to identify new data and guidance to inform the design of the Mumbles Coastal Protection Scheme.

1.1 Mumbles Coastal Protection Scheme Area

The scheme frontage runs from Knab Rock slipway in the south east to beyond the Dairy Car Park in the north west (Figure 1-1).



Figure 1-1: Site location

The existing sea defence along the scheme frontage supports the promenade and protects the surrounding village and its amenities. It is comprised of a concrete sea wall approximately 0.487 km long and a sloping concrete revetment approximately 0.707 km long. Along almost the entire length of the scheme frontage, the existing defences are topped by a metal post & rail barrier to provide edge protection to the promenade. Access points to the beach, comprising stairs, ramps and slipways, are widely scattered along the frontage of the scheme. In addition to the above primary defences, intermittent sections of a low, set-back masonry wall provide a secondary defence line.

The proposed scheme will involve the upgrading of the existing primary defences to provide an increased level of defence, whilst also seeking to provide further opportunities and wider benefits for regeneration and tourism. The scheme frontage has been divided into three sections: A, B & C. The proposed options for each of the three sections are summarised in Table 1 below.

¹ Mumbles Conceptual Understanding - Mumbles PAR (Arup, 2017)

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Table 1: Summary of design options for the Mumbles Coastal Protection Scheme

Section of the Mumbles frontage	Option number	Description of design option
A	1	Encase the upper part of the existing sea wall in reinforced concrete with a new stepped reinforced concrete revetment, with sheet piled toe, providing scour protection to the lower part of the wall.
	2	Encase the upper part of the existing sea wall in reinforced concrete with a new rock armour revetment providing scour protection to the lower part of the wall.
B	1	Encase the upper part of the existing sea wall in reinforced concrete, topped with a new re-curve wall, with a new stepped reinforced concrete revetment, with sheet piled toe, providing scour protection to the lower part of the wall.
	2	Encase the upper part of the existing sea wall in reinforced concrete, topped with a new re-curve wall, with a new rock armour revetment providing scour protection to the lower part of the wall.
C	1	Break out the existing concrete revetment and replace with a new sloping reinforced concrete revetment, topped with a new re-curve wall, and with a new sheet piled toe line set slightly forward of the existing toe.
	2	Break out the existing concrete revetment and replace with a new rock armour revetment, with a new re-curve wall at the top.
	3	Break out the existing concrete revetment and replace with a new reinforced concrete sea wall, with an integral re-curve wall at the top and reinforced concrete stepped revetment with steel sheet piling at the toe. This option will allow widening of the existing promenade behind the new sea wall.

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1.2 Scope of Report

This technical note is a review of the 2017 coastal processes report, aiming to identify new data and guidance to inform the design of the Mumbles Coastal Protection Scheme. Specifically, this report covers:

- **2017 report summary** – this review lists the content of the 2017 report and comments on its overall suitability.
- **Foreshore change** – the potential for foreshore change is a key aspect for design work including beach and toe-level lowering. The Wales Coastal Monitoring Centre (WCMC)² have undertaken recent beach surveys. This data has been obtained as part of the review and analysed to assess any recent changes in beach levels.
- **Sea level rise estimates** – Welsh Government have developed new climate change guidance in line with the latest UK Climate Projections (UKCP18)³ for sea level rise which is available in draft. They have offered transitional implementation of the guidance for schemes in progress before 1st April 2021, whereby the preferred option should undergo sensitivity testing against the revised sea level rise allowances. This ensures the design can remain the same, provided the Standard of Protection is reviewed. As such, this review includes a comparison of the latest sea level rise projections with the existing analysis presented in the 2017 report.
- **Wave and water level parameters** – these have been reviewed by Welsh Government as they deviate from standard best practice guidance to take into account site specific characteristics. The parameters have been recently approved by Welsh Government and are therefore not further reviewed here.
- **Coastal Protection Scheme impacts** – the potential impacts of the proposed Mumbles Coastal Protection Scheme on local coastal processes have been considered.

2 2017 Coastal Processes Work

2.1 Contents

The coastal process review for Mumbles was undertaken by Arup on behalf of ABPmer in March 2017. The coastal processes considered in the review include:

- Offshore seabed characteristics
- Local geomorphology
- Coastal change with a focus on the foreshore
- Predicted shoreline evolution
- Water levels – tidal, surge and extreme levels
- Tidal currents
- Waves – regional, local and extreme waves

² Wales Coastal Monitoring Centre: <http://www.welshcoastalmonitoringcentre.cymru/eng/Index.html>

³ UK Climate Projections (UKCP18): <https://ukclimateprojections-ui.metoffice.gov.uk/ui/home>

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2.2 Summary

The 2017 coastal processes review concludes that the primary coastal defence consideration in Mumbles should be to increase defence height to protect against increased still water levels due to rising mean sea level. Wave action and overtopping was identified as a less significant factor in Mumbles with respect to flood risk.

The coastal processes within the Mumbles frontage are modified by the presence of Mixon Shoal and Mumbles Head. These features result in reduced current speeds throughout the nearshore and intertidal areas, and act to reduce wave heights from south westerly storms through processes such as wave refraction, diffraction, and shoaling. Waves from NE and SE sectors therefore provide the greatest potential for larger waves. Following the 2017 report a separate note was undertaken to further assess the site-specific wave and water level conditions and these have been formally agreed with Welsh Government. These are not reviewed further in this coastal processes review.

Sediment transport rates within the mumbles frontage are noted to be low and relatively self-contained across the frontage and the report concludes that the intertidal area is consolidated and stable. Over the four-year available data set of beach profiles (2009-2013) only a small lowering of the foreshore was identified to the north of the study area of $\sim 0.05\text{m}$ and a variation of $\sim \pm 0.2\text{--}0.3\text{m}$ to the southern end of the frontage. Previous studies and the SMP all also indicate stability along the frontage.

The report overall concludes that the foreshore and coastline is stable, but there is a risk of scour and upper foreshore lowering in response to climate change as water levels and wave heights increase over time. There is limited ability for the foreshore to adapt to climate change and the exposure of defences to extreme water level and wave attack will increase over time.

Foreshore data and sea level rise guidance have both been updated since completion of the 2017 review and are investigated in Sections 3 and 4 of this report respectively.

3 Foreshore Change

The 2017 review by Arup used topographic data obtained from the Wales Coastal Monitoring Centre for 2009, 2010, 2012 and 2013. The data was used to plot beach profiles, starting inland at the defence line enabling assessment of toe-levels, and progressing offshore to build up an image of the foreshore gradient. Beach profiles were plotted for two locations along the Mumbles frontage, the locations of which are shown below in Figure 3-1.

Analysis of the beach profiles in the 2017 review suggested a stable foreshore showing very little change in overall foreshore or intertidal level over time. The profiles did reveal minor drawdown of material at the defence toe at the northern profile location and minor build-up of material at the defence toe at the southern profile location.

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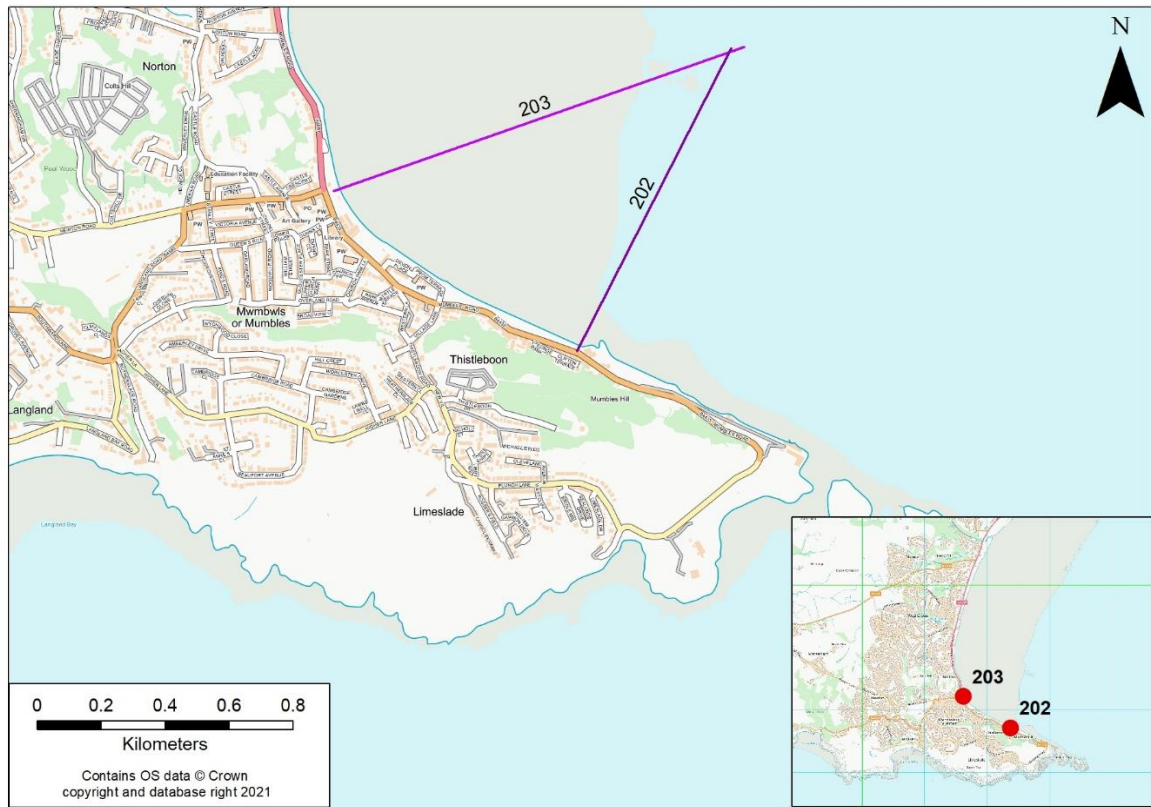


Figure 3-1: Locations of topographic surveys in Mumbles

Further topographic data for Mumbles is now available from the 2019 and 2020 surveys. This data has been obtained from the WCMC and plotted alongside the original data used in the 2017 review (Figure 3-2 and Figure 3-3). The more recent survey data indicates some lowering of the foreshore at the toe of the sea wall compared to earlier surveys.

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Profile 202

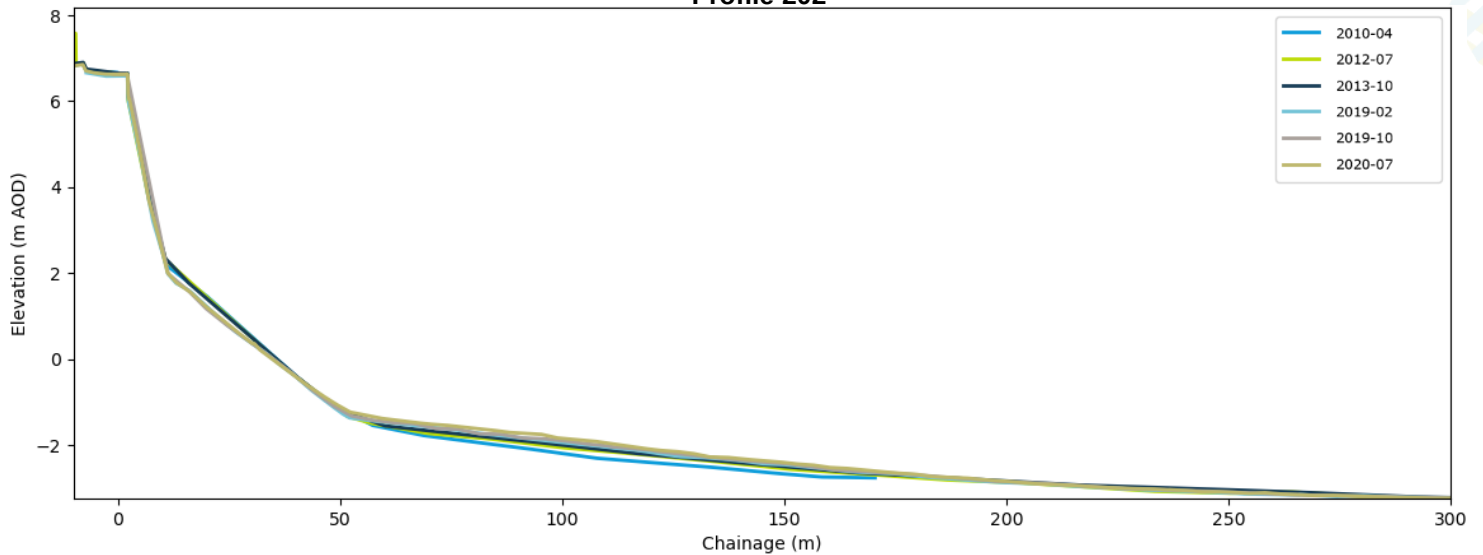


Figure 3-2: Beach profiles at section 202.

Profile 203

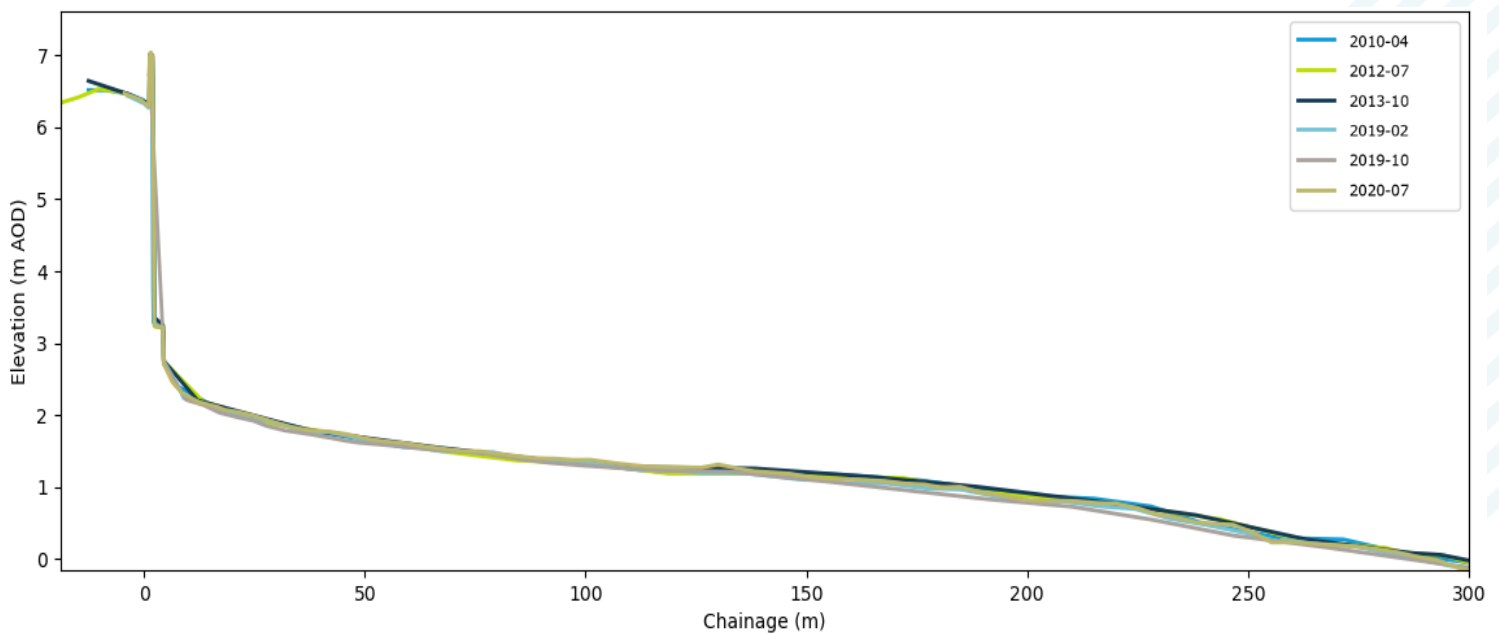


Figure 3-3: Beach profiles at section 203.

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Figure 3-4 and Figure 3-5 provide detailed plots of the toe levels at the two profile locations. Figure 3-4 shows the beach profile at the toe of the defence for the 202 profile (southern profile). Between 2010 and 2013, there was a minor build-up of material at the defence toe of approximately 0.2m, as reported in the 2017 report. This build-up of material was not sustained; the toe level was recorded at 2m AOD in the February 2019 survey, approximately 0.4m lower than the 2013 toe level. The toe level remained at approximately 2m AOD in the most recent survey in July 2020. Although there is a lack of data between 2013 and 2019, the data indicates that the toe and upper-foreshore levels may have not recovered to previous levels. In total, 0.4m of variation in toe and upper-foreshore levels has been recorded at this profile from 2010 to 2020. The potential for a longer-term trend of toe and upper-foreshore lowering should not be ruled out.

Figure 3-5 shows the beach profile at the toe of the defence for the 203 profile (northern profile). Between 2010 and 2013, there was a very minor drawdown of material at the defence toe, as reported in the 2017 report. Continued drawdown at the toe is seen in the October 2019 and July 2020 surveys; the toe level was recorded at 2.7m AOD in July 2020, a total drawdown of approximately 0.5m since 2010. From the data available, there is no evidence of accretion of material along this profile over the 10-year period since the first profile record. Therefore, the topographic surveys suggest the potential for a longer-term trend of toe and upper-foreshore lowering at this profile location.

It is recommended that the potential for lowering of the upper-foreshore, particularly around the northern defence profile, should be taken into account in the designs. It should be noted that the length of the available beach profile data set is limited and there is insufficient data to identify clear long-term trends in a dynamic beach environment. It is therefore recommended that coastal monitoring continue once the proposed scheme is implemented.

Profile 202

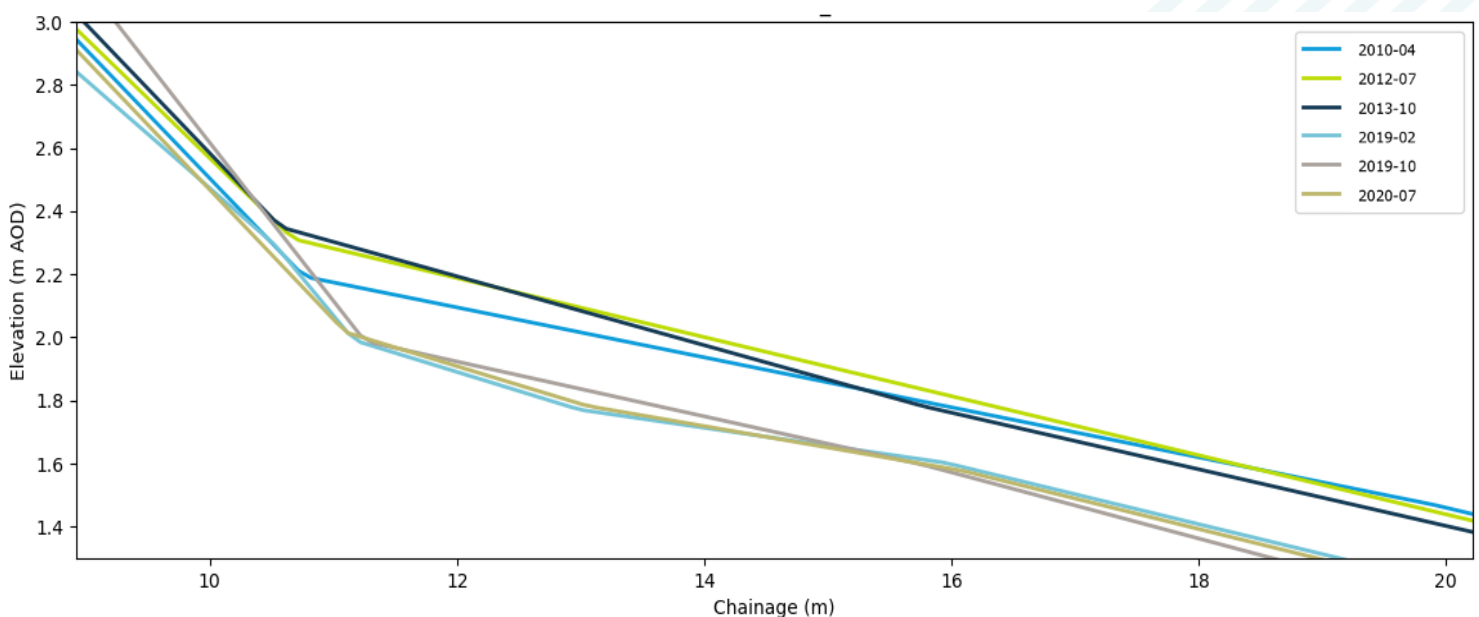


Figure 3-4: Beach profiles at section 202 – toe of defence

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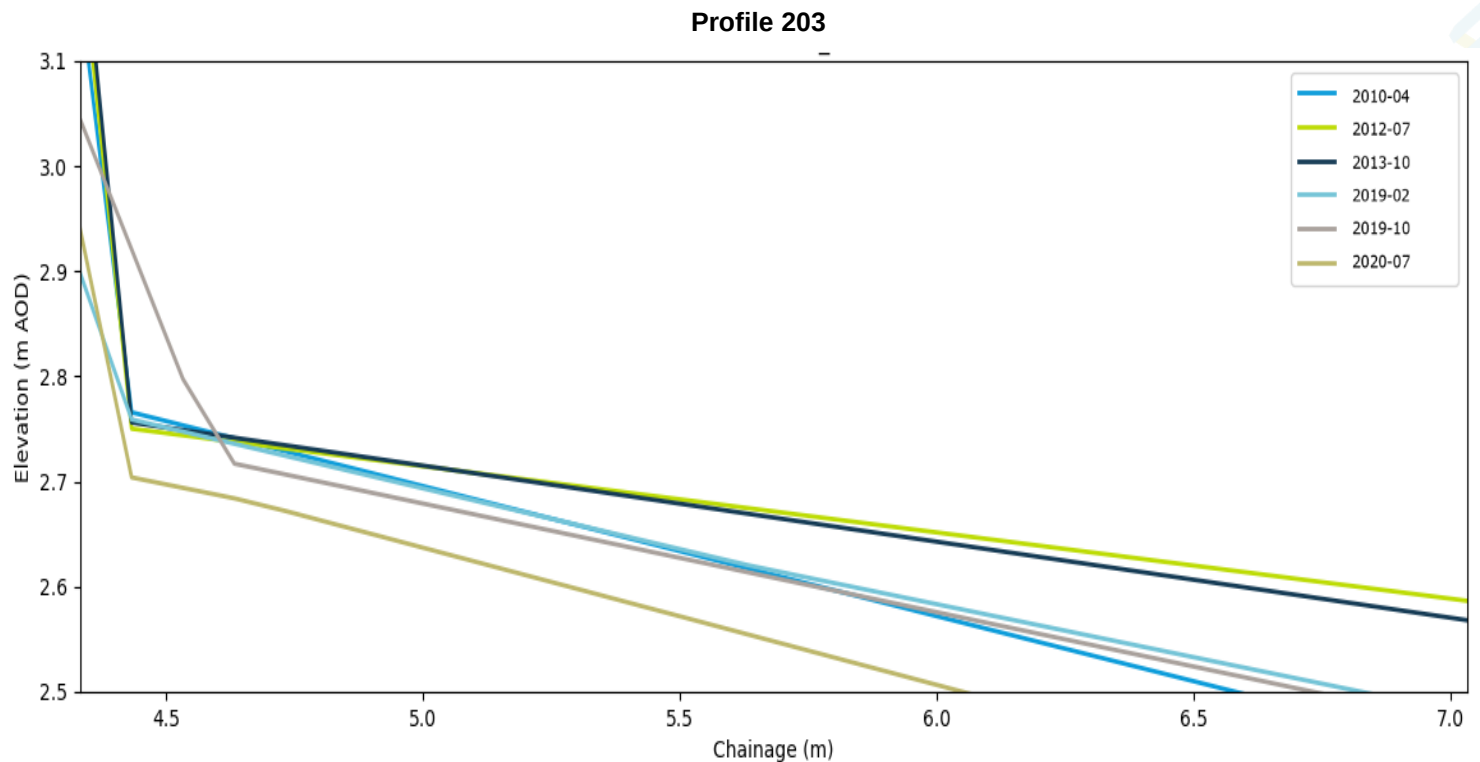


Figure 3-5: Beach profiles at section 203 – toe of defence

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4 Sea Level Rise

The Mumbles Coastal Protection Scheme is designed to provide a 1 in 200 Standard of Protection (SoP) for 50 years. This has been based on UKCP09. A comparison of this allowance for sea level rise against the latest draft climate change guidance from Welsh Government, UKCP18, is set out in Table 2 below for up to 50 years (2070). As per Welsh Government guidance, sensitivity testing is undertaken against the 95th percentile (RCP 8.5) sea level rise projections. The comparison shows a reduction in the predicted sea level rise allowances for the next 50 years under UKCP18. Therefore, under the new guidance, the planned 1 in 200 SoP will still be provided in Mumbles by the current scheme designs.

The sea level rise projections for 2118 have also been included, showing an increase from UKCP09 to UKCP18. As the Mumbles Coastal Protection Scheme will be designed to provide a 1 in 200 year SoP for 50 years, this does not affect the scheme design.

Table 2: Comparison of UKCP09 and UKCP18 sea level rise projections for Mumbles (95th percentile, RCP 8.5).

	UKCP09	UKCP18	Changes in sea level rise projections from UKCP09 to UKCP18
2040	0.265	0.139	-0.126
2070	0.476	0.470	-0.006
2118	0.889	1.242	0.353

*UKCP09 allowances cumulative since 1990. UKCP18 allowances cumulative since present-day (2021).

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5 Coastal Defences

5.1 Assessment of Proposed Defences and Coastal Processes

The proposed coastal defences for this scheme in the Mumbles extend along a frontage approximately 1.2km long, from beyond the Dairy Car Park in the northwest (approx. grid reference SS 61580 88470) to Knab Rock slipway in the southeast (approx. grid reference SS 62390 87725). Different options for the engineered defence solution have been proposed for three sub-frontages as follows (Figure 5-1):

- Frontage A is 120m long running from the northwest extent of the site to approx. grid reference SS 61600 88355
- Frontage B is 367m long running from frontage A to approx. grid reference SS 61780 88050
- Frontage C is 707m long and runs from frontage B to the southeast extent of the site

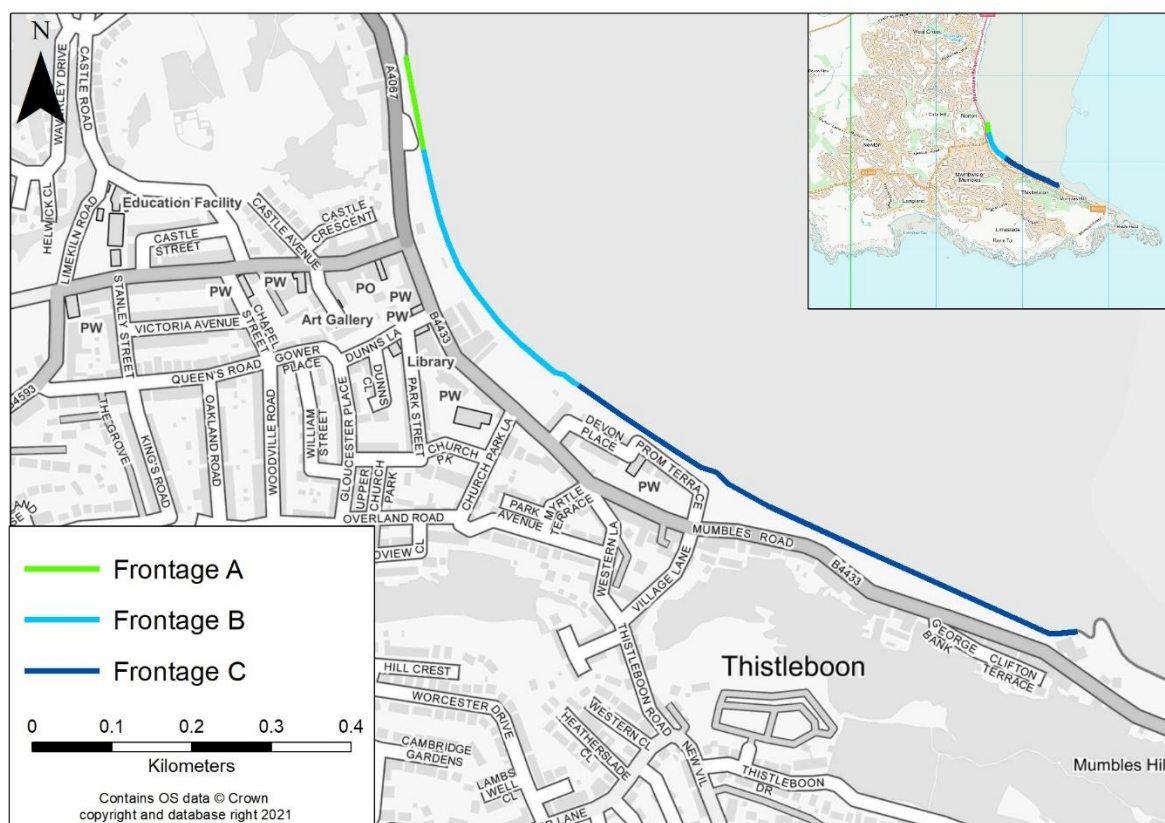


Figure 5-1: Map of Mumbles showing the three sub-frontages

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5.1.1 Frontage A

Along this sub-frontage, the proposed primary defence is formed of the existing seawall encased with reinforced concrete to the front face. The top level of this defence is +6.5mOD or higher and matches existing ground levels. The proposed secondary defence is formed from existing ground behind the promenade, which slopes up to the road behind. The two options under consideration along this sub-frontage are distinct due to their different toe details, both intended to manage the risk of scour undermining the existing sea wall.

Option 1 integrates a reinforced concrete stepped apron with the seawall encasement concrete to prevent scour. The apron is generally intended to be buried beneath the beach and descends to a sheet piled toe installed to prevent the apron itself from being undermined. Option 2 uses a small rock revetment at the toe of the seawall to prevent scour. The toe of the revetment is buried into the beach to manage undermining and the flexible structure will also be able to accommodate some movement.

These options are both designed to manage scour risk at the defence toe.

Frontage A Option 1 has a stepped apron to dissipate wave energy at the structure toe and the inclusion of the sheet pile toe manages the longer term risk of undermining of the apron should beach levels drop as a result of climate change impacts.

The rock toe in Frontage A Option 2 will also dissipate wave energy and prevent scour whilst being buried into the beach to manage the risk of undermining. The rock structure will be more flexible than other options as the rock can move in response to changes in beach levels but continue to provide scour protection.

The proposed works along this frontage are not expected to impact upon sediment transport processes; the proposed structures will not interrupt the low longshore transport rates, whilst the onshore/offshore transport rates at the frontage are very low and would not change from the existing case as there are existing hard defences in place.

5.1.2 Frontage B

Along this sub-frontage, the proposed primary defence is formed of the existing seawall encased with reinforced concrete to the front face and topped with an integrated reinforced concrete recurve seawall. The top level of the recurve wall is +7.2mOD. The proposed secondary defence is a set-back floodwall with a top level of +7.2mOD. The two options under consideration along this sub-frontage are again distinct due to their different toe details intended to manage the risk of scour undermining the existing sea wall. The two toe options are the same as those described for frontage A (5.2.2).

The proposed works along frontage B are not expected to impact upon sediment transport processes; the proposed structures will not interrupt the low longshore transport rates, whilst the onshore/offshore transport rates at the frontage are very low and would not change from the existing case as there are existing hard defences in place. Frontage B Options 1 and 2 comprise the two different toe features as described for Frontage A. As described in 5.2.1 both options would manage scour at the defence toe and also be designed to withstand the risk of foreshore lowering, but the rock tow would be more flexible and adaptable when considering potential climate change impacts.

5.1.3 Frontage C

Along this sub-frontage the existing sea defence is a concrete revetment. The three options are more distinct as follows:

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Option 1

The proposed primary defence is a recurve reinforced concrete wall with a top level of +7.5mOD. To the rear of the promenade, the proposed secondary defence is a set-back floodwall with a top level of +7.4mOD. In front of the primary defence wall, the concrete revetment is reconstructed in reinforced concrete with slope similar to the existing. The new revetment is likely to have features that disperse wave energy on its top face, most likely taking the form of a stepped revetment. At the toe of the new revetment a sheet pile will be installed to manage the risk of scour undermining the structure.

Option 2

The proposed primary defence is a recurve reinforced concrete wall with a top level of +7.3mOD. To the rear of the promenade, the proposed secondary defence is a set-back floodwall with a top level of +7.3mOD. In front of the primary defence wall, the concrete revetment is reworked to receive a rock revetment above. The toe of the revetment is buried into the beach to manage undermining and the flexible structure will also be able to accommodate some movement.

Option 3

The proposed primary defence is a large recurve reinforced concrete wall with a top level of +7.2mOD installed along the toe line of the existing concrete revetment. To the rear of the promenade, the proposed secondary defence is a set-back floodwall with a top level of +7.2mOD. The primary defence is integrated with a stepped apron at beach level which is generally intended to be below beach level. A line of sheet piles at the toe of the apron and the heel of the wall act as foundation support but also provide resilience against undermining.

As with Frontages A and B, the proposed works along frontage C are not expected to impact upon sediment transport processes; the proposed structures will not interrupt the low longshore transport rates, whilst the onshore/offshore transport rates at the frontage are very low and would not change from the existing case as there are existing hard defences in place.

Frontage C Options 1 and 2 involve revetment structures at the front of the primary defence wall to manage scour at the structure toe, with option 1 comprising a concrete revetment with features to disperse wave energy such as a stepped revetment, and Option 2 having a rock revetment. In both cases the toe will be designed to manage undermining should foreshore lowering take place, although Option 2 has the additional benefit of some flexibility in the rock structure to adapt to changing conditions.

Option 3 is also designed to be resilient to undermining with a sheet pile toe and a stepped apron to manage reflection and scour risk.

6 Conclusions

The 2017 coastal processes review concluded a stable foreshore and intertidal region in Mumbles, with a need to consider the risk of toe lowering. Sediment transport rates within the frontage are noted to be low and relatively self contained across the frontage and the report concludes that the intertidal area is consolidated and stable. The 2017 assessment identified the need to increase defence height in Mumbles to protect against increased still water levels due to rising mean sea level.

Updated Welsh Government guidance for climate change allowances have been produced based on UKCP18. This guidance is in draft but will shortly be implemented and provides

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updated sea level rise projections for application in coastal schemes. These updated projections have been compared against those used in the 2017 review (UKCP09). The comparison shows that the application of the updated guidance will not have a significant impact on the SoP provided by the Mumbles Coastal Protection Scheme and therefore no changes are required to the proposed defence designs.

Additional beach profile data has been collected by the WCMC since the 2017 assessment. In this review the more recent 2019 and 2020 beach profile data are added to the beach level analysis, and the results indicate some beach lowering at the toe of existing structures of ~0.4m. It is therefore recommended that the potential for lowering of the upper-foreshore, should therefore be taken into account in the designs. It should be noted that the length of the available beach profile data set is limited, however, and there is insufficient data to identify clear long-term trends in a dynamic beach environment. It is therefore recommended that coastal monitoring continue once the proposed scheme is implemented.

The proposed coastal defence options for the frontage have been assessed, taking into account how the proposed options will interact with baseline coastal processes.

- The proposed works along the Mumbles frontage are not expected to impact upon sediment transport processes; the proposed structures are parallel to the coast and as such will not interrupt the low longshore transport rates, whilst the onshore/offshore transport rates at the frontage are very low and would not expect to be change from the baseline case as a result of the proposed scheme.
- Each of the options have been designed to manage the potential scour risk through the inclusion of rock or stepped revetment at the toe of the structures. Furthermore, the toe structure for each option has been designed to manage the risk of future undermining should beach levels lower.