Appendix 13.3

Coastal Erosion Study

Indaver

Ringaskiddy Resource Recovery Centre

Environmental Impact Statement

Reference: 13.3 Coastal Erosion Study, Arup (2025)

Issue 2 | 29 August 2025

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Contents

Executive summary

Indaver proposes to develop a resource recovery centre (including waste-to- energy facility) in Ringaskiddy in County Cork.

The proposed development will consist principally of a waste-to-energy facility (waste incinerator). In addition, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, an amenity walkway along the eastern and part southern boundary of the site, as well as a viewing platform at the southern end connected by the walkway. Coastal protection measures are also proposed as part of the planning application and are discussed further in this report.

From 2008 to 2025 a series of studies were carried out to gain an understanding of the coastal erosion patterns in the area with a view to assess if any coastal protection measures are needed. This study involves a coastal processes and erosion study for the area and includes the following items:

- Assessment of the retreat rate based on historical information and topographic surveys
- Numerical wave and beach sediment transport models
- Cliff erosion modelling
- Assessment of expected coastal retreat
- Appraisal of potential impacts of expected coastal retreat on the proposed Ringaskiddy Resource Recovery Centre; and
- Mitigation measures to minimise potential impacts

The construction of the Ringaskiddy Resource Recovery Centre including site development works will take circa 31 months. However, in view of the complexity of the development, licensing requirements and the need for the advance agreement of all conditions, Indaver is applying for a 10-year planning permission to commence and complete the construction phase.

The expected retreat rate was estimated following an assessment of available historical information and a campaign of topographic surveys undertaken since 2008. From this assessment the expected conservative retreat rate of the cliffs was determined to be 0.5m/year in the absence of any mitigation measures. This is a conservative estimate.

Applying this conservative predicted rate of erosion gives an expected retreat of 15m in 30 years' time and 20m in 40 years' time.

The study found that, taking year 2025 as a baseline, there would be no impact on the proposed development after 30 years. The study found that there could be a risk of an impact on a small section of the proposed development after 40 years; however, this would be confined only to the amenity walkway and viewing platform located outside the proposed boundary fence. The waste-to-energy section of the proposed development will not be impacted by coastal erosion for the entire duration of the planning permission.

Wave modelling was carried out using the DHI MIKE 21 programme in order to predict the nearshore wave climate. The wave modelling output was then used to estimate wave run up onshore as well determining nearshore wave directions.

From the nearshore wave directions, the beach appears to be subject to a slightly oblique wave attack that drives sediment in a net northerly alongshore direction.

In addition to wave modelling, a sediment transport assessment was carried out. The assessment shows that the theoretical range of erosion of the beach is within the range of 10 to 30cm for the specified storm event and that local tidal currents are minimal at the site. There is a trend for sediment to move towards the north mainly due to wave-driven processes and the convex shape of the site, and with only a minor contribution from tidal currents on the flood flow.

Coastal protection mitigation measures are not required for the waste-to-energy facility element of the development. However, given the concerns raised by An Bord Pleanála during the previous planning application in 2008 and given the low risk that the amenity walkway and viewing platform could be impacted in 40 years' time, coastal protection measures have been included in this planning application as a precautionary measure so as to reduce the rate of erosion of the cliff.

Arup investigated a number of coastal protection options that could be applied to the Indaver site. Arup has recommended that the Indaver coastal boundary is monitored on an annual basis and the placement of approximately 1,150m^3 of sacrificial material (shingle of appropriate size and rounded shape with high density and resistance to abrasion) above the foreshore on Gobby beach along the eastern boundary of the Indaver site. This will be a 'soft' solution which will potentially reduce erosion rates by limiting the exposure of the toe of the cliff face to wave action.

The main aim of placing the material is to act as a proactive measure for the coastal area adjacent to the Indaver site only.

The solution will have no negative impacts on the adjoining areas. However, there will be benefits associated with the works as well as the provision of an environmentally friendly solution. The net coastal sediment transport goes from south to north according to wind conditions and swell; therefore, the material is likely to move towards the north in the medium and long term. The closest area of the Cork Harbour Special Protection Area (SPA) is located to the southwest of the site. Since the net movement of beach nourishment shingle is from south to north, the sacrificial material will not impact on this part of the SPA. Other sections of the SPA which are to the north of the site are more than two kilometres from the site and these are too remote from the site to receive any significant quantities of beach nourishment material.

It is proposed that the additional sacrificial material is placed during the construction period of the Indaver site. Thereafter, it is proposed that the placement of further additional sacrificial material is carried out if the cliff top retreat rate averaged over the entire length is more than 0.5m per year measured over a period of six years, which would indicate some acceleration in the current retreat rate, or when the cliff top has retreated locally by approximately 3m, whichever is sooner. There is also an option to proactively place shingle to maintain a healthy margin between the cliff top and the Indaver development. For this reason, the coastal boundary of the Indaver site will be monitored for erosion on an annual basis.

1. Introduction and History of Coastal Studies

Indaver proposes to develop a Resource Recovery Centre in Ringaskiddy in County Cork.

The proposed development will consist principally of a waste-to-energy facility (waste incinerator) for the treatment of up to 240,000 tonnes per annum of residual household, commercial and industrial non-hazardous and hazardous waste and the recovery of energy. Of the 240,000 tonnes of waste, up to 24,000 tonnes per annum of suitable hazardous waste will be treated at the facility. The proposed development will maximise the extraction and recovery of valuable material (in the form of ferrous and non-ferrous metals) and energy (in the form of 21 megawatts of electricity) resources from residual waste.

In addition to the provision of the waste-to-energy facility, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, coastal protection measures above the foreshore on Gobby Beach and an amenity walkway towards the Ringaskiddy Martello tower.

The proposed Resource Recovery Centre has a design life of 30 years. In view of the complexity of the development, licensing requirements and the need for the advance agreement of all conditions, Indaver is applying for a 10-year planning permission to commence and complete the construction phase.

The coastal protection measures are discussed further in this report.

The coastline along the eastern boundary of the proposed development site consists of a glacial till face adjoining Gobby Beach. The glacial till face is very low near the public car park to the north and gains in height to the south to a maximum of 10m high. The glacial till face will be referred to as a cliff for the purposes of this report.

From 2008 to 2025 a series of studies and surveys were carried out to get an understanding of coastal erosion patterns in the area with a view to assess if any coastal protection measures were needed for the coastal boundary of the site. In November 2008, Arup carried out an assessment of coastal retreat and coastal flooding at the site of the proposed development. The coastline, which forms the eastern boundary of the site, was found to have eroded over the past 100 years at a varying rate, with the most significant erosion occurring along the southeastern boundary of the site. It was also noted that some accretion or increase in levels by natural growth of sediment had occurred along a section of the beach to the northeast of the site.

In May 2012, Arup carried out site investigations of the proposed development site and Gobby Beach. The scope of works included an investigation of soil conditions at the base of the slope and of areas that will be exposed to erosion in the future, ground water levels in the cliff and sea water levels, wave climate and its interaction with the beach and cliff along the eastern boundary of the site. From the investigations it was concluded that the sea was likely to frequently reach the base of the cliff at the site when extremely high-water levels or extremely high waves are caused by storms. In addition, it was noted that the slope was susceptible to erosion due to wave action, ground water seepage and surface water overland flow. It was recommended that the coastal evolution of the area be monitored, and that a comprehensive topographical and bathymetric survey be carried out.

In 2014, Arup was commissioned by Indaver to provide consultancy services for the development of the Indaver site at Ringaskiddy. The services included:

- Topographic survey for the beach and cliffs at the eastern boundary of the Indaver site, in the area necessary to assess the coastal erosion processes which may have an impact on the proposed resource recovery centre
- Bathymetric survey in the nearshore area adjacent to the eastern boundary of the Indaver site, to be used as an input for the numerical wave model to assess the coastal erosion processes in the area
- Coastal erosion study (included as Appendix 13.3 to the 2016 EIS), which included:
  - Assessment of the retreat rate based on historical information and the surveys carried out in 2014

- Numerical wave model and assessment of beach sediment transport
- Assessment of expected coastal retreat
- Appraisal of potential impacts of expected coastal retreat on the proposed Ringaskiddy Resource Recovery Centre; and
- Mitigation measures to minimise potential impacts

In March 2016, Arup undertook a site investigation of Gobby Beach following several localised slope failures triggered by a season of extreme rainfall and winter storms. The investigation assessed the size, causes, and impacts of the failures to evaluate their effects on the site and its surroundings. The report was included as an addendum to the revised 2016 EIS. Extracts of the report that are relevant to this assessment are presented in **Appendix A** ***Assessment of the December 2015 slope instabilities (extracts)*** for further details.

In 2016, An Bord Pleanála commissioned an independent marine hydrodynamic consultant (Aqua Vision BV) to carry out a review of the proposed marine works as detailed in the pre application consultation (Refer to **Appendix 13.5** ***Coastal Expert Review of Arup Coastal Erosion Study*** **of** ***Ringaskiddy Resource Recovery*** of the updated EIS). This report also addressed the conclusions and recommendations of the independent review of the proposed works associated with the development as presented by An Bord Pleanála.

In 2025, Arup has prepared an updated Environmental Impact Statement (EIS) for the Indaver Resource Recovery Centre at Ringaskiddy, which had been requested by An Bord Pleanála. This report (**Appendix** ***13.3 Coastal Erosion Study***) forms part of the updated EIS and builds on previous submissions by incorporating to the 2016 Coastal Erosion Study new data and findings collected up to 2025. Key updates include:

- A new topographic survey of cliffs and beach at the site and adjoining coastal areas carried out on the 3rd March 2025
- Site investigation carried out in 2019. Refer to **Appendix 13.2** ***Hydrogeological Assessment*** of the updated EIS
- A site walkover conducted in May 2025. Refer to **Appendix B** ***Gobby Beach Site Visit Report (Arup, 2025*)** of this report
- A revised assessment of cliff evolution, including an updated estimate of retreat rates based on historical records, additional topographic surveys, and most recent site walkover
- An evaluation of the potential effects of projected coastal retreat on the proposed Ringaskiddy Resource Recovery Centre
- Updates to the beach sediment transport analysis, which now incorporates a SHINGLE-B model to support cliff erosion modelling
- Additional climate change considerations in relation to expected sea level rise following the Statutory Climate Change Adaptation Plan for the Transport Sector (T-SAP II) for Public Consultation released in June 2025 by the Department of Transport, Climate Adaptation Research and Energy Division [3]; and
- Proposed mitigation measures designed to minimise potential effects on the proposed development site

2. Assessment of Cliff Retreat

2.1 Historical Retreat – Desk Study

In the 2008 study carried out by Arup, the estimated future coastal retreat was based on historical data collected from various sources including the Geological Survey of Ireland (GSI) and the Ordnance Survey of Ireland (OSI). Rates up to 36 or 55m over 110 years (1897-2008) were extracted from these historical datasets depending on the assumptions and methodologies considered.

The following data was used in the aforementioned report:

S1) OS map, Cork Sheet 87, Ordnance Survey Ireland, 1844 edition, surveyed in 1841-42, scale 1:10560

S2) OS map, Cork Sheet 87-11 and 87-15, Ordnance Survey Ireland, 1898 edition, surveyed in 1896-97, scale 1:2500

S3) OS map, Cork Sheet 87-11 and 87-15, Ordnance Survey Ireland, 1932 edition, revised in 1929, scale 1:2500

S4) OS digital map, AutoCAD file, Ordnance Survey Ireland, 1997, scale 1:2500

S5) Survey at Ringaskiddy, Precise Control Ltd Land and Engineering Surveyors, 2000

S6) Survey at Spike Island and Ringaskiddy, Precise Control Ltd Land and Engineering Surveyors, 2001

S7) Beach Topographical Survey, Ringaskiddy, Precise Control Ltd Land and Engineering Surveyors, 2008

S8) Air Corps Aerial Photography courtesy of the Geological Survey of Ireland (GSI), 1952, scale 6 inches to 1 mile (approx.)

S9) AC1777 - Admiralty Chart, Port of Cork – Lower harbour and approaches, 1993 edition

Other data sources include:

S10) OS map, Cork Sheet 87, Ordnance Survey Ireland, 1902 edition, revised in 1896-97, scale 1:10560

S11) OS map, Cork Sheet 87, Ordnance Survey Ireland, 1934 edition, revised in 1928-29, scale 1:10560

S12) oblique aerial photograph (various years)

Historical data was collected from various sources including the Geological Survey of Ireland (GSI), and the Ordnance Survey of Ireland (OSI) (now Taillte Ireland).

The following data was used for the study of the coastline retreat:

- The 1897 OS map (S2)
- The 1929 OS map (S3)
- The 1997 OS map (S4)
- The 2000 Survey (S5)
- The 2001 Survey (S6)
- The 2008 Survey (S7)
- The 1952 Air Corps Aerial Photography (S8)

Historical OS maps (S2 and S3) were sourced from the Map Library in Trinity College Dublin. Each map consisted of 4 separate sheets. These were first scanned and then digitally (raster) joined. The resulting images were imported in Autocad and the main features (coastlines, roads, Martello tower, field boundaries, etc.) were traced so they could be digitally projected on the more recent maps and surveys.

Based on the 2008 assessment, the estimated range of average cliff retreat is 0.36m to 0.53m per year. However, cliff retreat occurs through intermittent events rather than being a linear continuous processes given the variable and episodic nature of cliff recession. The selected assessment period significantly influences the calculated retreat rates.

The level of uncertainty associated with this prediction was high due to different factors including:

- Significant variation in the coastal retreat over the assessed 110 year period
- Large gaps between available survey data and their limited precision, and
- Inability to verify the accuracy of historical mapping to the same standard as modern surveying/monitoring techniques

Therefore, to validate the retreat rate assessed from the historical datasets, a campaign of topographic surveys was undertaken between 2008 and 2025 as discussed in **Section 2.2**.

2.2 Topographic Survey Assessment

Periodic topographic surveys were carried out in the area between 2008 and 2025 to monitor coastal retreat and estimate a future erosion rate for the site. This estimate becomes more accurate as the timeframe of the dataset increases. The topographic surveys undertaken for this purpose are:

- 2008 Topographic survey
- 2010 Topographic survey
- 2014 Topographic survey
- 2016 Topographic survey; and
- 2025 Topographic survey

While survey data is available for the five topographic surveys, in the following assessment, two representative timeframes were chosen to assess the cliff erosion: the global monitoring period (2008–2025) and the latest period (2016–2025). The latest period between 2016 and 2025 was chosen to assess any potential accelerated retreat trends in any of the cross-sections of the cliffs in the most recent period monitored when compared with the global monitoring period.

Cliff behaviour was assessed by considering the evolution of two reference lines: the top and toe of the cliff. A plan comparison of these lines for 2008, 2016, and 2025 is provided in **Appendix C *Historical Cliff Evolution – Comparative Plan*.**

A more detailed analysis was conducted using eight cross-sections (A1 to G) located along the eastern cliffs of the site, as shown in **Figure 1.** The cross-sectional profiles and corresponding cliff evolution measurements are provided in **Appendix D *Historical Cliff Evolution – Comparative Sections*.** The sections in the appendix present all survey timeframes but measurements are only given for the two timeframes of interest in this assessment.

A summary of the findings for both the cliff top and cliff toe positions is presented in **Section 2.2.1** below.

The evolution of the beach was also assessed to explore potential correlations between beach behaviour and cliff retreat. This assessment was carried out by measuring vertical changes in the beach profile in front of the cliffs, using the cross-sections provided in **Appendix D**. Refer to **Section 2.2.2**.

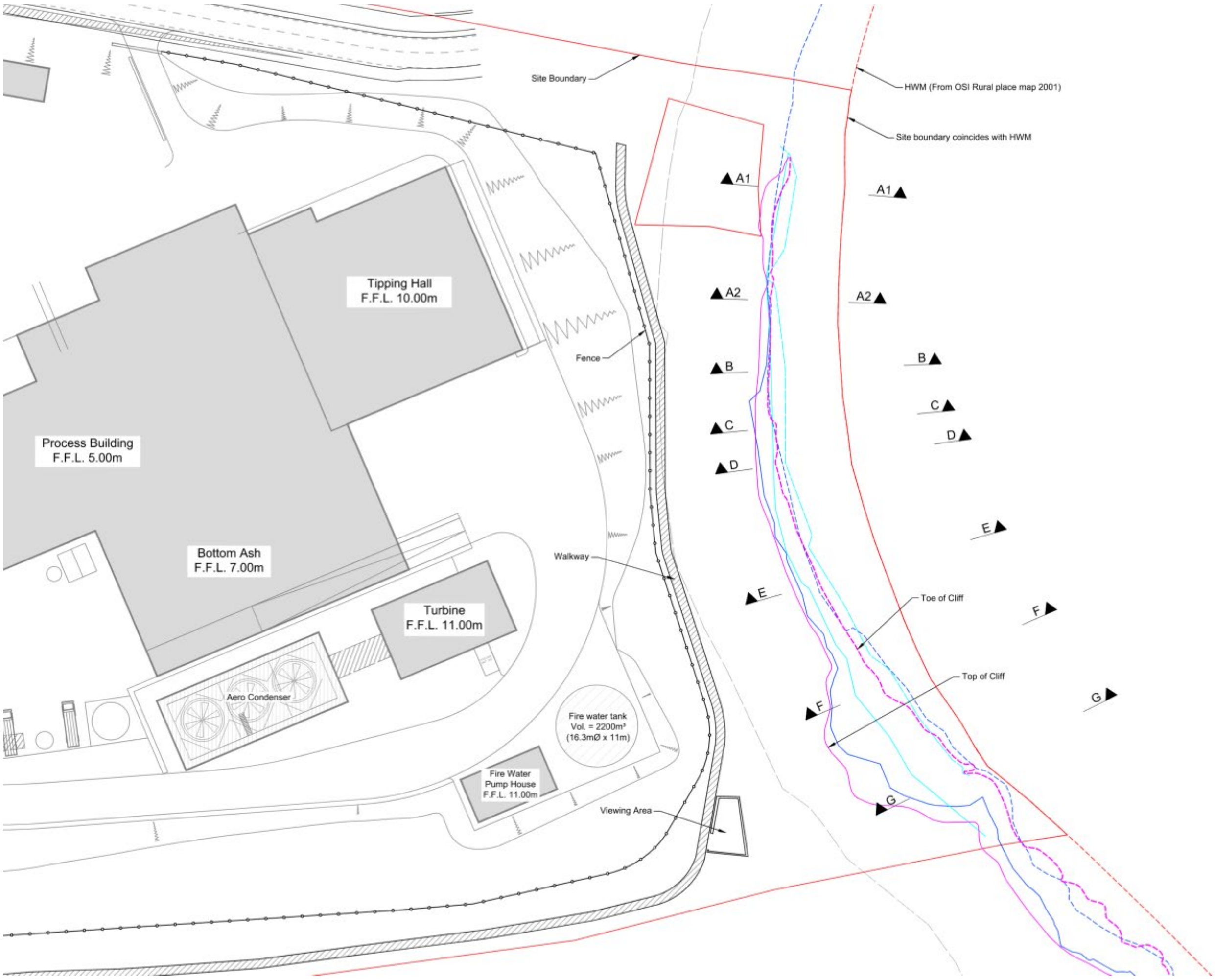

Figure 1 Plan of site showing cross-sections location

2.2.1 Cliff Evolution

Observations from the cliff evolution plan in **Appendix C**, indicate significant localised cliff retreat between sections F and G, resulting in a maximum cliff top retreat of approximately 12m between 2008 and 2025 and 7.5m between 2016 and 2025. This corresponds to a cliff slope failure located between sections F and G that is ongoing from 2015, and is described in more detail in the 2016 site walkover (**Section 2.3.1).**

The summary of the evolution of the cliff top line from the analysis of the cliff sections in **Appendix D**, is shown in **Table 1** and **Figure 2**. It is to be noted that the results for sections A1 and A2 are not shown in the summary tables, as a clear top and toe of the cliff lines could not be identified for these sections.

The analysis indicates that, over the full monitoring period (2008 to 2025), annual retreat rates at the top of the cliff ranged from 0.15 m/year (Sections B and E) to a maximum of 0.71 m/year, at the point of maximum retreat identified on plan between sections F and G. During the latest monitoring period (2016 to 2025), annual retreat rates ranged from 0.05 m/year (Section F) to a new maximum of 0.83 m/year.

Across all sections (excluding the local maximum), a general decrease in retreat rates was observed in the latest monitoring period (2016 to 2025) compared to the global monitoring period (2008 to 2025).

Finally, it was identified that the northern sections (A1 to E) have experienced lower cliff top retreat rates compared to the southern sections (F and G).

Table 1 Evolution of cliff top line retreat over the latest and global monitoring periods

Section	Retreat			
	2008 to 2025 (m)	Retreat per year 2008 to 2025 (m/year)	2016 to 2025 (m)	Retreat per year 2016 to 2025 (m/year)
B	2.49	0.15	1.29	0.14
C	3.52	0.21	0.53	0.06
D	3.52	0.21	0.85	0.09
E	2.50	0.15	1.16	0.13
F	5.99	0.35	0.42	0.05
MAX (between cross sections F & G) Ref. Drawing C-000-063	12.00	0.71	7.50	0.83
G	7.70	0.45	3.58	0.40
Average*	**4.29**	**0.25**	**1.31**	**0.15**

*Numerical average of retreat of baseline sections.

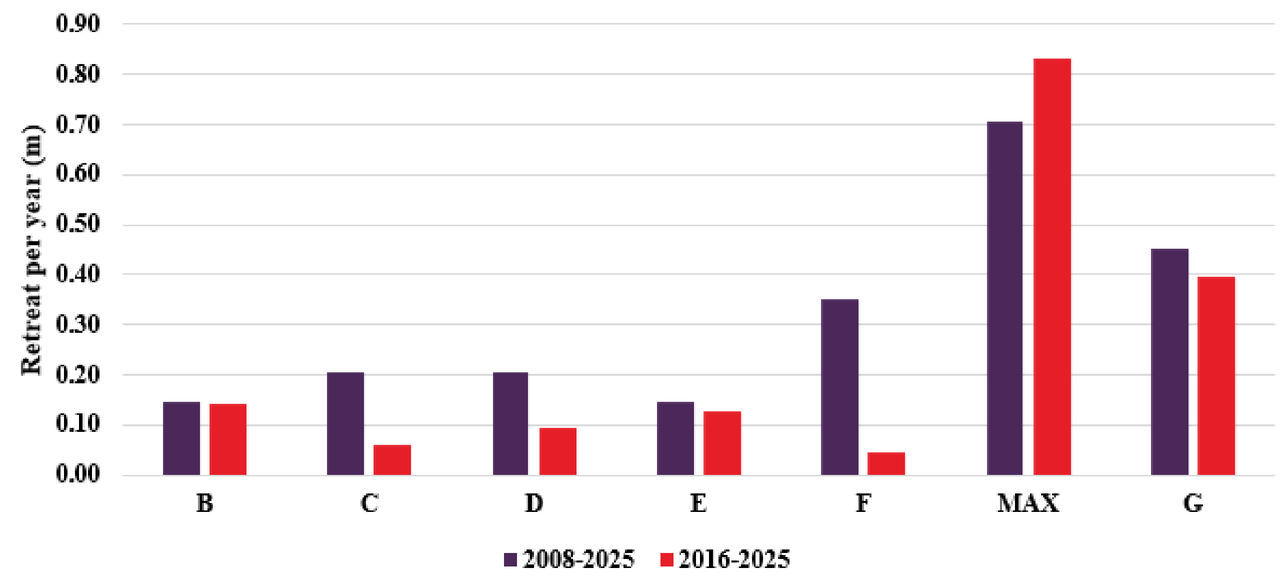

Figure 2 Retreat per year of the top of cliff line over the latest and global monitoring period

A summary of the evolution of the cliff toe line is shown in **Table 2** and **Figure 3**.

Cliff toe retreat has generally progressed at a significantly slower rate than retreat of the cliff top, with a maximum rate of 0.19 m/year observed between 2008 and 2025, and 0.22 m/year between 2016 and 2025, both recorded at Section F. This can also be observed from the plan in **Appendix C** which shows that, generally, the cliff toe seems to have retreated significantly less than the top of the cliff between 2008 and 2025.

The toe line advance observed at Sections B and G is interpreted as the result of slumped material from the upper cliff face accumulating at the toe, thereby temporarily concealing active retreat. Section G shown in **Figure 4** illustrates this process.

Table 2 Evolution of cliff toe line retreat over the latest and global monitoring periods

Section	Retreat			
	2008 to 2025 (m)	Retreat per year 2008 to 2025 (m/year)	2016 to 2025 (m)	Retreat per year 2016 to 2025 (m/year)
B	1.86	0.11	-0.36	-0.02
C	1.93	0.11	0.36	0.02
D	2.13	0.13	2.02	0.12
E	1.93	0.11	2.06	0.12
F	3.18	0.19	3.66	0.22
G	-1.56	-0.09	1.06	0.06
Average	**1.58**	**0.09**	**1.47**	**0.09**

Note: (+) retreat represents erosion of the cliff toe while (-) retreat represents accretion

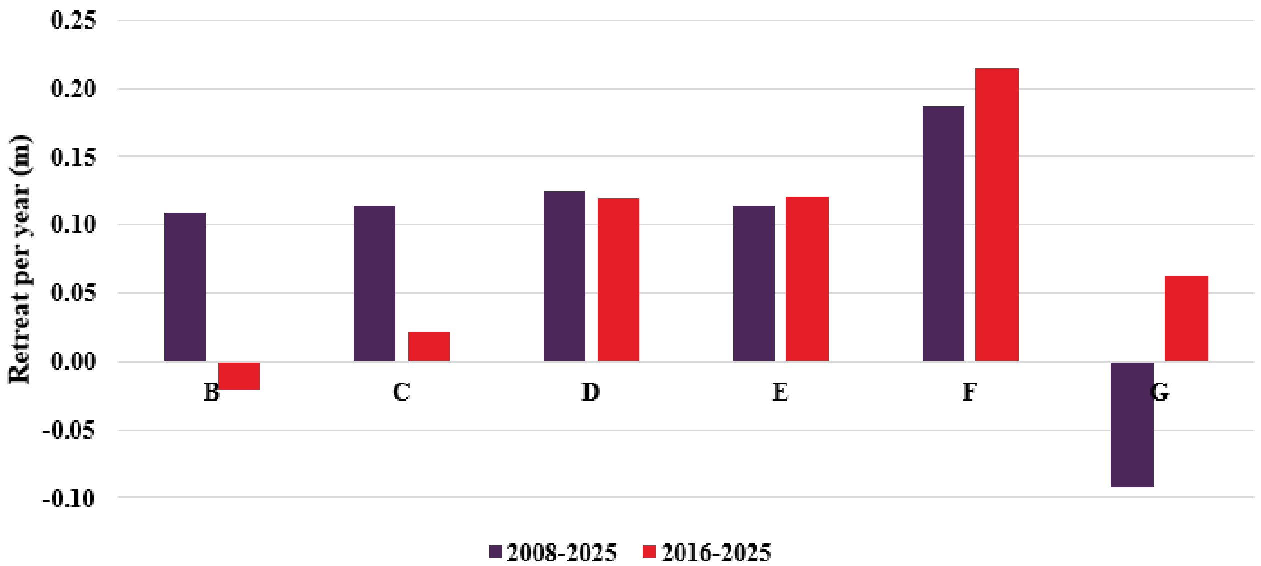

Figure 3 Retreat per year of the toe of cliff line over the latest and global monitoring period

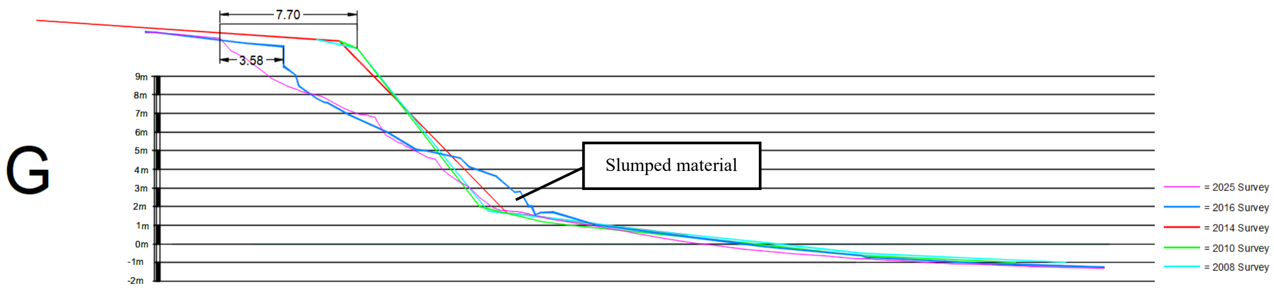

Figure 4 Section G showing slumped material at the cliff toe in the 2016 survey

2.2.2 Beach Evolution

The evolution of the beach was assessed by measuring the maximum vertical variation of the beach profile from the cross-sections in **Appendix D**, for the 2008, 2016, and 2025 topographic surveys.

Between 2008 and 2025, beach level reductions ranged from 0.3 m at Section B to 0.7 m at Section A2. Over the more recent period (2016 to 2025), the lowering ranged from 0.1 m at Section A2 to 0.4 m at Section F. The results suggest a general long-term lowering of the beach profile.

It should be noted that this analysis is based on survey data collected at different times of the year, and as such, the results are subject to seasonal variability in beach levels. Due to this limitation, the findings should be interpreted with caution.

Although no definitive trends can be confirmed, the beach lowering appears to be broadly consistent with the overall pattern of coastal retreat observed at the site.

2.3 Site Walkover Assessments

The topographic surveys were supplemented by site walkovers on Gobby Beach and the adjoining cliffs. This section presents the key findings of three site walkovers to enhance understanding of the cliff evolution: a site walkover conducted in March 2016 following the occurrence of two localised slope failures, a walkover inspection in February 2025 and the latest walkover survey carried out in May 2025.

2.3.1 March 2016 Site Walkover Findings

In March 2016, Arup carried out a site walkover of Gobby Beach following the identification of several localised cliff failures that had occurred along the site after a period of prolonged and intense rainfall and storm activity during the winter of 2015. The most significant slip was located between sections F and G, as also identified in the topographic survey assessment (see **Section 2.2.1**). The objective of the walkover was to assess the extent, causes, and implications of these failures.

Relevant extracts from the site walkover report are available in **Appendix A** ***Assessment of December 2015 Slope Instabilities (extracts) (Arup, 2025)***.

During the walkover, water was observed seeping through the cliff face and failed slopes, with the slipped material appearing visibly saturated and softened. This water infiltration is believed to have increased pore water pressure within the slope, significantly reducing the frictional strength of the surrounding soil layers. In addition, the presence of sand and gravel lenses within the cliff face likely contributed to internal erosion and further weakening of the cliff face, ultimately triggering slope failure.

Following review of survey data and site observations it was concluded that while sea erosion is causing erosion along this section of coast, the landslides observed during the site walkover were due to water pressure and flow within the cliff material causing instability and slip failure rather than just erosion due to wave action alone.

2.3.2 February 2025 Site Walkover Findings

In February 2025, Arup undertook a site walkover of the site, Gobby beach and the cliff along the eastern coastal boundary of the proposed development. The weather on the day of the site visit was cloudy with some moderate rainfall. Rain had fallen on the site the day before the site visit and Met Eireann weather data at Cork Airport revealed heavy rainfall for the area at the start of February.

During the site walkover the cliff face was noted as having fresh unvegetated slumps and landslide features along the extent of the proposed development coastal boundary. Upon inspection of these features, it appeared that the slumped material and the material in the slope scarps is silty and sandy in consistency. The slump and landslide features become more substantial as the height of the cliff rises towards the southern boundary. A stiff/hard brown sandy very gravelly clay with cobbles and boulders was visible in areas at the toe of the slope where it was not covered by slumped material. The overlying material comprises of firm brown, very sandy silt/clay.

Figure 5 Representative cross section of the stratigraphic profile of the eastern coastal cliff boundary

Erosion at the toe of the cliff face was noted and notching evident as outlined in **Figure 6**. There is evidence of overland water flow down the cliff face and is likely to contribute to slope failure. Surface water from the top of the cliff was recorded flowing through a landslide scarp and in other areas surface water channels are evident on the cliff face. Groundwater seepages were noted at the toe of the cliff slope.

Figure 6 Surface water channel in a landslide scarp

A larger landslide was recorded at the southern boundary of the site, which is the same failure that was recorded in 2016 between Section F and G. This landslide occurs at a 10m high cliff section and has a bowl like morphology with steepened side slopes. The landslide presents as a global slip of material. A surface water channel runs through the failure and the slumped material at the toe has been eroded.

Figure 7 Landslide between Section F and G

The beach comprises of a very stiff/hard glacial till that is recorded at the toe of the slope. The shingle on Gobby beach overlying the till is subangular in shape and is likely to be the gravel, cobble and boulder fraction from the cliff glacial till that has been eroded.

2.3.3 May 2025 Site Walkover Findings

In May 2025, Arup conducted a site walkover of Gobby Beach. In contrast to the 2016 site walkover, this visit followed a prolonged dry period, resulting in generally dry cliff face materials at the time of inspection.

The site visit report is available in **Appendix B** ***Gobby Beach Site Visit Report (Arup, 2025)***.

Despite the dry weather, the cliff toe appeared saturated at a number of locations along much of the beach, and a number of groundwater seepage springs were observed (see **Figure 8** as one example from the site visit report), indicating ongoing subsurface hydrological activity independent of the lack of rainfall.

Figure 8 View of the seepage at the cliff toe mid-way between cross-sections E and F

Several minor cliff failures were also observed, along with evidence of toe notching (see **Figure 9** as one example from the site visit report). Combined with the absence of vegetation at the cliff base, this suggests that the toe is periodically reached and influenced by tides and waves.

Figure 9 View of cliff toe notching at cross-section D

The significant cliff failure identified in the 2016 site walkover (refer to **Section 2.3.1**) and the topographic survey assessment (refer to **Section 2.2**), can be seen in **Figure 10**. Exposures of the underlying mudstone/sandstone bedrock (as identified in the GI for the area) were noted along the beach in this section.

Figure 10 View of the cliff face between Sections F and G

Just south of cross-section G, a distinct material change in the cliff face is observed. A very stiff/hard sandy very gravelly clay with many cobbles and occasional boulders extending approximately 1m above beach level was observed along the cliff toe, sloping gently downwards from south to north. This layer is an over consolidated glacial till and is significantly stiffer and more granular than the overlying strata (see **Figure 11**).

Figure 11 View of the cliff face south of cross-section G

Two distinct zones were identified in the superficial composition of Gobby Beach (see **Figure 10** and **Figure 12**). The upper section of the beach varies in width and is characterised by shingle, rocks, and boulders. In contrast, the lower section comprises predominantly shingle and silty sand with occasional rock outcrops. The beach profile exhibits a gentle lower slope and steeper upper slope at the toe of the cliff.

Figure 12 View of Gobby Beach and cliffs, looking south from the car park beach access ramp

2.4 Cliff Evolution Observations and Conclusions

Based on the findings from the topographic survey data (see **Section 2.2**) and site walkovers (see **Section 2.3**), the following trends in cliff evolution at Gobby Beach have been identified.

The cliff top at Gobby Beach has experienced measurable retreat between 2008 and 2025 with an average annual retreat value below 0.5m per year except at one location in the south (between cross-sections F and G). Retreat of the cliff has not occurred as a uniform, linear process, but rather through discrete, localised failure events that result in episodic setbacks to the cliff line. For example, a major local cliff failure between Sections F and G resulted in a maximum cliff top retreat of approximately 12m since 2008 and 7.5m since 2016. Several other minor failures were also identified throughout the site, during site walkovers in 2016 and 2025. Overall 0.5m/year is assessed as a conservative estimate of average cliff retreat between 2008 and 2025. This is consistent with retreat rates based on the assessment of historical maps, surveys and aerial photographs (1897-2008) which showed values within a similar range (36- 55m over 110 years)

The rate of cliff top retreat decreased in the latest monitoring period (2016–2025) compared to the global monitoring period (2008–2025). However, this observed reduction should be interpreted with caution given the episodic nature of the cliff retreat. Reduced retreat rate could reflect variable metocean conditions during this period or temporary protection afforded by previously eroded material accumulating at the cliff base.

Furthermore, it was observed, that retreat rates are not uniform along the site boundary, as the northern sections (A1 to E) have experienced lower retreat of the top of cliff line (less than 0.25m/year 2008 -2025) when compared to the southern sections (F and G) (generally less than 0.45m/year 2008-2025). It can be concluded that an overall retreat rate of 0.5m/year reflects the past evolution of cliff in the project site.

The cliff toe seems to have retreated at a slower rate than the cliff top across the site. This reduced rate of erosion is likely due to the presence of the stiff over consolidated glacial till where present at the southern end of the cliff and the periodic frequency at which the toe is reached and influenced by tides and waves. In some areas, such as Sections B and G, apparent toe accretion was observed. This is interpreted as the result of material slumping from the upper cliff face and temporarily accumulating at the toe, concealing underlying erosion.

The findings of the 2016 site walkover, conducted after a season of intense rainfall and storms, along with the persistent groundwater seepage observed at the cliff toe during the 2025 walkover, despite prolonged dry conditions prior to the site walkover, seem to indicate that subsurface hydrological activity is ongoing through the cliff face. This seepage contributes to internal weakening of the slope, promoting instability even during dry weather periods, as observed in the 2025 site walkover.

Furthermore, evidence of toe notching in the 2025 site walkover, combined with an absence of vegetation at the cliff base, suggests that wave action periodically reaches and erodes the cliff toe. This undercutting of the cliff face likely exacerbates slope instability and contributes to global cliff failures.

The apparent underlying mudstone/sandstone bedrock (as identified in the GI for the area) observed during the 2025 site walkover along the beach in front of the significant cliff failure between Sections F and G, is expected to limit the rate of future beach erosion along this section by limiting the impact of wave action.

The findings confirm that cliff retreat at Gobby Beach is an active and ongoing process, influenced by a combination of cliff toe erosion, softening of the weaker till in the upper cliff section due to water seepages, overland surface water flow, and weathering of the cliff due to rain, wind and freeze thaw action. Local exceedances, such as the collapse between Sections F and G, underscore the episodic and unpredictable nature of cliff failure, reinforcing the importance of ongoing monitoring and future risk management.

2.5 Assessment of Future Evolution of Cliffs

A conservative approach has been used in this assessment to estimate a conservative retreat line at the site based on the findings of the historical desk study, topographic survey data supported by site walkovers and the geotechnical assessment. As described in previous sections, cliff erosion is likely to be the result of episodic events i.e. a similar event will most likely not occur in the following year and may not occur for a number of years. Therefore, for the most accurate estimation of the erosion rate it is necessary to analyse data spanning the largest period available.

- Based on the assessment of the topographic surveys carried out between 2008 and 2025, and desk-based assessment of cliff retreat between 1897-2008 (refer to **Section 2.4**) a conservative predicted retreat rate of 0.5m/year will be used to forecast the evolution of cliff retreat during the design life of the development

This retreat rate will be applied to the entire length of the top of the cliff line adjacent to the site taking year 2025 as a baseline and is subsequently used to obtain the predicted retreat in 30 years and 40 years' time (allowing for 10 years for planning/construction and 30 years design operation period of the proposed development).

It is noted that this approach is generally conservative as:

- Most of cliff areas present retreat rates below this value and the estimated lines are based on the same retreat rate applied over the entire length
- The rate of erosion at the cliff toe is considerably lower, averaging 0.09m/year between 2008 and 2025

However, it needs to be noted that:

- The localised section in the south (between cross-sections F and G) exceeded this average rate in the time periods considered and indicate that episodic and localised significant failures are likely to occur in the future in this area.
- Other episodic failure events in other areas of the cliffs are less likely to occur based on the data assessed, but these may happen.
- Factors such as change in erosion pattern have not been taken into account for this assessment which is based on past cliff retreat measurements therefore, only the effects of sea level rise due to climate change during the measurement period have been considered. It should be noted that erosion patterns could be influenced and possibly accelerated by future climate-related factors.

2.6 Potential Effects of Erosion on the Proposed Development Site

Applying the conservative predicted retreat rate of 0.5m/year as described in **Section 2.4,** an expected conservative retreat of 15m in 30 years' time and 20m in 40 years' time is predicted. Refer to **Appendix E *Estimated Cliff Retreat Lines*** and **Figure 13** which show the estimated position of the top of cliff line for the assumed conservative retreat rate from the 2025 topographic survey baseline without any mitigation in place.

The assessment shows that, taking the top of cliff line from the 2025 topographic survey as a baseline, the waste-to-energy facility section of the proposed development (i.e. all elements contained within the proposed boundary fence) has been located far enough away from the edge of the cliff to ensure that the waste to energy facility will not be impacted by the predicted retreat rates over the design life of the planning permission (30 years).

However, the study found that there could be a risk of an effect on a small section of the proposed development after 40 years which would be confined only to the amenity walkway and viewing platform which are located outside of the proposed security fence line.

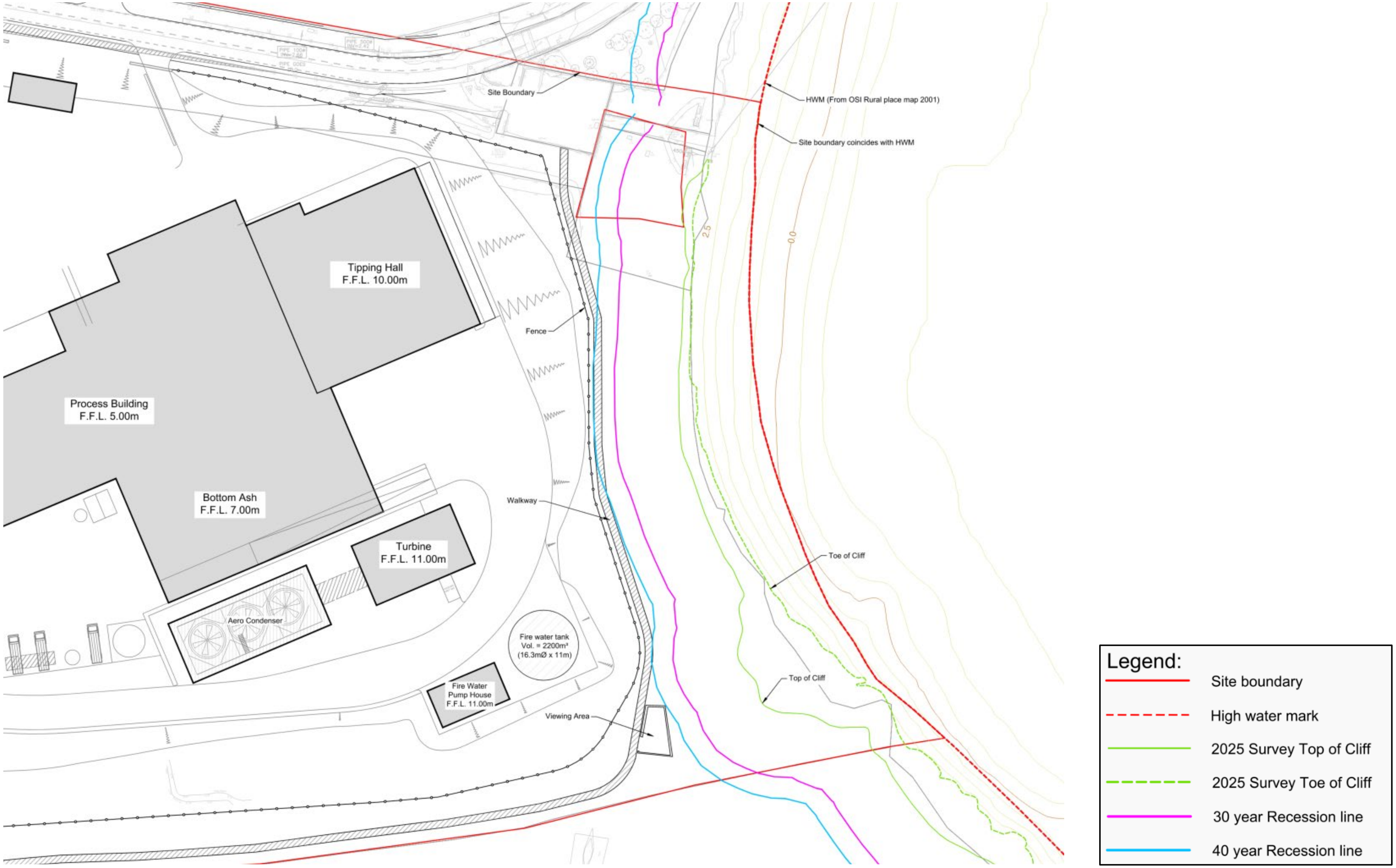

Figure 13 Projected Cliff Top Retreat Lines Based on the 2025 Topographic Baseline for 30-Year (2055) and 40-Year (2065) Timeframes

3. Assessment of Wave Conditions

This section of the report addresses the recommendation by Aqua Vision BV made in 2016 (as requested by An Bord Pleanála), to assess the coastal processes at the site and updates to the assessment of wave conditions and wave modelling study undertaken in 2015 and presented in **Appendix F: *Coastal Model – Wave Modelling Results.***

3.1 Metocean Conditions

3.1.1 Site Location

The site for the Ringaskiddy Resource Recovery Centre is located approximately 15km to the south-east of Cork City, in the townland of Ringaskiddy on the Ringaskiddy Peninsula in the lower part of Cork harbour. Refer to **Figures 1.1** and **1.2** in **Volume 3 *Figures*** of this updated EIS which show the site location.

The L2545, the main road from Ringaskiddy village to Haulbowline Island forms the northern boundary of the site. The eastern boundary of the site extends to the foreshore of Cork Harbour along Gobby Beach.

The lands to the immediate south are in agricultural use. The single carriageway from Barnahely to Ringaskiddy element of the M28 Cork to Ringaskiddy project (known as the 'Protected Scheme') is currently being constructed within the northwestern boundary of the proposed development site.

The site surrounds the Hammond Lane Metal Recycling Co Ltd facility. The site is located approximately 800m east of the village of Ringaskiddy.

The coastal boundary of the Indaver site is a small area (approximately 150m in length) of a larger bay situated to the west of Cork Harbour located between Paddy's Point and Golden Rock. In larger context this particular area is less likely to erode due to both its sheltered protection by rock outcrops (Paddy's Point and Golden Rock) and its convex layout shape.

The eastern coastal boundary is formed by a glacial till slope. Based on the 2025 topographic survey, the toe of the slope varies from 2.7m OD at the northern end to 1.8m OD at the southern end. The top of the slope varies from 3.0m OD at the northern end to 11.6m OD at the southern end. There are rock outcrops to the north and south of the site. Mean High Water Springs (MHWS) is 1.62m OD (4.20m Chart Datum (CD)) at the site.

Figure 14 Indaver Site Aerial Photo - Source: Google Maps. - ©2014 Google

The site is sheltered from open sea waves but is fully exposed to wind generated waves from the second quadrant (from east to south) and a large proportion of wind generated waves from the first directional quadrant (from north to east).


Figure 15 Location of the site - Source: Google Maps. - ©2014 Google

3.1.2 Wind and Wave Data

3.1.2.1 Sources of Data

Wind and wave data is used to define the boundary conditions of the nearshore model.

Wind data was sourced from Met Éireann for the nearby Roche's Point station which is located at Irish Grid reference W 82482 60071 and 'Irish national annex to the wind Eurocode (EN1991-1-4)' produced by Arup in 2009. The dataset covers 29 years from 1971 to 2000.

3.1.2.2 Directional Wind Distribution

At that time, there was no wave data available within Cork Harbour. Therefore, directional analysis of the wind climate was carried out to characterise the metocean conditions of the waves arriving at the site location.

The site will only be affected by storm waves approaching from the first and second quadrants due to the position of the coastline bordering the east of the site (see **Figure 16**). For this reason, only wind and wave conditions from the first and second quadrant will be considered for this project (i.e. directions from north to south clockwise).

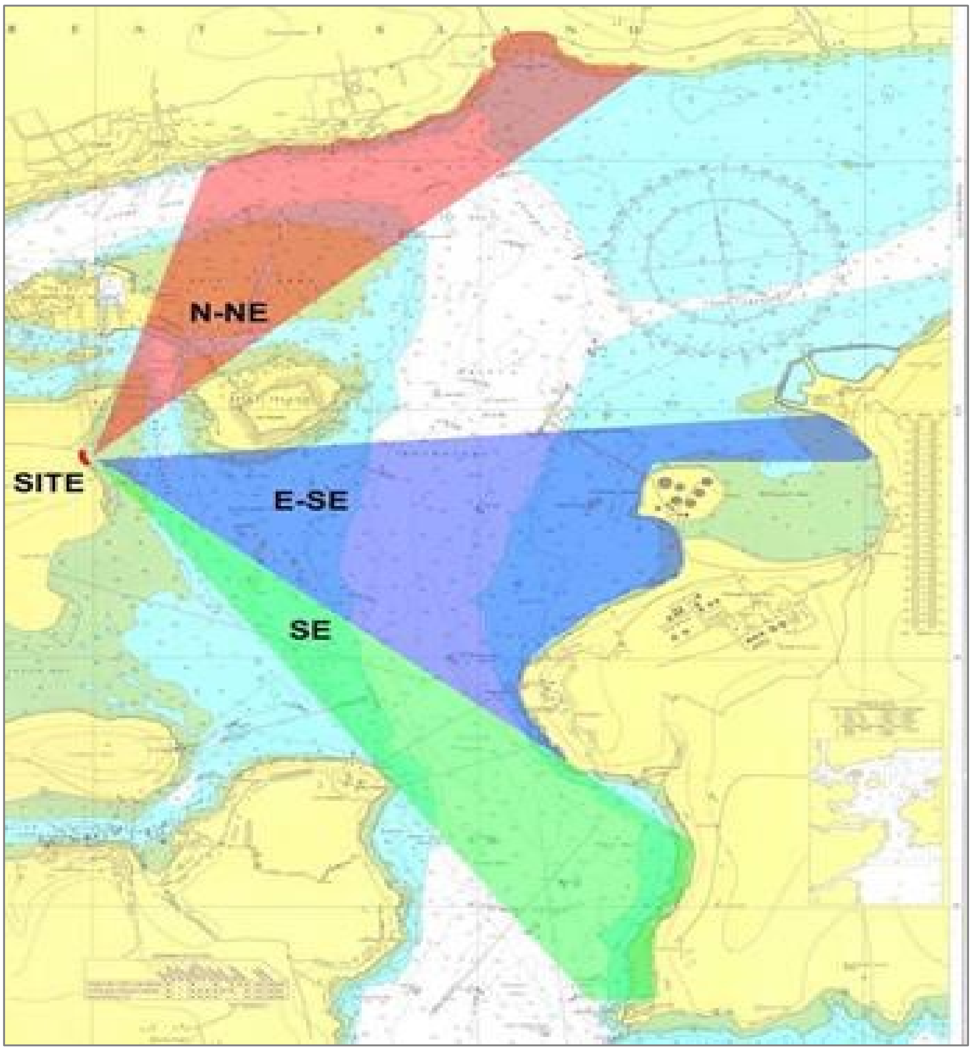

Figure 16 Wave fetch diagram

Figure 17 shows a full wind rose for Cork Airport for the period 1962 to 2010, which was obtained from the Met Éireann website (www.met.ie) [6]. The wind rose shows that the largest wind velocities and most frequent winds come from the SW.

However, the largest wind velocities and most frequent winds, which could affect the wave climate at the site, come from the south. In addition to this, the site can only be exposed to waves approaching from the first and second quadrant (N to S). For the site location, **Figure 17** shows that the SE direction has the largest fetch length. However, the characteristics of the bathymetry for waves approaching from the east, make these waves lose less energy in the propagation process than those from the SE. For these reasons the wave conditions generated by winds from E, SE and S direction will all be assessed.

The first sector (N to E) will not be considered in this assessment due to the fact that the shortest fetch length comes from the North, the site is protected by the presence of Spike Island, and winds coming from the NE are less frequent and intense.

The MIKE21 SW wave model used in this project (**Section 3.2**) also takes into account the effect of waves generated to the E of Spike Island, which will reach the site by diffraction around the island.

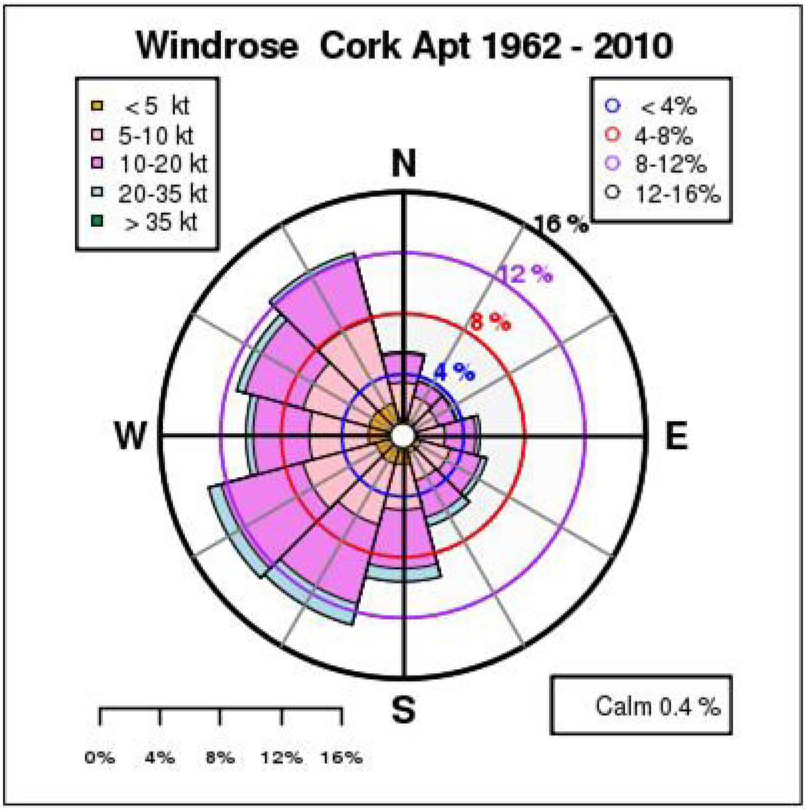

Figure 17 Wind rose for Cork Airport, Met Éireann

The site is exposed to open sea waves entering through the fairly narrow entrance to the harbour. However, the sheltered location of the site and the relatively long distance to the entrance support the assumption that the influence of the open sea wave action in relation to the locally wind generated waves is negligible. Wave modelling runs were performed to validate this assumption.

3.1.2.3 Wind Regime

The following sources have been used:

- Wind data was gathered for Roche's Point including the mean monthly velocity. This value is used as a representative of mean events. The data was gathered from the Met Éireann website, (www.met.ie) [6]
- Wind speed for 10-minute duration at a height of 10m (Vw 10, 10m) for 50yr return period was obtained from the 'Irish national annex to the wind Eurocode (EN1991-1-4)' produced by Arup in 2009. This value is used as representative of extreme events

3.1.2.4 Increased Storminess

Change in 'storminess' may mean an increase or decrease in the intensity, severity or frequency of storms. In the context of maritime engineering, this may lead to increased or decreased surge, design wave height and wave loads, combining to change the structural loading regime on maritime structures. In addition, this issue may affect changes in cyclical fatigue loading and increased potential for scour.

In a number of global climate models, it has been demonstrated that cyclones may change in frequency, tracked path and intensity. Studies in the North Atlantic Ocean have shown that wave heights have increased over the last few decades.

These studies show a strong relationship between the North Atlantic Oscillation and interannual variability as great as 20% in the analysis of the ERA-40 global waves re-analysis. This identified significant trends in wave height, particularly in the Southern Ocean, the North Atlantic and the North Pacific.

These trends are more pronounced in the high quartiles, indicating that the large wave events are increasing at a greater rate than the mean. However, it is noted that the results are far from conclusive and that more detailed investigations are required. This issue has been addressed by the reviewed climate change adaptation documents [2] and [9] in a number of different ways:

- Acknowledgement that storms may increase in intensity, but no immediate action required
- Recommendations for a sensitivity analysis either unstructured or structured (e.g. for England, DEFRA suggests an assessment based on increases to wave height and wind speed by +5 to +10%) outlined in **Table 3**

For this study an increase of 10% of the present storm conditions has been assumed to assess the future scenario.

Table 3 Increased storminess scenarios (From DEFRA guidance)

Parameter	1990 – 2025	2025 – 2055	2055 – 2085	2085 - 2115
Peak rainfall intensity (preferable for small catchments)	+5%	+10%	+20%	+30%
Peak river flow (preferable for larger catchments)	+10%	+20%		
Offshore wind speed	+5%		+10%	+10%
Extreme wave height	+5%		+10%	+10%

3.1.3 Sea Level Rise due to Climate Change

The Office of Public Works (OPW) "Planning System and Flood Risk Management Guidelines for Planning Authorities" [2] advise a precautionary approach with regard to climate change. The precautionary approach includes:

- Ensuring that the levels of structures designed to protect against flooding, such as flood defences, land-raising or raised floor levels are sufficient to cope with the effects of climate change over the lifetime of the development they are designed to protect
- Ensuring that structures to protect against flooding and the development are capable of adaptation to the effects of climate change when there is more certainty about the effects and still time for such adaptation to be effective

Guidance by the OPW advises on future scenarios and allowances for climate change. It identifies two scenarios: the Mid-Range Future Scenario (MRFS); and the High-End Future Scenario (HEFS) with an allowance for mean sea level in 2100 for both of +0.5m and +1m respectively [9].

- The former (the MRFS) is intended to represent a 'likely' future scenario, based on the wide range of predictions available and with the allowances for increased flow, sea level rise, etc. within the bounds of widely accepted projections
- The latter (the HEFS) is intended to represent a more extreme potential future scenario, but one that is nonetheless not significantly outside the range of accepted predictions available, and with the allowances for increased flow, sea level rise, etc. at the upper the bounds of widely accepted projections

In addition to the element of sea level rise, the guidance also notes that this area of the country is subsiding due to Glacial Isostatic Adjustment (GIA). The rate of GIA is given as 0.5mm/year. Taking into account all the recommendations, wave model runs were carried out using an adopted climate change allowance estimate of 0.55m by 2100 i.e. the MRFS.

It is important to compare the sea level rise guidance from OPW with the estimated sea level rise over the next 40 years (i.e. assuming a horizon year of around 2070).

In June 2025 the Department of Transport, Climate Adaptation Research and Energy Division released the Statutory Climate Change Adaptation Plan for the Transport Sector (T-SAP II) for Public Consultation.

The Plan provides sea level rise estimates based on the NASA Sea Level Rise tool (https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool) only for Dublin and Malin Head. Due to the spatial resolution of the tool, the closest point to the site is at Lat 59°N, Lon 8°W, almost 100km away. It is unclear, but inferred, that in the Plan, sea level rise estimates represent the 50%ile of projections for a given climate change scenario; and climate change scenarios RCP 4.5 and RCP 8.5 in the Plan correspond to SSP2-4.5 and SSP5-8.5, respectively, in the NASA tool.

It is unclear why the Plan does not reference the Climate Data Portal from the MetOffice (https://climatedataportal.metoffice.gov.uk/) which provides more detailed information around the southern coast of Ireland.

The sea level rise estimates from the two data sources are compared in **Table 4**. It is concluded that in a high emissions scenario, sea level rise should not exceed 0.37m until 2070 considering both sources.

Table 4 Sea level rise estimates

Data Source	Sea Level Rise (1) until 2070 from Climate Change Scenario (2)	
	RCP 4.5 50%ile	RCP 8.5 50%ile
NASA Sea Level Rise tool	0.31m	0.37m
MetOffice Climate Data Portal	0.21m	0.31m

(1) Relative to present day (2020s)

(2) Scenarios considered in the Statutory Climate Change Adaptation Plan for the Transport Sector

The discrepancy in estimates highlight the uncertainty in projections. Nevertheless, the 500mm allowance used in the wave modelling and other assessments, corresponding to the OPW guidance for Mid-Range Future Scenario, is on the conservative side.

3.1.4 Design Water Levels

3.1.4.1 Tidal Levels

The tidal range and associated levels have been derived from the United Kingdom Hydrographic Office Admiralty Chart Number 1777 Cork Harbour [13] for Cobh. Cobh and Ringaskiddy's gauges are both located close to the proposed development site. All levels are referenced to Chart Datum (CD), which is -2.58m OD. These levels are shown in **Table 5**.

Table 5 Tide Levels at Cobh

	Tide level (m CD)	Tide level (m OD Malin)
Highest Astronomic Tide (HAT)	4.60	2.02
Mean High Water Springs (MHWS)	4.20	1.62
Mean High Water Neaps (MHWN)	3.20	0.62
Mean Low Water Neaps (MLWN)	1.30	-1.28
Mean Low Water Springs (MLWS)	0.40	-2.18
Lowest Astronomic Tides (LAT)	-0.10	-2.68

3.1.4.2 Cases

A number of different extreme water levels were analysed and their relevance to the design cases in this report were assessed. The levels are based on tidal levels, climate change allowances and extreme water levels (comprising tidal and surge components) as noted in the ICPSS for this area [8]. This conservative approach has been adopted to account for the lack of an existing joint probability assessment. A joint probability assessment for surge and waves was not considered necessary for the study due to the fact that the extreme tidal levels will only occur for a few hours of the tidal cycle during Spring tide conditions.

Therefore, a wide range of likely extreme events and their associated conditions provide a robust assessment of the extreme situations likely to happen at the site is shown.

The final water levels adopted for the wave modelling incorporated different scenarios of water levels: sea level rise for both the MRFS and HEFS, storm surge and extreme tidal water level combined with MHWS and the extreme water level for the 0.5% Annual Exceedance Probability (AEP) at prediction point C_2 within Cork Harbour as noted in the ICPSS [8]. The cases and combinations assessed are shown in **Table 6**.

Table 6 Cases and combinations assessed in the wave model

Direction	Case Number	Case	Water Levels					
			Design Year	Climate Change Allowance	Return Period	Extreme Water Level	Total Water Level	
			(yr)	(m)	(yr)	mOD Malin	mOD Malin	mCD
E	1.1	MHWS + MRFS	2100	0.55			2.17	4.75
SE	2.1	MHWS + MRFS	2100	0.55			2.17	4.75
	2.2	MHWS + MRFS	2100	0.55			2.17	4.75
	2.3	MHWS + HEFS	2100	1.05			2.67	5.25
	2.4	0.5% AEP + MRFS	2100	0.55	200	2.73	3.28	5.86
	2.5	0.5% AEP + HEFS	2100	1.05	200	2.73	3.78	6.36
	2.6	MLWS + MRFS	2100	0.55			-1.63	0.95
S	3.1	MHWS + MRFS	2100	0.55			2.17	4.75
	3.2	MHWS + MRFS	2100	0.55			2.17	4.75

3.2 Wave Modelling

3.2.1 Overview

A wave model was undertaken as part of the Coastal Erosion Study (included as Appendix 13.3 to the 2016 EIS), with the aim of providing a more accurate estimation of the wave heights assessed in studies prior to 2016 using empirical formulae. The wave model provided as part of the 2016 EIS, therefore, improved previous empirical results.

The methodology that underpins the computational wave modelling study is outlined in the following steps:

- Set the wind climate conditions
- Set up the computational model (bathymetry, mesh configuration and boundaries)
- Set up boundary conditions for the model; and
- Obtain the required outputs at the site location

3.2.2 Software

The wave propagation model used was MIKE21 SW developed by DHI.

MIKE21 SW is a 3rd generation spectral wind-wave model that simulates the growth, decay and transformation of wind-generated waves and swells in offshore and coastal areas. The model includes the following physical phenomena:

- Wave growth by action of wind
- Non-linear wave-wave interaction
- Dissipation by white-capping
- Dissipation by wave breaking
- Dissipation due to bottom friction
- Refraction due to depth variations
- Wave-current interaction
- Diffraction; and
- Reflection

A major application area for this model is the design of nearshore structures where accurate assessment of wave loads is of utmost importance for a safe and economic design.

When waves approach the coastline, they undergo a number of changes caused by the processes listed above, which affect their characteristics: wave steepness, height, propagation velocity and direction. In this study the MIKE21 SW model was used to propagate wind-generated waves from offshore to nearshore at the site location. As stated previously, the influence of open sea waves in relation to local wind generated waves is assumed to be negligible, and this case is also investigated for validation.

3.2.3 Bathymetric and Topographic Data

The different sources of data used in this study include the following:

- Topographic survey carried out by Precise Control Land & Engineering Surveyors in 2014
- Bathymetric survey carried out by Irish Hydrodata Ltd. in 2015; and
- UK Hydrographic Office Admiralty Chart number 5622.10

In order to determine how waves propagate to the site, it is necessary to gather all available bathymetric data in the harbour both nearshore and offshore from the site. The offshore bathymetry for the model was obtained from the UK Hydrographic Office Admiralty Chart number 5622.10: The Sound to Spike Island, scale 1:12,500, depths in metres reduced to Chart Datum (see **Figure 18**) [13].

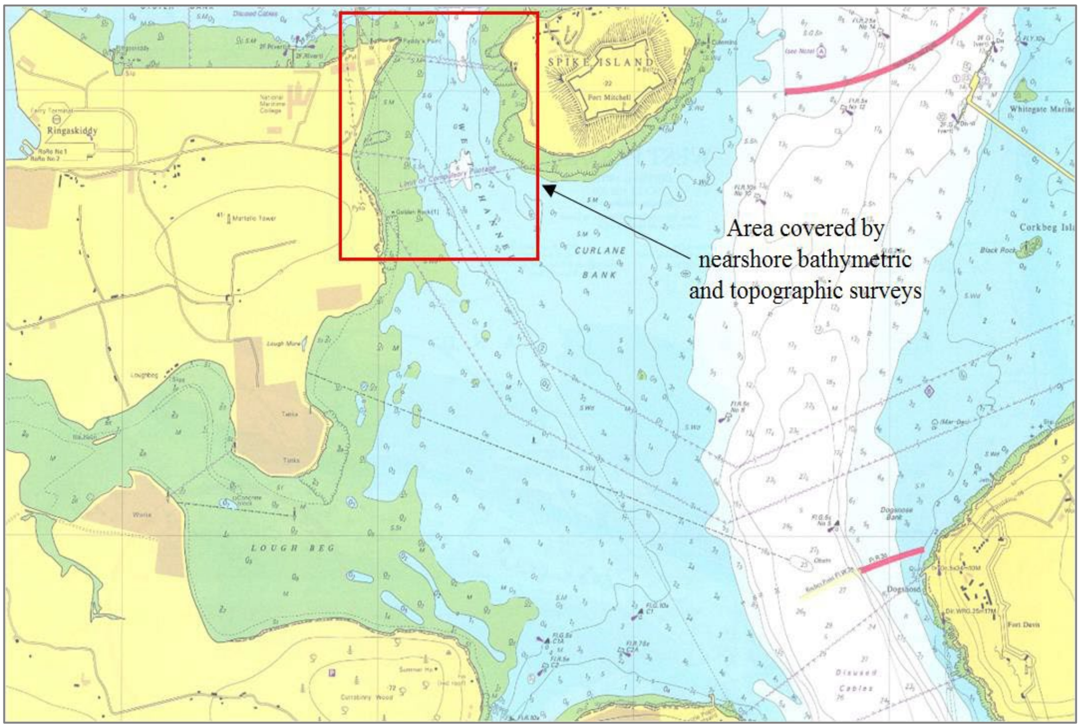

Figure 18 Snapshot of Admiralty Chart 5622.10 indicating the area covered by nearshore bathymetric and topographic surveys

Nearshore bathymetry was derived from a survey undertaken by Irish Hydrodata Ltd. in January 2015. On site topography was derived from a survey undertaken by Precise Control Land & Engineering Surveyors in November 2014.

3.2.4 Wave Propagation

3.2.4.1 Model Bathymetry

Figure 19 shows the digitized Admiralty Chart described in the previous section. The model bathymetry varies from roughly -28m CD to +9m CD and takes into account bathymetric features such as the Lough Beg to the southwest and the Curlane bank south of Spike.

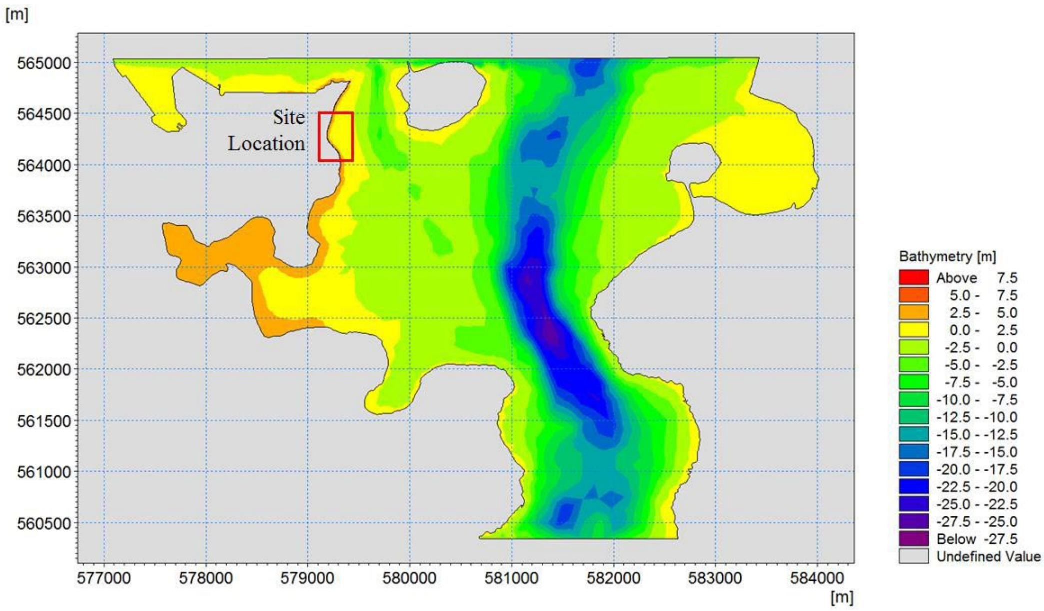

Figure 19 Bathymetric model derived from Admiralty Chart 5622.10 showing approximate site location

3.2.4.2 Computational Mesh

The MIKE21 SW model uses a flexible mesh to calculate wave parameters within the computational domain. This mesh can be denser in the areas of interest. The mesh used in the model for Ringaskiddy is shown in **Figure 20, Figure 21** and **Figure 22**.

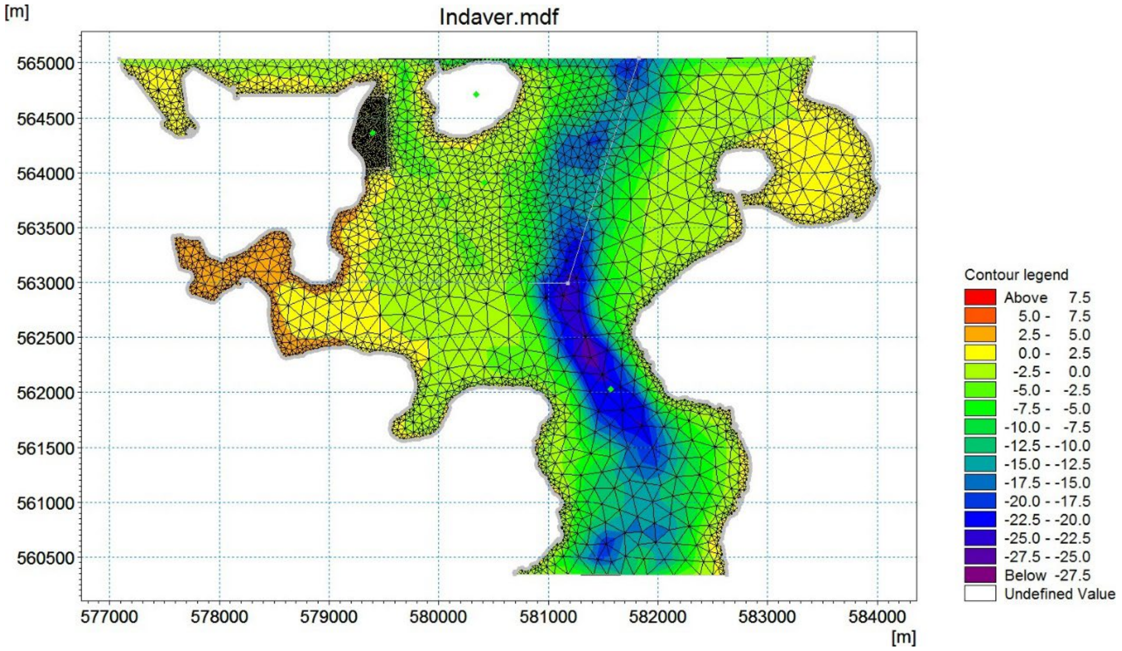

Figure 20 Bathymetry computational mesh in the MIKE21 SW model

Three different areas have been defined within the model for mesh generation. Each area had a different mesh size with a finer grid for the area of interest and coarser grid elsewhere. **Figure 20** shows the bathymetry used in the model whereas the size of the mesh in the various model areas is shown in **Figure 21**. **Table 7** below describes the different sized mesh used for each area.

Table 7 Mesh size for various areas in the computational domain

Section	Mesh Size
Nearshore	200 m^2
Intermediate	5,000 m^2
Offshore	20,000 m^2

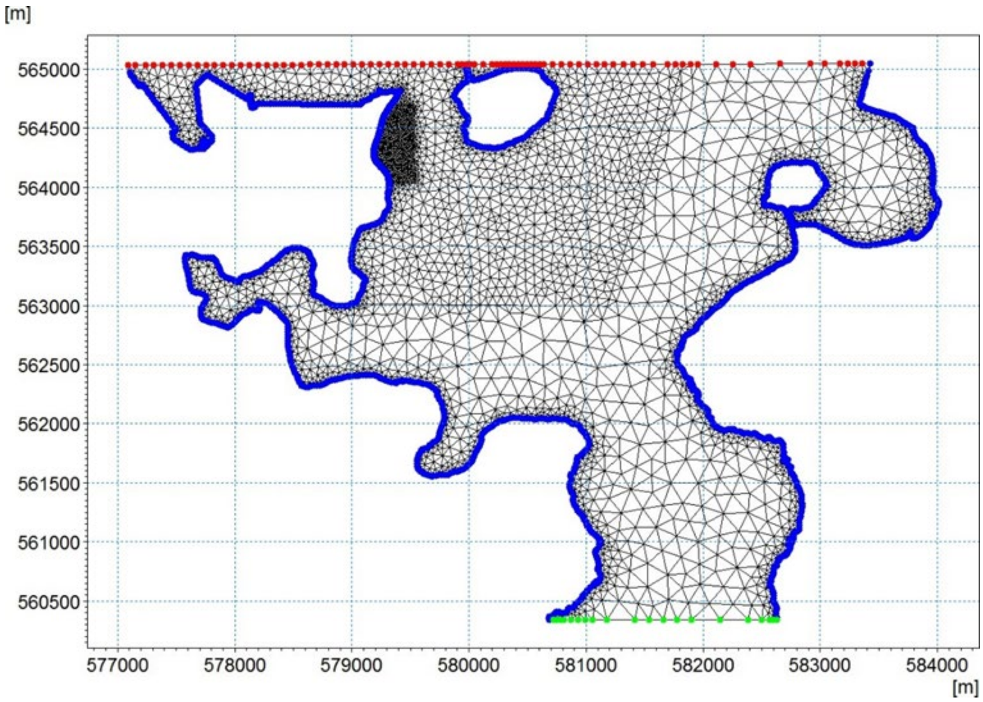

Figure 21 MIKE21 SW model mesh

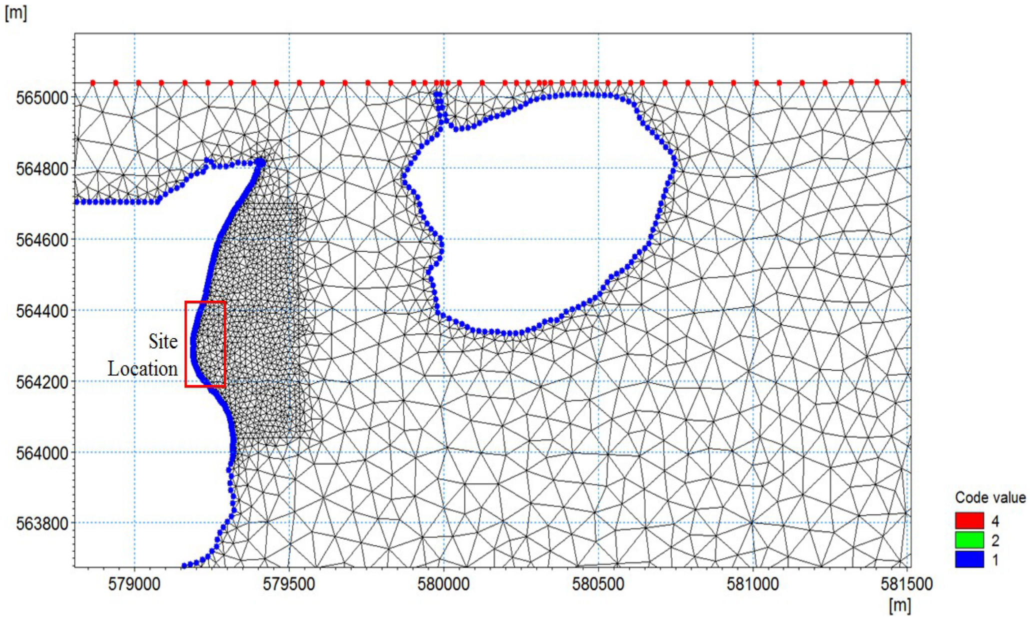

Figure 22 MIKE21 SW model mesh detail showing site location

3.2.4.3 MIKE21 SW Model Runs

The offshore waves were transformed over the domain, using a number of different input wind and wave conditions. The wind at Roche's Point was assumed to be acting along the entire computational domain (constant in time and space). The initial conditions of wave height, Hs, peak wave period, Tp, and direction of the offshore waves are provided as input data at the model boundaries.

The model was run as a fully spectral model. Two different situations were considered as follows: only considering wind generated waves, and considering both wind generated waves and waves from the open sea. The latter case was run in order to validate the assumption that open sea waves could be neglected in comparison with locally generated wind waves at the site. The model results showed that open sea waves entering the estuary are reduced in height by approximately 80% at the site (Cases 2.2 and 3.2).

For this reason, a unitary value for offshore waves was selected in order to see the relative importance in relation to locally generated winds, which proved to be negligible. Hence, the open sea waves were considered to be negligible in comparison with the locally wind generated waves in subsequent parts of the study. This conclusion was also supported by Arup's previous studies. Open sea waves coming from the S and SE direction were considered as these are the only open sea wave directions that can affect the site.

In relation to wind the same extreme wind speed is applied in cases where wind speed alone is considered regardless of direction. This was determined to be an appropriate assumption from analysis. However, this is a conservative assumption in that it takes the maximum statistically characterised wind speed and applies this to all likely directions. In addition, increased storminess as described in **Section 3.1.2.4** has also been factored into the wind speeds used in the model runs. As previously mentioned, this is a conservative estimate.

A wide range of extreme wave events caused by extreme wave conditions in combination with different extreme water levels have been run in the Mike 21 model to assess the effects of such extreme wave conditions at the site. The aim was to obtain a wide range of extreme potential wave conditions nearshore, which will contribute to the natural erosion of the cliffs and beach.

Table 8 shows the model results for the various combinations of wind for extreme and mean conditions and offshore wave data and various water levels taking into account fluvial and tidal conditions as well as sea level rise for all the directions assessed. The nearshore wave results correspond to the values obtained at approximately the 3.6m CD contour (1.0m OD), which is situated approximately 9.0m seaward of the toe of the cliff. These values are a conservative estimate of nearshore wave conditions at the site. The resultant graphics of the different wave model cases are shown in **Appendix F *Coastal Model – Wave Modelling Results*.**

The model output line is located along the 1m CD contour immediately seaward of the site boundary and is located approximately 10m from the toe of the cliffs. The output value is the maximum wave height along the 1m contour.

From **Table 8** it can be seen that storms from both the East and South East produce the most unfavourable wave conditions at the site. Although the fetch length in the South East direction is the longest unobstructed length, the characteristics of the bathymetry aligned with the East direction result in less wave energy being dissipated in the wave propagation process from the East. Hence Cases 1.1 and 2.1 show similar nearshore wave results. However, the SE direction is considered the most unfavourable for the following reasons:

- Winds from the SE direction are most frequent and have higher velocities than E direction
- Open sea swell waves will come from the S and SE direction and, (although smaller) will combine with waves generated by winds from the same direction

Table 8 MIKE21 SW Results

Direction	Case Number	Case	Water Levels			Wind Conditions			Offshore Waves		Nearshore Wave Results	
			Climate Change Allowance (m)	Total Water Level mOD Malin	mCD	Case	Wind Velocity (ms-1)	Duration (mins)	Hs (m)	Tp (s)	Hs (m)	Tp (m)
E	1.1	MHWS + MRFS	0.55	2.17	4.75	50yr return period	28.3	10			1.0	3.9
SE	2.1	MHWS + MRFS	0.55	2.17	4.75	50yr return period	28.3	10			1.0	4.1
	2.2	MHWS + MRFS	0.55	2.17	4.75	mean wind speed	6.3	10	1.0	8	0.2	3.7
	2.3	MHWS + HEFS	1.05	2.67	5.25	50yr return period	28.3	10			1.3	4.2
	2.4	0.5% AEP + MRFS	0.55	3.28	5.86	50yr return period	28.3	10			1.6	4.2
	2.5	0.5% AEP + HEFS	1.05	3.78	6.36	50yr return period	28.3	10			1.7	4.1
	2.6	MLWS + MRFS	0.55	-1.63	0.95	50yr return period	28.3	10			0.0	0.0
S	3.1	MHWS + MRFS	0.55	2.17	4.75	50yr return period	28.3	10			0.8	4.1
	3.2	MHWS + MRFS	0.55	2.17	4.75	mean wind speed	6.3	10	1.0	8	0.2	7.2

Figure 23 and **Figure 24** show the wave height distribution over the computational domain for Case 2.1 for a storm period equivalent of 50-year return period wind conditions, sea level rise for year 2100 and MHWS conditions. Case 2.1 (see **Table 9**) can be used to provide an example of expected extreme wave conditions at the site.

Table 9 Nearshore wave conditions

Direction	Case Number	Case	Wind Conditions		Nearshore Wave Conditions	
			Velocity (ms-1)	Duration (min)	Wave Height (m)	Period (s)
SE	2.1	MHWS + MRFS	28.3	10	1.0	4.1

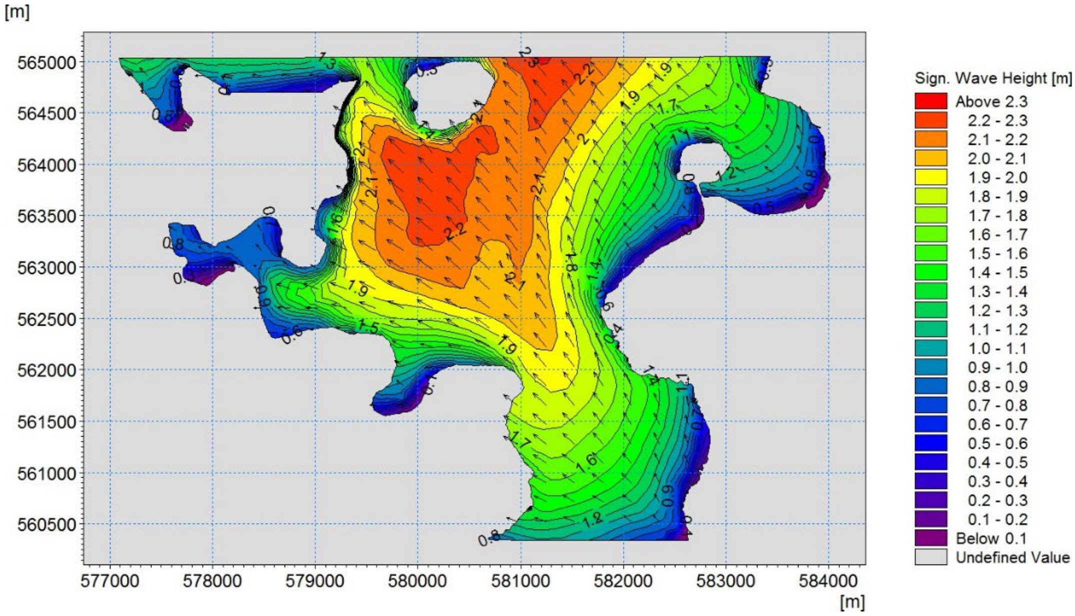

Figure 23 Offshore wave height distribution - Case 2.1 Waves from the SE

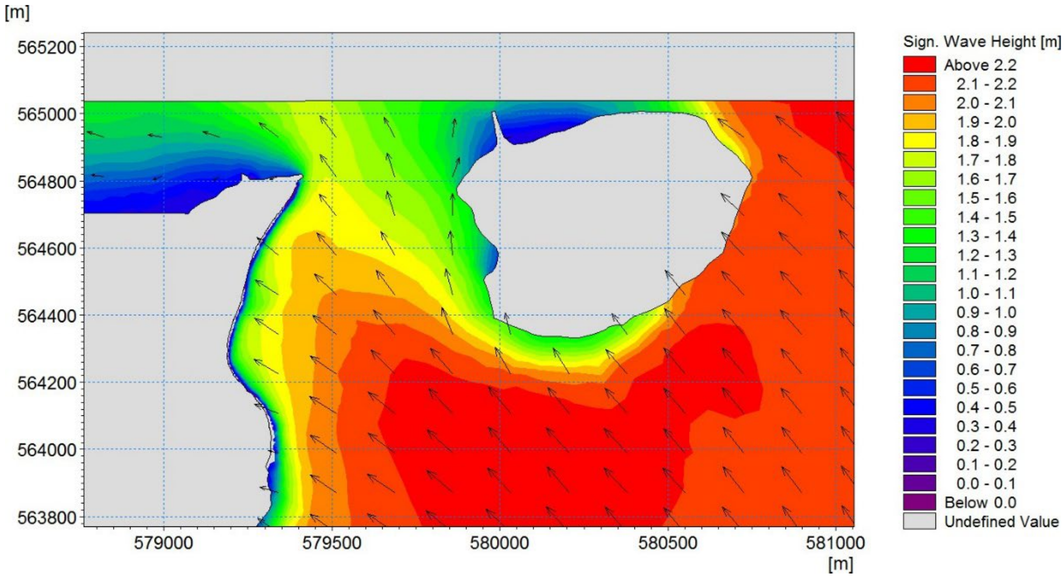

Figure 24 Nearshore wave height distribution - Case 2.1 Waves from the SE

3.2.5 Nearshore Wave Directions

The consideration of nearshore wave directions is a key element for the assessment of sediment transport within the coastal cell. **Figure 25** to **Figure 27** show the nearshore velocity component for Cases 1.1, 2.1 and 3.1 from the wave modelling output.

The velocity component indicates the direction of the waves as the approach the shoreline. Generally speaking, it is normal for waves to remain perpendicular to the nearshore bathymetry as can be seen in **Figure 25**. However, in **Figure 26** and **Figure 27** this is less apparent due to the local wind conditions forcing the waves from the SE and S respectively.

Table 10 Mean wave directions for all cases

Direction	Case Number	Mean wave direction (º from S)
E	1.1	271
SE	2.1	279
	2.2	282
	2.3	285
	2.4	287
	2.5	287
	2.6	288
S	3.1	283
	3.2	286

The directions obtained from these design cases from the wave model (see **Table 10**) indicate that there is a slight tendency for waves to push sediment towards the northern extent of the site boundary since the beach is subject to oblique wave attack that drives sediment in a net northerly alongshore direction. Due to the presence of a rock outcrop towards the north it is likely that most of the sediment will remain in the bay as the rock will act as a natural barrier to the movement of sediment. Hence, the presence of the rock outcrops will likely reduce the potential for sediment to be lost from the coastal cell.

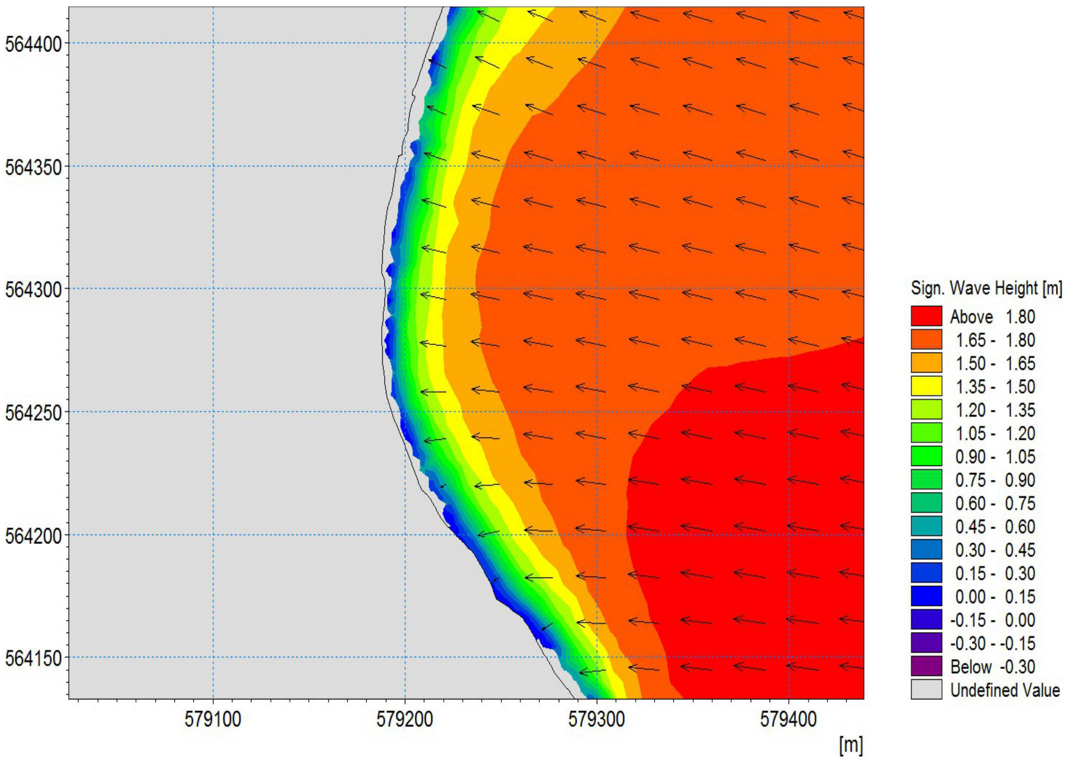

Figure 25 Case 1.1 (E direction) showing nearshore wave direction

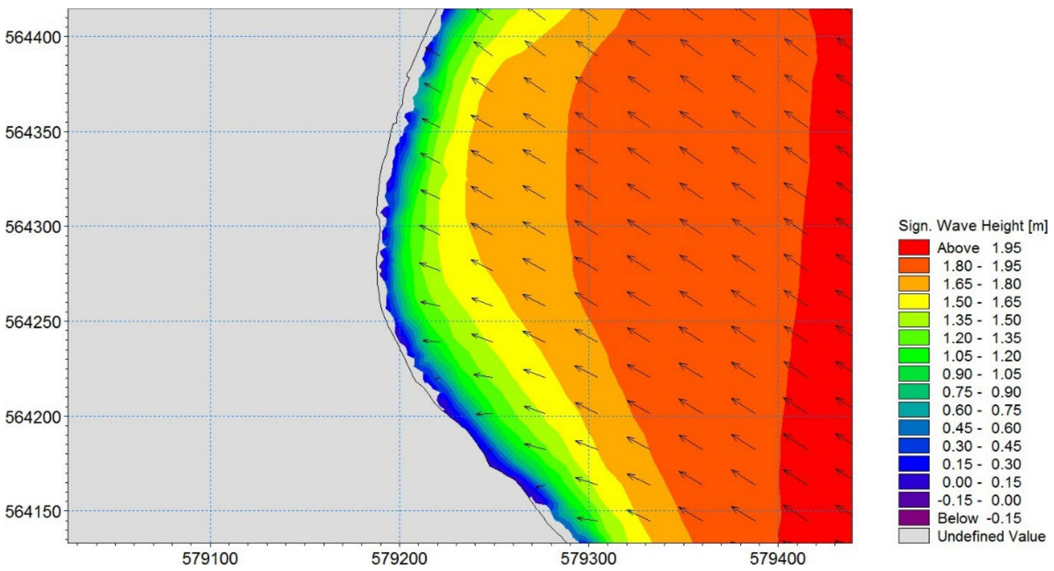

Figure 26 Case 2.1 (SE direction) showing nearshore wave direction

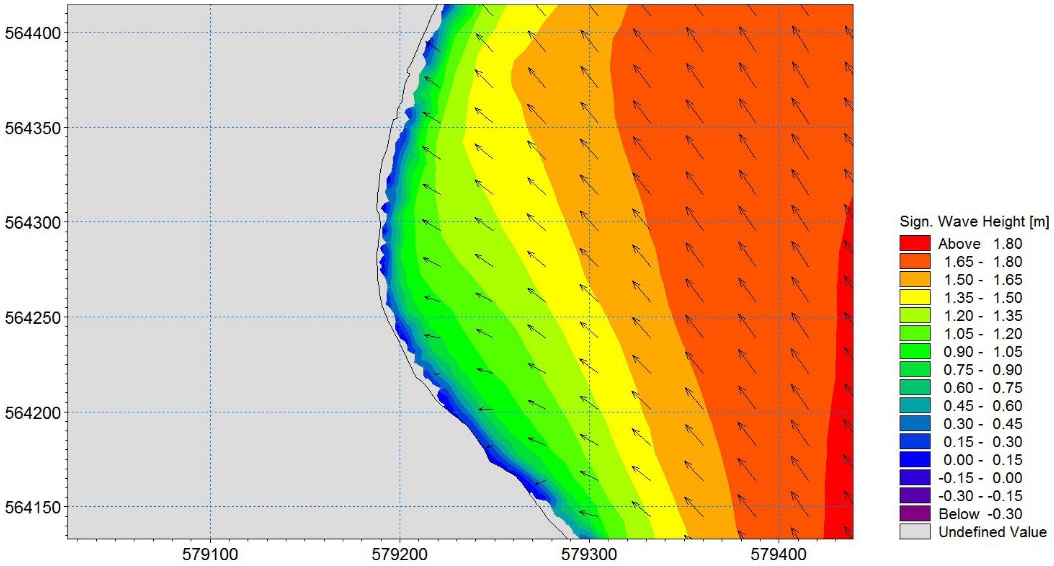

Figure 27 Case 3.1 (S direction) showing nearshore wave direction

3.2.6 Conclusions from the Wave Modelling

The following conclusions can be drawn from the modelling:

- The most unfavourable wind direction for the site is the SE. This direction has the longest fetch and it gives a wave height (Hs) in the same order as in the E direction. However, this direction may produce the largest Hs on site for the extreme return period considered and it may be combined with the swell open sea Hs of the same direction. The model used for this study was run as a fully spectral model. Model runs considering both wind and open sea swell waves showed that the reduction of the open sea wave energy is significant enough that a calculation of the most extreme wave conditions at the site can be based on local wind generated waves only. Joint probability figures for the combination of surge and waves were not available and therefore a conservative approach was taken by assuming that the extreme surge will only occur for a few hours of the tidal cycle during Spring tide conditions.
- The influence of mean wind conditions on wave conditions at the site is negligible.
- Hs values of 1m are obtained for a MHWS tidal level. MHWS occurs approximately twice per month with the highest portion of the tide lasting for less than three hours. For the maximum run-up to occur, a severe storm (50 yr wind conditions) is required within the harbour coinciding with MHWS.
- Case 2.1 gives an accurate reflection of expected extreme wave conditions at the site. This corresponds to an Hs value of 1.0m with an associated period of 4.1s. These values correspond to a tidal water level of MHWS with the MRFS (0.55m sea level rise).
- The beach appears to be subject to a slightly oblique wave attack that drives sediment in an alongshore direction rather than cross-shore. Due to the presence of a rock outcrop towards the north it is likely that most of the sediment will remain in the bay.

3.3 Wave Run-Up Calculation

Breaking of waves on the beach results in a periodic wave ‘uprush’ above the still-water level known as run-up. This is not an inundation of water but can result in water intermittently reaching higher elevations on the beach. As described in the Arup “Coastal Recession Mechanisms Investigation” Report, 2012, the water may reach the toe of the cliff in storm conditions and this in turn may increase erosion rates of the cliffs. The wave run-up height (Ru2%) is defined as the vertical difference between the highest point of wave run-up and the still water level (SWL). See **Figure 28**.

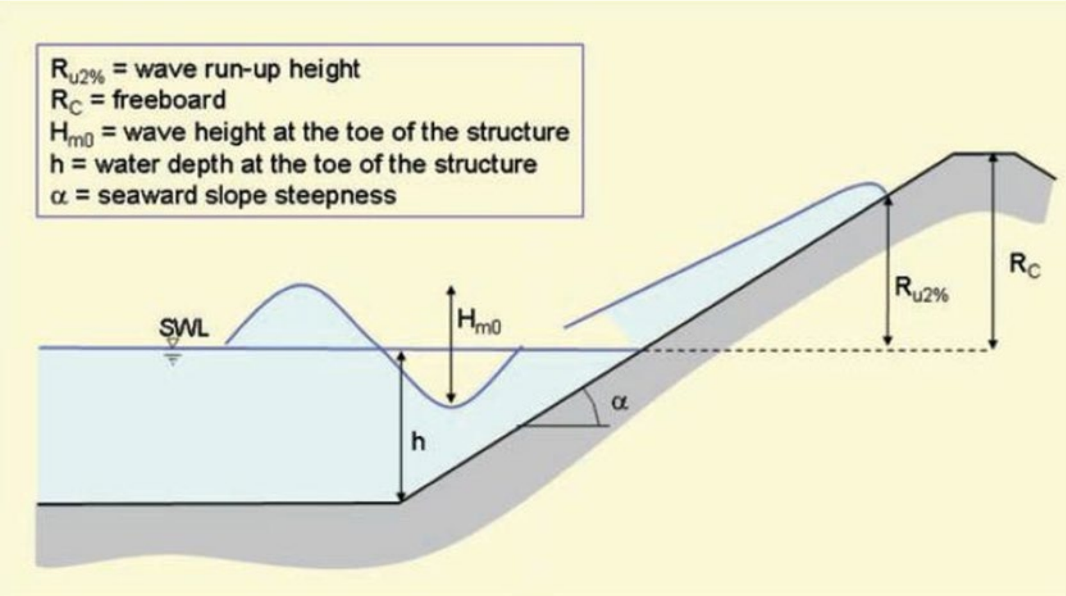

Figure 28 Definition of the wave run-up height Ru2% on a smooth slope, Eurotop Manual 2007

Calculations of wave run-up height were carried out for the cases as described in the previous section. The calculations were based on empirical formulae outlined in the Eurotop Manual [10] and CIRIA Rock Manual [1] as follows:

$$\frac{R_{u2\%}}{H_{mo}} = c_1 \cdot \gamma_b \cdot \gamma_f \cdot \gamma_\beta \cdot \xi_{m-1,0}$$

$$\text{with a maximum of } \frac{R_{u2\%}}{H_{mo}} = \gamma_f \cdot \gamma_\beta \left(c_2 - \frac{c_3}{\sqrt{\xi_{m-1,0}}} \right)$$

$Ru_{2\%}$	wave run-up height exceeded by 2% of the incoming waves (m)
c_1, c_2, c_3	empirical coefficients
H_{m0}	significant wave height (m)
$\xi_{m-1,0}$	Iribarren number or Surf Similarity Parameter
γ_b	influence factor for berm
γ_f	influence factor for roughness
γ_β	influence factor for oblique wave

Table 11 shows the various input parameters used in the calculation of the wave run up.

Table 11 Wave run up calculation inputs

	Symbol	Inputs	Units
Still Water Level	SWL	6.36	m OD Malin
Slope angle	α	10.00	o
Berm Factor	γb	1	-
Roughness factor	γf	1	-
Oblique wave factor	γβ	1	-
Coefficients	A	1.65	-
	B	4	-
	C	1.5	-

	Symbol	Inputs	Units
Gravity	g	9.81	m/s^2

The maximum wave run-up height was calculated for waves from the SE and is approximately 1.6m above SWL for the extreme scenario of the design wave storm and 1m sea level rise and MHWS. This corresponds to an approximate level of 5.86m CD for the HEFS. **Table 12** summarises the wave run up height results for the various cases assessed. Note that cases 2.2, 2.6 and 3.2 from the wave modelling study were not considered in this analysis as the nearshore wave heights as shown in **Table 8** were negligible. Note that the parameters used in the calculations were considered to be constant across the entire site which is a conservative estimate.

Table 12 Wave run up results for different cases

Direction	Case Number	Case	Water Levels		Nearshore Wave Results		Wave run up height	Total Water Level
			mOD Malin	mCD	Hs (m)	Tp (s)	RU2% (m)	mCD
E	1.1	MHWS + MRFS	2.17	4.75	1.0	3.9	1.3	6.05
SE	2.1	MHWS + MRFS	2.17	4.75	1.0	4.1	1.4	6.15
	2.3	MHWS + HEFS	2.67	5.25	1.3	4.2	1.6	6.85
	2.4	0.5% AEP + MRFS	3.28	5.86	1.6	4.2	1.8	7.66
	2.5	0.5% AEP + HEFS	3.78	6.36	1.7	4.1	1.8	8.16
S	3.1	MHWS + MRFS	2.17	4.75	0.8	1	1.2	5.95

Figure 29 and **Figure 30** below show the beach profile at section D in relation to the wave run up height for Cases 2.1 and 2.3 respectively. It can be seen that the run-up for the cases combining sea level rise with MHWS and the design storm results in a water level above the level of the toe of the cliff.

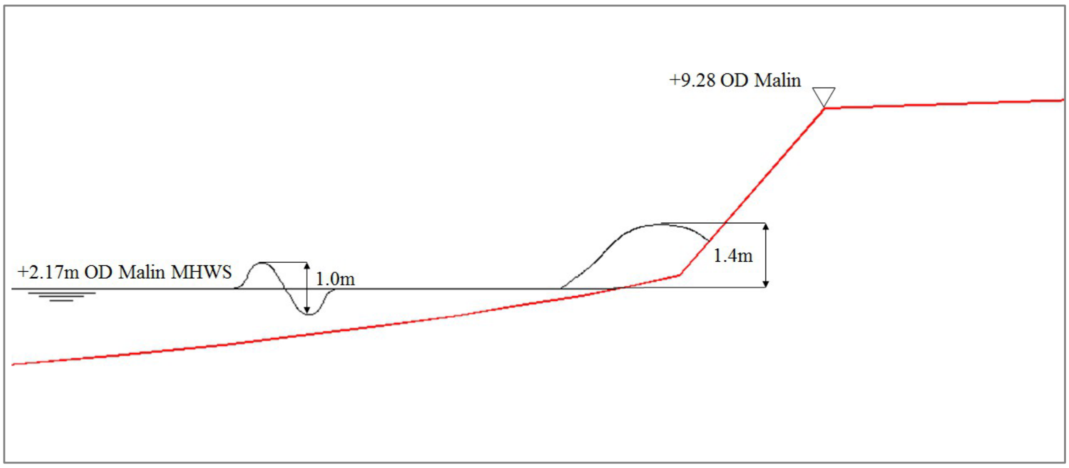

Figure 29 Beach profile for Section D showing wave run up heights for case 2.1

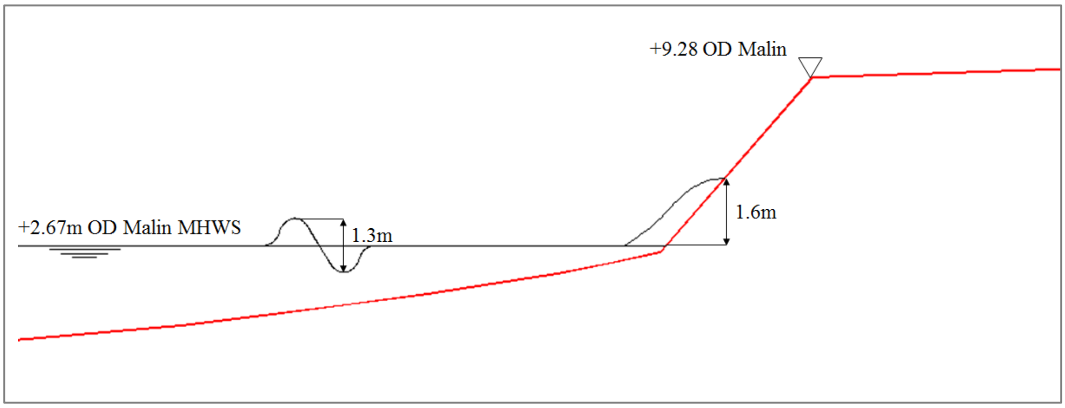

Figure 30 Beach profile for Section D showing wave run up heights for case 2.3

This estimation of wave run up does not include the set-up of the water level under breaking waves. Based on methods presented on the CIRIA Rock Manual [1], wave set up is estimated to be approximately 10% of the incoming wave height. For case 2.3 this corresponds to an additional 150mm.

4. Assessment of Sediment Transport

4.1 Beach Evolution

The previous Arup study into the coastal recession at the site investigated movement of the High Water Mark (HWM) since 1897. It appears from the movement of the HWM on historical mapping that erosion of the beach has occurred along the southeastern boundary of the site. The cross sections assessed indicated the beach in this area to be steeper than the areas to the north.

The estimated wave action to the east of the site is sufficient to mobilise any fine sediment on the beach. Finer sediment from the glacial till overlying the rock on the beach may have been removed over time by wave action. Any fine sediment which has collected on the beach from the cliff is also likely to have been transported from the beach due to wave action. Grab samples taken from the beach at the base of the cliff in previous geotechnical surveys indicate that the material remaining on the beach is a large granular material (median grain size, d50 = 11.4mm). The removal of fine sediment by waves may be contributing to the granular make-up of the beach along the eastern boundary of the site.

Portions of the beach along the eastern boundary of the site are currently at the level of bedrock. The southeastern area of the beach appears to have undergone the biggest removal of overlying sediment and contains the most exposed bedrock. Moving northwards along the beach, patches of the overlying glacial till are visible through the gravel beach material.

The reduction of the beach level to bedrock along the southeastern boundary of the site may be due to more aggressive wave action. However, the higher elevation of bedrock in this area may also lead to it being exposed sooner than rock towards the north.

In the northeastern boundary of the site rock protection has also been installed to protect an electricity pylon. The rock armour may contribute to some slight alteration of the wave pattern on the beach, which could have an impact on the area to the south.

Large cobbles and boulders were noted at the base of the cliffs along the southeastern boundary of the Indaver site. These may have been pushed up to the base of the cliffs due to wave action on the beach or have become exposed through the removal of sediment from the beach and base of the cliff.

The build-up of material on the beach (particularly towards the northeastern boundary of the site) may provide some minor protection to the cliff along the site. The material may help to reduce the cliff erosion as extreme water levels and wave run-up will reach the cliff less frequently. The build-up of material to the north also shows that the beach is subject to oblique wave attack that drives sediment in an alongshore direction from south to north.

It is important to note that the beach's sand and shingle is likely to erode and partially recover during storms. The beach profile would also change seasonally. Accretion and erosion of the beach may occur along the Indaver site at the same time as sediment is removed from the base of the coastal slope.

One of the identified mechanisms contributing to the cliff erosion is 'notching' (localised removal of sediments) of the cliff material by the sea water reaching the coastal slope. This may happen during storms combined with extreme high tides, but some notching may also happen at MHWS if the waves are large enough to create run-up. The erosion process has been explained in detail in the previous 2012 Arup report, the main points of which will be covered in this section.

This section of the report also addresses the recommendation by Aqua Vision BV to assess the coastal processes at the site. Results from the 2025 survey showed an apparent erosion trend of the beach since 2008 (refer to **Section 2.2.2**). However, the seasonal variation of the beach profile has not been assessed, and the beach's evolution may be influenced by associated fluctuations.

4.2 Sediment Transport Dynamics

As previously stated, the site is sheltered from the direct open sea swell waves which enter Cork Harbour from the south. The shape of the harbour and the location of the nearby Spike Island (to the northeast) provide some shelter to the site from wind generated waves within the harbour.

The Indaver coastal area belongs to a physiographic unit formed by a coastline surrounded by two headlands. The stretch of coast under analysis is like a hollow between two outcrops. There are rock outcrops on the beach to both the north and south of the site. A revetment to the north of the site maintains a hard line for this headland. To the south of the site the headland cliffs are eroding, but the rate of erosion is somewhat limited by the rock outcrop on the beach. These rocky outcrops may contribute to keep the material relatively stable within this cell.

The beach is approximately described as a 'shingle' (i.e. gravel as described in the geotechnical investigation undertaken) type beach. The beach in Ringaskiddy has an upper slope of approximately 1:8 and a lower slope of 1:44. The d_{50} based on the 2012 SI figures is 11.4mm for the upper beach but the shingle appeared to be larger than this in the 2025 walkover survey.

4.3 Influence of Tidal Currents

It is also beneficial for the assessment of the coastal erosion at the site to consider the potential effects of tidal currents on the local sediment regime. **Figure 31** and **Figure 32** show the flow plots for the ebb (outgoing) and flood (incoming) tides as well as expected current speeds. From the plots it is evident that there are substantial current speeds approaching 0.9m/s in the area between Haulbowline Island and Paddy's Point. However, it can be seen that current speeds at or near the project site are very low in relation to the adjoining areas which is a factor which contributes to sediment stability at the site (less than 0.1m/s for the ebb flow and less than 0.2m/s for the flood flow). These are relatively low current speeds, and they are likely to cause very little movement of sediment in the local area.

From the model results it is inferred that there is a trend for sediment to move towards the north due to the higher current speeds on the flood flow and the convex shape of the site. However, it is likely that the majority of this sediment will remain in the coastal cell due to the presence of a rock outcrop to the north of the area and the low values of the currents observed in this particular sheltered site.

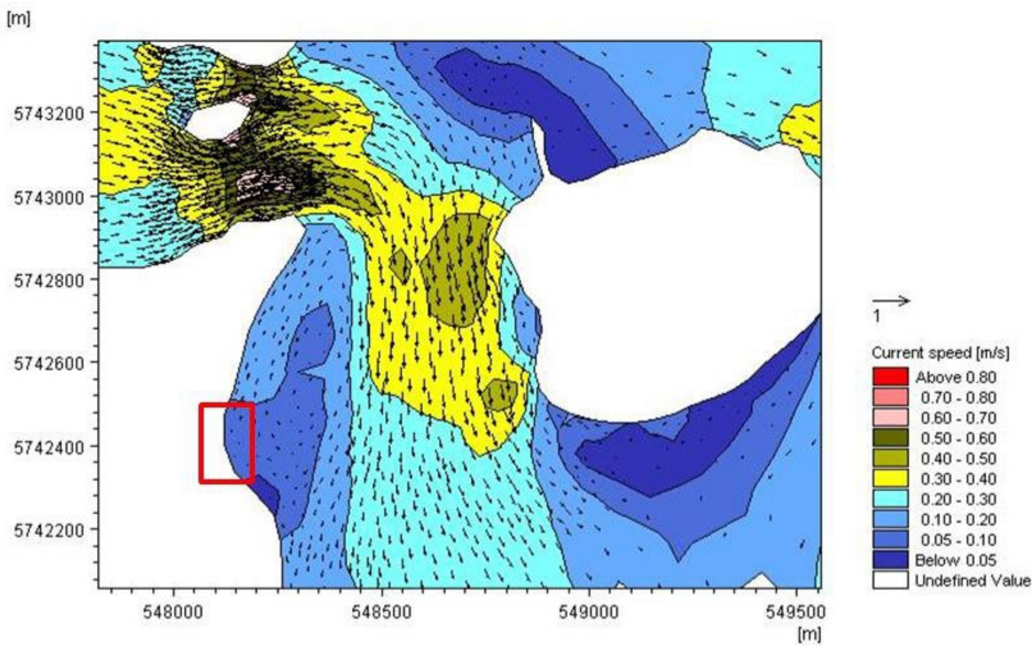

Figure 31 Ebb flow plot

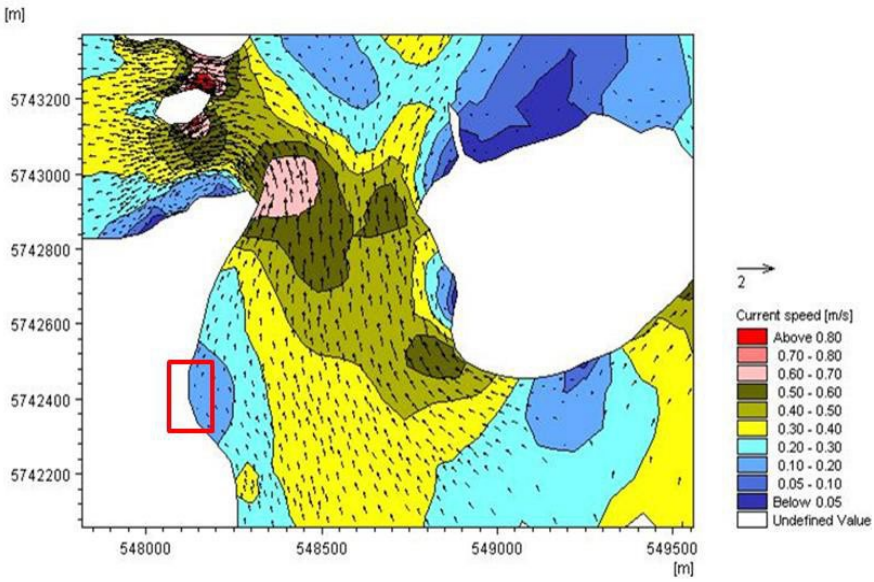

Figure 32 Flood flow plot

Given the low tidal currents predicted by the model, it is confirmed that the extreme wave action will be the key factor driving coastal erosion.

4.4 Cliff Erosion Modelling

4.4.1 Conceptual Model of Cliff Erosion

In 2012, as part of the coastal recession investigation undertaken by Arup, a geotechnical investigation was carried out comprising 4 boreholes, 4 trial pits, five cliff scan lines, four groundwater monitoring standpipe installations, two variable head permeability tests and associated geotechnical laboratory testing.

This investigation was concentrated 10 – 15m inland of the coastal eastern boundary of the site in order to determine the ground conditions of the existing slope.

The ground conditions in the existing slope along the eastern coastal boundary of the Indaver site contribute to coastal erosion. A hard over consolidated clay underlayer exists on the foreshore except where the bedrock is exposed. This beach clay underlayer is much more resistant to erosion than the overlying weaker.

The following geotechnical findings were described in the Arup "Coastal Recession Mechanisms Investigation" Report, 2012 and confirmed and added to during analyses of site observations and survey data in 2015, 2016 and 2025. These ground conditions contribute to and have an impact on coastal erosion in the area:

- The ground conditions along the cliff face are variable. The slope comprises a profile of topsoil overlying glacial till comprising of firm light brown sandy gravelly clay/silt stratum with interbedded sand, gravel and silt lenses. The localised granular material lenses are possibly fluvioglacial in origin and deposited within the till. These deposits are concentrated along the southern boundary of the cliff where it is at its highest (10m). Underlying this stratum is a very stiff/hard brown sandy very gravelly clay with many cobbles and occasional boulders. This is an over consolidated glacial lodgement till. The lodgement till extends approximately 1m up the cliff face from the toe at the southern end and falls to the level of the cliff toe further north. Mudstone/sandstone bedrock outcrops are located on the beach at the southern end of the cliff. Site investigation data from 2019 suggests the bedrock is at 5.84m OD at the southern boundary and falls to -1.50 OD at the northern end. Site walkover records show that the rock rises and outcrops at the beach further north of the car park. This rock outcrop comprises of the Waulsortian Limestone.

- The firm light brown sandy gravelly clay/silt stratum with interbedded lenses of sand and silt is weaker than the underlying very stiff/hard glacial till. Seasonal heavy windswept rain and freeze – thaw conditions can weaken exposed sand and silt layers and continuously ravel the exposed face of the soil. Burrowing activity from insects will also contribute to loosening of the soil and promote erosion. Water seepages on the cliff face were observed during the 2016 and the 2025 site walkovers. It is likely that the granular deposits of sand and silt (lenses) which are considerably more permeable than the surrounding till will transmit water through the ground, and out through the face of the cliffs where exposed. Considerable surface water flows over the ground surface and down the cliff face were recorded during the site walkover in February 2025. These water seepages and overland surface water flow will contribute to the slope erosion. The site investigation and topographic data and site walkover observations indicate that the cliff is eroding due to a combination of cliff toe erosion, softening of the weaker till in the upper cliff section due to water seepages and overland surface water flow, and weathering of the cliff due to rain, wind and freeze thaw action. Each of these processes shown in **Figure 33** ensure that the cliff face will continue to recede inland. The removal of glacial till at the base of the slope undermines the overlying weakened material and causes the slope to slip and fail. The slumped debris at the base of the slope is eroded by sea water ingress, removing protection from the base of the slope and causing the process to begin again and the slope to recede.

- In 2016, it was concluded that the significant landslide that occurred at the southern end of the cliff occurred mainly due to water pressure and flow within the cliff material causing instability and slip failure. In 2025, this localised landslide continues to retreat at a faster rate than other areas of the cliff. Analysis of the 2025 and historical survey data reveal that the erosion and undermining of the toe of the cliff north of cross section G in this area leads to an unravelling of the cliff immediately overhead and to the south along the northly dipping slip surface of the very stiff/hard glacial lodgement till.

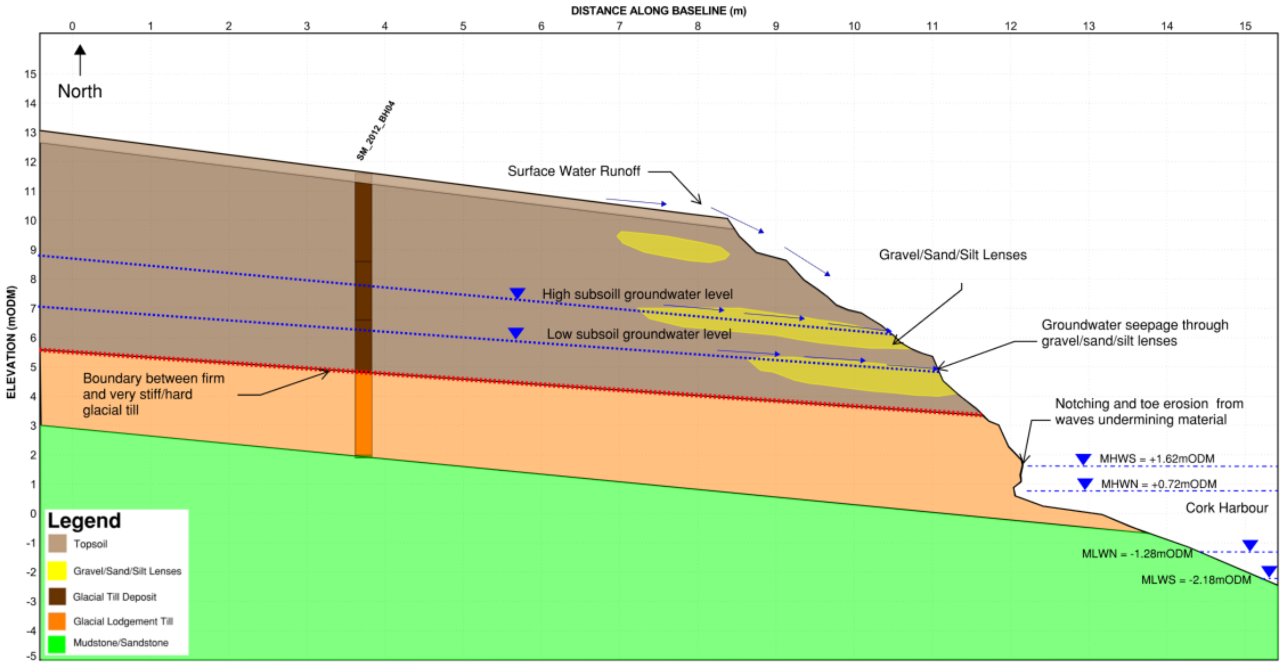

Figure 33: Representative section displaying the coastal erosion mechanisms

4.4.2 SBEACH Modelling

One model used for estimate cliff erosion was the Coastal Engineering and Design Analysis System, SBEACH developed by Veri-Tech, Inc.

The Storm-induced BEAch CHange model (SBEACH) is a numerical simulation model of cross-shore beach, berm, and dune erosion produced by storm waves and water levels. The model is applied in beach fill project design and evaluation and in other studies of beach profile change. SBEACH operates in the CEDAS graphical user interface designed to facilitate data input, model setup and execution, and analysis of model results. The latest version allows simulation of dune erosion in the presence of a hard bottom.

This model is generally used for the estimation of erosion rates and assessment of sediment transport trends in dunes and beaches. SBEACH is intended to be used for grain sizes up to 1.0mm. Due to the larger sediment size on the beach in Ringaskiddy (50 to 100mm) the results need to be treated with caution. Furthermore, the cliffs are made of different materials. At the base of the cliff the material is relatively coarse and the lower beach is relatively fine. SBEACH can only take as input one single particle size which is a limitation.

A section of coast derived from the November 2014 topographic survey was input into the SBEACH model as a reach. **Figure 34** shows a typical profile with MHWS conditions. **Figure 3**5 shows the reach profile for section D.

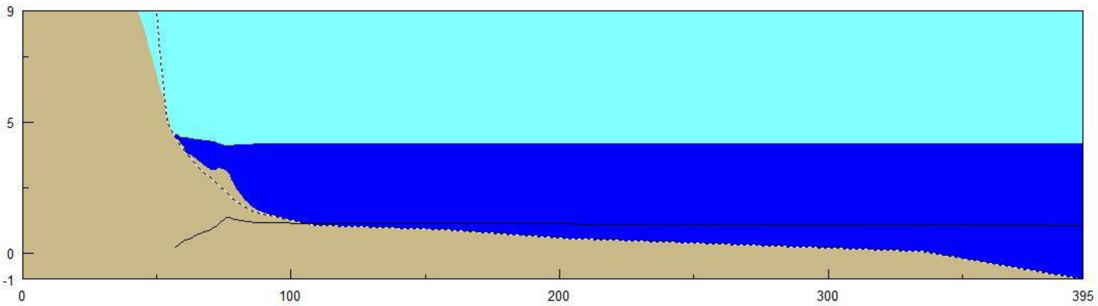

Figure 34 Typical profile with MHWS conditions

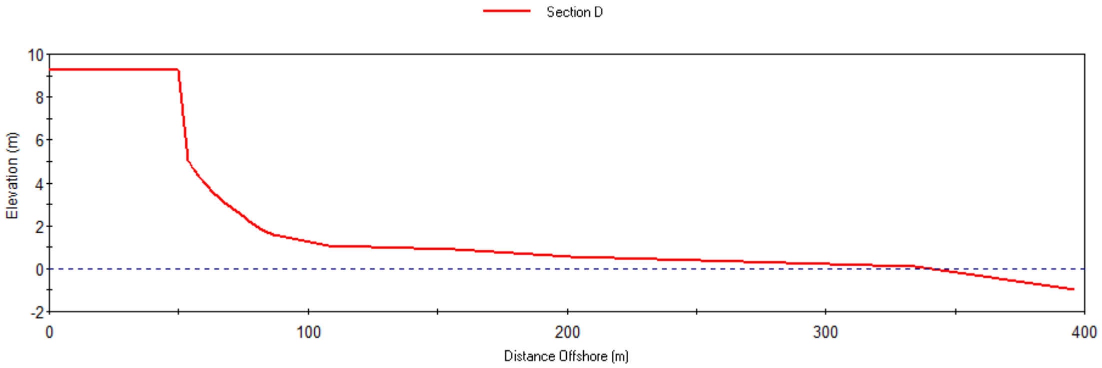

Figure 35 Reach for Section D derived from Nov. 2014 survey

Input storm conditions are specified by values of the following parameters.

- Water level elevation
- Wave height and period
- Wave angle
- Wind speed and angle

The storm input was chosen to reflect a 3.3hr storm which can be assumed to be representative of a typical storm at MHWS. The calculation was carried out for a monochromatic wave in shallow water at a depth of 3.6m OD at MHWS (deeper for MRFS and HEFS), which has been assumed to include the closure depth; therefore, no significant sediment transport should occur beyond this point. The closure depth is the most landward depth seaward of which there is no significant change in bottom elevation and no significant net sediment transport between the nearshore and the offshore area.

A number of calculations were carried out for various combinations of water elevations and wave height. **Table 13** summarises the input conditions for the most severe scenarios. The MRFS scenarios include a 0.55m increase of water level due to climate change, while the HEFS scenarios include an increase of 1.05m. The extreme water levels as given in the ICPSS for the 1 in 200 year event (0.5% AEP) are also used.

The wave angle refers to angle at which the wave crest makes contact with the shoreline. The wave angle was set as 0 in a conservative approach i.e. all waves are parallel to the coast. The wind conditions used were the 50-year return period.

Separate storms were set up for the three different water levels, with and without wind conditions for the worst wind direction i.e. southeast as identified from the wave modelling. **Table 13** describes the various input parameters for the different cases analysed.

Table 13 SBEACH input conditions

Direction	Case Number	Case	Water Levels		Wind Conditions		Wave conditions at closure depth		
			mOD Malin	mCD	Velocity (ms-1)	Duration (hr)	Hs (m)	Tp (s)	h (m)
E	1.1	MHWS + MRFS	2.17	4.75	28.3	3.3	1.0	3.9	4.15
SE	2.1	MHWS + MRFS	2.17	4.75	28.3	3.3	1.0	4.1	4.15
	2.3	MHWS + HEFS	2.67	5.25	28.3	3.3	1.3	4.2	4.65
	2.4	0.5% AEP + MRFS	3.28	5.86	28.3	3.3	1.6	4.2	5.26
	2.5	0.5% AEP + HEFS	3.78	6.36	28.3	3.3	1.7	4.1	5.76

Direction	Case Number	Case	Water Levels		Wind Conditions		Wave conditions at closure depth		
			mOD Malin	mCD	Velocity (ms-1)	Duration (hr)	Hs (m)	Tp (s)	h (m)
S	3.1	MHWS + MRFS	2.17	4.75	28.3	3.3	0.9	4.2	4.15

In addition to the cases mentioned in Table 13 an assessment was also carried out for MSL and MLWS. For all the cases shown water levels reach and exceed the toe of the cliff, whereas at MSL and MLWS the water will only reach the lower beach, and hence the rate of erosion during MSL and MLWS is substantially lower than during MHWS.

It is also evident that rates of erosion increase linearly with increased wave height. In all cases negligible erosion occurs during MLWS and MSL.

Note that the accuracy of the results in the cliffs area can only be treated as qualitative since the slope exceeds the maximum values that the software can take. Only values at the lower beach may be informative for the assessment. **Figure 36** and **Figure 37** show the model results for the MSL and case 2.3 respectively. Note the model was built with elevation relative to Chart Datum.

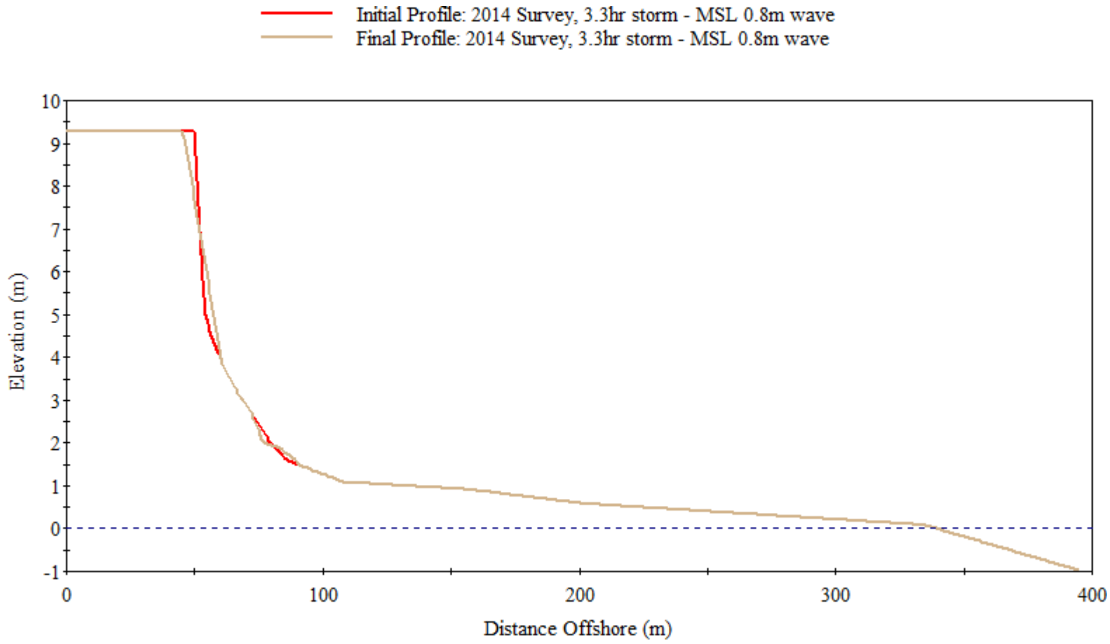

Figure 36 Erosion results for MSL case

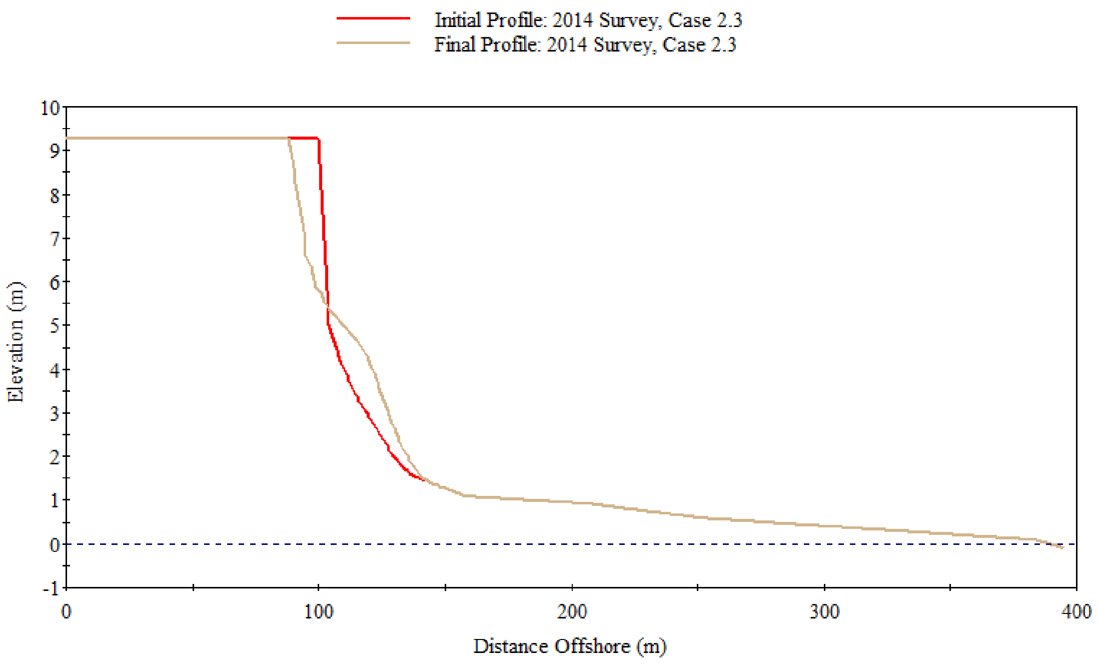

Figure 37 SBEACH Erosion results for case 2.3

4.4.3 SHINGLE B Modelling

SHINGLE B is an online tool for prediction of shingle beach profile response. It was developed by the Environment Agency in association with HR Wallingford and is available through the Channel Coastal Observatory website.

To allow a direct comparison with the SBEACH, the cliff geometry in **Figure 37** and input conditions modelled for this profile with SBEACH were reproduced in SHINGLE B. The results are presented in **Figure 38**. On a qualitative basis, SHINGLE B shows similar profile evolution, with erosion of the cliff above the water level and deposition of material at the toe. The cliff retreat at the top is reduced by 50% in SHINGLE B compared with SBEACH. However, the SHINGLE B online tool flagged that the inputs (geometry and environmental conditions) were outside the training dataset, which indicates potentially low confidence in the quantitative output such as the cliff retreat.

Modelling cliffs with SHINGLE B has similar challenges to SBEACH regarding the cliff representation, the use of a single particle size (the tests used to develop SHINGLE B had a D50 of 12.5mm) and the inability to model what is a continuous process of erosion of cliffs over time through gradual undermining combined with accelerated erosion during storm events.

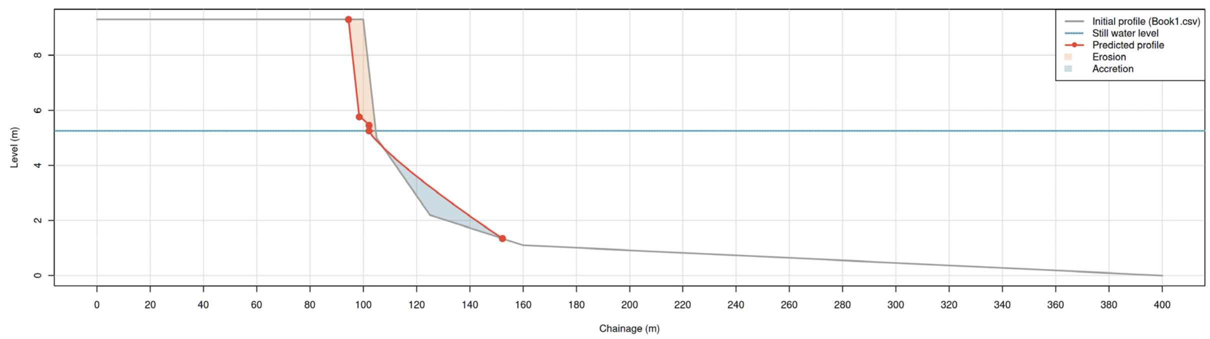

Figure 38 SHINGLE B Erosion results for case 2.3

4.4.4 Shore and cliff sensitivity to accelerating sea level rise

In 2025 the Environment Agency published technical report and analytical tool to estimate shore and cliff sensitivity to accelerating sea level rise [4].

The 'Rebaseline Tool' was selected. The inputs used were:

- baseline period 2008-2025
- the estimated maximum cliff toe retreat of 3.2m which occurs at profile F
- the estimated minimum cliff toe retreat of 1.9m which occurs at profiles B, C and E
- the estimated average cliff toe retreat of 2.2m. It is noted that profile G was not used to estimate the average toe retreat since there was a local cliff failure at the southern edge of the site boundary
- sea level rise scenario. Two scenarios considered: RCP4.5 50%ile and RCP8.5 50%ile
- Location along the coast. Since the Environment Agency tool only covers England and Wales, a location on the Pembrokeshire coast was selected since it has similar sea level rise projections to Cork/Ringaskiddy, in some locations has similar estimated coastal erosion according to the Wales National Coastal Erosion Risk Management map and may have similar cliff types from a geological point of view. Sensitivity studies were conducted using other areas, for example at the Norfolk coast which has one of the highest rates of cliff erosion in England and slightly higher projected sea level rise than Cork and the differences were marginal

Figure 39 shows the estimated cliff toe retreat until 2070 under RCP 4.5 and RCP 8.5 scenarios which range between 6m and 14m.

It is noted that the Environment Agency tool does not consider constraints to the evolution of cliff retreat such as the potential accumulation of material at the toe and flattening of the cliff slope which naturally slow down the retreat rate. Therefore, it is likely that the results in **Figure 39** are conservative.

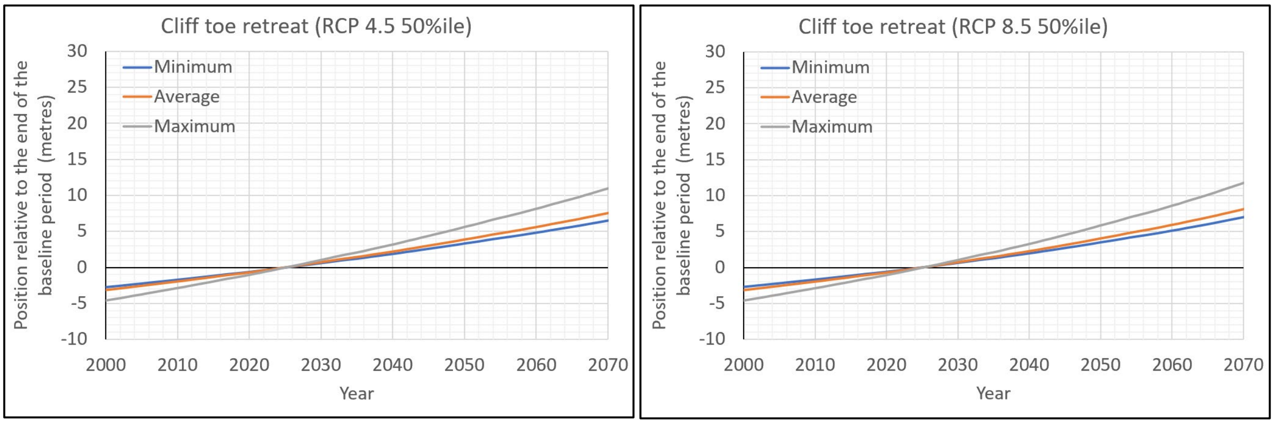

Figure 39 Estimated cliff toe retreat under different sea level rise scenarios

To isolate the effect of sea level rise on cliff erosion rates, a lower bound of a low emissions scenario (RCP 2.5 5%ile) is compared with an upper bound of high emissions scenario (RCP 8.5 95%ile) in **Figure 40.** The difference in average cliff erosion until 2070 is only 2m, considered relatively minor.

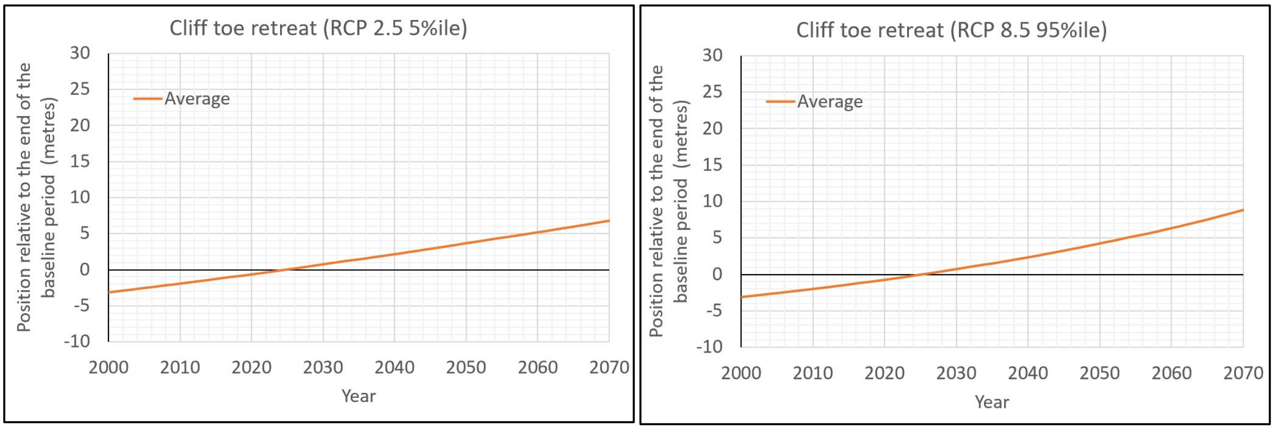

Figure 40 Impact of sea level rise on cliff erosion

4.5 Conclusions

The upper layer of the beach consists of an over consolidated clay overlain by small amounts of sand and shingle. The clay layer will erode slowly but irreversibly when exposed to wave stresses, especially when there is suspended sediment that can act as an abrading agent. The erosion rates depend on several factors, the hardness of the clay, the exposure time to water, the strength of local wave and current motion on the clay surface, the presence of suspended sand, and the exposure time.

A beach down cutting rate has been calculated on the assumption that the cliff and foreshore maintain the same shape relative to the mean sea level when affected by sea level rise [10] and [13]. Using this assumption, a beach down cutting rate in the order of up to a few centimetres has been estimated if no protective measures are undertaken.

This mechanism also directly affects the exposure of the cliff toe, which leads to stability failure and collapse.

From the studies carried out it can be inferred that the erosion of the cliffs is influenced by wave action at the site. This mechanism of erosion is due to a combination of cliff toe erosion, softening of the weaker till in the upper cliff section due to water seepages and overland surface water flow, and weathering of the cliff due to rain, wind and freeze thaw action, which cause cliff collapse and retreat.

Modelling with SBEACH and SHINGLE B shows typical mechanisms of cliff erosion, with erosion above the water line and material deposition at the toe of the cliff, consistent with the conceptual understanding. Due to the limitations of the models, the recommended approach to estimate cliff retreat is still using empirical data from surveys.

The impact of sea level rise until 2070, estimated to be around 0.3m in a high emissions scenario and is considered to be relatively modest and have low impact in accelerating cliff erosion rates. Nevertheless, regular monitoring is still recommended and represents the most reliable way to forecast future cliff evolution and manage risk.

5. Recommended Coastal Management Measures

As identified in the previous sections, the cause of erosion at the Indaver coastal boundary is due to a combination of cliff toe erosion, softening of the weaker till in the upper cliff section due to water seepages and overland surface water flow, and weathering of the cliff due to rain, wind and freeze thaw action.

From the assessment in **Section 2**, a conservative retreat rate of 0.5m/year has been applied in order to assess the potential impact of the retreat rate on the proposed development.

The study found that, without mitigation measures, taking year 2025 as a baseline and assuming the determined conservative retreat rate of 0.5m/year, there would be no impact on the proposed development after 30 years. However, there could be a risk of an impact on a small section of the proposed development after 40 years however this would be confined only to the amenity walkway and viewing platform outside of the security fence line. The waste-to-energy section of the proposed development (within the boundary fence) would not be impacted by coastal erosion for the entire duration of the planning permission.

Coastal protection mitigation measures are not required for the waste-to-energy facility element of the development. However, given the concerns raised by An Bord Pleanála during the previous planning application in 2008 and given the risk that the amenity walkway and viewing platform could potentially be impacted in 40 years' time, coastal protection measures have been included in this planning application as a precautionary measure so as to reduce the rate of erosion of the glacial till face.

Arup investigated a number of coastal protection options that could be applied to the Indaver site in order to reduce the current retreat rate.

Considering the results of the various assessments, a number of typical coastal engineering solutions that could be used at the Indaver site have been assessed. A summary of the advantages and disadvantages is given in **Appendix G *Coastal Engineering Solutions***. The options range from 'hard' solutions such as breakwaters, revetments and sea walls to 'soft' solutions such as beach nourishment, replanting and the placement of sacrificial material (shingle).

In modern coastal engineering practice, it is generally thought that the benefits of using 'soft' solutions (where possible) far outweigh the benefits of using 'hard' solutions. Also, 'soft' solutions have a degree of adaptability and dynamism compared to 'hard' solutions. Similarly, there is evidence that certain 'hard' solutions can cause wave reflection and can in fact worsen the issue of erosion impacting also adjoining areas. For these reasons there is a trend in employing 'soft' solutions wherever possible.

Therefore, Arup has recommended that the Indaver coastal boundary is monitored on an annual basis and the placement of approximately 1150m^3 of sacrificial material (shingle of appropriate size and rounded shape with high density and resistance to abrasion) above the foreshore on Gobby beach along the eastern boundary of the Indaver site. The preliminary proposed plan and sections of the solution are shown in **Appendix H *Beach Nourishment Solution*.**

This will be a 'soft' solution which will potentially reduce erosion rates by limiting the exposure of the toe of the glacial till face to wave action. The main aim of placing the material is to act as a proactive measure for the coastal area adjacent to the Indaver site only.

The solution will have no negative impacts on the adjoining areas. However, there are benefits associated with the works as well as the provision of an environmentally friendly solution. The net coastal sediment transport goes from south to north according to wind conditions and swell; therefore, the material is likely to move towards the north in the medium and long term. The closest area of the Cork Harbour Special Protection Area (SPA) is located to the southwest of the site. Since the net movement of beach nourishment shingle is from south to north, the sacrificial material will not impact on this part of the SPA. Other sections of the SPA which are to the north of the site are more than two kilometres from the site and these are too remote from the site to receive any significant quantities of beach nourishment material.

The following sections describe the recommended coastal management measures.

5.1 Sacrificial Material

It is proposed that approximately 1,150m^3 of sacrificial material is placed in the area spanning from the car park at the northern end to the southern boundary of the Indaver site. According to Pye & Blott [11], nourishment should be undertaken using rounded pebble or cobble-sized material which is similar in size, or slightly coarser, than the existing beach. In addition, the material should have relatively high density and resistance to abrasion.

This material would act as beach nourishment on the emerged beach above the foreshore i.e. above the high-water mark. The purpose of the sacrificial material is to dissipate the wave energy at the site and protect the toe and lower area of the cliffs from direct wave action and hence reduce the rate of erosion. This solution protects the cliffs and provides extra material to the adjoining foreshore areas since the material can be transported within the coastal cell depending on the direction and severity of wave action in the area. The preliminary plan and representative sections of the proposed solution are shown in **Appendix H**.

The main advantages of this solution as outlined in **Appendix G** are as follows:

- Introduction of 'sacrificial material' to the area at the toe of the cliff would reduce erosion rates by increasing beach levels i.e. reducing nearshore water depth and wave heights
- Protects the cliff face from breaking waves
- Regarded as a very natural way of combating coastal erosion
- Less material than conventional beach nourishment needed
- The shingle can be placed within the proposed development site boundary
- It does not affect the current state of the cliffs (no need for re-shaping)
- It does not have any negative impact on the existing structures in the vicinity and adjoining areas (cliffs and beaches)
- It protects the site and also the adjoining areas to it
- It enhances the amenity and recreational aspects of the area, providing additional beach area at high tide
- It enhances the visual appearance of the beach;
- It provides an adaptive approach to the erosion and retreat issues of the coastline while working with nature
- Material is free to move in the coastal cell (bay) so it can help to promote the growth (accretion) of the beach
- Sacrificial material will protect the beach clay layer from further erosion; and

It is proposed that the additional sacrificial material is placed during the construction period of the proposed development. Thereafter, it is proposed that the placement of further additional sacrificial material is carried out if the cliff top retreat rate averaged over the entire length is more than 0.5m per year measured over a period of six years, which would indicate some acceleration in the current retreat rate, or when the cliff top has retreated locally by approximately 3m, whichever is sooner. There is also an option to proactively place shingle to maintain a healthy margin between the cliff top and the proposed development. For this reason, the coastal boundary of the proposed development site will be monitored for erosion on an annual basis.

5.1.1.1 Stability of the New Material

In normal conditions it is not expected that there will be significant movement of the imported new material outside the sediment cell delineated by the headlands, for the following reasons:

- As the material is designed to be placed above the High Water Mark, it is not expected that the alongshore sediment drivers will have a significant impact on these works, except in storms with high tides

- Local currents in this particular sheltered stretch of coast have been assessed to be low, and very low in comparison with the currents in the adjoining areas (refer to **Section 4.3**)
- The relatively sheltered location of the site
- Previous experiences with beach nourishment above the foreshore in more exposed locations. Refer to **Section 5.1.1.3**
- Evidence of existing shingle material in the upper beach
- The headlands and rocky outcrops on the beach to the north and south of the site which provide and element of containment to the sediment cell

Hence, it is in principle expected that the material will reshape but mostly remain in place during regular weather conditions. However, it is acknowledged that the beach is a dynamic system and therefore sacrificial material may move seasonally and also as a result of storm events. Even if the material on the beach is displaced from the cliffs toe, it may continue to provide a protective function as long as it remains within Gobby Beach as it will increase beach levels locally. This would affect the nearshore wave dynamics by decreasing water depth and causing waves to break further from the toe of the cliffs helping to lower the erosion rates within the site.

The Coastal Erosion report included as Appendix 13.3 to the 2016 EIS provided an estimation of a reduced erosion rate of 0.40m/year due to the placement of sacrificial material. This estimate was based on the assessment of cliff erosion due to ground water seepage and wave action as separate processes. However, given the complexity of the mechanisms involved in the retreat of the cliff, the quantification of the effectiveness of the sacrificial material is recommended to be assessed only qualitatively as described in the present study.

5.1.1.2 Effects on Amenity and the Adjoining Areas of the Site

The sacrificial material will provide a beneficial solution for the site and the adjoining areas of the beach.

The stability of the material depends on the severity and frequency of storm events which occur. Some conclusions are as follow:

- Given the predominant south and southeast wind and wave directions, the likely direction for the movement of the material due to extreme events would be from South to North
- Potential seasonal movements of the material are expected; however, this effect is positive for the beach, since the material offers an additional protection for the emerged beach in storm conditions
- The addition of the sacrificial material will increase the local amenity value of the area by providing a pathway which is accessible to members of the public during all states of tide
- The final profile of the additional material is expected to adapt to the natural topography of the area

The closest area of the Cork Harbour Special Protection Area (SPA) is located to the southwest of the site. Since the net movement of beach nourishment shingle is from south to north, the sacrificial material will not impact on this part of the SPA. Other sections of the SPA which are to the north of the site are more than two kilometres from the site and these are too remote from the site to receive any significant quantities of beach nourishment material.

5.1.1.3 Reference Case for Implementing Soft Coastal Measures

Arup has previously designed, supervised and monitored beach nourishment works at Greystones Co. Wicklow. The location of the proposed works is immediately north of Greystones Harbour extending to Bray Head at the North Beach. The placement of beach nourishment (10,000m^3 of shingle) was carried out by the contractor in April and May 2014 as recommended by Arup. This nourishment is helping to mitigate the retreat of the north beach in the northern area and erosion of the cliffs in the southern area at Greystones beach.

A continuous monitoring and observation of natural evolution has been carried out at Greystones beach since 2008, when a previous beach nourishment campaign was undertaken. The monitoring campaign is ongoing but early indications are that the additional material placed at the toe of the cliffs has been beneficial for the cliffs.

Figure 41 Completed beach nourishment works at Greystones in the area between the revetment and the Gap Bridge. Site visit 25 May 2014

5.2 Proactive Monitoring Plan

The proposed measures comprise:

- Annual topographic surveys which will include 0m contour, top and toe of cliff face monitoring and specified sections
- An assessment of the retreat and reporting over the design life of the proposed development including the construction period (40 years)
- Proactive and reactive management of the beach comprising placement of imported shingle to areas of the beach where deemed necessary from beach monitoring data

5.3 Conclusions and Recommendations

Coastal protection mitigation measures are not required for the waste-to-energy facility element of the proposed development. However, given the concerns raised by An Bord Pleanála during the previous planning application in 2008 and given the risk that the amenity walkway and viewing platform could be impacted in 40 years' time, coastal protection measures have been included in this planning application as a precautionary measure so as to reduce the rate of erosion of the glacial till face.

Arup has recommended that the Indaver coastal boundary is monitored on an annual basis and the placement of approximately 1,150m^3 of sacrificial material (shingle of appropriate size and rounded shape with high density and resistance to abrasion) above the foreshore on Gobby Beach along the eastern boundary of the proposed development site. This will be a 'soft' solution which will reduce erosion rates by increasing beach levels i.e. reducing near shore water depth and wave heights and will protect the glacial till face from breaking waves.

With the application of the sacrificial material, there will continue to be no impact on the entire proposed development after 30 years. However, there is still a risk of an impact on the amenity walkway and viewing platform after 40 years. The waste-to-energy section of the proposed development will not be impacted by coastal erosion for the entire duration of the planning permission.

The main aim of placing the material is to act as a proactive measure for the coastal area adjacent to the proposed development site only. The solution will have no negative effects on the adjoining areas. However, there will be benefits associated with the works as well as the provision of an environmentally friendly solution.

6. Conclusions and Recommendations

6.1 Conclusions

The topographical beach surveys carried out between 2008 and 2025 have confirmed that the erosion rates found based on the topographical, survey and photographic evidence from the period 1897 to 2003 were within a similar range. Using the surveys since 2008, a conservative retreat rate of 0.5m/year for the entire length of the top of the cliffs line is established.

The proposed resource recovery centre has a design life of 30 years. In view of the complexity of the development, licensing requirements and the need for the advance agreement of all conditions, Indaver is applying for a 10-year planning permission to commence and complete the construction phase.

The study found that the waste-to-energy facility section of the proposed development has been located far enough away from the edge of the cliff to ensure that the waste to energy facility will not be impacted by the predicted retreat rates over the design life of the planning permission.

However, the study found that there could be a risk of an impact on a small section of the proposed development after 40 years however this would be confined only to the amenity walkway and viewing platform outside of the security fence line.

The proposed development will not increase the current rate of retreat. Coastal protection mitigation measures are not required for the waste-to-energy facility element of the development. However, given the concerns raised by An Bord Pleanála during the previous planning application in 2008 and given the low risk that the amenity walkway and viewing platform could be impacted in 40 years' time, coastal protection measures have been included in this planning application as a precautionary measure so as to reduce the rate of erosion of the glacial till face.

6.2 Recommendations

After consideration of various 'hard' and 'soft' coastal protection options, Arup has recommended two 'soft', less-invasive solutions:

- The placement of approximately 1,150m^3 of sacrificial material (shingle of appropriate size and rounded shape with high density and resistance to abrasion) above the foreshore on Gobby beach along the eastern boundary of the Indaver site. This will be a 'soft' solution which will reduce erosion rates by increasing beach levels i.e. reducing near shore water depth and wave heights and will protect the glacial till face from breaking waves
- Annual monitoring of the Indaver coastal boundary

The main aim of placing the material is to act as a proactive measure for the coastal area adjacent to the Indaver site only. The solution will have no negative impacts on the adjoining areas. However, there will be benefits associated with the works as well as the provision of an environmentally friendly solution.

The closest area of the Cork Harbour Special Protection Area (SPA) is located to the southwest of the site. Since the net movement of beach nourishment shingle is from south to north, the sacrificial material will not impact on this part of the SPA.

Other sections of the SPA which are to the north of the site are more than two kilometres from the site and these are too remote from the site to receive any significant quantities of beach nourishment material.

It is proposed that the additional sacrificial material is placed during the construction period of the proposed development. Thereafter, it is proposed that the placement of further additional sacrificial material is carried out if the cliff top retreat rate averaged over the entire length is more than 0.5m per year measured over a period of six years, which would indicate some acceleration in the current retreat rate, or when the cliff top has retreated locally by approximately 3m, whichever is sooner. There is also an option to proactively place shingle to maintain a healthy margin between the cliff top and the proposed development. For this reason, the coastal boundary of the proposed development site will be monitored for erosion on an annual basis.

It is possible that the material will be moved from the beach to the foreshore, but it is unlikely that the material will become suspended and move offshore or to adjoining coastal cells.

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Appendix A

Assessment of the December 2015 Slope Instabilities (Extracts)

ARUP

Indaver

Resource Recovery Centre, Ringaskiddy, Co. Cork

Appendix A to Appendix 13.3 Assessment of the December 2015 slope instabilities (extracts)

Reference: WM/REP/0002

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Contents

1. Introduction

1.1 Coastal Erosion Report for the EIS

This document is a new report which comprises extracts from the report "Coastal erosion report addendum: Assessment of the December 2015 slope instabilities" that was submitted during the Public Hearing in April 2016 and formed part of the EIS and planning application. These findings have been considered in the Coastal Erosion report 2025.

1.2 Background to the Addendum (2016)

December 2015 was the wettest month on record in many areas of Ireland, particularly in the Southwest where rainfall amounts were approximately 3 times the average. By the end of December, many areas were entirely saturated and even normal rainfall events resulted in very significant flooding.

Storm Frank, the 6th major winter storm of 2015 brought high winds and significant rainfall between the 29 December 2015 and the 2 January 2016. Significant flooding resulted across much of the country. County Cork was badly affected with major flood events on many rivers such as the Blackwater, Bandon, Glashaboy, Owenacurra and many others. Between 29 December 2015 and 30 December 2015 immediately following the extreme rainfall associated with Storm Frank there were several localised slope failures at Gobby Beach on the eastern extent of the proposed Indaver site. Following these events Arup carried out an assessment of the size and causes of the failures.

This report details the findings of the assessment of the effects of the 2015 and 2016 events on the proposed Indaver site and adjoining Gobby beach.

2. Summary of Winter 2015 Events

In late December 2015 and early January 2016 Ireland was exposed to extreme storm conditions, comprising heavy rainfall, high seas and high winds. This storm, known as Storm Frank, combined with a series of large storm events over the preceding months led to extensive damage and flooding to both inland and coastal areas throughout Ireland. Winds varied in direction from south to southwest to westerly direction. In county Cork approximately 60mm of rain fell between Tuesday 29 December and Wednesday 30 December. This combined with high tides and a substantial storm surge led to flooding at a number of locations throughout the county. There were reports of wave overtopping and flooding in Kinsale and Garretstown, as well as extensive flooding due to rising water levels in Passage West and Cork City. However, there are no reports of flooding or erosion due to wave action or overtopping in Cork Harbour.

December 2015 was the wettest month on record in many areas of Ireland, particularly in the southwest where rainfall amounts were approximately 3 times the average.

Met Éireann's December 2015 Weather Summary notes the following:

'All stations reported well above Long-Term Average (LTA) rainfall with most stations across the country reporting double or triple their normal rainfall for December. Wettest conditions (compared to LTA) were in county Cork where nearly all stations reported over 300% of LTA. Roche's Point reported the highest percentage of LTA with 342% (340.6 mm of rain) it's highest for December since 1955.'

It is further noted that the highest rainfall total for the month of December was recorded at Cork Airport where some 402.2mm of rainfall fell, approximately 3 times the long-term average. 324mm of rainfall, 312% of the LTA rainfall was also recorded at Fermoy, Moore Park.

Figure 2 below provides the depth duration curve for 1 in 200 year rainfall event at Cork Airport. It is extrapolated from 25 days to 31 days as Met Éireann's Depth Duration Frequency (DDF) data only extends to 25 days. It can be seen that the monthly calendar rainfall total for December of 402mm has a return period of more than 1 in 200 years.

Clearly, December's rainfall was exceptional. By the end of December, many areas were entirely saturated and even normal rainfall events resulted in very significant flooding. Groundwater levels were therefore also extremely elevated.

Storm Frank, the 6th major winter storm of 2015, brought high winds and significant rainfall between the 29 December 2015 and the 2 January 2016. Prior to 28 December 2015, approximately 312mm of rainfall had already fallen in the month at Cork Airport, with 248mm having fallen at Moore Park, Fermoy for the month to that date. A further 16mm of rain fell at both locations on the 28 December in the run-up to Storm Frank.

The largest rainfall amounts fell in a 21-hour window between about noon on the 29 Dec 2015 and 7am on the morning of the 30 Dec 2015 with 61mm being recorded at Cork Airport, 46mm at Moore Park, Fermoy.

In the days following the heavy rainfall associated with Storm Frank two section of the cliffs adjacent to the proposed Indaver development site at Ringaskiddy suffered a slip failure. The slope failures were contained to the southern area of the bay along an area with a substantial height of cliff. The northeastern part of the site adjacent to the car park was largely unaffected save for some shingle being moved from the beach to the adjacent lands.

In January 2016 Indaver commissioned a drone survey of the coast adjacent to the proposed development site. **Figure 1** and **Figure 3** below show two areas where significant slope failures occurred. The first area shown in **Figure 1** (circled in blue) is approx. 20m long and cliff height is roughly 2 to 3m. This area is located approximately 50m south of the car park. The second area shown in **Figure 3** (circled in blue) is a further 20m south and is approximately 40m in length and cliff height is roughly 7 to 9m.

Figure 1 Drone photography showing first area of slope failure and minimal damage to the beach north of this location

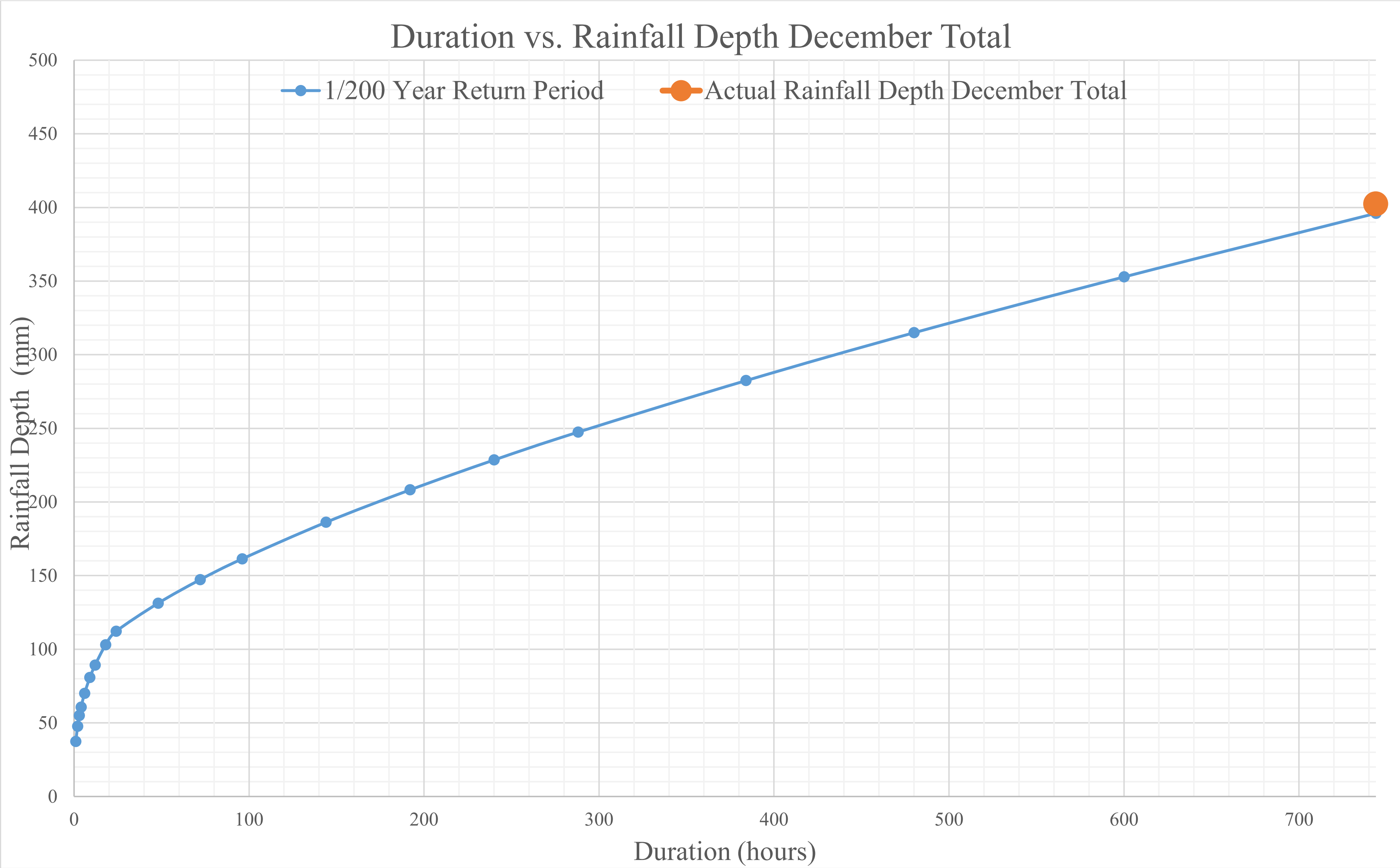

Figure 2 Depth duration graph for 1 in 200 year rainfall event

Figure 3 Drone photography showing slope failure to the southern section

Figure 4, Figure 5 and **Figure 6** below show the affected area to the south of the beach as recorded in June 2009, September 2015 and December 2015. From the imagery it is clear that there has been localised slope failure between 2009 and 2016. Minor erosion occurred between June 2009 and June 2015 and a large slope failure occurred between September 2015 and December 2015. The nature and timeline of the failure will be discussed further in the following sections.

Figure 4 Cliff adjacent to proposed development site, June 2009

Figure 5 Cliff adjacent to proposed development site, September 2015

Figure 6 Cliff adjacent to proposed development site, December 2016 following failure

3. Site Walkover and Assessment

3.1 Site Observations

Following the storm events and associated slope failure over December and January 2016 Arup carried out a site walkover. The site walkover was attended by a number of staff with expertise in the following areas: coastal engineering (Julie Ascoop), geotechnical engineering (Sean Mason) and environmental engineering (Fiona Patterson). The site walkover was undertaken on 1 March 2016 prior to low tide.

Figure 7 and **Figure 8** below show the two areas of slope failure as described previously.

Figure 7 First area of slope failure approximately 50m south of car park

Figure 8 Second area of slope failure further 20m south

During the site walkover the following were the main items observed:

- A number of slope failures
  - There were two slope failures observed along the Indaver site, as shown in **Figure 7** and **Figure 8**
  - The first one approximately 50m south of the car park was rather small. The embankment is only approximately 2m high here and the failure looks to have adjusted the over-steep embankment to a more stable slope
  - The second slope failure was quite large and V-shaped back landward. A significant amount of material was slumped down in this failure
- Water running out of the slope of the cliffs through the failures (there had been no recent rain in the days prior to site walkover). (Refer to **Figure 9**)
  - In both failures water could be seen running out of the embankment. In the larger failure a small stream (of fresh water) ran out through the V-shaped failure into the sea
- Sand lenses in the slope failures (Refer to **Figure 10**)
  - In the large failure sand lenses were observed in the cliff slope
- No evidence of coastal erosion at the bottom of the cliffs
  - There was no evidence of any significant coastal erosion at the bottom of the cliffs. They did not have a 'notched' shape at the bottom and overall the beach shingle was high up on the beach covering the toe of the cliff. (Refer to **Figure 11**)

Figure 9 Water running out of the slope failure

Figure 10 Sand lens in the slope failure

Figure 11 Currently no evidence of 'notching' at the bottom of these cliffs

3.2 Site Assessment

The soil cliffs are primarily a 'boulder clay' deposit, i.e. soils created, deposited and compacted by ice action. They generally comprise of sands, gravels and cobbles, with occasional boulders, embedded within a silty clay matrix, (hence the term 'boulder clays').

At this location there are local 'fluvio-glacial' deposits of sands and gravels within the boulder clay. These more granular deposits (lenses) are considerably more permeable than the surrounding boulder clays, and transmit water through the ground, and out through the face of the cliffs where exposed. Therefore, the surface water (rainfall) both (a) flows over the ground surface and down the cliff face, and (b) infiltrates into the ground and flows through these permeable lenses and channels out through the cliff face.

Figure 12 Surface water (which has infiltrated the ground and flows through the permeable lenses) flowing out through cliff face

Over time this infiltration of surface water leads to softening of the surrounding boulder clays and erodes the sands and gravels from the face of the cliffs (as witnessed by pock-marks and erosional features across the cliff face). In periods of excessive rainfall the infiltrated surface water volume and pressure significantly increases and correspondingly reduces the frictional strength of the boulder clay and sand/gravel deposits. This can result in the weight of sections of the cliffs exceeding the sliding resistance of the soil along planes of weakness, leading to slope failure.

The continued flow of water out through the face of the failed slopes and the saturated and softened condition of the slipped boulder clay soils, confirms this failure mechanism.

The impact of sea erosion on the recently slipped slopes appears to be minimal. In general, the sea action in storm conditions erodes the face of the slopes within the tidal range, leading to the creation of cliffs (steepened slopes) and ongoing slip failures (see **Figure 13** below). These over-steepened slopes are unstable in the long-term but remain steep due to the erosion mechanism which effectively removes 'slices' of cliffs over time.

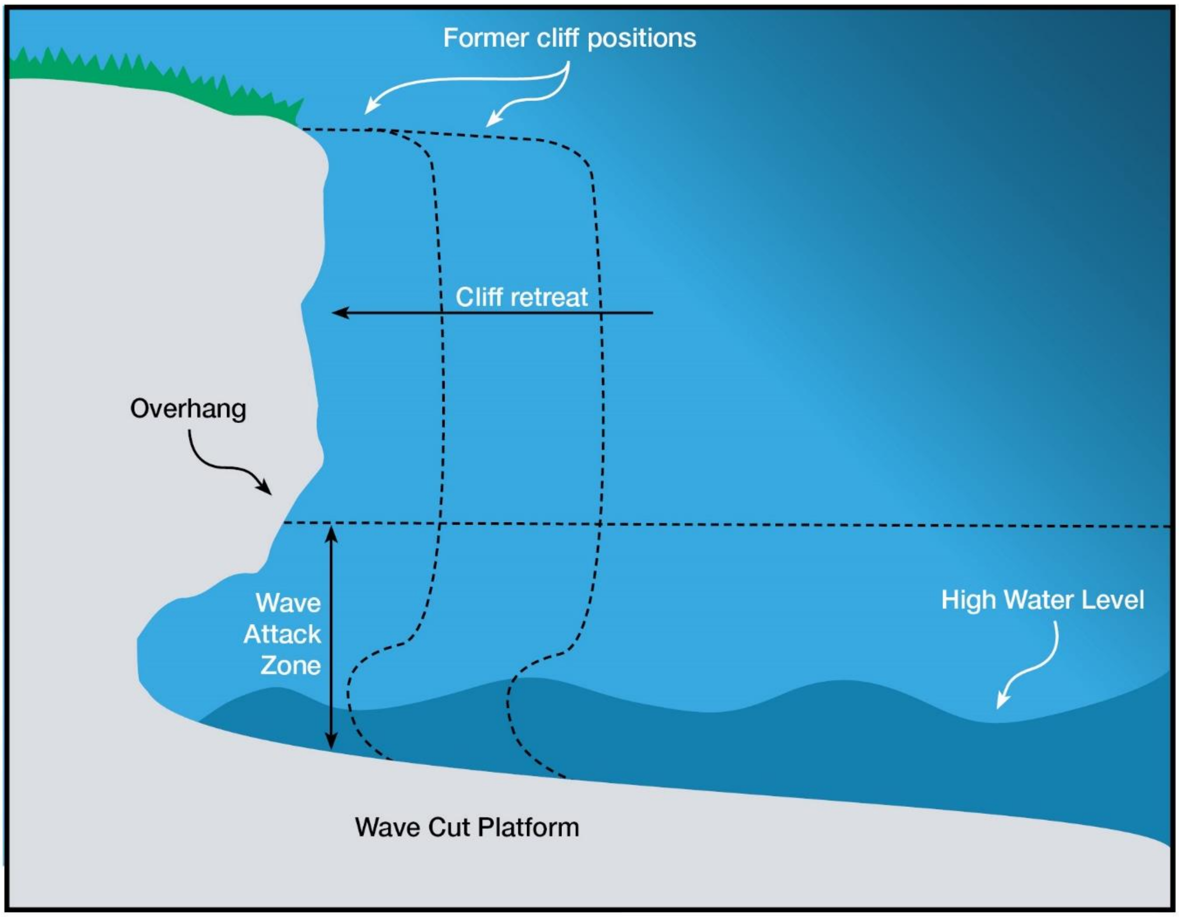

Figure 13 Typical steepened cliffs eroded by wave action

The photographs show that where tallest and steepest, the cliffs are predominately boulder clay soils with some minor local gravelly lenses. Where the recent slips have occurred there are significant deposits of sands. The presence of these sand deposits (lenses), and the ‘flatter’ or more circular slip surfaces observed, with significant flow of water through the face of the slips, clearly indicates failure due to infiltration of surface water (See **Figure 14** and **Figure 15** below). A circular geotechnical failure like that causes a larger retreat in the cliff than the ‘slices’ of cliff eroded by wave action.

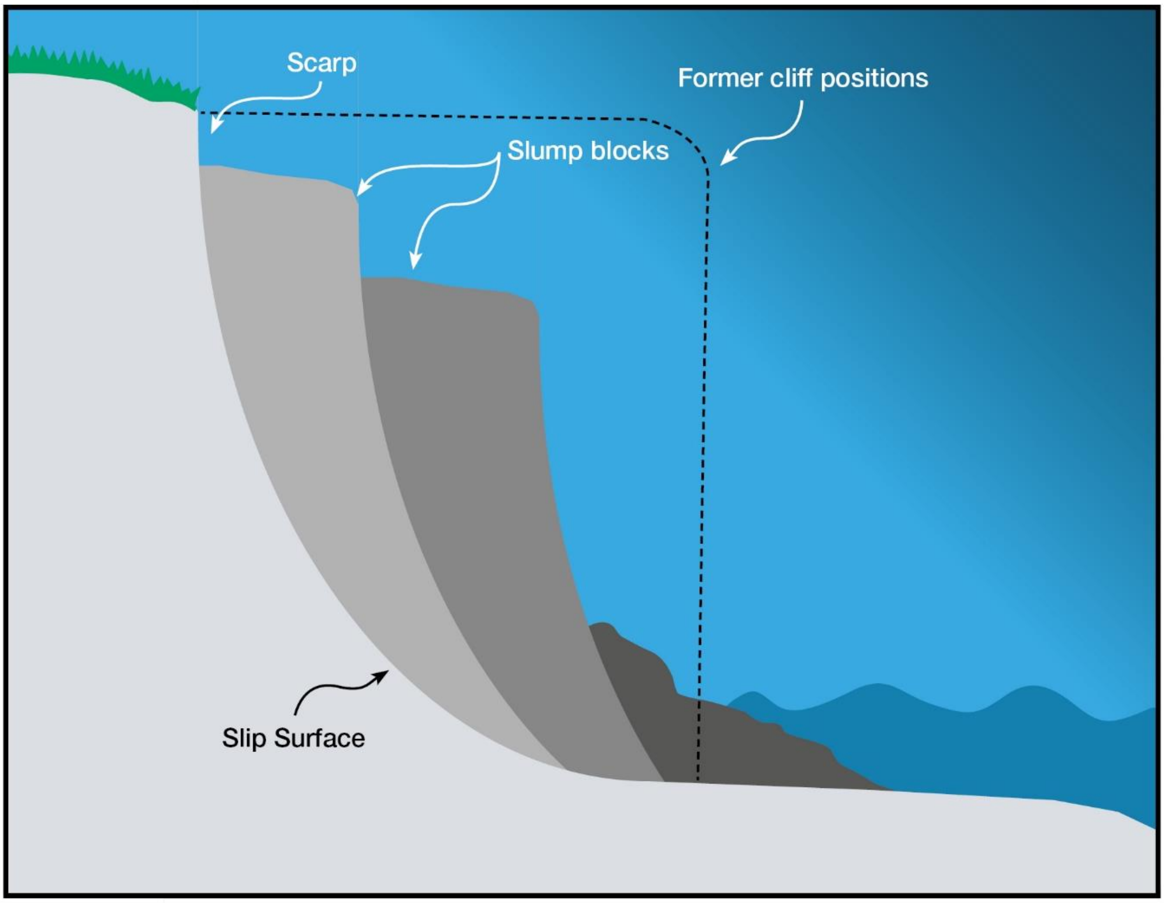

Figure 14 Typical slope failure showing circular slip surface

The evidence observed on site shows that the recent slope failures are due to the effects of the excessive rainfall over the month of December. While sea erosion is a contributing factor to erosion along this section of coast, the recent slips were triggered by water pressure and flow within the cliff material causing instability and slip failure.

Figure 15 Area of collapse showing flatter slope

4. Conclusions

Following significant rainfall events in December 2015 and January 2016 a number of localised slope failures occurred adjacent to the proposed Indaver development site at Ringaskiddy. The slope failures were located south of the car park off the L2545 road and formed a small failure approximately 50m south of the car park and a larger failure approximately a further 20m south.

Arup carried out a site walkover with a team of experts from different disciplines following these events. Arup inspected the coast adjacent to the proposed development including the localised slope failures. The conclusions drawn from the site walkover were as follows:

- Surface water is being transmitted through the cliff face where granular deposits are present in the boulder clay leading to softening of the surrounding boulder clays, and erosion of the sands and gravels from the face of the cliffs (as witnessed by pock-marks and erosional features across the cliff face)
- Excessive rainfall has caused infiltrated surface water volume and pressure to increase and correspondingly reduces the frictional strength of the boulder clay and sand/gravel deposits resulting in slope failure
- The continued flow of water out through the face of the failed slopes and the saturated and softened condition of the slipped boulder clay soils, confirms this failure mechanism
- The ‘flatter’ or circular failure mechanism indicates that the slope failure is due to infiltration of surface water rather than by wave action

Appendix B

Gobby Beach Site Visit Report, 2025

Indaver

Resource Recovery Centre, Ringaskiddy, Co. Cork

Appendix B to Appendix 13.3 Gobby Beach Site Visit Report, Arup (2025)

Reference:

Issue 2 | 29 August 2025

Job number 307174-06

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Contents

1. Introduction

On Tuesday, 13 May 2025, Arup and representatives from Indaver conducted a visual survey of Gobby Beach and the adjacent cliffs at the eastern boundary of the proposed site for the Indaver waste-to-energy project. This is a factual report that presents the findings of the site inspection and includes a compilation of photographs taken during the visit.

The site inspection was carried out between 12:00 pm and 1:30 pm, coinciding with a low tidal peak of 0.76m Chart Datum, as recorded at the nearest tidal gauge located in Cobh Harbour, approximately 1.5 km to the north. The primary objective of the visit was to inspect the condition of the cliffs and beach, identify observable trends in coastal evolution, and detect any signs of potential future cliff instability.

Weather conditions during the visit were dry and sunny, with moderate winds. It is important to note that minimal rainfall had occurred in the weeks leading up to the visit, resulting in dry cliff face materials. As such, observations made during this inspection may not fully reflect the behaviour of the cliff material under wetter conditions.

The entire extent of the beach was accessible on the day. However, dense vegetation along much of the cliff face and adjacent landward areas obscured portions of the geology and limited visibility of some features.

The top of the cliff for was accessed for further assessment, but similarly, thick vegetation cover significantly restricted access and visibility.

The visual observations recorded during the site visit are supported by the findings of the 2025 topographic survey, which provides additional spatial and elevation data for both the cliffs and the beach. Where quantitative measurements are referenced in the main body of the report, these are derived from the topographic survey data. No measurements were taken during the site visit.

2. Site Visit Photos

This section presents a selection of photographs taken during the site visit to support the key observations described in the report.

The cross-section lines from the 2025 topographic survey are used as spatial references along Gobby Beach to aid cross-referencing with the main assessment findings. These lines, along with the locations of the site photographs, are illustrated in **Figure 1**.

Figure 1 Spatial and picture references along Gobby Beach

2.1 Car Park Beach Access Ramp to Cross-Section A2

Two distinct zones were identified in the superficial composition of Gobby Beach (see **Figure 2** to **Figure 4**). The upper section of the beach varies in width and is characterised by shingle, rocks, and boulders. In contrast, the lower section comprises predominantly shingle and silty sand with occasional rock outcrops (see **Figure 4** and **Figure 5**). The beach profile exhibits a gentle lower slope and steeper upper slope at the toe of the cliff.

A concrete slab with signs of undermining was observed at the bottom of the car park ramp (see **Figure 5**).

A distinct line of green seaweed visible on sections of lower beach see **Figure 2** and **Figure 3**.

Figure 2 View of Gobby Beach and cliffs, looking south from the car park beach access ramp

Figure 3 View of Gobby Beach, looking north from the car park beach access ramp

Figure 4 View of Gobby Beach and cliffs, looking south of cross-section A1

Figure 5 View from the beach towards the car park ramp

2.2 Cross-Sections A2 to C

Along this stretch, the cliffs range in height from approximately 1.4m at cross-section A1 to 3.6m C.

Between cross-sections A2 and C, dense vegetation cover significantly limited visibility and hindered a comprehensive assessment of the cliff face conditions (see **Figure 6**). No evidence of toe notching was observed along this stretch during the site visit however a near vertical face of bare soil less than a metre high could be seen at the toe of the slope.

Figure 6 View of the cliff face at cross-section B

2.3 Cross-Sections C to E

The cliffs along this section vary in height from approximately 3.6m at cross-section C to 6.1m at E.

Evidence of localised slips was observed around the toe of the cliff along this stretch, as shown at cross-section C (see **Figure 7**) and at cross-section D (see **Figure 8** and **Figure 9**). These were accompanied by notching at the cliff toe (see **Figure 10** and **Figure 11**). No signs of groundwater seepage were detected at the sites of these minor cliff failures. There appeared to be a small, localised slip failure at cross section D, see **Figure 8** and **Figure 9**, however dense vegetation cover partially obscured this feature.

Dry seaweed was observed near the cliff base (see **Figure 12**). No significant waterlogging or wet conditions were observed at the time of inspection.

Additionally, dense vegetation cover was noted along portions of the cliff toe, which may obscure early signs of instability (also visible in **Figure 12**).

Figure 7 View of the cliff toe at cross-section C

Figure 8 View of the cliff face at cross-section D

Figure 9 View of the cliff top slip at cross-section D

Figure 10 View of cliff toe notching at cross-section D

Figure 11 View of cliff toe notching just south of cross-section D

Figure 12 View of the cliff toe between cross-sections D and E

2.4 Cross-sections E to F

The cliffs along this section vary in height from approximately 6.1m at cross-section E to 7.9m at F.

Evidence of active erosion was noted along the cliff toe (**Figure 13** to **Figure 15**). Observations included notching and voids where rocks had fallen out of the toe material (**Figure 16** and **Figure 17**).

The cliff toe was generally saturated, and multiple seepage springs were identified along this stretch, (**Figure 18**).

Additionally, dry seaweed was observed at the base of the cliff (see **Figure 13**).

Figure 13 View of cliff face just south of cross-section E

Figure 14 View of the cliff face mid-way between cross-sections E and F

Figure 15 View of the cliff toe at cross-sections F

Figure 16 View of the cliff toe mid-way between cross-sections E and F

Figure 17 View of the cliff toe notching mid-way between cross-sections E and F

Figure 18 View of the seepage at the cliff toe mid-way between cross-sections E and F

2.5 Cross-section F to Southern Site Boundary

The cliffs along this section vary in height from approximately 7.9m at cross-section F to 9.9m at the southern end of the site boundary.

The significant cliff failure identified in the 2025 topographic survey, can be seen in **Figure 19** and **Figure 20**. The retreat of the cliff top in this area extends considerably inland. The slope within the failed area was accessed by foot.

Between cross-sections F and G, three distinct channels (or "valleys") were observed (see **Figure 19**). The central channel is visible in **Figure 20** and **Figure 21**, while the southern channel is shown in **Figure 22**. The northernmost channel could not be accessed safely and was therefore not photographed.

Evidence of ongoing coastal erosion was noted at the cliff toe in this area, including visible undercutting and notching (see **Figure 23** and **Figure 24**). The cliff toe was also observed to be saturated, with several seepage springs discharging groundwater along this stretch (see **Figure 24** and **Figure 25**).

Just south of cross-section G, a distinct material change in the cliff face could be observed. A band reaching approximately 1m above beach levels was observed along the cliff toe, sloping gently downwards from south to north. This layer appeared more cemented and cohesive than the overlying materials. It was firmer to the touch and contained a higher concentration of shingle-sized particles (see **Figure 26** and **Figure 27**).

Exposures of the underlying mudstone layer (as identified in the GI for the area) were noted along the beach in this section (see **Figure 19** and **Figure 28**).

Figure 19 View of the central and southern channels at sections F and G


Figure 20 View of the central channel at cross-section G from the beach


Figure 21 View of uppers slope of central valley at Section G

Figure 22 View of the lower section of cliff face at cross-section G


Figure 23 View of cliff toe notching between cross-sections F and G


Figure 24 View of cliff toe notching and seepage at the southern site boundary limit


Figure 25 View of seepage at the cliff toe between cross-sections F and G


Figure 26 View of the cliff face south of cross-section G

Figure 27 View of the cliff toe south of cross-section G

Figure 28 View of mudstone rock outcrops on the beach at cross-section G

2.6 South of the Site

To the south of the site, the cliff height increases progressively in a near-linear manner.

Evidence of toe notching was observed along this section, with the cliff toe notably wet. (see **Figure 29**).

Several localised cliff face failures were identified in this area (**Figure 30** and **Figure 31**). These failures appeared to be associated with surface water drainage channels running down the cliff face, some of which directly corresponded to the locations of the observed failures (see **Figure 31**).

The cliff face exhibited two distinct material layers, a darker, wetter lower layer and a lighter, drier upper layer (see **Figure 31**). The lower layer appeared to be saturated with groundwater, as indicated by its colour and moisture content.

Additionally, the green line of wet seaweed was observed to lie closer to the cliff toe in this southern section compared to the northern areas of the beach. This observation is supported by a comparison between **Figure 4** and **Figure 30**.

Figure 29 View of the cliffs north of cross-section H

Figure 30 View of the cliffs south of cross-section H

Figure 31 View of the cliff face south of cross-section H

2.7 North of the Site

Beyond the northern extent of the site, there is a stretch of low unprotected embankment before a rock revetment provides protection to a lower-lying bank adjacent to the L2545 road (see **Figure 32** and **Figure 33**). This structure appears to serve as coastal defence for the road.

A prominent rock outcrop is present offshore, in front of the beach stretch to the north of the site, as well as a concrete drainage pipe outfall were also observed in this area (see **Figure 34Error! Reference source not found.**).

The upper beach shingle observed along this beach stretch is noticeably smaller in size than the material found along the upper section of the beach fronting the site.

Figure 32 View of the beach immediately north of the car park access ramp

Figure 33 View of the rock revetment along the bank north of the site

Figure 34 Drainage network outfall

2.8 Cliff Top

The top of the cliff was accessed for further visual assessment. However, dense vegetation cover significantly restricted both access and visibility in this area (see **Figure 35** and **Figure 36**).

The water table monitoring wells seen in **Figure 35** were observed to be within five metres of the cliff edge at the top of the central valley.

The sharp ridge separating the northern and central valleys, as described in **Section 2.5**, was visible from this vantage point and is illustrated in **Figure 36**.

Figure 35 View from the top of the cliff at cross-section E

Figure 36 View from the cliff top at cross-section G

Appendix C

Cliff Evolution Comparative Plan

Notes:

1. Topographical survey to ITM grid reference and Malin Head ordnance datum.
2. Do not scale from this drawing.
3. All dimension are in metres unless noted otherwise.

Rev	Date	By	Chkd	Appd
PL01	29/08/25	J.B.	J.B.	JMacC
	Issued for RFI			

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INDAVER

Project Title

Ringaskiddy Resource Recovery Centre

Drawing Title

Cliff Evolution Plan

Scale at A1: 1:500

Role: Site Infrastructure

Suitability: Response to Request for Information

Arup Job No: **307174-00**

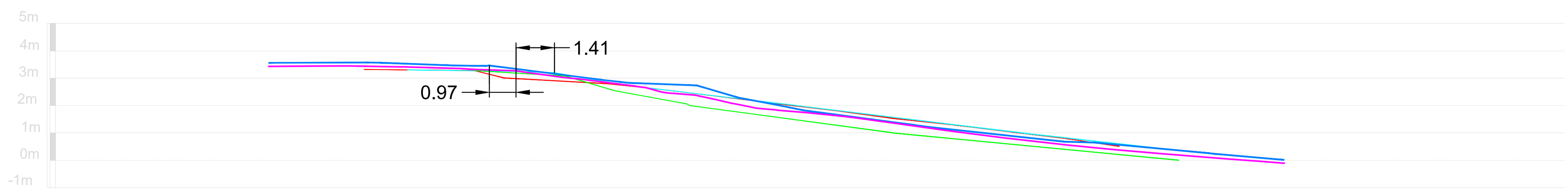
Rev: **PL01**

Name: **C-000-063**

Do not scale

Appendix D

Cliff Evolution Sections



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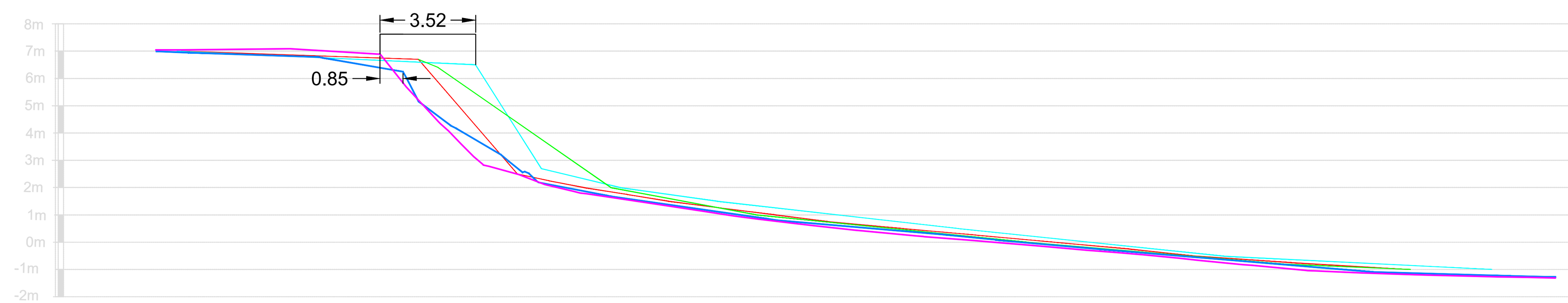

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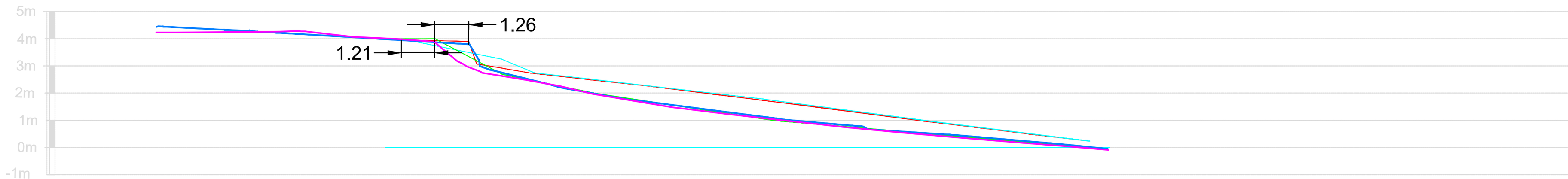

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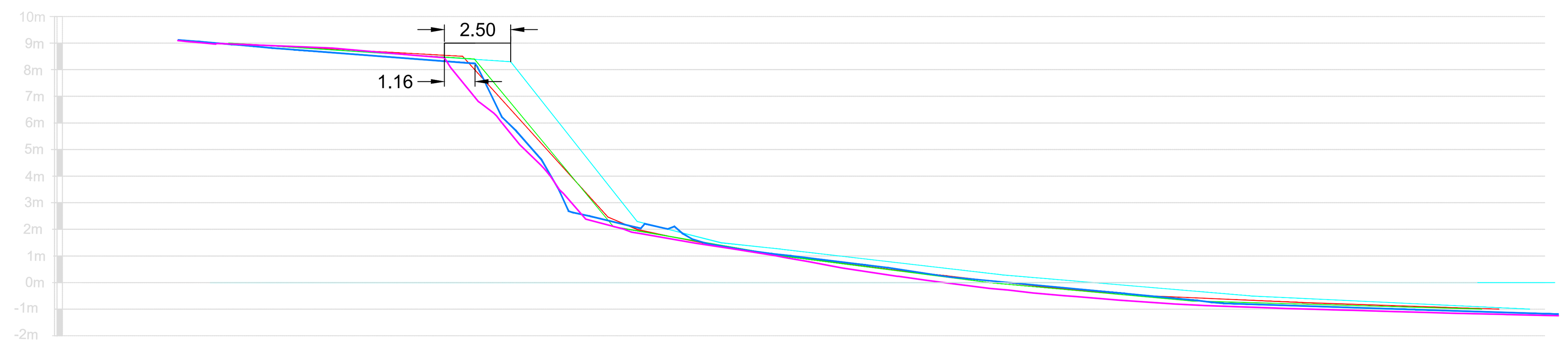

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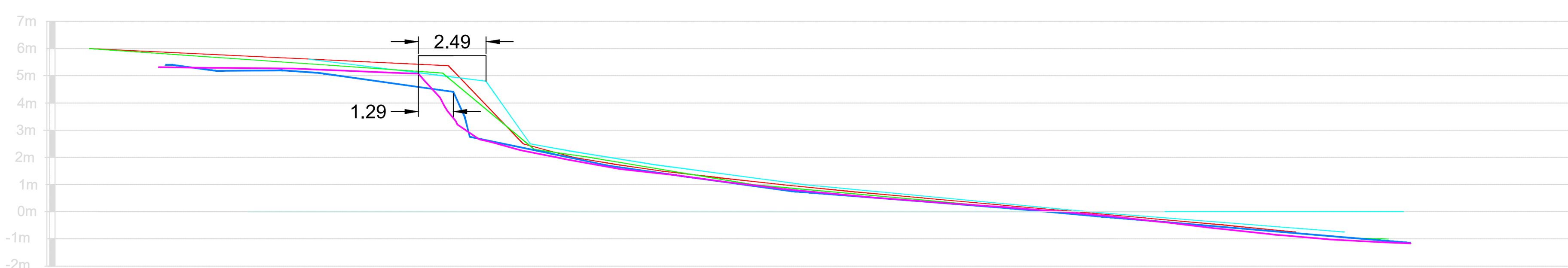

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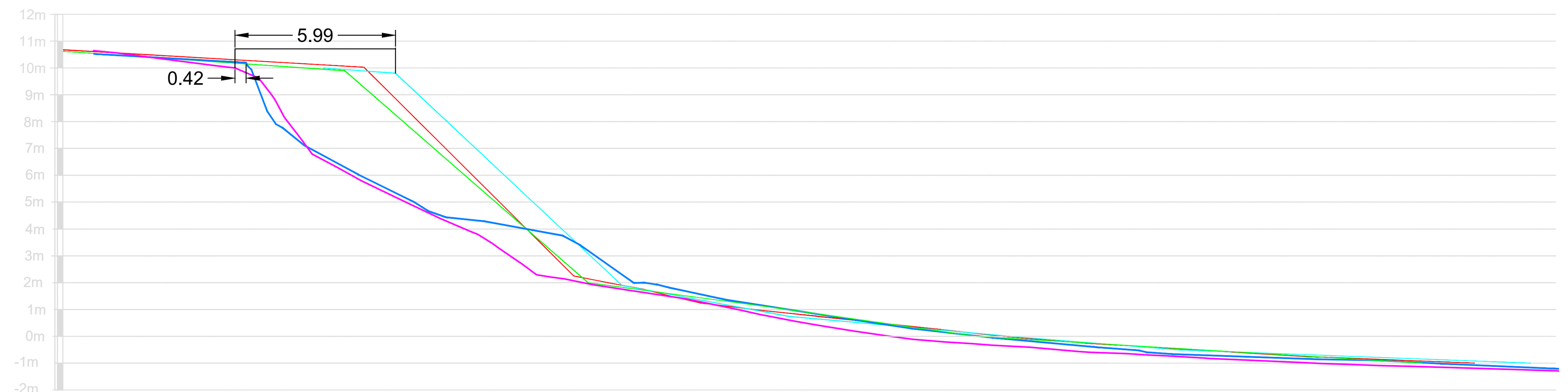

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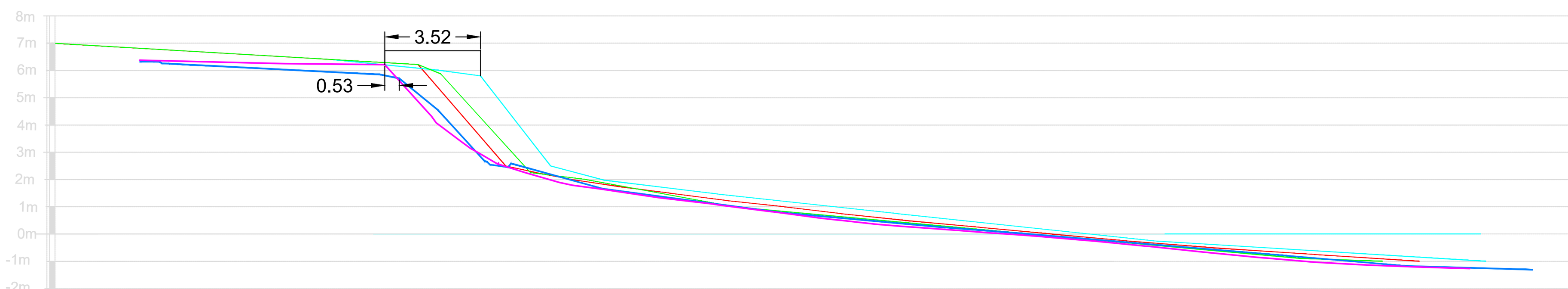

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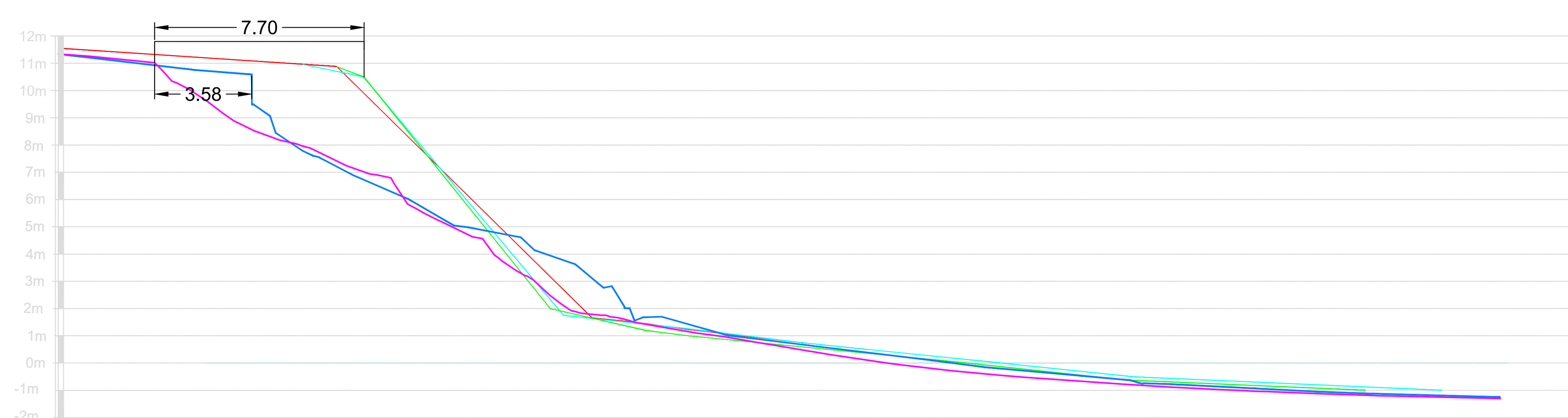

Section G-G

Notes:

1. Information shown on this drawing is to be considered as indicative only.
2. Do not scale from this drawing.
3. All dimension shown are in metres unless noted otherwise.
4. All levels shown are in metres above ordnance datum.
5. For the 2008, 2010 and 2014 surveys the lines shown for the cliff face are straight line interpolations between measurements at the top and bottom of the cliff.

Legend:

- 2025 Survey
- 2016 Survey
- 2014 Survey
- 2010 Survey
- 2008 Survey

Rev	Date	By	Chkd	Appd
PL01	29/07/25	MM	SS	CU
	Issued for RFI			

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Project Title
Ringaskiddy Resource Recovery Centre

Drawing Title
Cliff Evolution Sections

Scale at A1: 1:200
Role: Site Infrastructure
Suitability: Response to Request for Information
Arup Job No: 307174-00
Rev: PL01
Name: C-000-064

Do not scale

Appendix E

Estimated Cliff Retreat Lines

Notes:

1. Topographical survey to ITM grid reference and Malin Head ordnance datum.
2. Do not scale from this drawing.
3. All dimension are in metres unless noted otherwise.

Rev	Date	By	Chkd	Appd
PL02	29/08/25	MM	SS	CU
	Issued for RFI			
PL01	11/12/15	J.B.	J.B.	JMacC
	Issued for Planning			

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Client: INDAVER

Project Title: Ringaskiddy Resource Recovery Centre

Drawing Title: Estimated Cliff retreat lines

Scale at A1: 1:500

Role: Site Infrastructure

Suitability: Response to Request for Information

Arup Job No: 307174-00

Rev: PL02

Name: C-000-060

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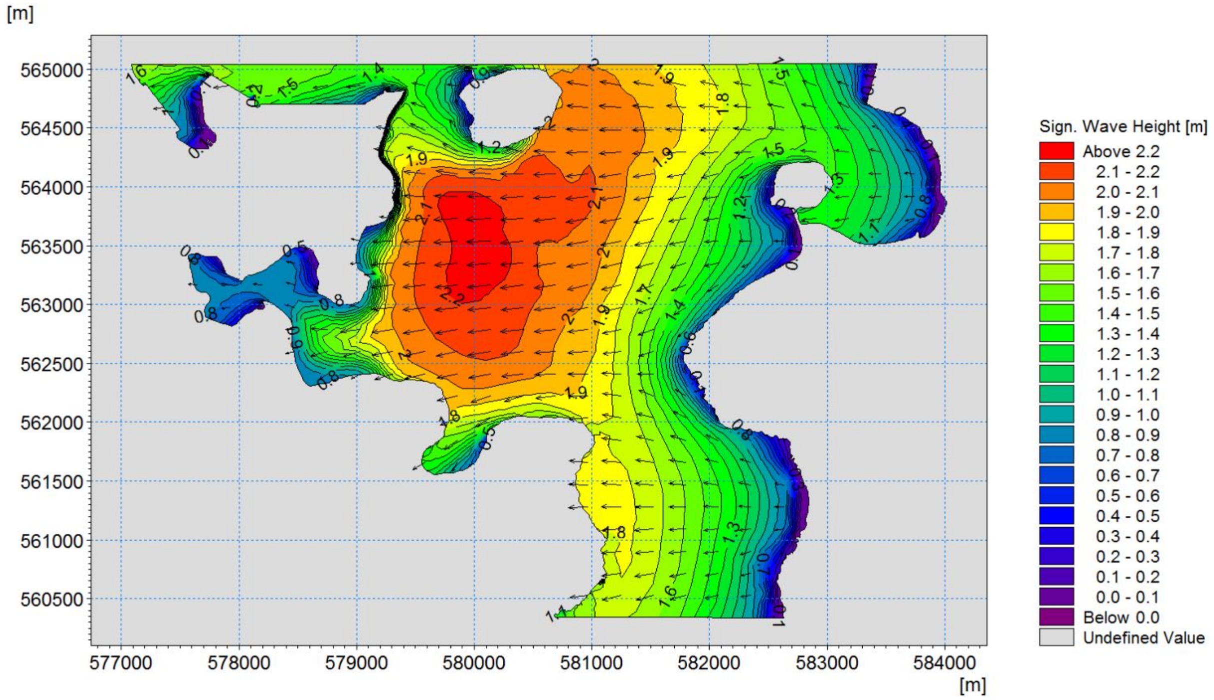
Appendix F

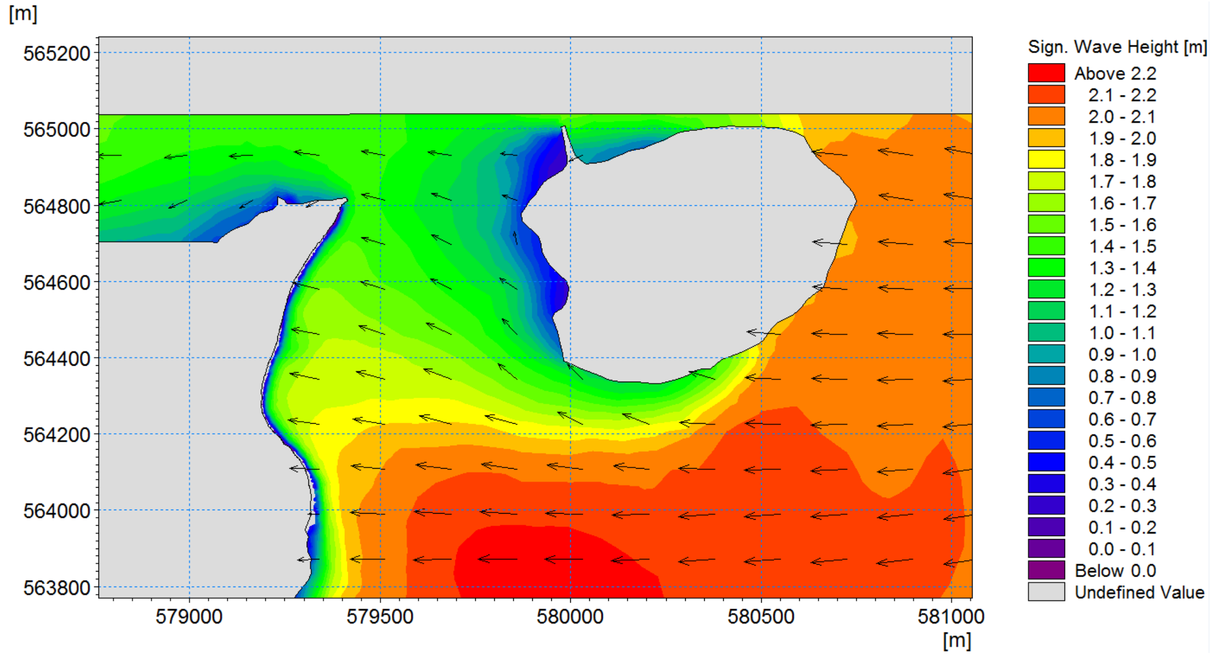
Coastal Model - Wave Modelling Results

F.1 Wave Modelling Results

F.1.1 Case no. 1.1 results



Offshore wave height distribution



Nearshore wave height distribution

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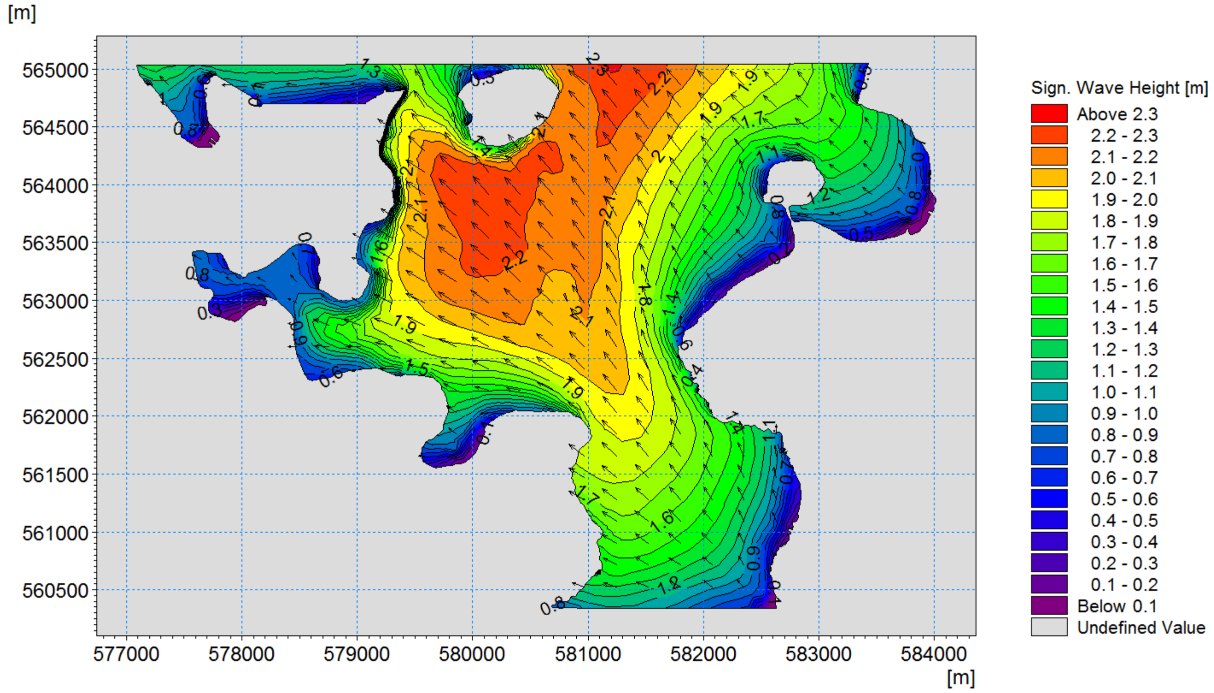

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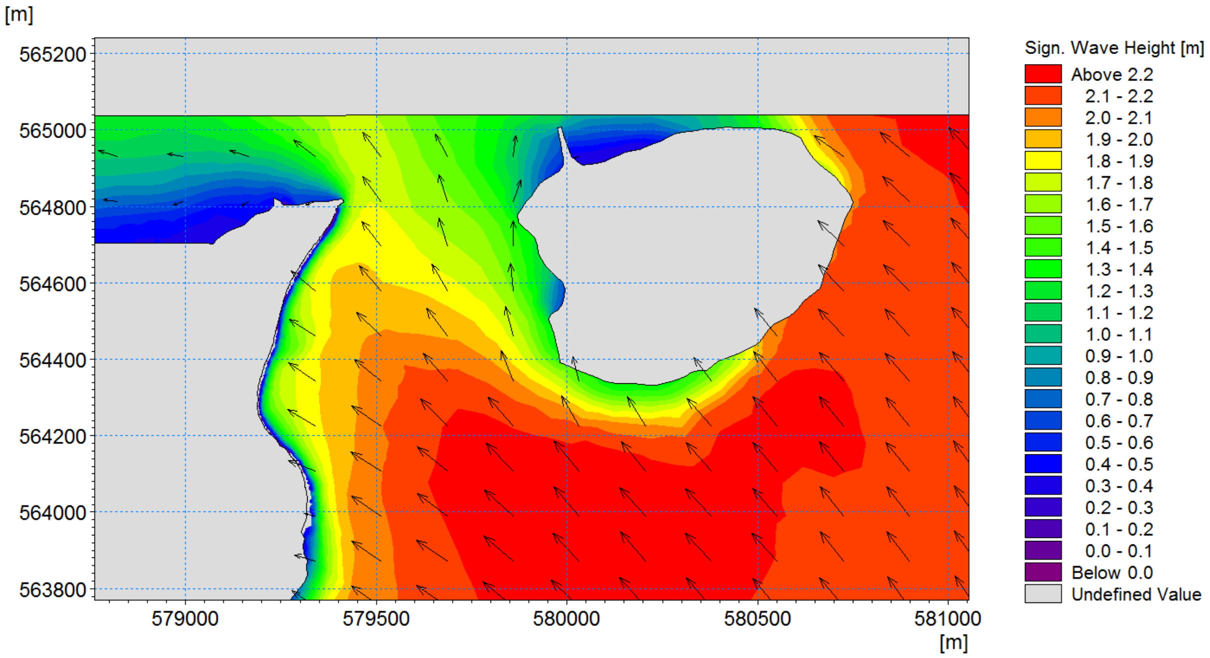
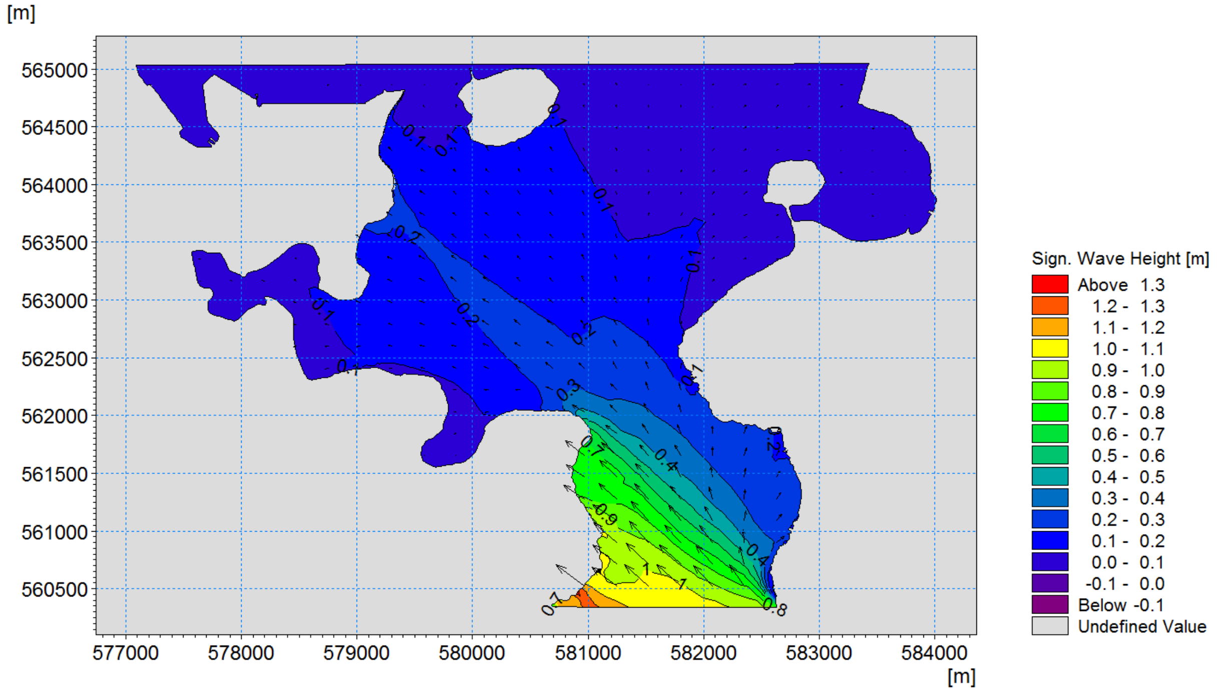


Nearshore wave height distribution

F.1.3 Case no. 2.2 results



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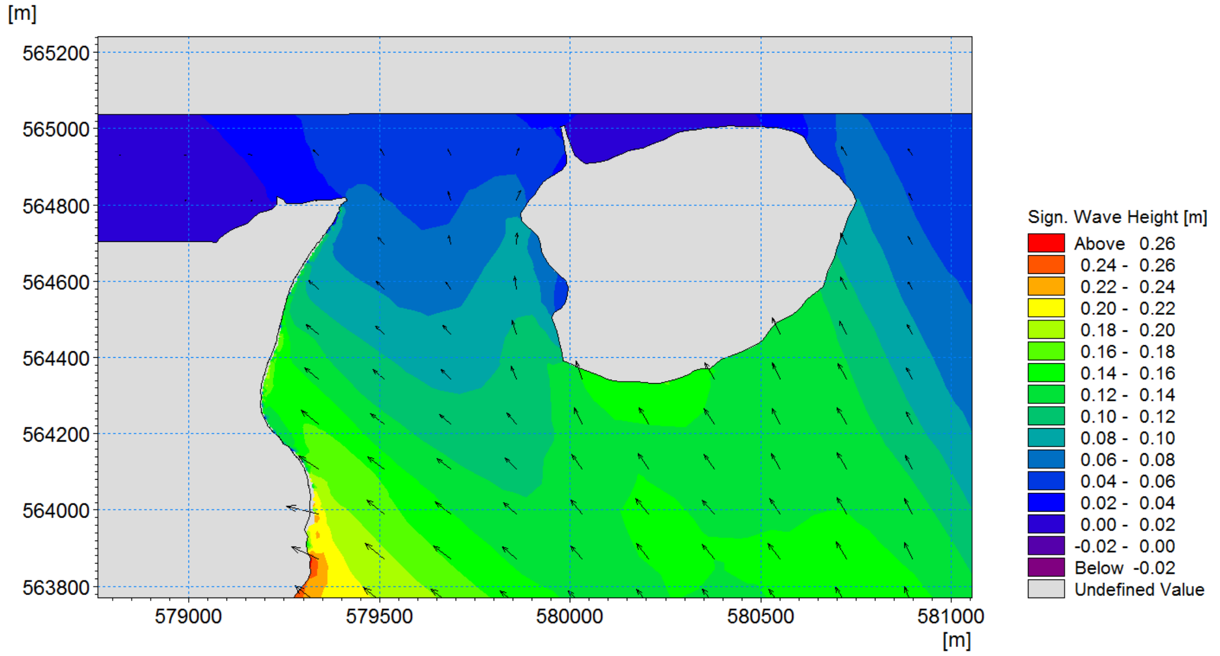

Nearshore wave height distribution

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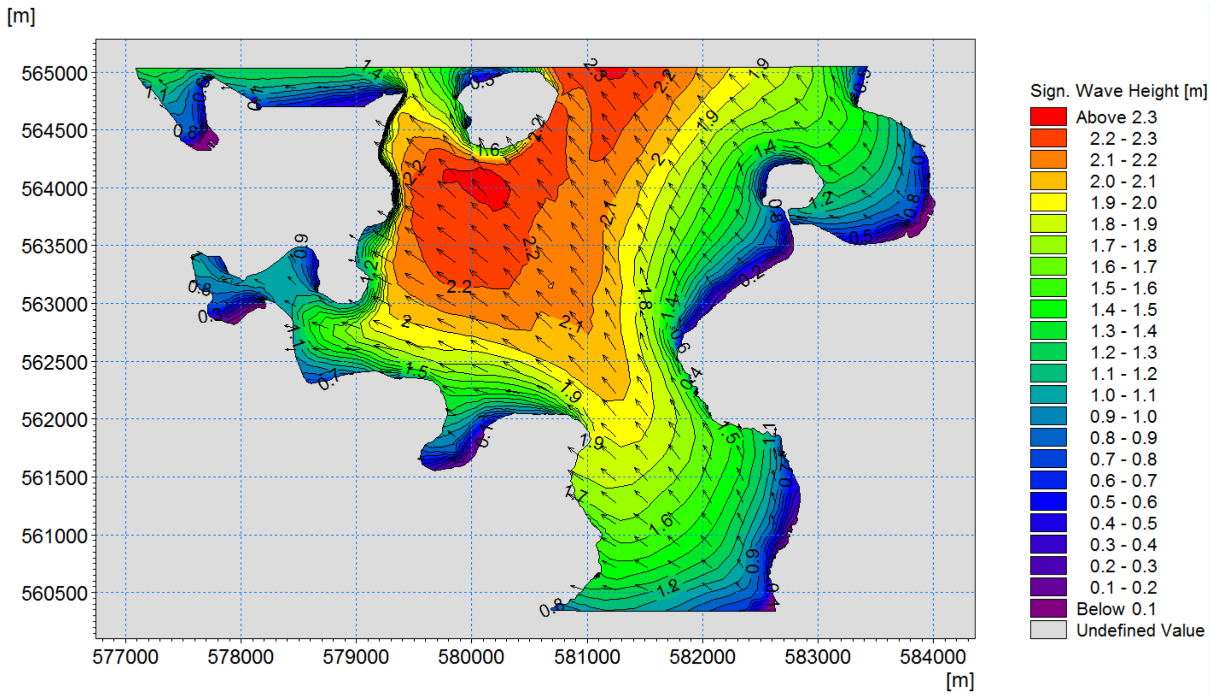

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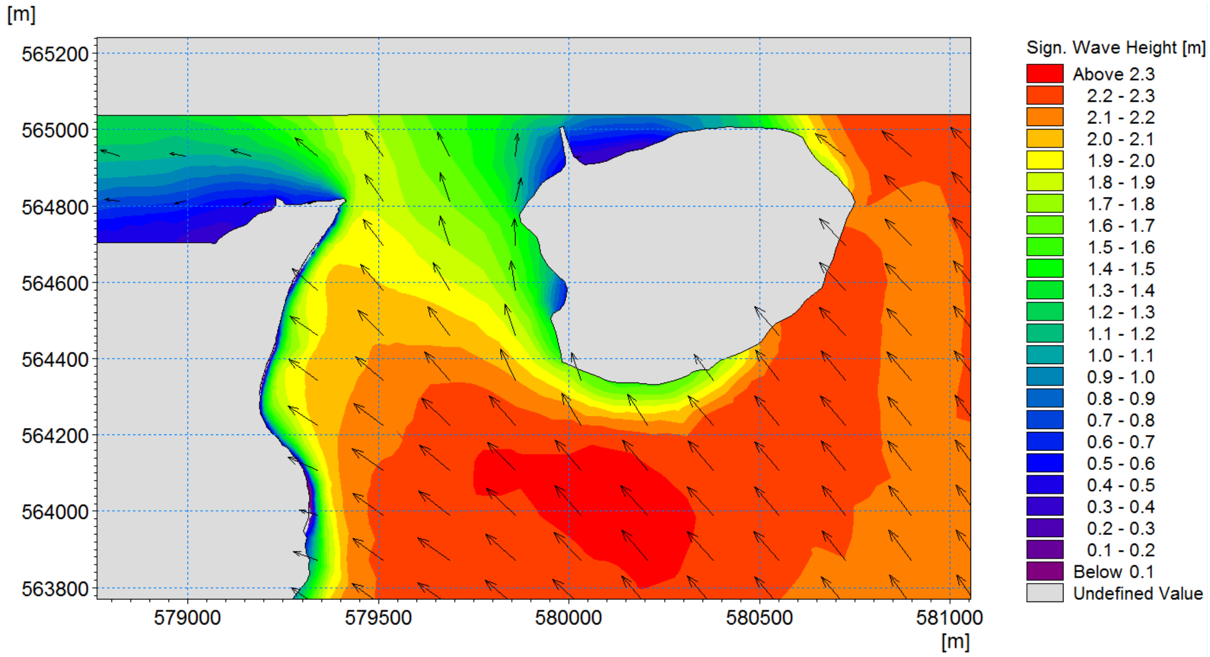

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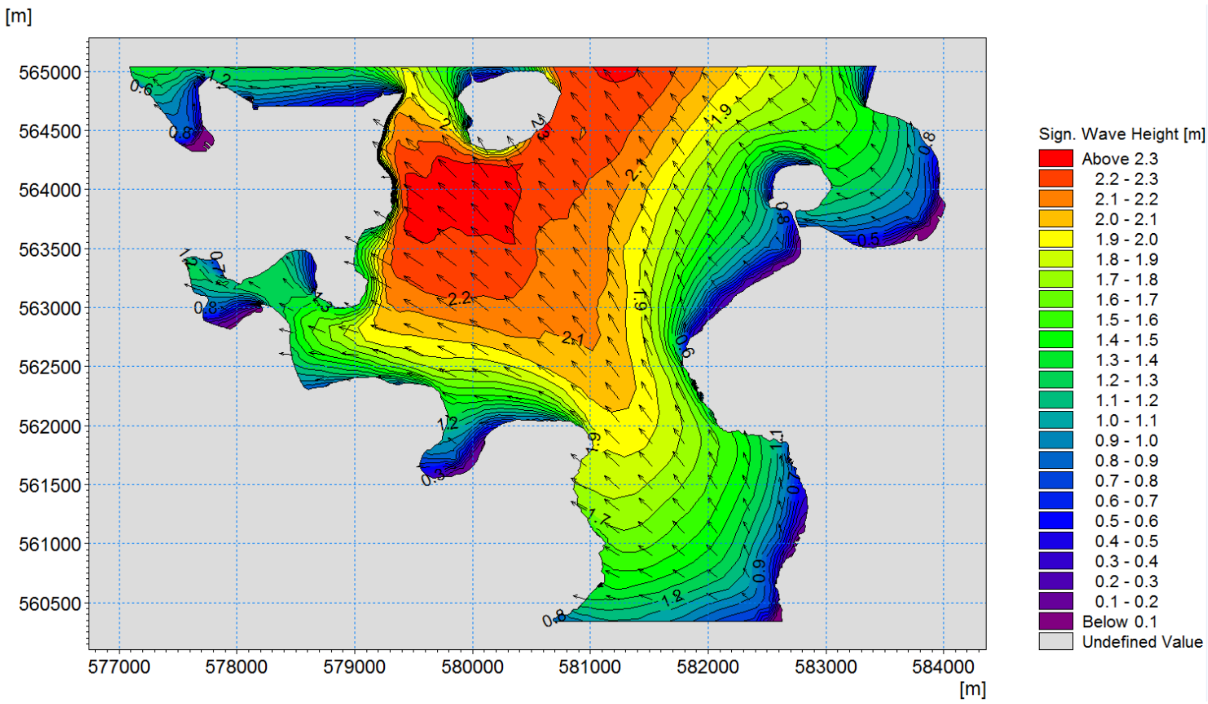
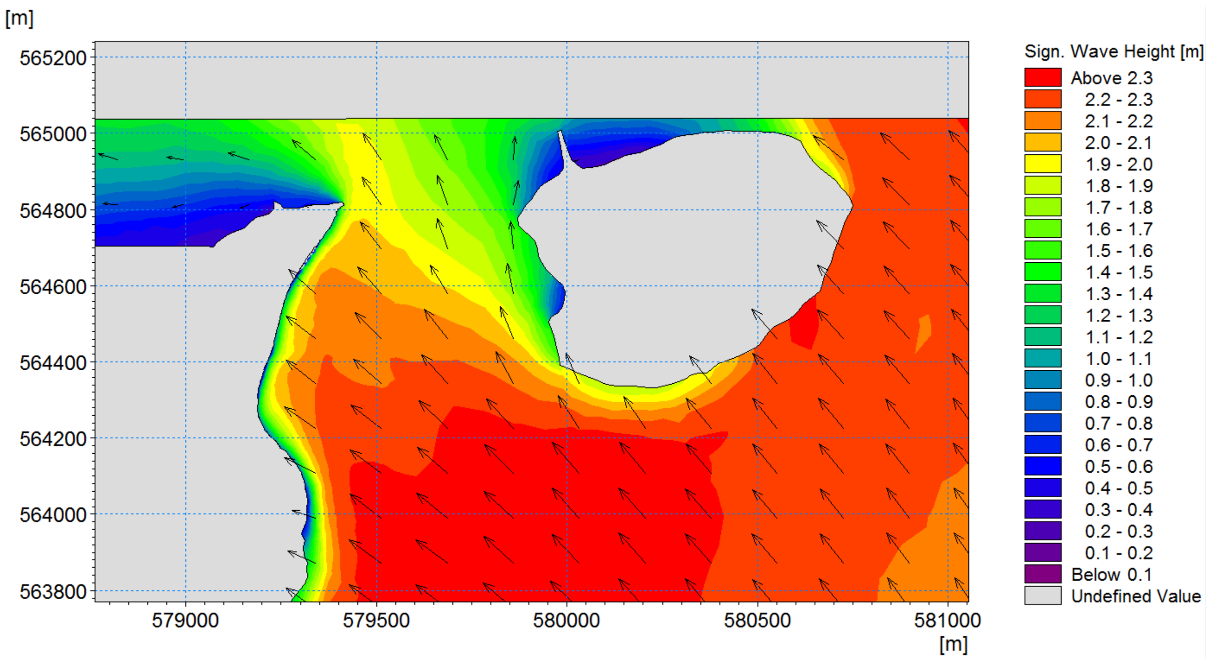


Offshore wave height distribution



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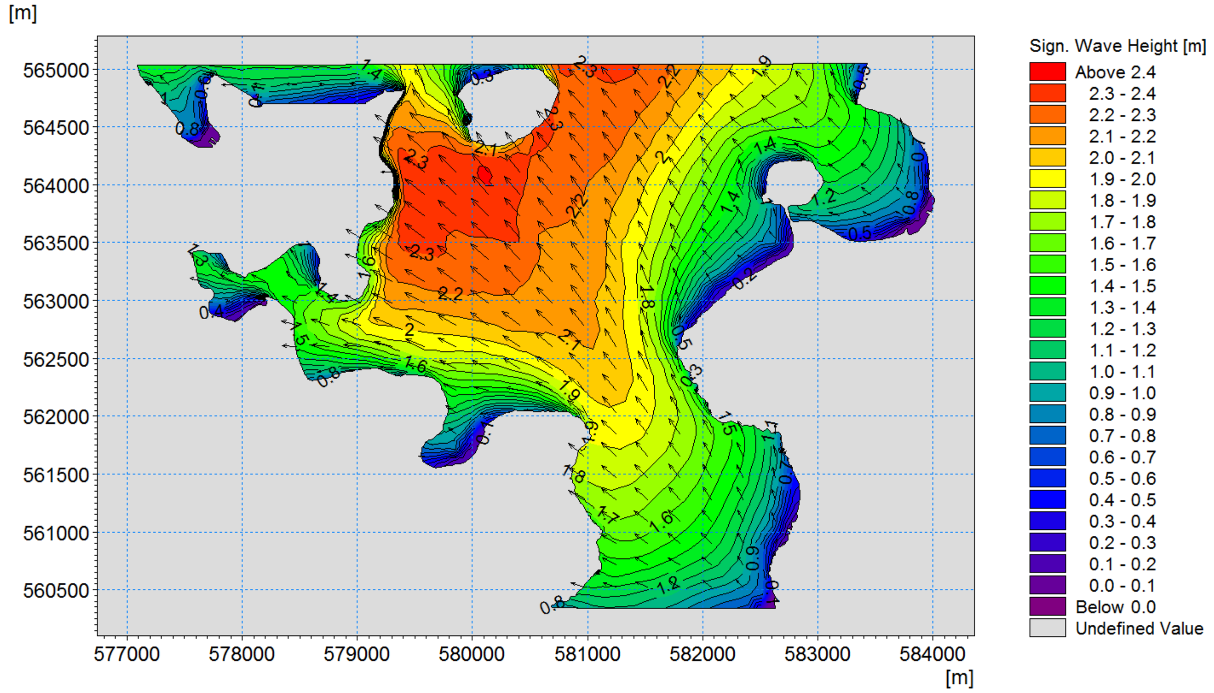

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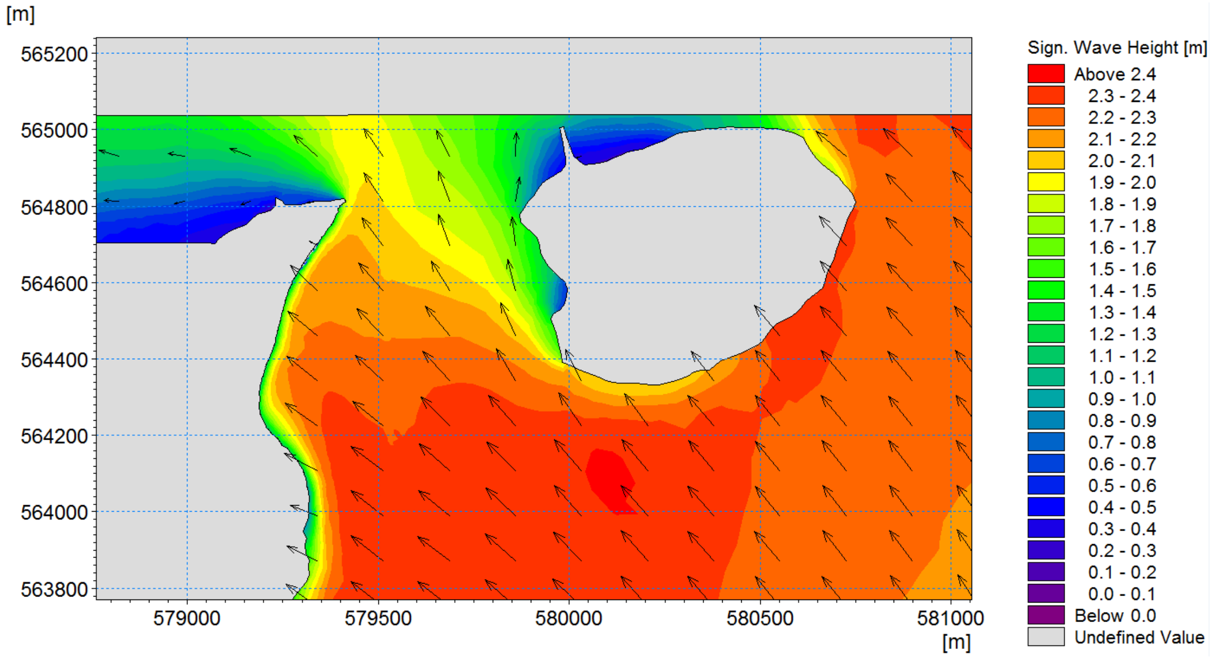

Nearshore wave height distribution

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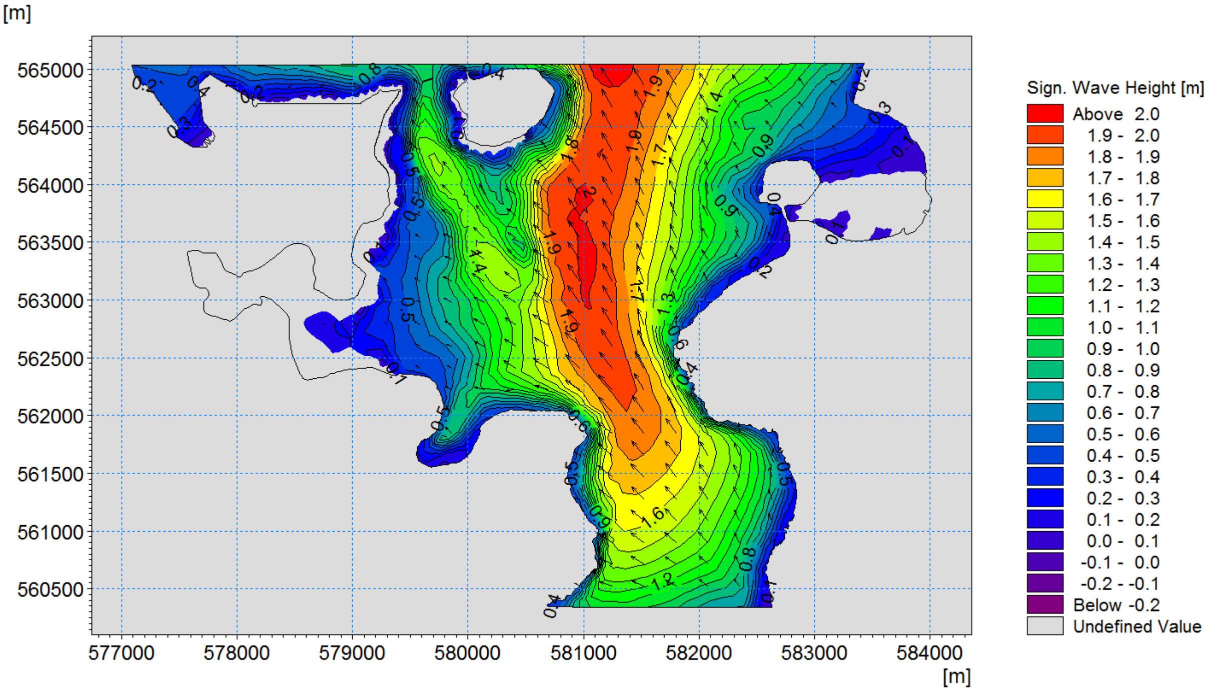

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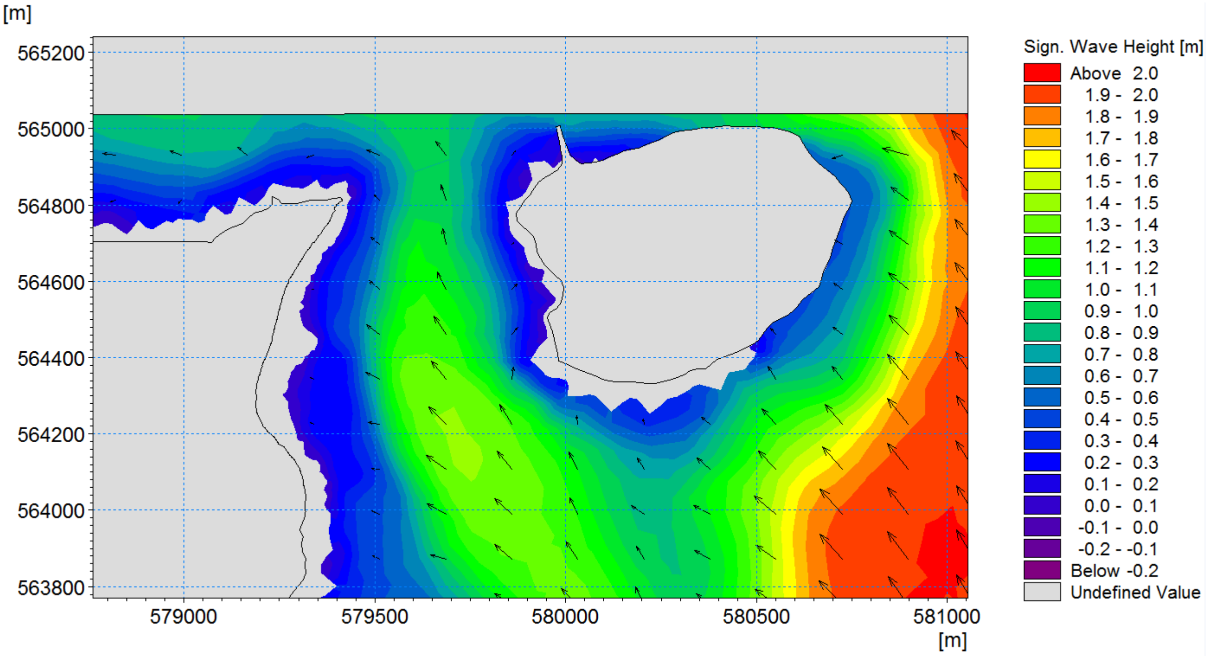

Nearshore wave height distribution

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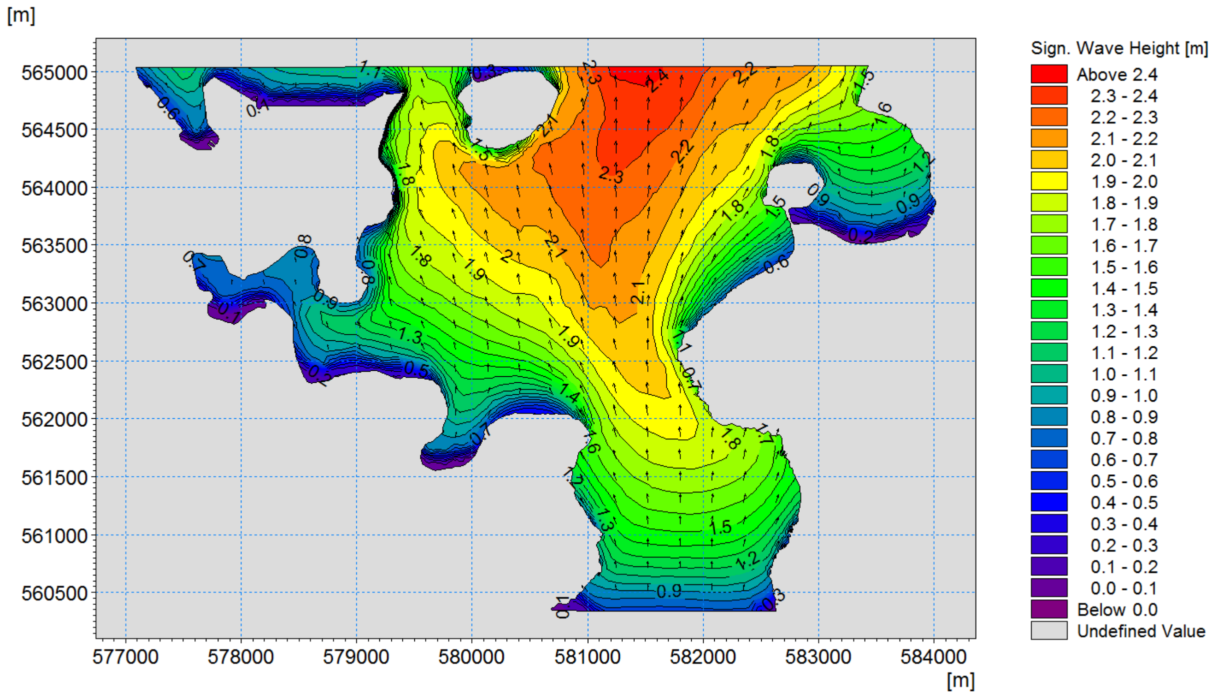

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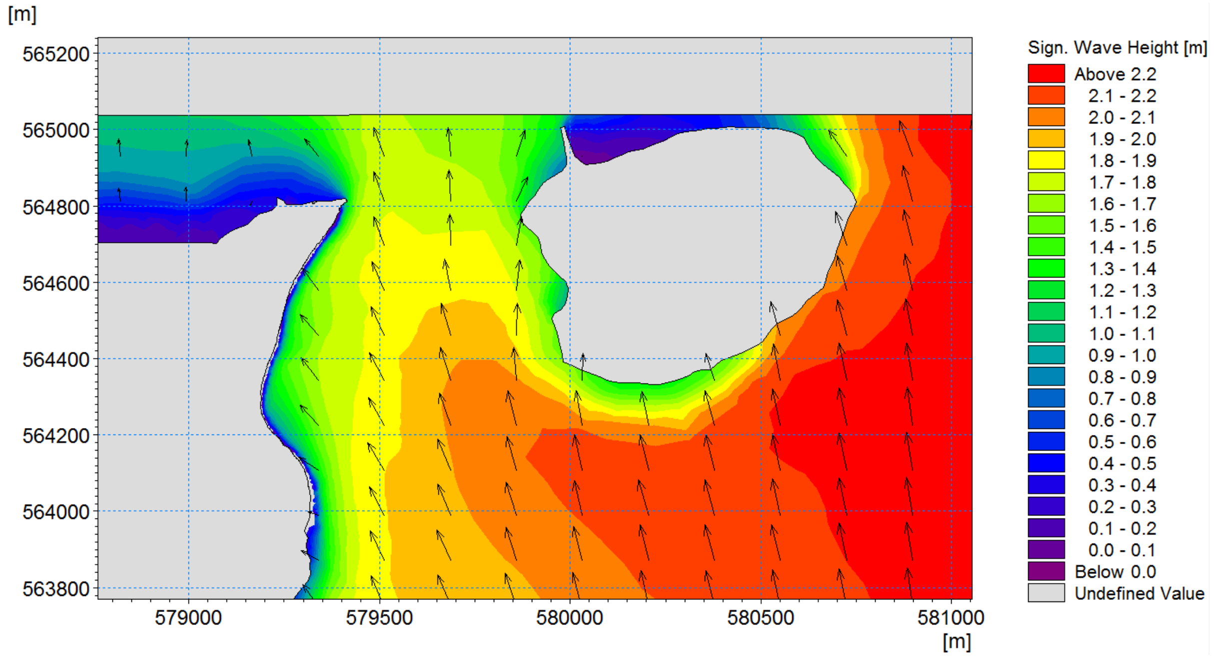

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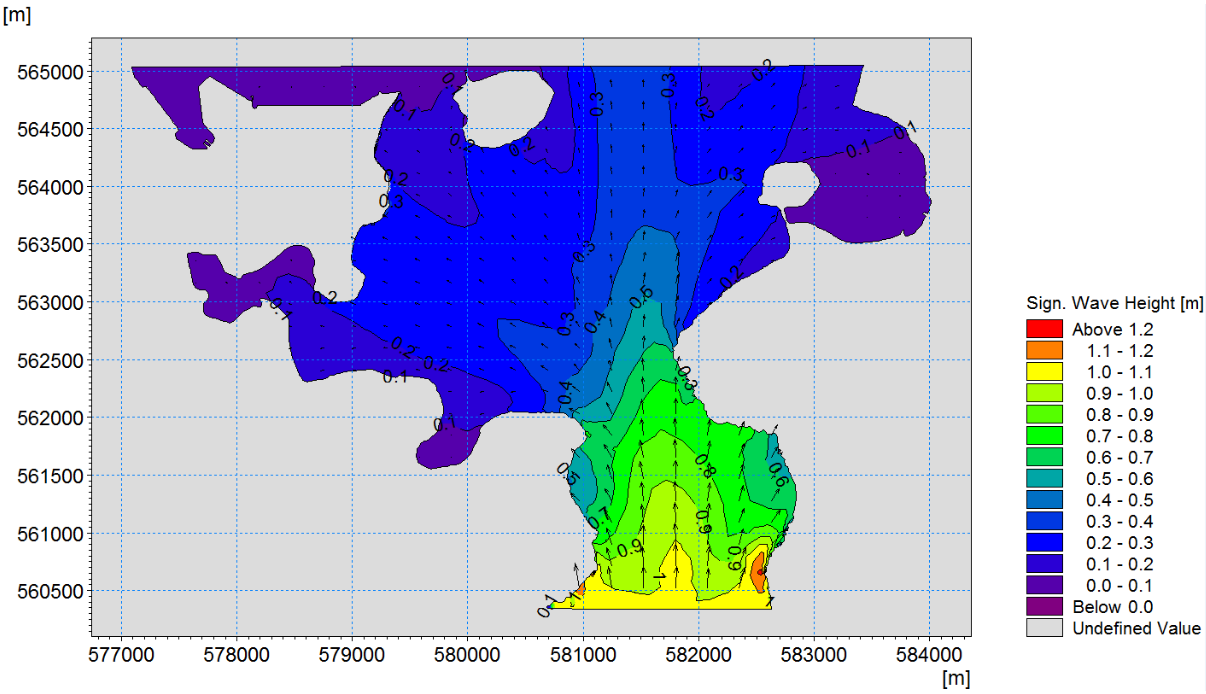

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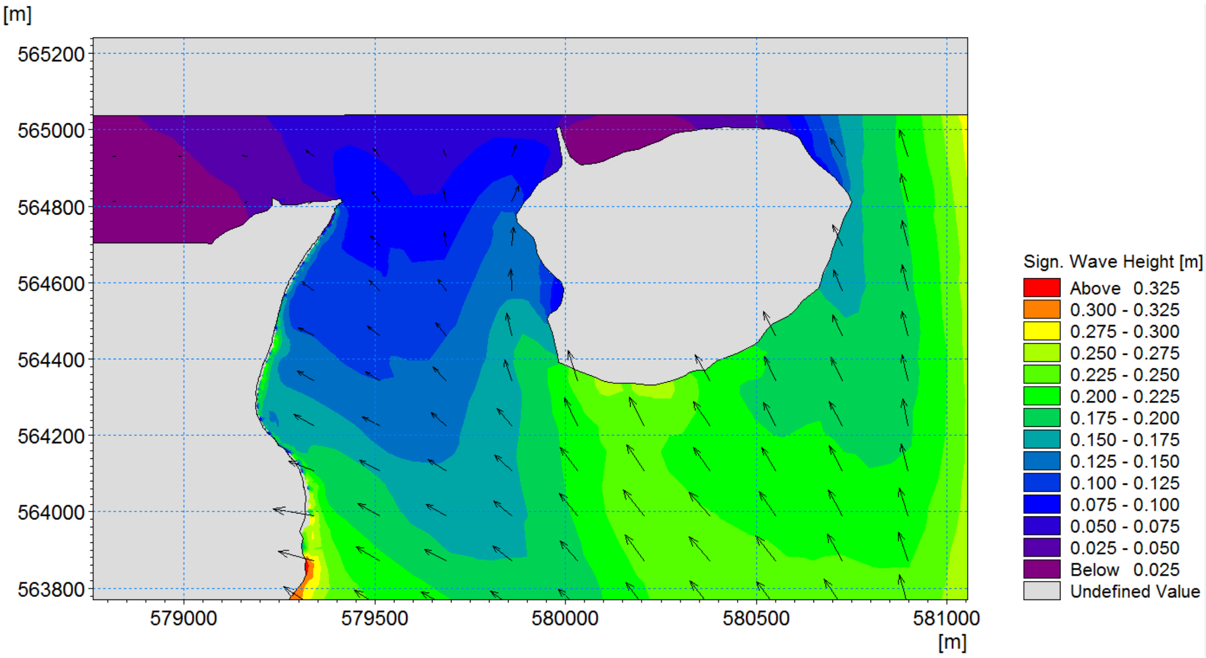

Nearshore wave height distribution

Appendix G

Coastal Engineering Solutions

Solution	Technique	Advantages	Disadvantages	Licensing
Detached Breakwaters	Intermittent structures made of a loose material core which is covered with a resistant outer skin composed of rocks or concrete units. It is constructed in the wave breaking zone.	Dissipate wave energy further seaward than under natural conditions. Encourage beach build-up at the shoreline in the lee of the structure.	Requires construction outside of the Indaver site boundary. May pose as a hazard to vessels navigating the waters, however, it is envisaged the breakwaters would not be a hazard to ships in this case.	Foreshore licence needed
Sills	Un-segmented, structures parallel to the shore, always or occasionally submerged, usually built of rock and designed to hold beach material on their landward side.	They alter the cross shore sediment transport, preventing offshore loss of sediment resulting in a perched beach behind the sill. They also absorb some of the wave energy reaching the cliff.	Requires construction outside of the Indaver site boundary. May cause some scour of the beach immediately to the seaward. Risk to small craft users and swimmers due to submerged structure. May trap sand that would have deposited at other beaches.	Foreshore licence needed
Groynes	Narrow structures built usually at right angles to the shoreline which can be made of timber piles, rock, sheet pilling and concrete. They extend across the beach but rarely below the low water mark	Hold back sediment that would otherwise move along the beach under the action of waves and long-shore currents. Results in the accumulation of sand on the updrift side of the groyne to protect the coastline	Requires construction outside of the Indaver site boundary. Can increase the erosion along the down drift shoreline.	Foreshore licence needed
Revetments	Revetments are a means of protecting soft cliffs and slopes from wave impact forces. The most common methods are with rock armour or gabions.	Depending on size and location, it may not require construction outside of the Indaver site. Reduce wave impact energy on the cliff or coastal slope.	Depending on size, and location it may require construction outside of the Indaver site. Visually intrusive and may be hazardous to beach users if the rocks are very large. Requires beach access for construction.	Foreshore licence likely not to be needed
Sea Walls	Vertical or near vertical walls, usually built at the high water mark between the shore and the land from concrete or stone.	It can be constructed within the Indaver site boundary. They can reflect or absorb the wave impact energy and prevent erosion.	Visually intrusive and may prevent access to the beach or sea. Prevent normal development of the shoreline and may hamper strand line flora and fauna.	Foreshore licence likely not to be needed
Bulkheads	Vertical retaining walls with either cantilevered or anchored sheet piles or gravity structures.	Can be constructed within the Indaver site boundary. Reduce land erosion and loss to the sea by preventing soil from sliding seaward.	They commonly cause a change to the beach profile, normally resulting in sediment deposits along the shore where the bulkheads end.	Foreshore licence likely not to be needed
Cliff Strengthening	Applied above the tidal zone for soft rock or glacial till cliffs, techniques include the provision of drainage lines within the cliff face to minimize moisture or planting suitable vegetation on the cliff face.	Can be constructed within the Indaver site boundary. Reduce mass failure of cliff face by increasing the material strength or decreasing the strain forces put on them.	Can have an impact on the ecology or land use at the cliff top (not expected for Indaver site). Can have an impact on shoreline sediment budgets. However, considering the short length of the cliff at the Indaver site this would only be minor.	Foreshore licence likely not to be needed

Solution	Technique	Advantages	Disadvantages	Licensing
Beach Nourishment	Artificially importing material (sand or shingle) to the beach in order to overcome a deficit in the sediment budget.	Raises beach levels. Reduces wave attack on cliff face.	Long-term maintenance effort usually required.	Foreshore licence needed
		Regarded as a very natural way of combating coastal erosion.	Cause of the erosion is not eliminated as beach material is sacrificed with time.	
			Requires construction outside of the Indaver site boundary	
Sacrificial beach material (shingle) at the toe of the cliffs	Artificially adding material to the beach above the foreshore in order to protect the toe of the cliff from wave action	Protects the cliff face from breaking waves.	Long-term maintenance effort usually required.	Foreshore licence likely not to be needed
		Regarded as a very natural way of combating coastal erosion.	Cause of the erosion is not eliminated as beach material is sacrificed with time.	
		Less material than conventional beach nourishment needed		
		It can be constructed within the Indaver site boundary.		
Planting	On cliffs, grass, bushes and trees protect the cliff slope against surface erosion by rain and melt-water.	Landslides on the cliff slope are reduced by the presence of planting.	In isolation they are generally not sufficiently effective.	Foreshore licence likely not to be needed
		It can be constructed within the Indaver site boundary.	Vegetation may fail due to environmental conditions	
			May be successful in low energy environment but not for example on the open coast.	

Appendix H

Beach Nourishment Solution

Notes:

1. Topographical survey to ITM grid reference and Malin Head ordnance datum.
2. Do not scale from this drawing.
3. All dimension are in metres unless noted otherwise.
4. Information shown on this drawing is to be considered as indicative only.
5. Material type and dimensions are assumed based on visual inspection and site investigation works.

Rev	Date	By	Chkd	Appd
PL2	29/08/25	MM	SS	CU
Issued for RFI				
PL01	11/12/15	J.B.	J.B.	JMacC
Issued for Planning				

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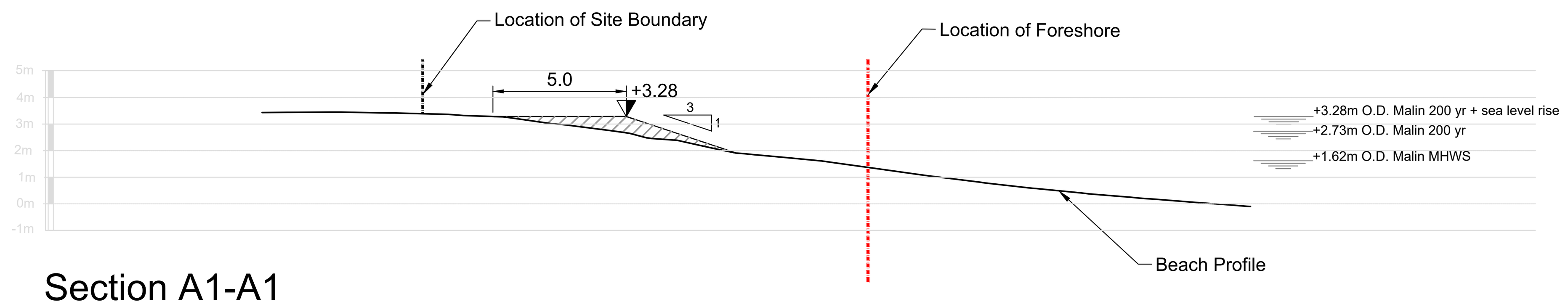
Client: INDAVER

Project Title: Ringaskiddy Resource Recovery Centre

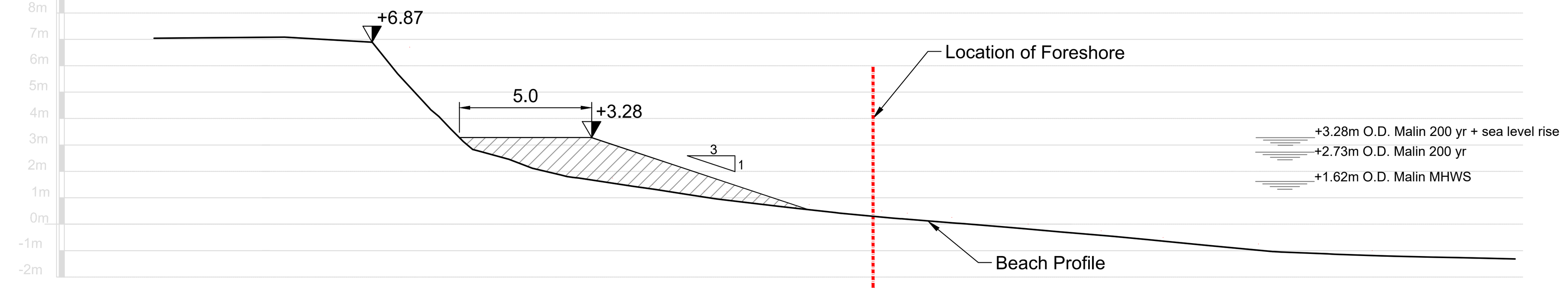
Drawing Title: Beach Nourishment Solution Plan

Scale at A1: 1:500
Role: Site Infrastructure
Suitability: Response to Request for Information
Arup Job No: 307174-00
Rev: PL2
Name: C-000-061

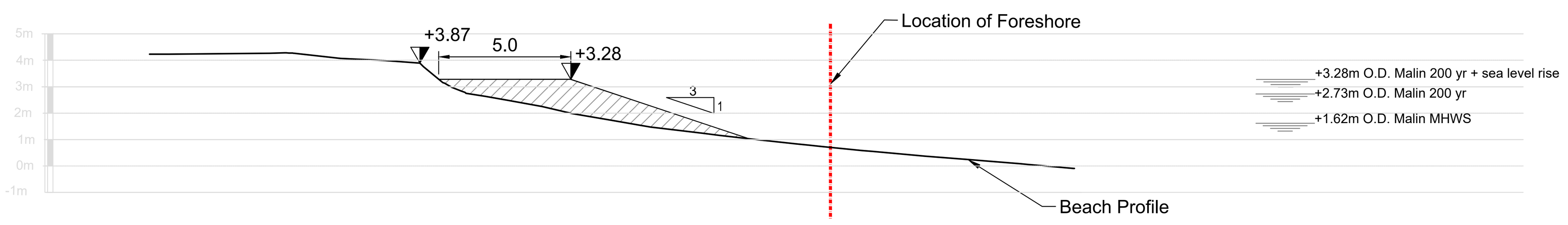
Do not scale



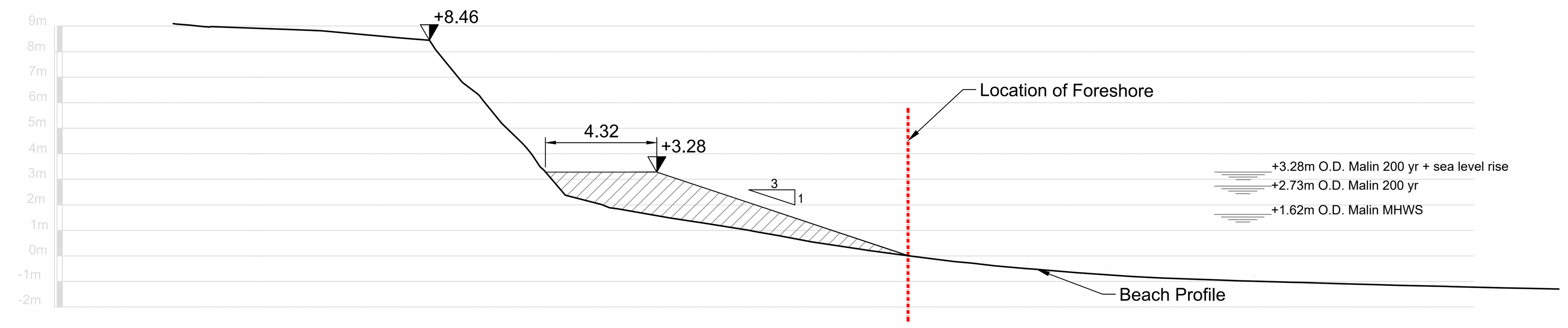
Section A1-A1



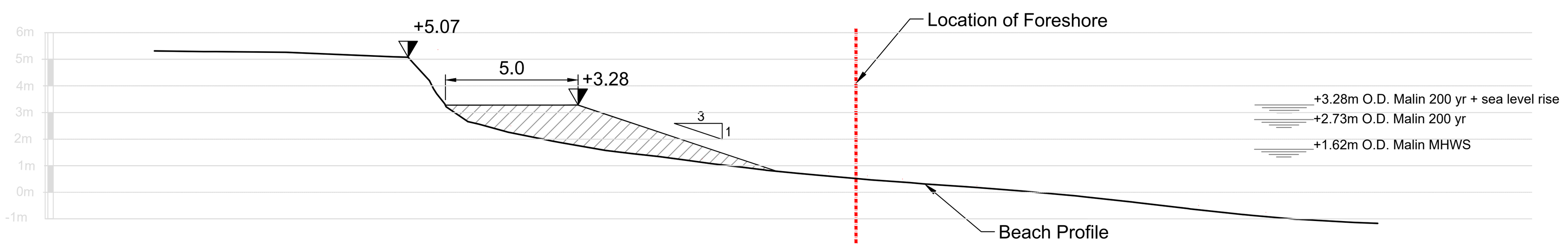
Section D-D



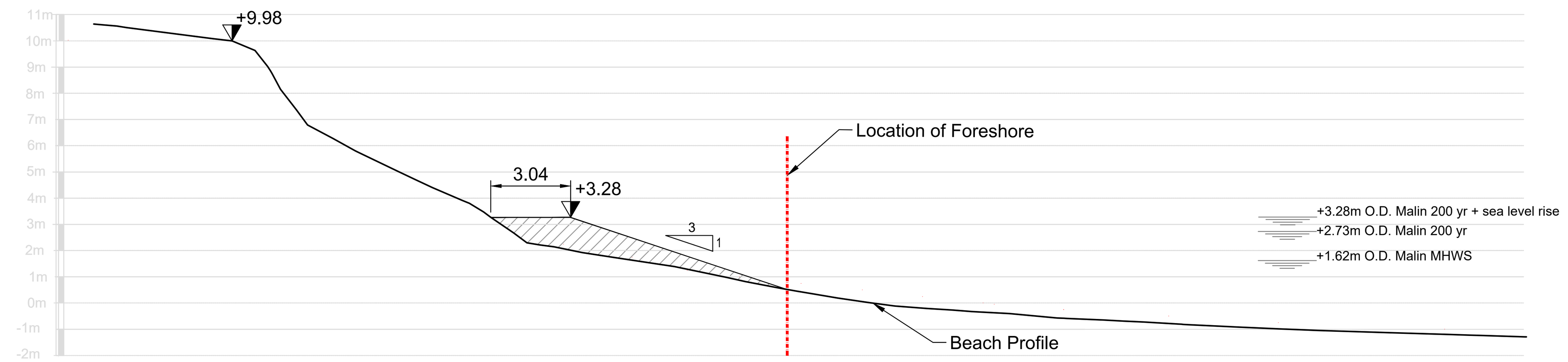
Section A2-A2



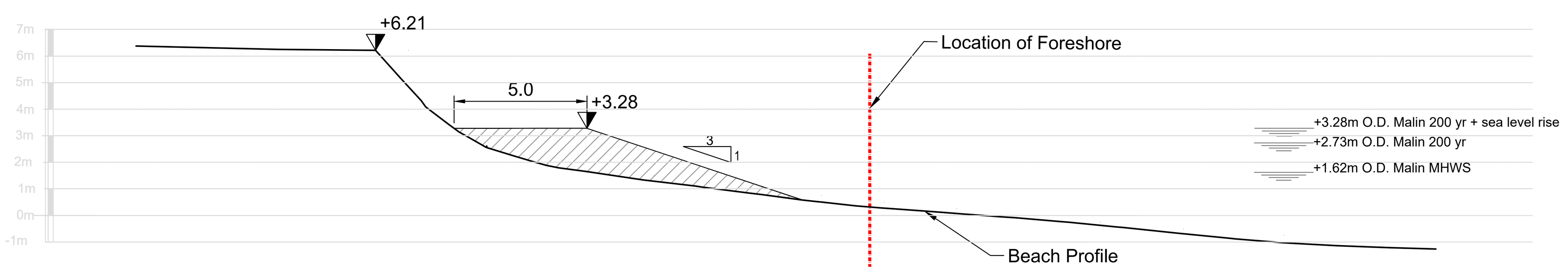
Section E-E



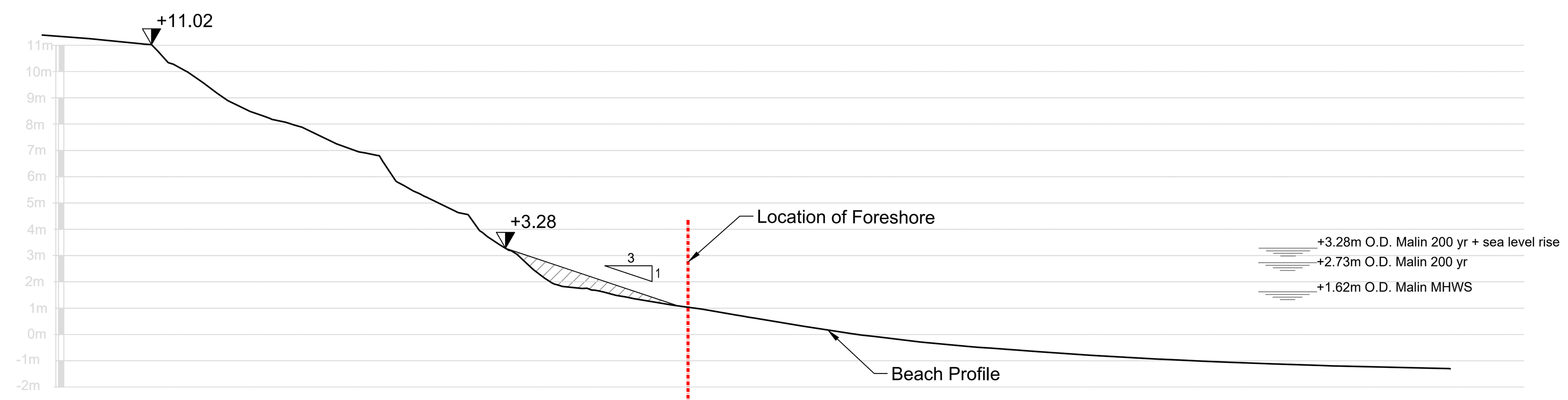
Section B-B



Section F-F



Section C-C



Section G-G

Notes:

1. Topographical survey to ITM grid reference and Malin Head ordnance datum.
2. Do not scale from this drawing.
3. All dimension are shown in metres unless noted otherwise.
4. Information shown on this dwg is to be considered as indicative only.
5. Material type and dimensions are assumed based on visual inspection and site investigation works.
6. The Foreshore line is the High Water Mark (From OSI Rural place map 2001).

Rev	Date	By	Chkd	Appd
PL02	29/08/25	J.B.	J.B.	JMacC
	Issued for RFI			
PL01	11/12/15	J.B.	J.B.	JMacC
	Issued for Planning			

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Client
INDAVER

Project Title
Ringaskiddy Resource Recovery Centre

Drawing Title
Beach Nourishment Solution Cross Sections

Scale at A1: 1:500
Role: Site Infrastructure
Suitability: Response to Request for Information
Arup Job No: 307174-00
Rev: PL02
Name: C-000-062

Do not scale