Killiney and Whiterock CCA2/3 – Coastal Processes Assessment

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1. Background information

1.1 Study site

This technical memorandum assesses the potential impact of proposed coastal defence improvements on coastal processes at Killiney and Whiterock, which are located within the CCA2/3 frontages of the East Coast Railway Infrastructure Protection Projects (ECRIPP) (Figure 1-1).

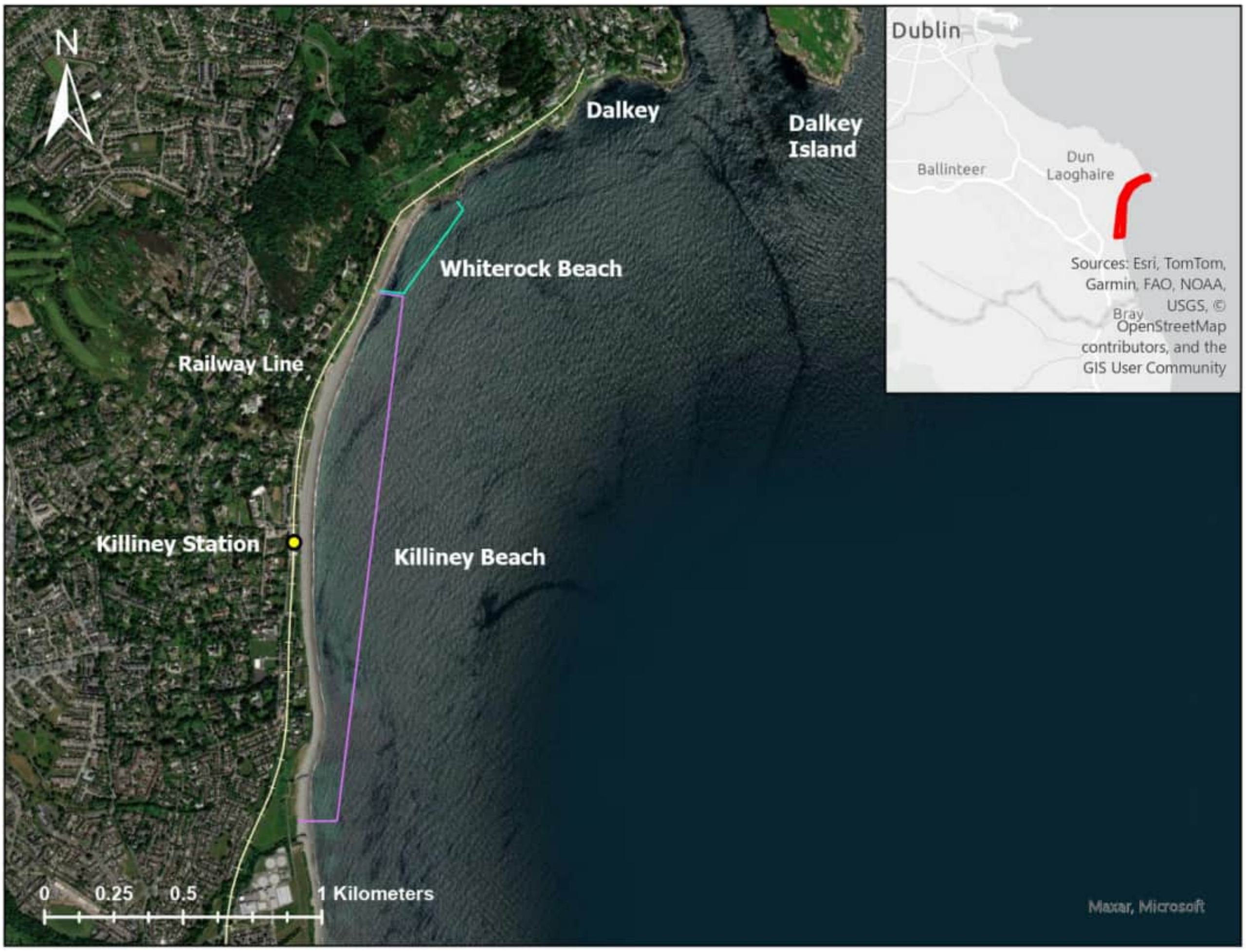

Figure 1-1. Location of Killiney Beach and Whiterock Beach. *Background Imagery source: Maxar, Microsoft*

CCA2-3 covers the section of coast from Sorrento Point (in the lee of Dalkey Island) in the north, to Killiney beach in the south (just north of Shanganagh Bray wastewater treatment plant).

Killiney has a mixed sand and gravel beach which is backed by soft cliffs of glacial sediment along most of the southern and central parts of the frontage. These transition to hard granite cliffs with boulder shore platforms in the northern part of the Killiney frontage from Whiterock Beach to Sorrento Point. These cliffs form a barrier to transport of coarse sand and gravel. The CCA2-3 coast benefits from various hard defences which provide erosion protection to the railway line north of Killiney railway station. The cliffs fronting the station and south to the Shanganagh-Bray treatment works are not defended.

The purpose of this assessment is to use the available data to characterise the existing coastal processes in this area and use this to inform an assessment of (a) the potential future coastal evolution **without** the ECRIPP proposed works and (b) the potential impact of the proposed works on coastal processes and geomorphology. This geomorphological review has been undertaken alongside numerical coastal modelling by Jacobs for ECRIPP, to validate the results of modelling using available data and observations, and to use modelling outputs to assess potential impacts of ECRIPP proposed works on coastal processes and geomorphology. This review supports the preliminary design of the ECRIPP works and more comprehensive studies will be undertaken at detailed design if required.

2. Data and Methods

To assess potential impacts of the proposed ECRIPP works on coastal processes, an Expert Geomorphological Assessment (EGA) (DEFRA, 2009) has been undertaken based on a combination of:

a) a review of relevant existing literature, reports and numerical modelling;

b) new analysis of existing data; and

c) a site visit completed by a Jacobs Senior Coastal Scientist in February 2025.

Existing strategic coastal monitoring data is limited along the CCA2/3 frontage. Aerial imagery and historical mapping records from pre-2000 are sparse, but even with the more recent aerial imagery available, it is not possible to obtain an accurate characterisation of past beach width changes over the long term as this is dependent on water levels which will vary depending on when imagery is captured during the tidal cycle and may also have been effected by surges. There have been no ground-based topographic beach profile surveys along this frontage, limited Light Detecting And Ranging (LiDAR) data has been collected since 2011, and drone photogrammetry has only been collected within the last 5 years. Therefore, this assessment is limited to the short range of available data.

Table 2-1 lists the datasets reviewed in this coastal process analysis of Killiney Beach and Whiterock.

Table 2-1. Data used for this assessment

Data type	Description / Title	Format	Source
Numerical modelling	Assessment of Coastal Evolution	Report	Arup (2020a)
	Phase 1 Wave and sediment transport modelling	Report	Jacobs (2023)
	Phase 2 Sediment Transport and Beach Profile Evolution Modelling	Report	Jacobs (2024)
	Phase 3 Coastal Area Modelling	Powerpoint Report	Jacobs (2025a)
Imagery	Coast of Ireland Oblique Imagery Survey	Photographs	Floodinfo.ie (2003)
	Google Earth	Web Map/Imagery	Google Earth (2025)
	Site Photographs	Photographs	Jacobs (2025)

Topography	Drone Photogrammetry	DSM/Point Cloud	Murphy Surveys (Sept 2023, Oct 2023 post storm, Oct 2024)
	LiDAR (2011)	DTM/DSM	OPW
Bathymetry	Seabed Mapping Project	Web Map	INFOMAR
	Bathymetric Survey	DTM	Murphy Surveys (2018)
Seabed Sediments	Sediment Survey	Web Map	INFOMAR

3. Baseline understanding of existing coastal processes and geomorphology

In order to assess the potential impact of the proposed works on coastal processes and geomorphology, it is important to gain an understanding of the **existing** conditions. This section draws on a review of available literature/reports, new data analysis, and observations from the site visit, to characterise the existing hydrodynamics, coastal sediment dynamics and geomorphology at the Killiney and Whiterock frontages.

3.1 Hydrodynamics

3.1.1 Waves

There are no measured nearshore wave data available for Killiney and Whiterock frontages. The nearest wave measurement device is the Dublin Bay wave buoy located midway between Howth and Dun Laoghaire in 13m water depth, and next nearest is the Marine Institute's M2 wave buoy further offshore located roughly 50 km northeast of Killiney in 95m water depth. The data from these buoys, combined with other hindcast wave data from further south, was used to model nearshore waves along the CCA2-3 frontage as part of ECRIPP Phase 1 modelling by Jacobs (2023). Wave roses were generated by Jacobs (2023) using modelled wave data extracted from nearshore locations 6-9 in Figure 3-1. These wave roses (Figure 3-2) show both the dominant wave direction, plus the frequency in which waves come from each direction.

Figure 3-1. Locations of extraction points for modelled wave data along the CCA2/3 frontage. *Background Imagery source: Maxar, Microsoft*

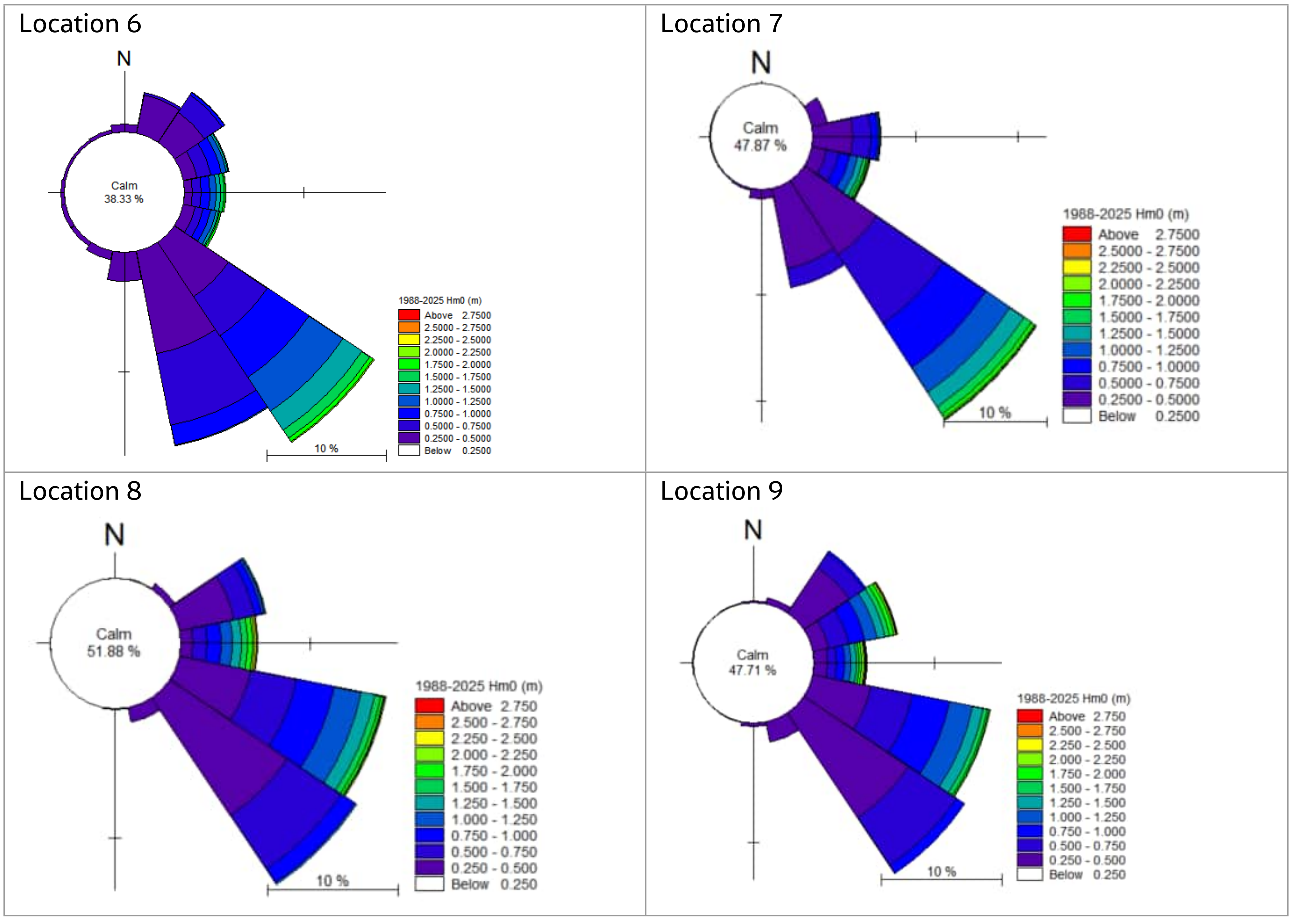

Figure 3-2. Wave roses generated for the CCA2/3 frontage from the nearshore extraction points 6-9.

The wave modelling indicates that waves are predominantly from east-southeast to south-southeast along this section of coast. More waves approach the coast from south of the shore normal than from north of the shore normal. South of Killiney, waves from the southeast and east-southeast decrease in height. At Whiterock, the dominant wave direction turns clockwise to be from the southeast with increasing waves from the south-southeast towards the northern end. This change in wave direction is a direct result of a change in orientation of the shoreline (Jacobs, 2024).

3.1.2 Water levels

The tidal regime on the Irish east coast around Dublin is characterised as semi-diurnal (two high tides and two low tides per day). Key tidal reference levels at the nearest Port (Dublin) are tabulated in Table 3-1. Based on these levels, the mean spring tidal range is 3.8 m which is classified as meso-tidal (i.e. a tidal range of 2-4m).

Table 3-1. Tidal reference levels for Dublin and Wicklow (Source: Dublin Port Company)

Reference Level	Dublin Port mCD	Dublin Port mODM
Highest Astronomical Tide (HAT)	4.50	1.99
Mean High Water Springs (MHWS)	4.10	1.59

Mean High Water Neaps (MHWN)	3.40	0.89
Mean Sea Level (MSL)	2.40	-0.11
Mean Low Water Neaps (MLWN)	1.50	-1.01
Mean Low Water Springs (MLWS)	0.70	-1.81
Lowest Astronomical Tide (LAT)	-0.10	-2.61

In addition to astronomical tidal fluctuations, water levels at Killiney and Whiterock are influenced by meteorological conditions. The Irish Sea is susceptible to elevated water levels due to storm surges, predominantly caused by the propagation of external surges into the Irish Sea basin from either the Celtic Sea to the south or the North Atlantic Ocean to the north (Olbert and Hartnett, 2010).

Water levels can also be locally elevated at the shoreline by wave-setup, caused by large waves breaking as they reach shallow water near the beach. During the Jacobs site visit to Killiney and Whiterock on 19 February 2025 it was observed that the water level at low tide did not drop as low as expected, and this could have been a result of wind and/or wave setup as there were relatively large waves breaking at the shoreline due to a period of sustained easterly winds.

3.1.3 Currents

The ECRIPP Phase 3 coastal modelling for CCA2/3 included modelling of current speeds and directions for the Killiney and Whiterock area. Tide-only currents were modelled to simulate conditions when there are no waves, as well as combined tide and wave-driven currents for a set of representative wave conditions.

The modelling results for **tide-only** currents are shown in Figure 3-3 for the wider CCA2/3 area and also in Figure 3-4 for a smaller area at Whiterock. The modelling indicates that the flood tide mainly flows northwards and the ebb tide flows southwards, which agrees with the overall understanding of main tidal current directions in the Irish Sea and Dublin Bay (Dun Laoghaire Regatta, 2025).

In terms of tidal current speeds, the modelling indicates that with no waves, current speeds are generally low (<0.2m/s) close to the shoreline throughout the tidal cycle, with current speeds increasing a few hundred metres offshore, particularly 2 hours after low water (Figure 3-3).

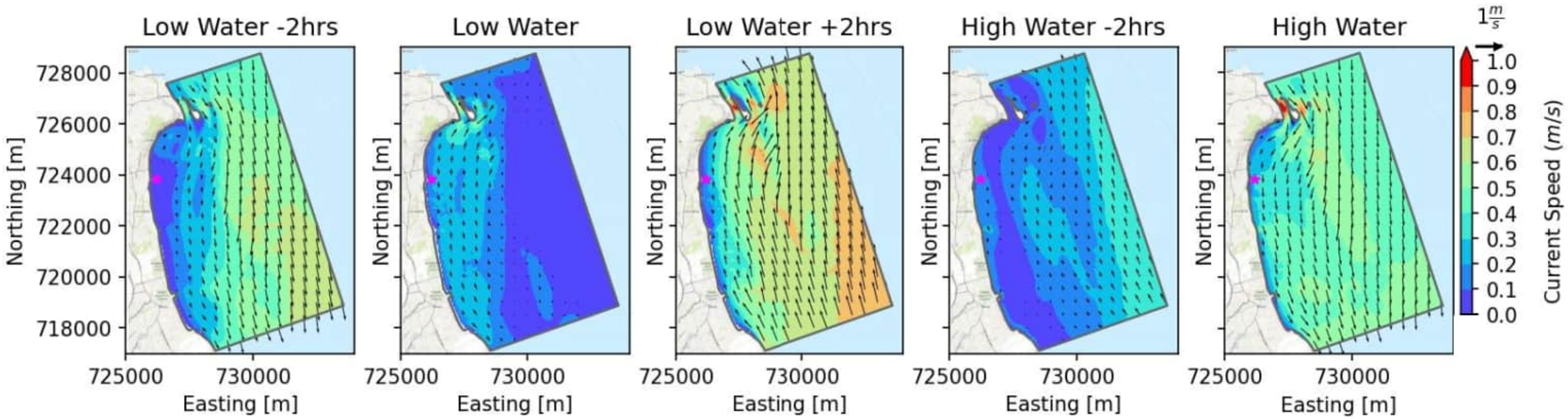

Figure 3-3: Tide-only current speeds and directions in the CCA2-3 area, modelled for ECRIPP Phase 3 (Jacobs, 2025a).

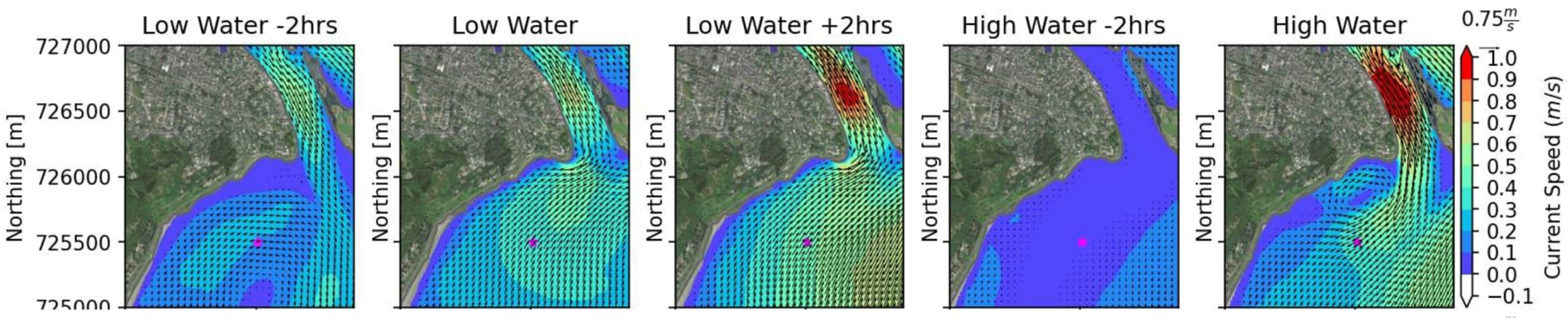

Figure 3-4: Tide-only current speeds and directions in the Whiterock area, modelled for ECRIPP Phase 3 (Jacobs, 2025a).

The highest tidal current speeds (up to 1m/s) occur between Sorrento Point, Dalkey Island, and Muglins rocks (1-2km northeast of Whiterock) due to constriction of flows through narrow channels between the islands. The modelling also indicated some tidal-driven eddies (rotating currents) ~500-900m offshore of Whiterock Beach at high water (Figure 3-4).

These ECRIPP modelling confirm previous tidal current modelling undertaken for the Shanganagh Sewerage Scheme (Irish Hydrodata Ltd, 2010) shown in Figure 3-5. These indicated that the maximum spring flood and ebb tidal flows were lowest within ~500m of the shoreline at Killiney and Whiterock (<0.25m/s), increasing to between 0.25-0.5m/s further seaward, with the highest current speeds in the narrow channels around Dalkey Island and the Muglins.

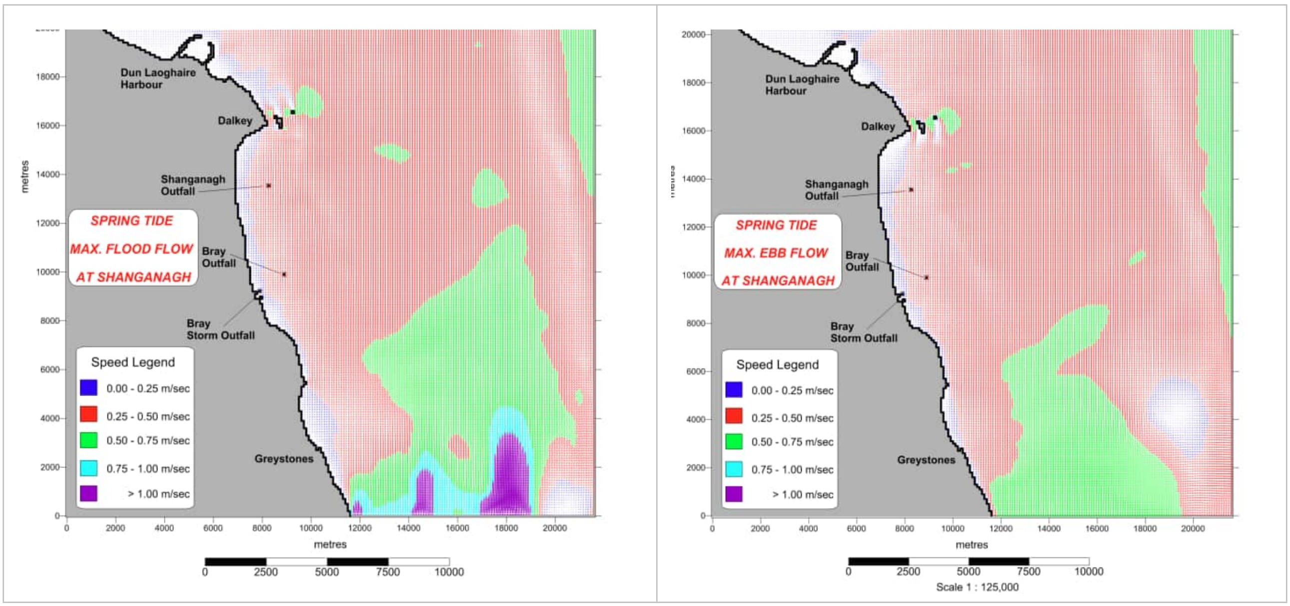

Figure 3-5: Modelled maximum tidal flow speeds on the flood tide (left) and ebb tide (right) between Howth Head and Greystones (Irish Hydrodata Ltd, 2010).

When the effects of **wave-**driven currents were incorporated into the ECRIPP Phase 3 coastal modelling, the results showed that stronger shore-parallel currents, with speeds up to 1m/s, are generated close to the shoreline by breaking waves under high energy wave conditions, particularly at and just before high water (e.g. in Figure 3-6).

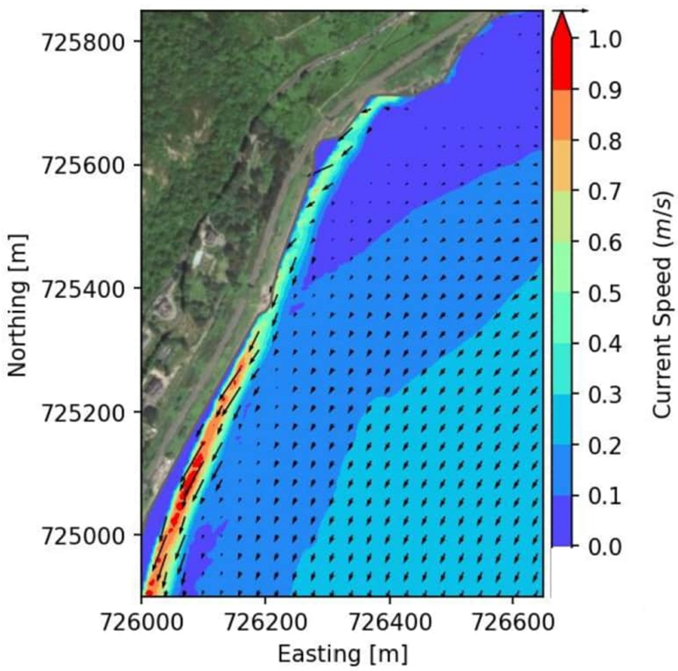

Figure 3-6: Modelled currents(both tide and wave driven) at Whiterock at high water under northweasterly wave conditions (‘wave E’ - 2.26m wave height, 6.1 second period, 45 degree direction; Jacobs 2025a).

The modelling also indicates there is a tendency for wave-driven eddies and rip currents to be locally generated in certain areas under certain wave conditions. For example, under the most representative wave conditions (south-southeasterly 185 degree wave approach, 2.83m wave height), there is a convergence of alongshore currents at the centre of Whiterock Beach, causing a narrow seawards-flowing rip current to be generated (Figure 3-7). Under the same wave conditions there is also a tendency for circulatory flows to form at South Killiney, near the southern limit of Strand Road, with a wide seawards-flowing current just south of where the shoreline protrudes seawards (Figure 3-7).

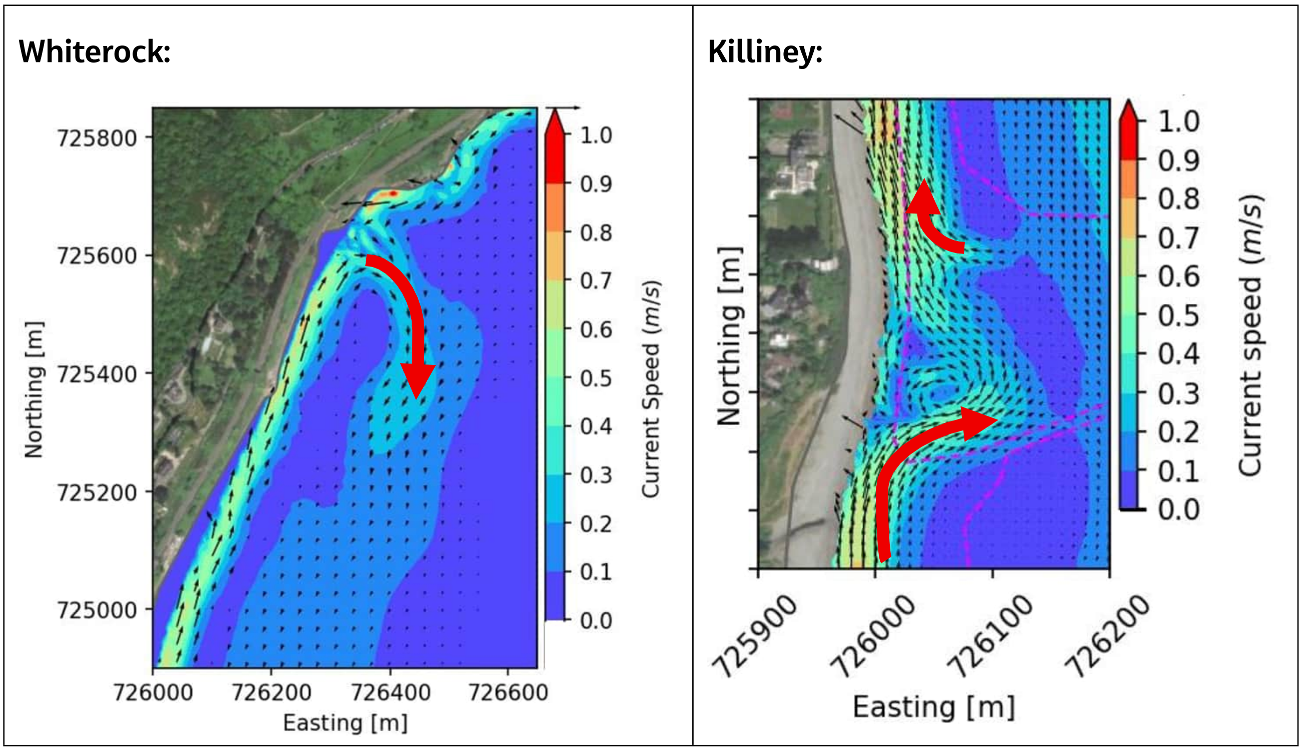

Figure 3-7: Modelled currents(both tide and wave driven) at Whiterock and Killiney 2 hours before high water under the most representative wave conditions ('wave T' - 2.83m wave height, 7.3 second period and 185 degree direction; Jacobs 2025a). Red arrows highlight seawards and landwards flowing currents near the shoreline.

3.2 Coastal sediment dynamics

3.2.1 Sediment size

Coastal sediment sampling and grain size analysis was undertaken previously at the sites shown in Figure 3-8 by Arup (2020b). The results indicated that for sites 2 and 3 at Killiney, the emerged sediment at the northern site 2 (726024E, 725057N) had median sediment size (D_{50}) of 12.8-14.8 mm, classified as medium gravel, whereas further south at site 3 (725950E, 724075N), the emerged sediment had a larger D_{50} of 16.1mm, classified as coarse gravel (Arup, 2020a).

Samples were taken from the submerged part of the beach at 25m intervals seaward from the initial co-ordinates listed above. The submerged sediment sampled at chainages of 50m, 75m and 100m had a D_{50} of 0.65-7.7mm at the northern site 2, and a D_{50} of 0.56-6.0mm at the southern site 3, both of which ranged from coarse sand to fine gravel.

This data suggests that sediment on the emergent upper beach is generally coarser than the lower submerged beach and sediment is generally coarser in the south than in the north of the Killiney frontage.

This aligns with observations during a site visit in February 2025 which found a gravel upper beach and sandy lower beach across the Killiney frontage; however, interstitial sand amongst the gravel was observed just below the surface, indicating poorly sorted sediment (Figure 3-9). The upper gravel beach is likely to likely to be rarely exposed to waves that would sort the material, and instead the sand is likely to have accreted in episodic storms that tend to deposit material rapidly, before it can be sorted. This interstitial sand on the upper beach can make the beach sediment prone to 'cliffing' during high wave energy conditions, which was observed in some locations during the site visit.

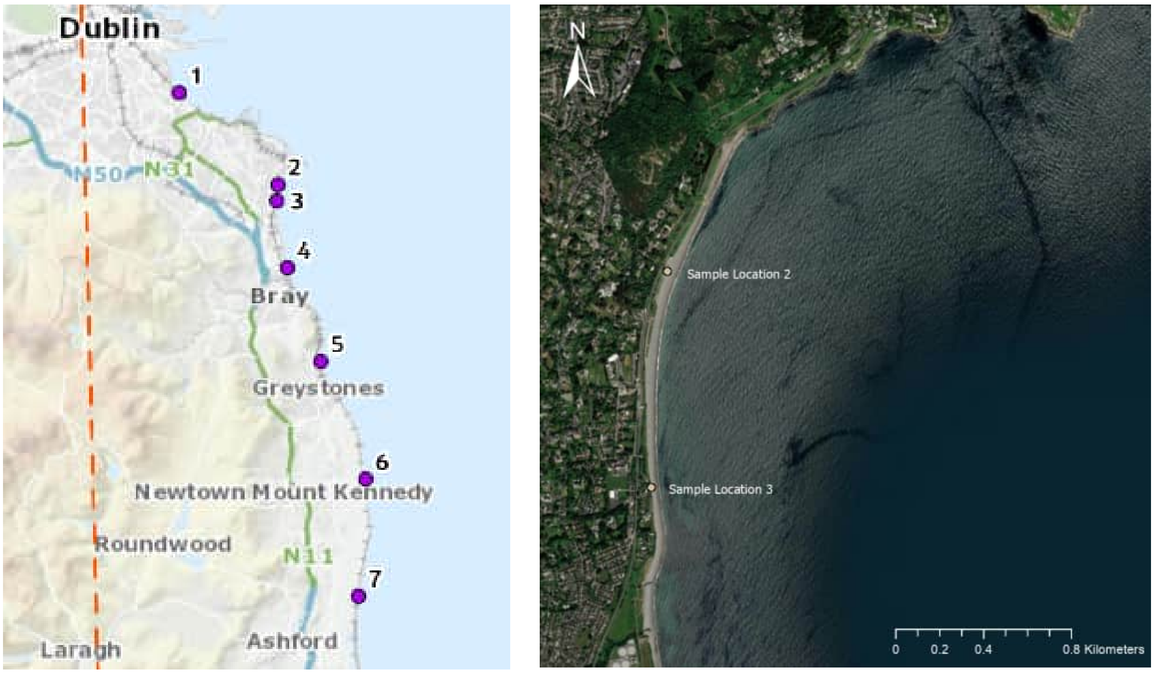

Figure 3-8. Sediment sampling locations (Arup, 2020b) across the whole ECRIPP frontage (left), with a zoomed in view of sampling locations 2 and 3 at Killiney (right). *Background Imagery source: Maxar, Microsoft*

Figure 3-9: The upper gravel and lower sand beach at Killiney (left, looking south towards the train station), with interstitial sand present amongst gravel just below the surface, indicating poorly sorted beach sediment (right). *Source: Jacobs site visit February 2025.*

The volumes of coarser gravel appeared to reduce gradually moving northwards towards Whiterock, tailing off ~100m south of the rock bluff between Whiterock and Killiney Beaches, to leave a beach of lower elevation mainly comprising finer gravels and sand surrounding the bluff and at Whiterock (Figure 3-10).

This suggests there is limited longshore sediment transport of coarser gravel between Killiney Beach and Whiterock Beach, but finer gravels and sands are readily transported to Whiterock, at least during high-energy wave conditions like those experienced before and during the February 2025 site visit.


Figure 3-10: Coarser gravel tailing off at the northern end of Killiney beach (left) with mainly finer gravel and sands at Whiterock (right). *Source: Jacobs site visit February 2025.*

3.2.2 Sediment transport modelling

Three phases of coastal sediment transport modelling have so far been completed by Jacobs for ECRIPP.

The Phase 1 modelling (Jacobs 2023) used a two-dimensional spectral wave model to derive multi-decadal hourly time series of nearshore wave data along the East Coast of Ireland and used this to drive a process-based littoral drift model (LITDRIFT) to estimate longshore sediment transport and predict future shoreline positions.

The Phase 2 coastal modelling (Jacobs 2024) improved on the Phase 1 modelling work to further refine future coastline predictions. The Phase 2 modelling used a shoreline evolution model (LITLINE) to estimate present longshore sediment transport and how this may change over the coming decades.

The results of the Phase 2 sediment transport modelling for CCA2-3 showed that net annual sediment transport from Whiterock beach to Killiney beach varies alongshore due to changing shoreline orientation. The net annual sediment transport is generally northwards between a point c. 700 m south of the Killiney station to Whiterock beach, except for ~300 m section where the net annual sediment transport is southwards in the next ten years. From the Shanganah Bray wastewater treatment plant to about 700 m south of Killiney station, the net annual sediment transport is predicted to be southward. This causes a convergence of alongshore sediment transport directions which is likely driving the accumulation of beach sediment evident where the shoreline protrudes outwards north of the treatment plant.

The Phase 3 coastal modelling for CCA2/3 (Jacobs 2025a) then further improved on both the Phase 1 and 2 modelling work to incorporate morphodynamic feedback (the effect of changes in foreshore and nearshore elevations on sediment transport), the effect of the rocky shore platform, and address potential previous overestimations of the cross-shore element of sediment transport in future. This helped to refine the magnitudes of sediment transport occurring across the Killiney and Whiterock frontages. Full details are provided in the Phase 3 modelling report (Jacobs 2025d). The results of this Phase 3 sediment transport modelling refined the estimation of future beach and shoreline evolution both in the short term and in the medium-longer term (50 years) under climate change, which is discussed in Section 4.

Sediment transport modelling has not been undertaken at the northern end of CCA2/3 between Whiterock Beach and Dalkey as this area is generally rocky with very little mobile sediment.

3.2.3 Seabed sediments and bedforms

In addition to the numerical modelling of sediment transport discussed above, seabed sediment mapping (INFOMAR, 2024) and bathymetric mapping data (INFOMAR 2025) have been reviewed to validate the results of the modelling and to enhance understanding of the wider coastal sediment system in the nearshore and offshore zones. The spatial distribution of different types of seabed sediment, variations in seabed elevations and the positioning and alignments of bedforms has been interpreted to provide observed evidence of potential sediment transport patterns and to identify any possible nearshore/offshore sediment sources, stores and sinks.

The seabed sediment mapping indicates that sediments offshore of Killiney and Whiterock comprise rock, sand, cobbles, and mixed sediment reflecting erosion and reworking of mixed glacial sediment during the Holocene marine transgression to form coarse lag deposits and contemporary transport of fine-grained marine sediment to form bars (Figure 3-11). A shore-parallel strip of exposed rock near the shore along the Killiney frontage indicates that bedrock is close to the seabed here, with little or no overlying mobile sediment (pink strip in Figure 3-11 and pink oval in Figure 3-12). This suggests there may be limited cross-shore sand and gravel transport between the beach and the nearshore zone at Killiney under ambient conditions, with beach sediment mainly transported alongshore within the littoral zone.

However, further seawards of this exposed rock, the mapping indicates a wider band of mixed sediment around 500-750m offshore (brown area in Figure 3-11), and the shore-parallel bedforms in this zone are indicative of gravel/sand ridges (green oval in Figure 3-12). These may be relict features as their distance offshore mean they are not likely to be currently influenced by any wave action under most conditions. However, their presence does suggest that there is potential for some cross-shore transport of both sand and gravel between the beaches and the nearshore / offshore zone under very high energy wave conditions.

These seabed datasets also indicate there may be greater potential for cross-shore sediment exchange at Whiterock than Killiney because:

a) the strip of uneven bed visible indicative of bare rock stops ~500m north of Killiney Station (Figure 3-12) and gravel ridges are faintly discernible instead, suggesting the exposed rock dips below the seabed towards Whiterock and becomes covered by a thicker sequence of mobile sediment

b) the -10m seabed contour juts seaward around a mound ~1km offshore of Whiterock Beach (red cross in Figure 3-12) which appears to be a bank of mobile sediment rather than a rock bluff as it has gravel/sand bedforms rather than an uneven rocky surface.

The existence of a popular surf break at Whiterock (observed during the site visit) also supports this notion that there are nearshore sand and/or gravel banks here that may feed (and be fed by) cross-shore sediment transport.

These observations, identified in both measured seabed data and anecdotal accounts of surf breaks, agree with the results of the Phase 3 current modelling (Jacobs 2025a; discussed in Section 3.1.3) and suggest that sediment is likely to be transported from the beach seawards by the rip current to feed nearshore banks.

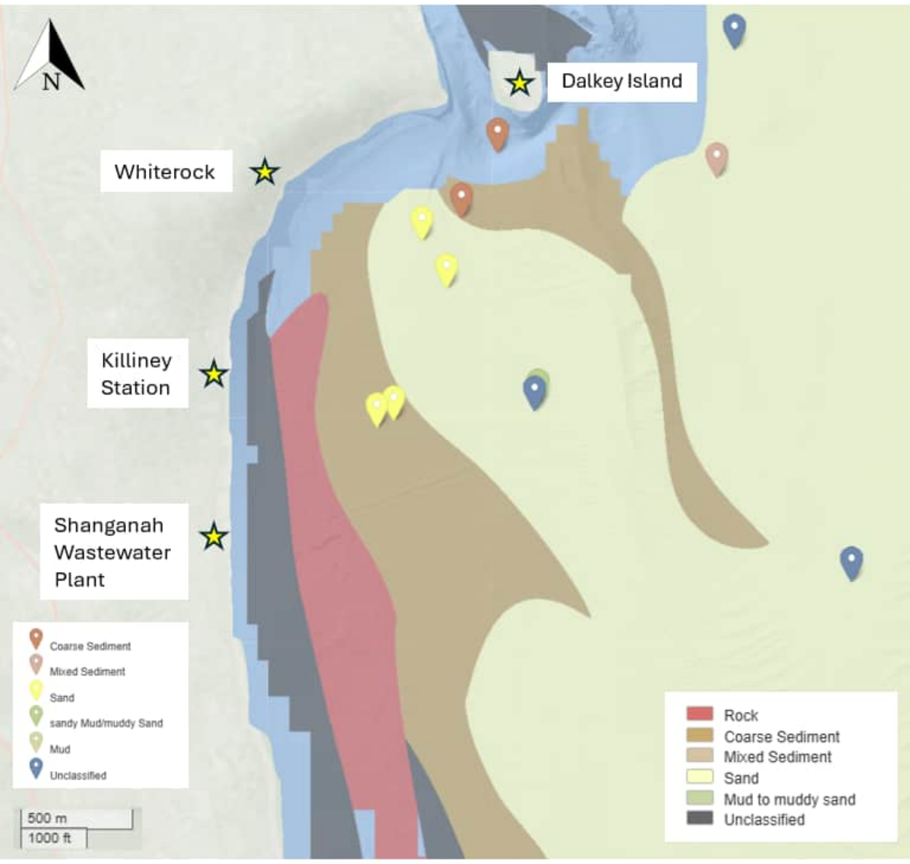

Figure 3-11. Seabed sediment map. Source: Adapted from INFOMAR (2024)

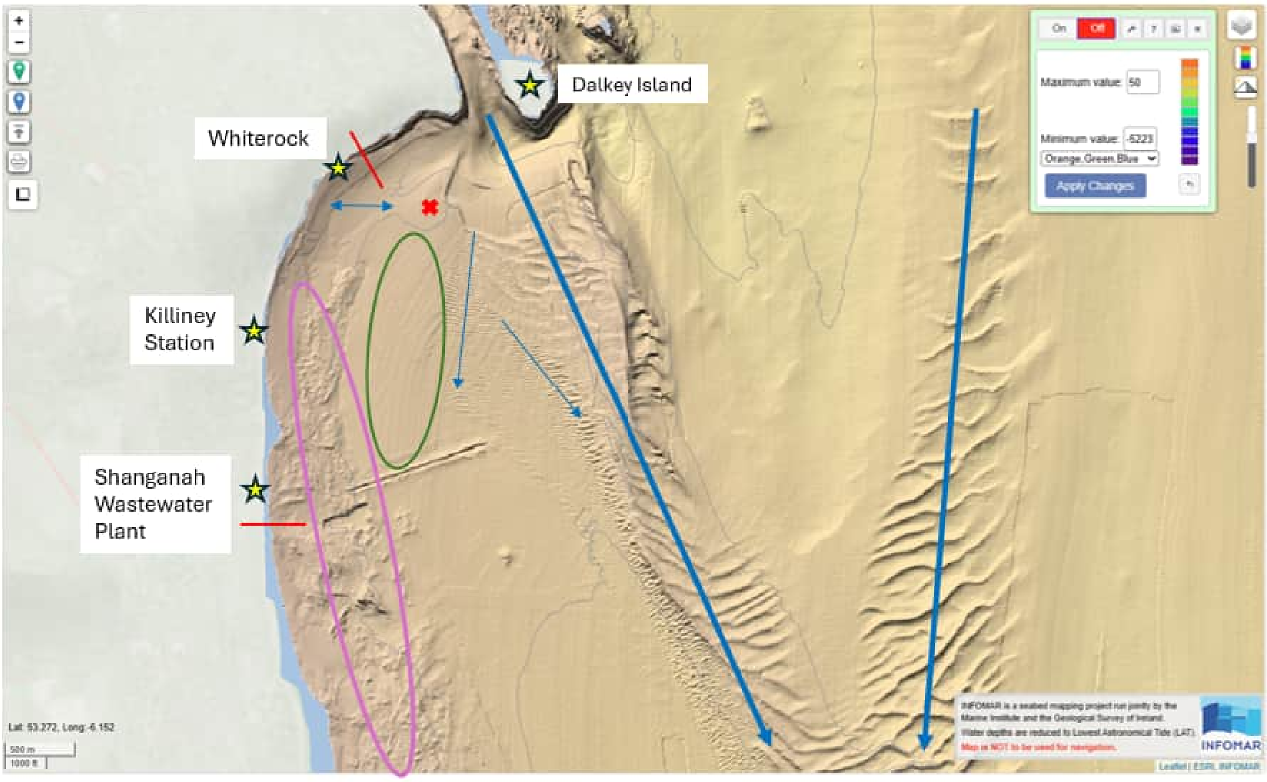

Figure 3-12. Bathymetric mapping, with red lines indicating site extent, blue arrows indicating sediment transport directions inferred from bedforms, and other notable features/processes annotated by coloured shapes described in the text. Source: Adapted from INFOMAR (2025).

3.3 Coastal geomorphology

3.3.1 Beaches

To assess beach morphology and how it changes over time at Killiney and Whiterock, beach profile data has been sourced by extracting cross sections from photogrammetry-derived elevation data at various locations along CCA2/3 shown in Figure 3-13. The data used for this analysis was from three recent surveys covering a very short 13 month period:

- 29 September 2023 – Murphy Surveys drone photogrammetry survey at North Killiney and Whiterock;
- 26-29 October 2023 - Murphy Surveys 'post-storm' drone photogrammetry survey across the whole of CCA2-3 following the easterly Storm Babet in mid-October;
- 4 October 2024 - Murphy Surveys drone photogrammetry survey at South Killiney.

Beach elevations were also initially extracted from 2011 LiDAR survey data sourced from the Office of Public Works (OPW) for comparison with the above surveys. However, there were erroneously large differences in elevation between the OPW and Murphy datasets, which cannot be easily explained. The LiDAR was therefore excluded from this analysis misinterpretation of beach changes. This limits this assessment to the characterisation of the beaches' short-term response to storms.

Figure 3-13. Location of beach profiles extracted from drone photogrammetry surveys. ***Background imagery: Maxar, Microsoft***

The beach profile data extracted is graphed in Figure 3-14 to Figure 3-17.

The two surveys available at Profile B1 at Whiterock (Figure 3-14) and Profile B4 at North Killiney (Figure 3-15) were captured approximately 2 weeks before and after easterly Storm Babet, so comparing these provides an indication of how the beaches here respond to storm conditions. Both profiles B1 and B4 show that on the upper profile between Highest Astronomical Tide (HAT; 1.99mODM) and Mean Sea Level (MSL; -0.11m ODM) there was generally 0.2-0.5m beach lowering, whereas on the lower profile seaward of MSL, there was up to 1.2m accretion. This indicates seawards transport of beach material during storm conditions here, and indicates that sediment is capable of being transported alongshore across the lower profile, seawards of the rock bluff, between North Killiney and Whiterock Beach.

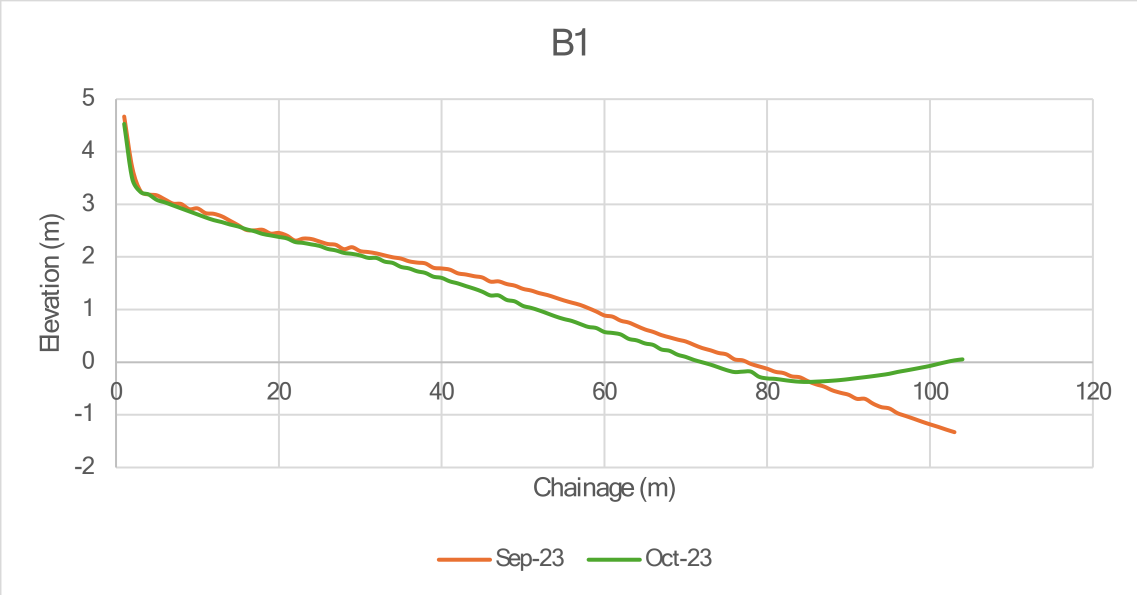

Figure 3-14. Beach profiles extracted from Murphys drone photogrammetry surveys at location B1 at Whiterock Beach

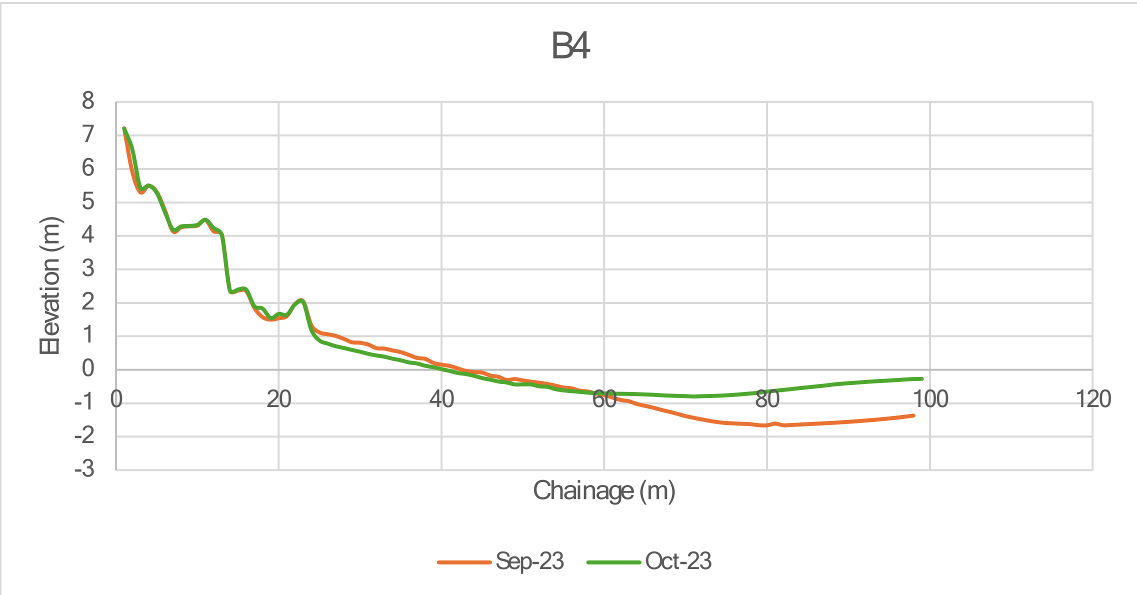

Figure 3-15. Beach profiles extracted from Murphys drone photogrammetry surveys at location B4 near the rock bluff between Whiterock Beach and Killiney Beach.

At South Killiney there was no pre-Storm Babet data available as the Sept-23 drone survey was erroneous in this location and had to be re-flown in September 2024; therefore it was only possible to compare the Oct-23 (post-storm Babet) survey and the Sept-24 data at Profile C3 (Figure 3-16) and D1 (Figure 3-17). This comparison provides an indication of how the beaches recover following storm conditions and also how they vary year to year.

The C3 and D1 profiles show that there was generally ~0.2m accretion across the upper beach to MSL between October 23 and September 2024, with up to ~1m accretion of a beach berm feature at C3.

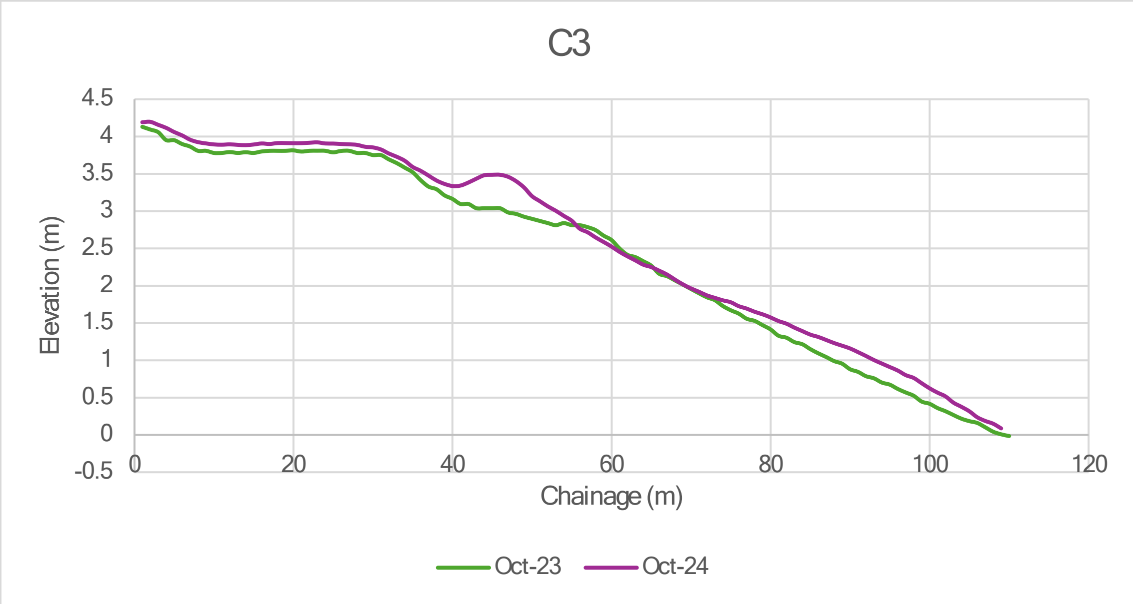

Figure 3-16. Beach profiles extracted from Murphys drone photogrammetry surveys at location C3 north of Killiney Station

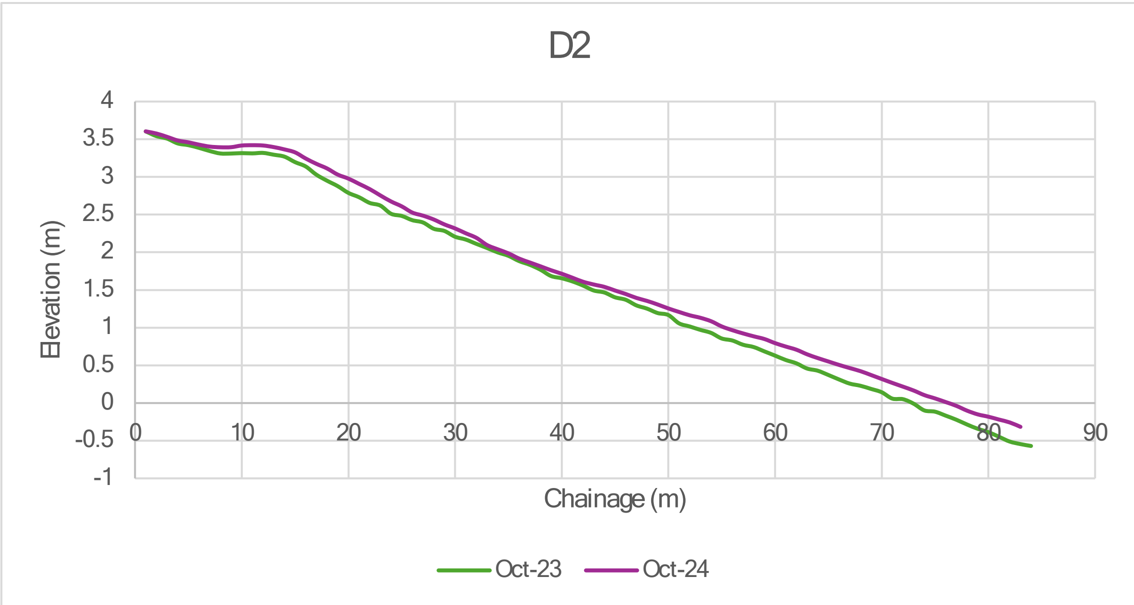

Figure 3-17. Beach profiles extracted from Murphys drone photogrammetry surveys at location D2 south of Killiney Station

3.3.2 Cliffs

With the exception of the Shanganagh-Bray water works frontage, which is characterised by a low alluvial plain, the CCA2/3 frontage is formed in cliffs. The cliffs at the northern end of the study area north of Whiterock are composed of granite, whereas at the southern section, between lower Whiterock and Shanganah Water treatment works, the cliffs are formed in glacial sediments (Rijsdijk et al. 2010; Geological Survey Ireland, 2025).

The granite cliffs are generally resistant to erosion and instability, but are characterised by a series weaker zones associated with joints or faults that have been preferentially eroded to form gullies. The railway spans these areas with a series of masonry structures.

The glacial sediment cliffs are much weaker, but rarely experience erosion. The cliffs tend to be sub-vertical and fronted by a vegetated debris slope ('talus') formed by periodic erosion of the cliff, predominantly by wind, rain and groundwater seepage.

Figure 3-18: Cliffs at the northern end of CCA2-3 near Whiterock (left) and further south near Killiney Station (right)

Jacobs (2023a) mapped historical cliff top positions to assess the historical rates of change. This was achieved using georeferencing OSI maps from 1830, 1900 and 1940, and aerial imagery from 1995, 2000, 2005, 2012, 2017, mapping the cliff features and then analysis using the Digital Shoreline Analysis System (DSAS) GIS tool to calculate change rates. Georeferencing error was calculated for each epoch of data and incorporated in the results, which are presented in Figure 3-19.

This analysis showed that no change can be detected above the error for the cliffed sections of the frontage since the 1830s. Erosion of the alluvial plain at the Shanganagh water works is indicated, which is known to have caused Irish rail to reroute the railway to its current inland route in the early 20th Century.

The general absence of cliff recession reflects the sheltered and low energy frontage, the long term protective effect of the beach at Killiney and the resistance of the cliffs at Whiterock to erosion. Future cliff recession is strongly dependent on the persistence of the beach with rising sea-levels.

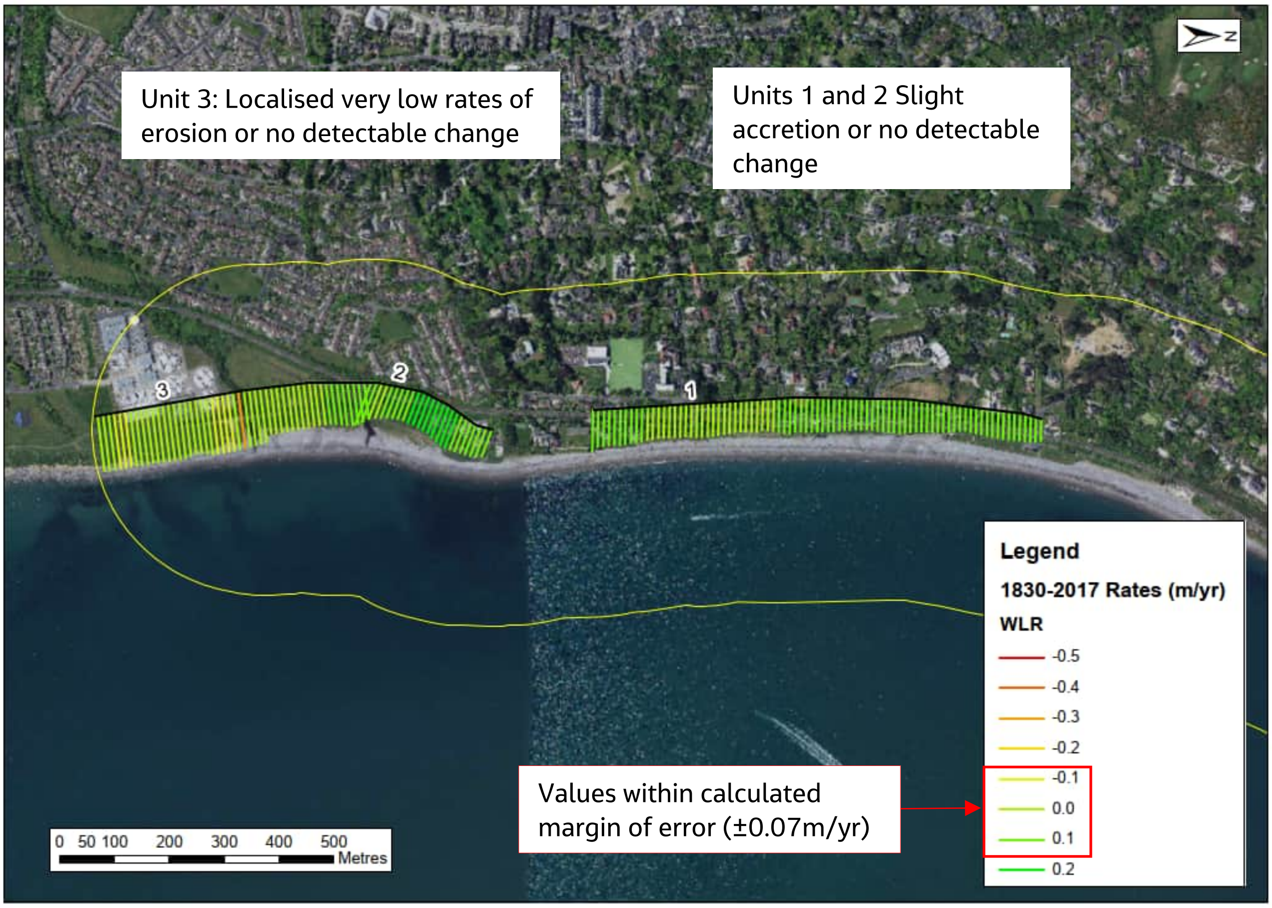

Figure 3-19. Cliff recession data from historical maps and aerial photos (Jacobs 2023a)

4. Potential future coastal evolution without proposed works

This section assesses how the coastal processes and geomorphology at Killiney and Whiterock may evolve in future if the proposed ECRIPP works do **not** take place. Open coast systems can be very dynamic over time, particularly with climate change, so the coastal conditions at this site are likely to change and evolve in future, regardless of whether new structures are built or not. Therefore, it is important to assess any potential impacts of the proposed ECRIPP works in the context of *changing* background conditions in future, rather than only comparing potential impacts to *present* coastal conditions.

The Phase 3 coastal modelling used detailed simulations of local hydrodynamics and sediment transport processes to estimate future beach volume changes over time across the Killiney and Whiterock frontages in the ‘baseline’ case - i.e. no changes to the coastal structures - but accounting for future climate change projections.

The results indicated that for both current conditions and with future climate change, there will generally be a natural tendency for net beach erosion at South Killiney along the extent of Strand Road. The Phase 3 modelling suggested a ~10m landwards beach recession by 2075 at the southern extent of the proposed ECRIPP works, increasing southwards to 50m where the shoreline currently protrudes seawards near the southern end of Strand Road (Jacobs, 2025a).

North of Strand Road to Killiney Station, the modelling indicated a net trend of beach accretion in the medium-long term, which could result in ~30-40m widening of the beach here by 2075 (Jacobs, 2025a). These modelling results suggest a tendency for the beach to straighten in future, with the accumulation of sediment currently present near the southern end of Strand Road being redistributed northwards.

In terms of short-term beach response to episodic storm events, cross-shore beach profile evolution modelling using Xbeach-G indicated that there could be a further 0.4-0.95 m lowering of beach elevations due to sediment drawdown by storm waves along the Killiney frontage, independent of any longer term erosion/accretion trends (Jacobs, 2024).

Future beach volume changes and beach storm response under the baseline scenario were not modelled at Whiterock, but the Phase 2 shoreline evolution modelling indicated that Whiterock beach would erode over the next 25-75 years, possibly causing the beach to be completely lost and causing the existing seawall to be undermined. If no works were undertaken to protect and stabilise the seawall at Whiterock, it would eventually fail and the rocks/soil from the steep slope that it retains would collapse onto the beach, along with debris from the railway track at the top of the slope. This would cover the upper part of the beach and could significantly reduce beach widths, beach access, beach amenity and public safety at Whiterock.

5. Potential impact of proposed works on coastal processes and geomorphology

5.1 Summary and extent of proposed works

The alongshore extent of ECRIPP works proposed to protect the coastline and infrastructure at Killiney and Whiterock are shown in Figure 5-1 and include:

- Installing a new rock revetment in front of the existing seawall to manage the risk of instability of the cliffs/slopes that support the railway line (areas B2 and B4)
- Installing a new raised walkway with steps down to the beach (areas C3, C4) plus a rock toe at the southern end (D1).

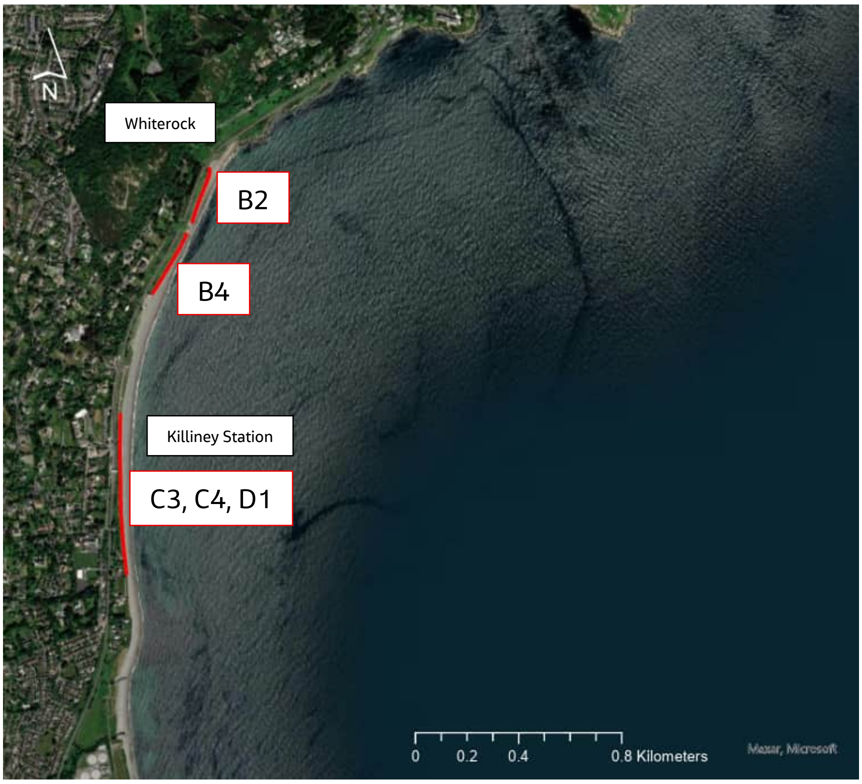

Figure 5-1. Locations of proposed works (red lines show extents). *Background Imagery source: Maxar, Microsoft.*

5.2 Potential impact of works at Whiterock and North Killiney (B2 & B4)

A typical cross section of the rock revetment proposed for Whiterock and North Killiney is shown in Figure 5-2 and a general arrangement plan is provided in Appendix A.

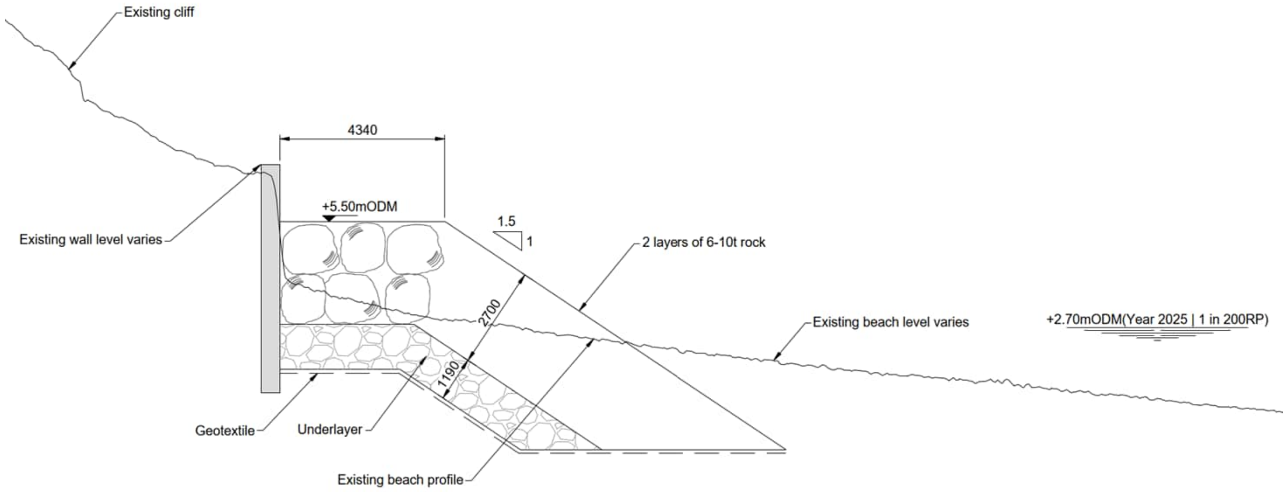

Figure 5-2: Typical cross section of proposed works at Whiterock and North Killiney (B2 & B4)

The proposed rock revetment will extend further seawards than the existing rock present at the base of the seawall. As the toe of the new revetment will be buried underneath the existing beach level, the exposed width of the structure will vary depending on the variable beach levels, but if it were to be entirely uncovered its footprint would extend 13-15m seaward from the existing wall.

5.2.1 Impacts on hydrodynamics

Currents: To the north of the proposed revetment, where there is an existing tendency for a rip current to form during certain wave conditions (see Section3.1.3), the Phase 3 coastal modelling (Jacobs 2025a) indicated that it would not increase the maximum speed of the rip current generated under the worst-case wave and tide conditions (Figure 5-3). Instead the modelling suggests there could be a minor decrease (<5%) in the maximum speed of this rip current from ~0.48m/s to 0.46m/s (Figure 5-3), but a change of this magnitude is unlikely to cause any notable decrease in seawards sediment transport, so impacts on sediment feed to the nearshore banks are likely to be negligible.

Despite negligible changes in current speeds, the modelling showed that the new revetment may cause a ~20-30m northwards shift in the *location* of this the rip current under the worst case conditions of 185 degree wave approach (Jacobs, 2025a). However, this change is within the present range of natural variability in rip current location without the new revetment, caused by natural variations in wave direction, as indicated by modelling of different wave directions +/- 10 degrees from the185 degrees approach (Figure 5-3).

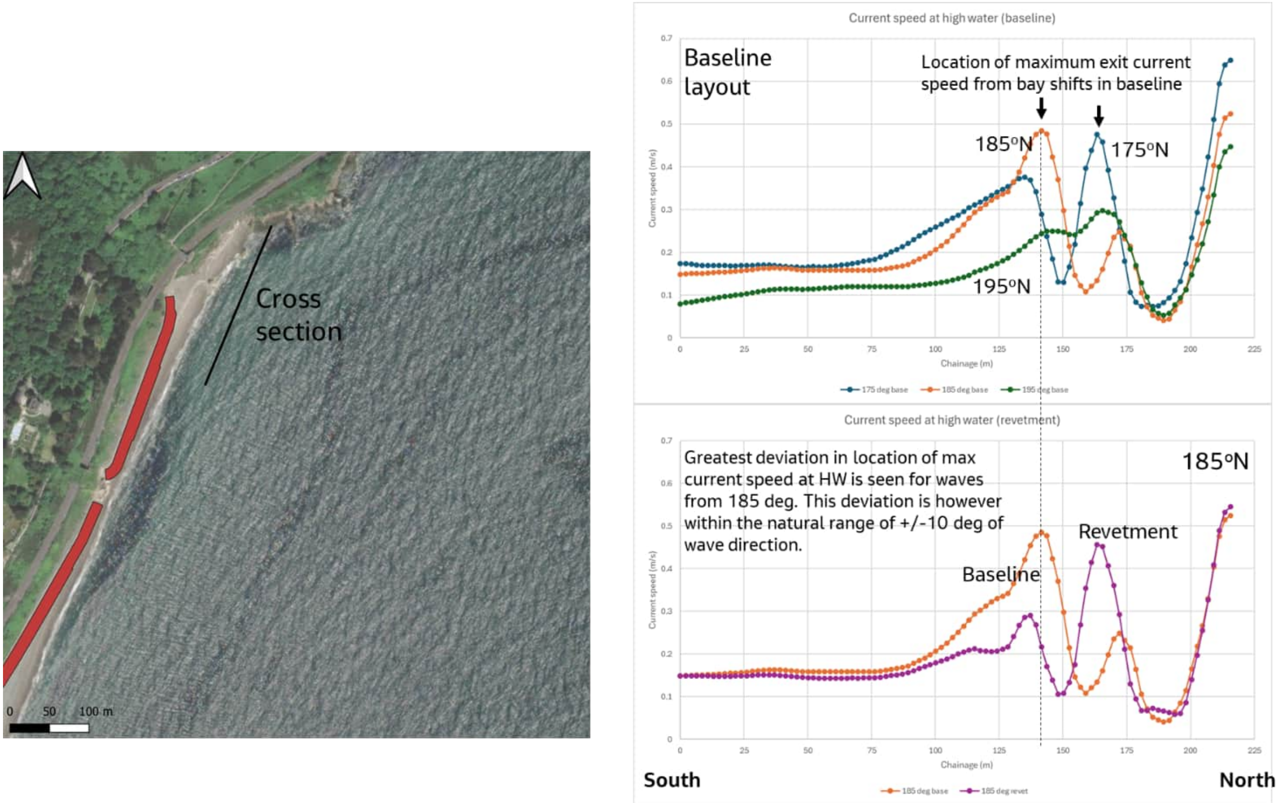

Figure 5-3: Cross section of modelled current speeds at Whiterock for waves from 175, 185 and 195 degrees without the new revetment (graph on top right), and with vs without the new revetment for waves from 185 degrees (graph on bottom right) (Jacobs 2025a)

Waves: Regarding wave energy reaching the shoreline, the new revetment will locally enhance wave energy dissipation at the top of the foreshore when water reaches the structure at high tide (as it is designed to, to protect land/structures behind) due to the sloped angle of the revetment, high surface roughness of the rock and the gaps between the rock.

Regarding waves further seaward in the surf zone off Whiterock Beach, the Phase 3 coastal modelling (Jacobs 2025a) indicates that any changes in sediment transport and deposition due to the change in rip current location discussed above would have a minor change (<0.1m) in wave heights in the surf zone and no significant impact on wave breaking location under all wave conditions modelled.

5.2.2 Impacts on sediment dynamics and geomorphology

In terms of impacts on **cross-shore** sediment transport, this enhanced dissipation of wave energy by the new rock revetment should reduce scour of beach sediment directly beneath and immediately in front of the revetment, allowing beach sediment to be better retained in the gaps between the rock. There may be very localised scour around induvial rocks at the base of the revetment, but this is likely to be limited to a few centimetres around each rock.

Although the modelling suggests there could be a minor decrease (<5%) in the maximum speed of the seawards flowing rip current at Whiterock from ~0.48m/s to 0.46m/s (Figure 5-3), a change of this magnitude is unlikely to cause any notable decrease in seawards sediment transport, so impacts on sediment feed to the nearshore banks are likely to be negligible.

In terms of impacts on **longshore** sediment transport, the new revetment would locally decrease the area of upper beach across which sediment can be transported alongshore a few hours either side of high tide. This has the potential to reduce the alongshore sediment feed to Whiterock Beach. Initial modelling of sediment transport in Phase 3 suggested that this reduction in northwards sediment transport caused by the revetment could be in the order of 20-30% for three southerly wave directions tested (175, 185 and 195 degrees; Jacobs, 2025a). Although the new rock revetment would cover a relatively small proportion of the littoral zone for a limited duration a few hours either of high tide, the estimated magnitude of this reduction is because modelled longshore transport rates are highest on the upper beach where the new revetment would sit, due to the steeper beach slope and greater sediment depths landward of the natural rock platform.

However the magnitude of this reduction is considered likely to be an overestimation, and the effect of the revetment on sediment transport northwards to Whiterock Beach is considered likely to be smaller than this modelling suggests because:

- the modelling does not account for the presence of the existing rock revetment on the upper beach here (Figure 5-4), which will limit sediment availability and transport under the existing conditions of the baseline case, particularly under storm conditions when beach drawdown exposes more of this rock.
- the modelling does not account for the observed decrease in sediment size at Whiterock compared to North Killiney (see Section 3.2.1), which suggests that coarse gravel is not readily transported to Whiterock Beach, even under the high energy south-easterly wave conditions before and during the site visit when this was observed. The sediment reaching Whiterock beach tends to be finer gravels and sands, which on is more prevalent on the lower profile at North Killiney, which will be unaffected by the rock revetment. Based on the general arrangement plan in Appendix A, there would still be at least 10-30m width of mobile beach between the revetment toe and the natural rock platform across which longshore transport of these finer gravels can continue towards Whiterock beach.
- the modelling does not directly account for onshore sediment feed onto Whiterock Beach from the nearshore sand banks (see Section 3.2.3) during ambient ‘beach building’ wave conditions, which would be unaffected by the new rock revetment.
- the modelling does not include cross-shore sediment transport processes (to avoid the previous overestimation of seawards transport - see modelling report for explanation; Jacobs 2025a); however, this may mean that this modelling underestimates the influence of storm-driven drawdown of beach material to the lower beach. The pre- and post-storm beach profiles at North Killiney (B4) and Whiterock (B1; Section 3.3.1) provides evidence of this drawdown of sediment to below MSL occurring here, increasing sediment availability on the lower beach where it could be transported northwards to feed Whiterock beach, unimpeded by the new rock revetment higher up.

Further modelling for detailed design will aim to address these factors to refine the estimated impact of the new revetment on sediment transport to Whiterock Beach, and any potential implications of this on beach widths.

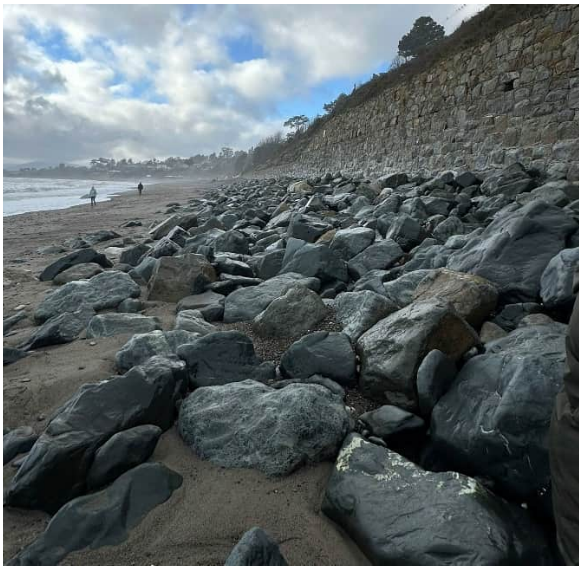

Figure 5-4: Existing rock revetment covering the upper beach at North Killiney (left) and Whiterock (right).
Source: Jacobs site visit February 2025.

In terms of impacts on beach morphology, if Whiterock beach lowers due to sea level rise and most/all of the new rock revetment becomes exposed, then the presence of the new revetment would have a direct impact via a reduction in beach widths, irrespective of its effects on sediment transport. However, this would likely be equivalent to, or less than, the beach width reduction caused by collapse of the existing seawall and embankment onto the beach if nothing is done to protect the existing wall from undermining in future (as discussed in Section 4).

5.3 Potential impact of works at South Killiney (C3, C4 & D1)

Typical cross sections of the raised walkway and revetment proposed for South Killiney are shown in Figure 5-5.

A raised walkway and stepped revetment are proposed for locations C3 and C4, and at D1 there is also a buried rock toe proposed in front of the sheet pile beneath the stepped revetment.

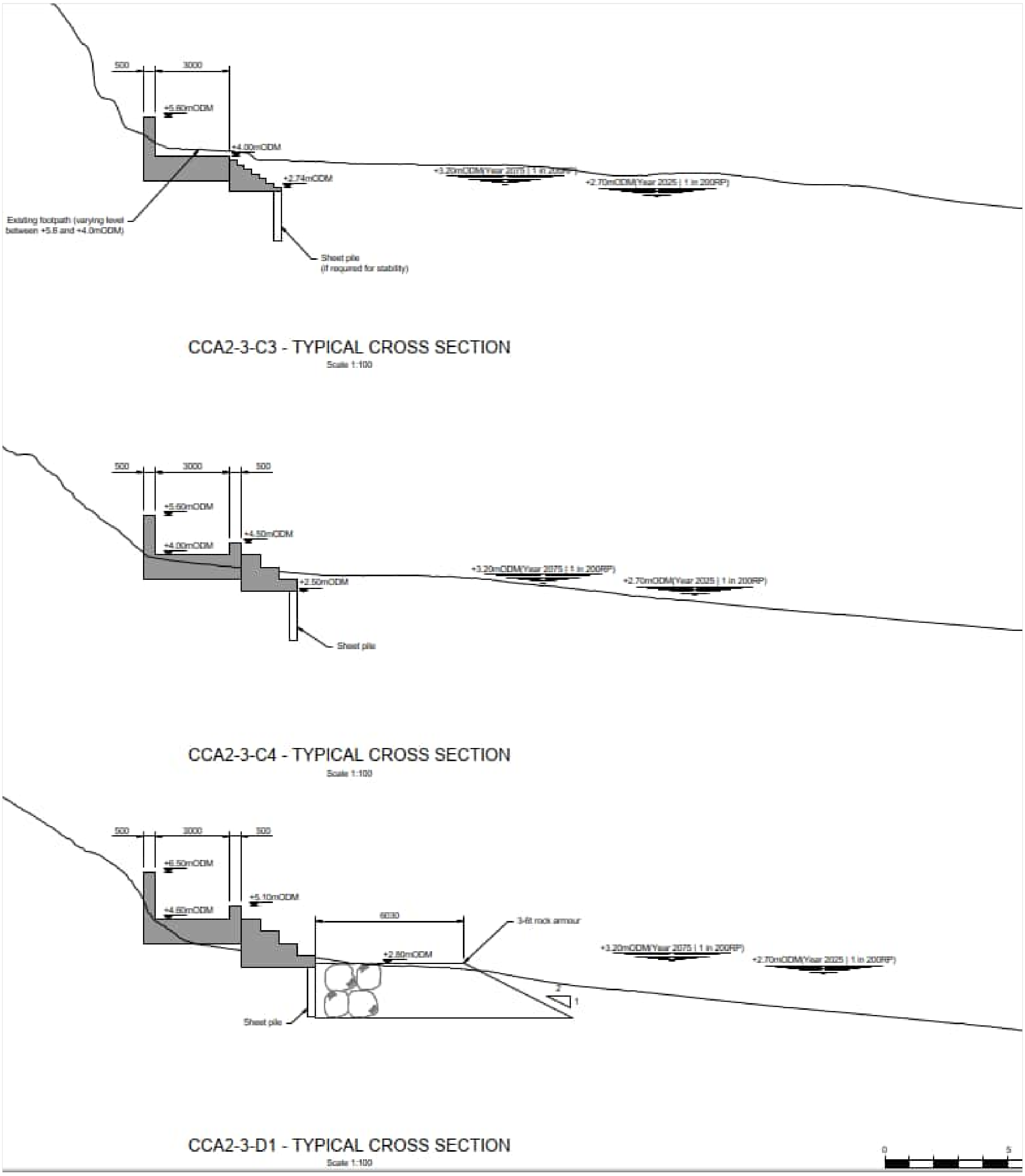

Figure 5-5: Typical cross section of proposed works along frontage CCA2/3-B

5.3.1 Impacts on hydrodynamics

Along most of the South Killiney frontage, there would be a wide beach in front of the proposed structures, and the exposed part of the steps/revetment would lie several metres landward of the normal limit of high tide and wave runup. Therefore, under ambient conditions the structures would not interact with or impact coastal processes if beach levels remain relatively stable.

Coastal modelling indicates that under present-day storm conditions, the beach in front of the new structures at locations C3 and C4 would remain wide enough to prevent waves from reaching the new stepped revetment (Jacobs 2025b), therefore would still have no effect on local hydrodynamics. However in future, Computational Fluid Dynamics (CFD) modelling shows wave runup reaching and overtopping the proposed structures under the 1 in 200yr return period storm in 2075 with climate change (Jacobs 2025b). The presence of the hard structures at the top of the beach may then cause greater wave energy reflection compared to the cliff base, but the sloped profile of the stepped revetment should limit this effect and minimise any associated scour of beach sediment at the base of the defences.

Further south at location D4, the modelling indicated that there would be greater potential for beach drawdown under storm conditions here. The additional rock toe proposed for this location would then locally dissipate wave energy reaching the base of the structure, as it is designed to, so is likely to have a negligible impact on scour and currents.

5.3.2 Impacts on sediment dynamics and geomorphology

In terms of sediment supply, although the structures would be installed at the cliff toe, they are not likely to affect sediment supply from the cliffs to the beaches because the cliffs are not currently contributing sediment to the beaches. This is based upon the following evidence:

- analysis of historical cliff top positions has shown no change in 150 years;
- the heavily vegetated talus at the toe of the cliffs indicates that there has not been any erosion of the cliff toe in recent years;
- the cliffs primarily comprise fine-grained sediments, so even they were to be reactivated and eroded in future, the eroded fines would be transported away in suspension and any volumes of coarser material released suitable for beach building would be negligible.

In terms of sediment transport, waves and water levels are only likely to reach the new structures under storm conditions with future climate change (as outlined above), so their effect on sediment transport will be limited to episodic storm events. The sloped profile of the revetments and proposed rock toe at location D4 (Figure 5-5) should minimise scour of beach sediment directly below and adjacent to the structure during storm conditions, which could reduce seawards gravel transport from the very top of the beach. However, this effect is likely to be small relative to the volumes of sediment moved seawards along the rest of this coast because (a) it is limited to a localised area under the footprint of the new structure, and (b) would be limited short duration and low frequency storm events.

In terms of impacts on beach morphology, the presence of the new revetment would have a direct impact by locally reducing the width of the mobile beach widths; however this effect would be small relative to the remaining beach widths, as structures would only extend ~5m seawards from the cliff toe relative to an existing minimum beach width of 40-70m at high tide, and over 100m at low tide. Indirect impacts on beach morphology via altering of sediment processes would also be negligible due to the limited effects on sediment dynamics discussed above.

6. Summary

The key outcomes of this assessment of potential impacts of proposed coastal defence improvements on coastal processes and geomorphology at Killiney and Whiterock are summarised below.

Whiterock and North Killiney:

- **Hydrodynamics:** Any changes in waves and currents caused by the proposed rock revetment are likely to be small, limited to a local enhancement of wave energy dissipation at the top of the foreshore when water reaches the revetment at high tide, small shifts in the locations of rip currents during storms, and minor (<5%) decrease in rip current speeds.

- **Sediment dynamics:** The new rock revetment is likely to have a negligible effect on *crosshore* sediment transport to nearshore banks. The new rock revetment would locally decrease *longshore* transport of sediment, but only at the very top of the beach for a limited duration a few hours either side of high tide. Modelling suggests that this may reduce the overall longshore sediment feed to Whiterock Beach by 20-30%; however this reduction is likely to be smaller than the modelling suggests due to some overestimations in the modelling (detailed above), some of which could be addressed by further modelling for detailed design.
- **Coastal geomorphology**: The new revetment would have a direct impact on beach morphology via a local reduction in beach widths in front of the structure. This would likely be equivalent to, or less than, the beach width reduction caused by collapse of the existing seawall and embankment onto the beach if nothing is done to protect the existing wall from undermining in future. Any potential *indirect* effects on beach widths at Whiterock north of the new revetment due to changes in northward longshore sediment transport to are likely to be small due to the limited effects on sediment dynamics discussed above; this could be better quantified by further modelling for detailed design.

South Killiney:

- **Hydrodynamics:** Along the South Killiney frontage, modelling suggests that the beach in front of the proposed structures will remain wide enough to prevent waves and water levels reaching them under present-day ambient conditions; therefore the new structures would have no effect on local hydrodynamics where this is the case. However, in future with climate change, there would be greater potential for waves and water levels could reach the new structures under storm conditions. The sloped profile of the revetment and the rock toe proposed for location D4 would then locally dissipate wave energy reaching the structure.
- **Sediment dynamics:** The new structures are unlikely to affect sediment supply from the cliffs to the beaches principally because the contemporary supply of beach-building sediment is negligible. Any impacts on sediment transport will be limited to the southern end of the frontage at Strand Road, where they may be a local reduction in the scour of gravel from the very top of the beach directly at the structure during storm conditions; however the effect of this change is likely to be small relative to the volumes of sediment moved seawards along the rest of this coast.
- **Coastal geomorphology:** The presence of the new structures would have a direct impact by locally reducing the width of the beach; however this effect would be small relative to the remaining beach widths which are generally >100m at low tide. Indirect impacts on beach morphology via altering of sediment processes would also be negligible due to the limited effects on sediment dynamics discussed above.

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Appendix A – Phase 3 Design Drawings

Drawing No.	Title	Description
7694-CCA2_3-P3-DWG-CV-JAC-0010	SITE LOCATION PLAN	Overview of frontages between Whiterock and South Killiney
7694-CCA2_3-P3-DWG-CV-JAC-0100	LOCATION PLAN	Location of proposed works between Whiterock and South Killiney
7694-CCA2_3-P3-DWG-CV-JAC-0200	GENERAL ARRANGEMENT PLAN 1 OF 3	Location of proposed works in Whiterock
7694-CCA2_3-P3-DWG-CV-JAC-0201	GENERAL ARRANGEMENT PLAN 2 OF 3	Location of proposed works in Killiney
7694-CCA2_3-P3-DWG-CV-JAC-0202	GENERAL ARRANGEMENT PLAN 3 OF 3	Location of proposed works in South Killiney
7694-CCA2_3-P3-DWG-CV-JAC-0300	GENERAL ARRANGEMENT CROSS SECTIONS 1 OF 5	Proposed cross-sections at Whiterock (north)
7694-CCA2_3-P3-DWG-CV-JAC-0301	GENERAL ARRANGEMENT CROSS SECTIONS 2 OF 5	Proposed cross-sections at Whiterock (south)
7694-CCA2_3-P3-DWG-CV-JAC-0302	GENERAL ARRANGEMENT CROSS SECTIONS 3 OF 5	Proposed cross-sections at Killiney (north)
7694-CCA2_3-P3-DWG-CV-JAC-0303	GENERAL ARRANGEMENT CROSS SECTIONS 4 OF 5	Proposed cross-sections at Killiney (central)
7694-CCA2_3-P3-DWG-CV-JAC-0304	GENERAL ARRANGEMENT CROSS SECTIONS 5 OF 5	Proposed cross-sections at Killiney (south)