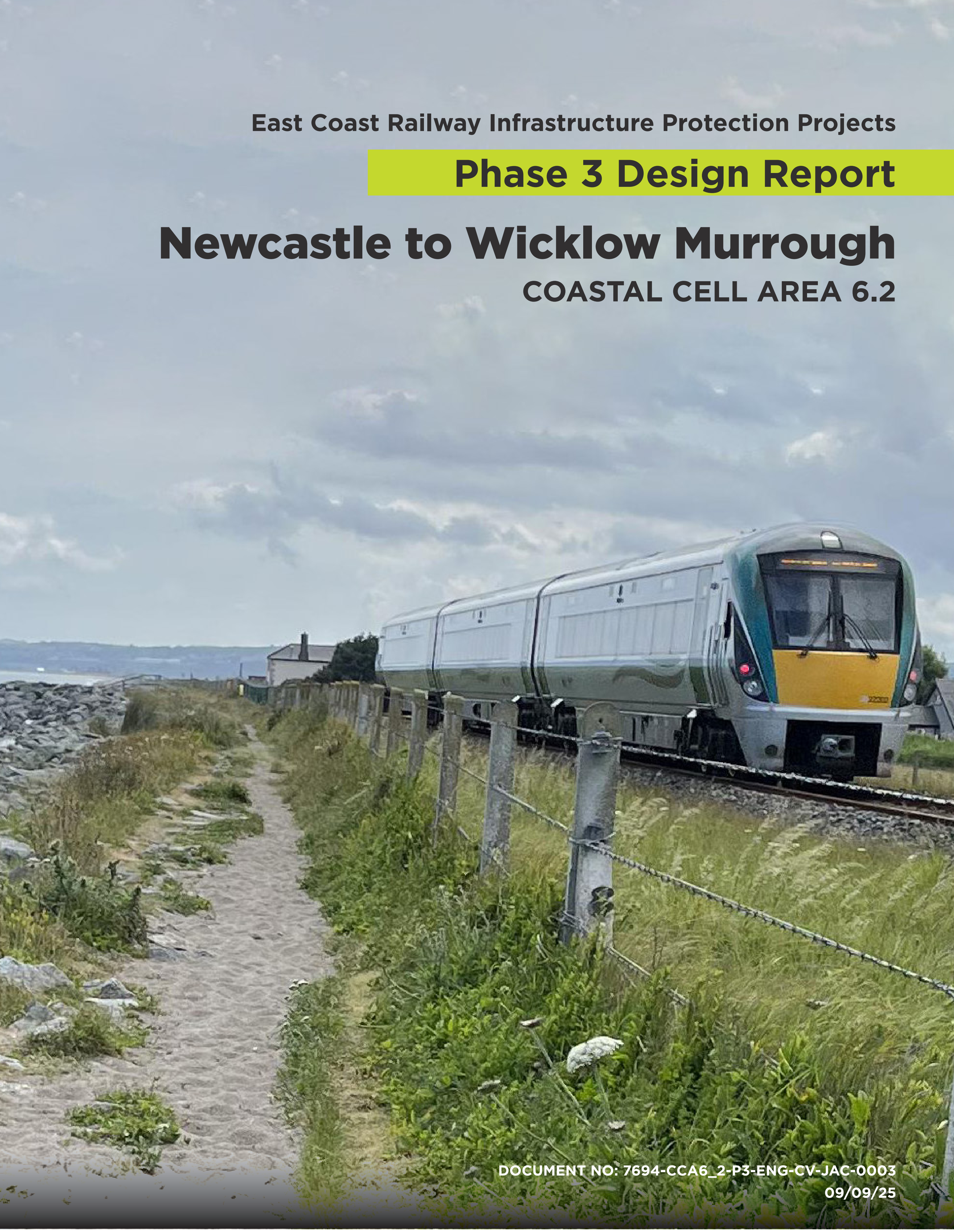
East Coast Railway Infrastructure Protection Projects

Phase 3 Design Report

Newcastle to Wicklow Murrough

COASTAL CELL AREA 6.2



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Executive summary

The East Coast Railway Infrastructure Protection Projects (ECRIPP) were established by Iarnród Éireann Irish Rail (IÉ) to provide improved coastal protection against predicted climate change effects of sea level rise and coastal erosion on the railway corridor. This project extends between Newcastle and Wicklow Murrough (the 'Project').

The Project aims to deliver improved coastal protection measures to the railway infrastructure, addressing vulnerabilities related to coastal erosion, wave overtopping and cliff instability that are projected to worsen due to climate change. To improve resilience, the Project will be designed to withstand against a1 in 200 year return period event, for a minimum of 50 years (i.e. to year 2075).

This report presents the Phase 3 designs for Newcastle and Wicklow Murrough, within Coastal Cell Area 6.2 (CCA6.2), that will subsequently inform the detailed design phase.

The Project is situated in the rural area between Newcastle and Wicklow Murrough. The objectives for the Project are to reduce the impacts of wave overtopping discharges on railway infrastructure and operations and to reduce the potential for coastal erosion undermining the railway

The existing engineering measures comprises rock revetments and long stretches of the frontage are currently undefended. Structures have been designed to address wave energy under projected sea-level rise to 2075 and 1:200 year return period storm conditions. Rock revetments are proposed for many of the currently undefended areas along the frontage.

Future adaptability has been considered during the design process. The proposed rock revetments can be adapted in future to provide additional protection to the railway through the inclusion of a set-back wall close to the railway. This additional protection could be provided by a concrete wave wall or a sheet pile wall. The proposed crest alignment for the rock revetment provides a wide buffer between the railway and the proposed revetment, leaving a corridor for future works to be constructed without compromising the revetment.

The principal construction risks identified relate to the interaction of plant on site with construction workers and the public, construction in an exposed marine environment and unforeseen ground conditions.

The next phase of the Project covers Statutory Process focussed on preparation of an environmental assessments which will comprise the preparation of an Environmental Impact Assessment Report (EIAR), Appropriate Assessment (AA) Screening Report and Natura Impact Statement (NIS).

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1. Introduction and scope

1.1 Project background

The East Coast Railway Infrastructure Protection Projects (ECRIPP) were established by Iarnród Éireann (IÉ) to provide improved coastal protection against predicted climate change effects of sea level rise and coastal erosion on the east coast railway corridor between Merrion Gates (Co. Dublin) and Wicklow Harbour (Co. Wicklow).

ECRIPP aims to deliver improved coastal protection measures to the railway infrastructure, addressing vulnerabilities such as coastal erosion, wave overtopping, and cliff instability, that are projected to worsen due to climate change. To improve resilience, the proposed works will be designed to withstand against a 1 in 200-year return period event, for a minimum of 50 years (Year 2075).

This report presents the Phase 3 design for Newcastle to Wicklow Murrough, within Coastal Cell Area 6.2 (CCA6.2) (hereafter referred to as the 'Project').

Figure 1-1. ECRIPP locations

1.2 Project location and description

The Project is situated between Newcastle and Wicklow Murrough and is approximately 8km long with works proposed for 4km of this frontage. The location of key features within the Project are shown in Figure 1-2. The trainline runs along a natural embankment at the back of the beach; this is a barrier beach feature and is soft, underlain by hard geology. The railway is currently protected for approximately 2.4km by sections of rock revetment; the remainder is undefended although approximately 2.9km has a wide buffer between the beach and the railway (25-70m wide). The Project is located within several designated sites, most notably The Murrough SPA (Code 004186), the Murrough Wetland SAC (Code 002249) and the Murrough pNHA (Code 000730).

The main hazards here are coastal erosion (shoreline recession), wave overtopping (the railway is very low-lying and the beach is generally narrow) and steepening and narrowing of the beach due to long-shore transport and drawdown during storm conditions. The latter hazard may lead to undermining of the rock structures and the railway itself in the long term.

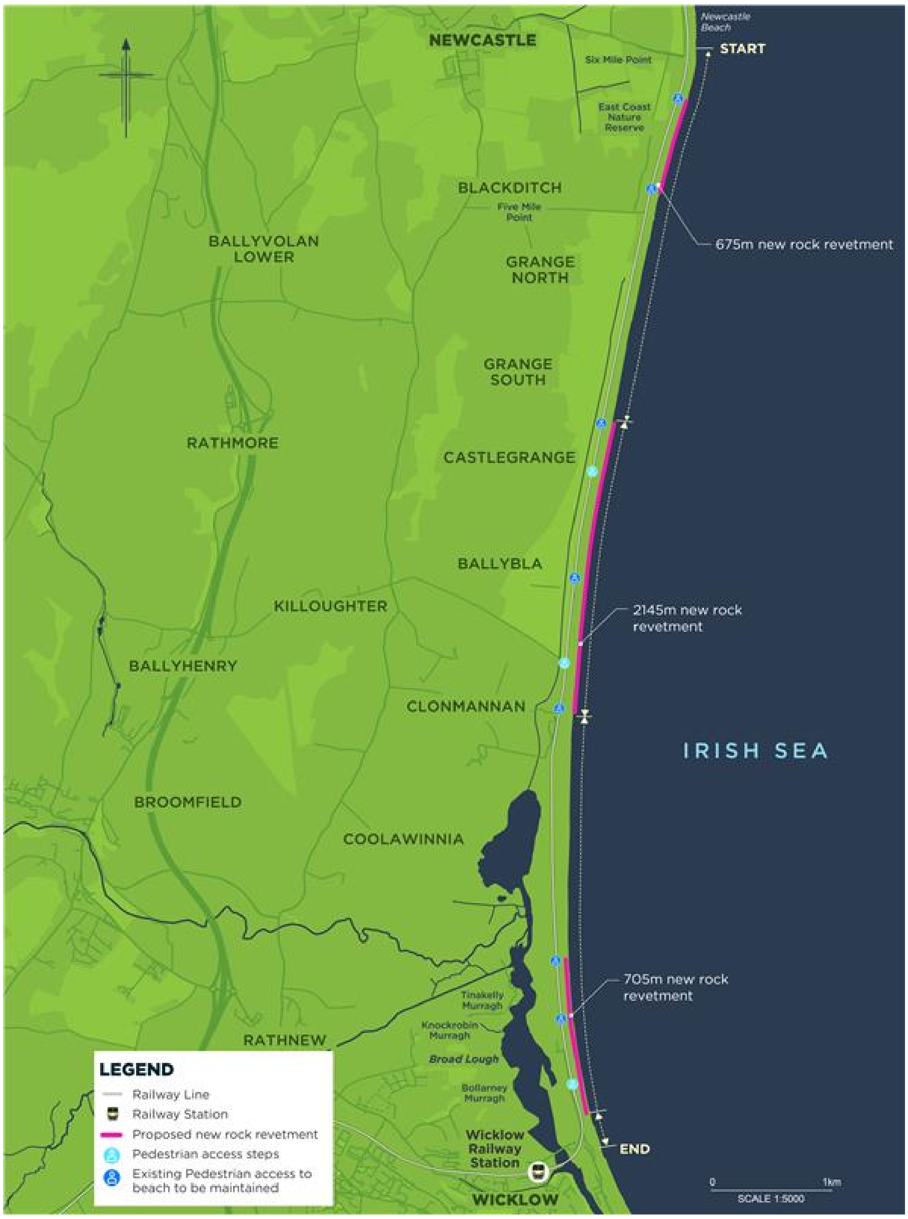

Figure 1-2. Project location plan

1.3 Project objectives

The objectives of engineering interventions between Newcastle and Wicklow Murrough (the Project) are two-fold:

- To reduce the impacts of wave overtopping discharges on railway infrastructure and operations,
- To reduce the potential for coastal erosion undermining the railway

1.3.1 Transport benefits

The proposed works will ensure that the railway remains safe to operate over the next 50 years. Proposed works will reduce the wave overtopping impacts to the railway, increasing service reliability under minor storm conditions and preventing significant damage to railway infrastructure under large storms. The works will also reduce the potential for undermining of the track due to coastal erosion.

IÉ infrastructure at the site comprises a single-track railway with no overhead electrification equipment (OHLE). A diesel service that links Dublin with Wicklow and the Wexford Europort uses the railway.

The proposed design works take into consideration potential future expansion of the rail services in this area.

1.4 Project status

The project is currently in Phase 3 Design (preliminary level of design). By integrating the proposed options (Options Selection Report) with the results of the Public Consultation (Report PC1), a Phase 3 design has been developed, which aims to satisfy stakeholders whilst delivering the design requirements.

The design is likely to be recalibrated, based on further technical and environmental analysis and feasibility studies.

1.5 Purpose of this report

This document provides the Phase 3 Design Report for CCA6.2 - Newcastle to Wicklow Harbour. The report defines the design which will subsequently inform the detailed design phase.

This report should be read in full in conjunction with the associated appendices.

- Modelling outputs (Appendix A). This describes the numerical modelling of waves and water levels that support overtopping calculations and revetment design.
- Consideration of Need for Set Back Wall (Appendix B). This presents the spatial analysis of wave overtopping behind the proposed revetment defences.
- Geotechnical outputs (Appendix C). The ground investigation report (GIR) presents the results of desk studies and ground investigations in an engineering ground model. The document uses the ground model to undertake geotechnical calculations on the stability and settlement potential of the proposed structures. The GIR documents the geotechnical risks arising from the scheme that feed into the designers risk assessment (Appendix D)
- DEHERR, designers' risk assessment (Appendix D). A Design Hazard Elimination & Risk Reduction Register or DEHERR has been developed alongside the design of the preferred option at Phase 3 design. The DEHERR allows the designer to determine potential risks and design (where possible) against the risks presented. Where the risk is not possible to eliminate at this stage of design, further evaluation of the risk will occur at detailed design, before the risk is transferred to the contractor for them to consider when developing their safe system of works.

2. Design criteria and requirements

2.1 Design criteria

Key design criteria for all disciplines are summarised in Table 2-1.

Table 2-1. Key design criteria

Criteria	Description	Reference
Design Life	▪ 50 years for new permanent works ▪ Variable for existing structures, beaches and soft solutions	Scope of Services
Proposed Standard of Protection – Damage to structures	0.5% AEP (1 in 200RP)	Refer to technical note 7694-ZZ-P1-MMO-CV-JAC-0002
Proposed Standard of Protection – Reduction of disruption to services	10% AEP (1 in 10RP) for damage to rolling stock / lineside assets 100% AEP (1 in 1RP) for temporary line speed restrictions	Refer to technical note 7694-ZZ-P1-MMO-CV-JAC-0002
Proposed Standard of Protection – Pedestrian Safety	100% AEP (1 in 1RP)	Refer to technical note 7694-ZZ-P1-MMO-CV-JAC-0002
Wave overtopping thresholds	Design protection measures to limit wave overtopping to: ▪ 20 l/s/m or 2000 l/m under a 0.5% AEP storm	Refer to technical note 7694-ZZ-P1-MMO-CV-JAC-0002.
Maintenance requirements	For new permanent works: zero heavy maintenance for up to 25 years.	Scope of Services

2.2 Design standards

Key design standards are summarised in Table 2-2 below.

Table 2-2. Key design standards and codes of practice

Discipline	Code/Standard	Application
Chief Civil Engineer (CCE), IE Requirements	PWY-1101 Requirements for Track and Structures Clearances	Geometrical constraints on proposed solutions, including installation and maintenance
Chief Civil Engineer (CCE), IE Requirements	CCE-TMS-389 Drawing Certification Process	All drawings produced on the project
Chief Civil Engineer (CCE), IE Requirements	CCE-TMS-399 Glossary of Civil and Permanent Way Engineering Term	All technical reporting relating to railway terminology
Chief Civil Engineer (CCE), IE Requirements	CCE-TMS-390 - Preparation of Drawings (Approval and Certification Process)	All drawings produced will follow the general guidelines in this standard. It is noted that as no track works are within scope, many of the specifics in this standard will not be applied.
Chief Civil Engineer (CCE), IE Requirements	CCE-TMS-410 - Civil Engineering and Structures Design Standard	Main IE standard for design (alongside Eurocode)

Discipline	Code/Standard	Application
Chief Civil Engineer (CCE), IE Requirements	CCE-STR-PSD-005 - Technical Approval for Civil Engineering Structures	Main IE standard for design reporting
Electrification Manager, IE Requirements	I-ETR-4004 Iss1.0 Clearance Requirements for DC 1500V Electrified Lines	Assessing the hazards arising from the increased height of the sea boundary walls on the DART. Future proofing of DART extension to Wicklow should also be considered
Electrification Manager, IE Requirements	I-ETR-4009 Iss.2.0 Principles of Traction Bonding	Assessing the hazards arising from the increased height of the sea boundary walls on the DART. Future proofing of DART extension to Wicklow should also be considered
Electrification Manager, IE Requirements	I-ETR-4703 Iss1.0 Earthing and Bonding Guidelines	Assessing the hazards arising from the increased height of the sea boundary walls on the DART. Future proofing of DART extension to Wicklow should also be considered
Electrification Manager, IE Requirements	I-ETR-4021 Iss1.0 Maintenance Requirements for the DC 1500V DART Electric Traction System and its Interfaces	Assessing the hazards arising from the increased height of the sea boundary walls on the DART. Future proofing of DART extension to Wicklow should also be considered
Railway Electrification	EN 50162 :- Protection against corrosion by stray current from direct current systems	Electrical safety and installation of modified defences along the electrified railway (DART), including possible extension to Wicklow.
Railway Electrification	EN 50522:- Earthing of power installations exceeding 1 kV AC	Electrical safety and installation of modified defences along the electrified railway (DART), including possible extension to Wicklow.
Railway Electrification	EN 50562:- Railway applications. Fixed installations. Process, protective measures and demonstration of safety for electric traction systems	Electrical safety and installation of modified defences along the electrified railway (DART), including possible extension to Wicklow.
Railway Electrification	EN 50122: Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Protective provisions against electric shock	Electrical safety and installation of modified defences along the electrified railway (DART), including possible extension to Wicklow.
Structural	EN 1990:2002 Eurocode - Basis of structural design	Principles and Requirements for the safety, serviceability and durability of structures, describes the basis for their design and verification and gives guidelines for related aspects of structural reliability
Structural	EN 1991 Eurocode 1	Provides comprehensive information on all actions that should normally be considered in the design civil engineering works, including some geotechnical aspects.
Structural	EN 1992 Eurocode 2	Applies to the design of civil engineering works in concrete. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design in EN 1990.
Structural	EN 1996 Eurocode 6	Applies to the design of civil engineering works, or parts thereof, in masonry. The execution is

Discipline	Code/Standard	Application
		covered to the extent that is necessary to indicate the quality of the construction materials and products that should be used and the standard of workmanship on site needed to comply with the assumptions made in the design rules
Structural	BS EN 206-1:2000 Concrete – Part 1: Specification, performance, production and conformity	Additional reference where Eurocode does not cover a specific topic adequately for the design of concrete structures
Geotechnical	Eurocode 7: Geotechnical Design	Default standard for geotechnical design, but may require other supporting documentation e.g. British Standards
Geotechnical	Engineers Ireland Specification and Related Documents for Ground Investigation in Ireland, 2016	For defining approach and content of the Ground Investigation Interpretive Report
Coastal	The Rock Manual: The use of rock in hydraulic engineering (Ciria/CUR/CETMEF, 2007)	Design of rock structures, including: armour stability, scour, toe design
Coastal	BS6349 Maritime Works	Design of breakwaters, dredging, geotechnical design and materials used in maritime works
Coastal	Manual on wave overtopping of sea defences and related structures (EurOtop, 2016)	Wave overtopping performance assessment of defences
Coastal	The Coastal Engineering Manual (USACE, 2002)	Additional methods for scour, armour stability, hydrodynamic wave loading
Coastal	The Beach Management Manual (Ciria, 2010)	Design of beach nourishment and management
Coastal	Revetment Systems against Wave Attack (McConnell, 1998)	Design of concrete blockwork and open stone asphalt
Coastal	The Use of Concrete in Maritime Engineering – a guide to good practice (Ciria, 2010)	Design of concrete structures
Coastal	Toe Structures Management Manual (Environment Agency, 2012)	Design of nearshore/offshore structures

2.3 Consideration of alternatives

Consideration of alternatives has been undertaken throughout the design process to try to maximise efficiency of the design while reducing the impact on the landscape. Under Phase 2, a broad range of solutions were considered; many of these were discounted due to their inability to provide protection against the eroding nature of the shoreline (e.g. vertical walls) or due to their low resilience against large storms (e.g. nature-based solutions).

The proposed defences have been designed with the idea of maintaining as much useable public area as possible. The revetment slope adopted is as steep as possible to reduce the overall defence footprint.

Opportunities to exclude the crest wall presented at Phase 2 between Newcastle and Wicklow Murrough are explored in the Phase 3 analysis presented in this report.

2.4 Design elements

2.4.1 Rock revetment

A rock revetment will be constructed for some of the frontage to prevent erosion and reduce overtopping onto the railway corridor.

The rock revetment will comprise two layers of graded armour rock overlaying an underlayer placed on a geotextile. The rock grading has been selected to provide stability over the design life using modelled wave conditions that allow for sea level rise. This rock will be of high quality to ensure that it meets and exceeds the design life.

The geometry of the rock revetments is determined through design calculations to limit the wave overtopping to acceptable thresholds to prevent disruption and damage to the railway corridor. This is a combination of the slope, height and width of the revetment.

2.4.2 Wave wall

At concept design in Phase 2, a wave wall at the rear of the crest was recommended to provide an impermeable barrier at the back of the rock revetment. These walls were assumed to be precast reinforced concrete and relatively small.

Through design development in Phase 3, the wave loads calculated suggested the walls would be subject to large forces, making the walls unfeasibly large. Therefore, additional analysis to refine the revetment cross-section and consider whether a set-back wall could be considered instead was undertaken in Phase 3. This is discussed in Section 5.3.5 of this report.

2.4.3 Pedestrian access steps

To facilitate safe pedestrian access/egress from the beach pedestrian access steps are included within the Phase 3 design. 10 no. sets of pre-cast concrete pedestrian access steps are proposed between Newcastle and Wicklow Murrough to reduce the possibility of pedestrians getting cut-off by the tide. Access locations are driven by the defence geometry, the presence of existing adjacent defences and locations of level crossings; sets of steps are typically separated by 600m, reducing the distance a pedestrian needs to walk to exit the beach to 300m.

2.5 Design assumptions and decisions

The design assumptions principally reflect the absence of historical monitoring data that provide information on long-term trends or patterns in beach behaviour and storm response. The primary dataset for the ground surface is the 0.1m resolution digital elevation model derived by photogrammetry from high resolution drone imagery flown in 2023 under 'normal' conditions. This survey extends to around mean low water. The bathymetric survey data used starts significantly further offshore than the mean low water and as such extrapolation between the two surveys has taken place.

Due to the limitations of access to the site via land all materials will need to be delivered from the sea and/or rail. Due to the large volumes of rock armour required, sea delivery is assumed to be preferred. There is extremely limited land access to the frontage, particularly for the delivery of large plant and/or volumes of material. There is ample room along the back of the beach for plant to operate safely and retreat to high ground in the event of storms occurring during construction.

The storm duration has been reduced from 12 hours to 6 hours during Phase 3 design. This reflects the semi diurnal tides seen at the coastline. It reduces the conservativism set at concept design to allow for a more optimised design.

Significant design decisions during Phase 3 (removal of crest wall, extension of underlayer and adopting a shallower revetment slope) have led to increases in footprint of the works to provide a robust basis for development of the EIAR. A consistent crest level for the rock revetment has been adopted throughout the Project; this is informed by a combination of the existing beach level and the median rock size of the proposed rock gradings, ensuring that only one rock is above the existing beach levels.

During Phase 3, a representative cross-section has been analysed for each sub-cell; and therefore, in some locations a single cross-section is representing several kilometres of frontage with variable wave exposure and existing beach profile. During detailed design additional sub-sections can be analyses to refine the design to local variations.

2.6 Safety certification and approval

2.6.1 Workplace safety: roles and responsibilities

Workplace safety in construction projects in Ireland follows the Safety, Health and Welfare at Work Act 2005 and the Safety, Health and Welfare at Work (Construction) Regulations 2013. The Safety, Health and Welfare at Work (Construction) Regulations 2013 aim to:

- Prevent accidents on construction sites.
- Define roles and responsibilities of key duty holders in a construction project.
- Ensure proper planning, coordination, and communication of health and safety throughout the construction process.

The 2013 Regulations ensure that health and safety is:

- Considered from the design stage through to completion.
- Managed by competent, clearly assigned roles.
- Proactively monitored and reviewed on all construction projects

Under these regulations, the responsibilities of duty holders are as follows:

Clients must:

- Appoint Project Supervisors for both the Design Process (PSDP) and Construction Stage (PSCS).
- Ensure that the PSDP and PSCS are competent and adequately resourced.
- Keep a copy of the Safety File at the end of the project.

Project Supervisor for the Design Process (PSDP) must:

- Identify hazards during the design stage.
- Coordinate designers to eliminate or reduce risks.
- Ensure early planning and coordination for safety.
- Prepare a Preliminary Health and Safety Plan.
- Maintain and update the Safety File.

Project Supervisor for the Construction Stage (PSCS) must:

- Coordinate health and safety during construction.
- Prepare and implement the Construction Stage Health and Safety Plan.
- Ensure compliance by all contractors.

Designers must:

- Eliminate hazards and reduce risk through design.
- Cooperate with the PSDP.

- Consider health and safety implications of their designs.

Contractors, including subcontractors, must:

- Comply with the Construction Stage Safety Plan.
- Provide relevant training and PPE to workers.
- Coordinate their activities with other contractors.
- Report incidents and cooperate with safety inspections.

2.6.2 Notification and training

Projects lasting more than 30 working days or 500 person-days must be notified to the Health and Safety Authority (HSA) before work begins. The AF1 form is used for this and is the responsibility of the client with the help of the PSDP

In relation to training and competence:

- All workers must have received Safe Pass training.
- Construction workers must be trained in manual handling, working at heights, etc., as applicable.
- Site-specific induction is required.

2.6.3 Iarnród Éireann safety standards

Due to the proximity of the proposed works to the railway corridor between Newcastle and Wicklow Murrough, the safety certification and approvals will be aligned with the process stated in Iarnród Éireann (IÉ) standards and the general good practices of safety assurance and management.

Based on the consultation with the stakeholders of IÉ, it has been confirmed that the scoped work included between Newcastle and Wicklow Murrough is considered non-significant in accordance with the Common Safety Method Risk Assessment (CSM-RA) and does not require Authorisation to Place in Service (APIS). In addition, the potential work will

- Have minimal impact on the day-to-day operations and activities of Irish Rail
- Have minimal impact on the operations of trains and rail services.

With respect to this, IÉ's technical management standards CCE-TMS-391 will be generally followed for the safety certification and approvals, and the delivery process will be conducted through the engagement with stakeholders of IÉ.

The objectives of the safety certification and approval are to ensure

- The compliance with applicable legal and technical requirements
- The credible hazards identified, and their impact assessed
- Safety associated with the work sufficiently controlled and managed.

The following will be considered to support the safety certification and approval:

- The detailed definition of the change (i.e. scope of work and activities)
- Project team with the roles and responsibilities defined for project delivery and safety assurance.
- Identification of compliance requirements.
- Identification of potential affected stakeholders
- Hazards identification and risk assessment to support the identification, assessment, control and management of safety hazards and risks.
- Gathering evidence of demonstrating these requirements achieved

3. Modelling results

3.1 Wave modelling

A two-dimensional spectral wave model has been used to derive multi-decadal hourly time series of nearshore wave data and extreme nearshore wave and water level conditions along the East Coast of Ireland. The model includes the effects of spatially varying water levels, wind forcing, spatially varying boundary data and climate change. The model was calibrated and validated using measured nearshore wave data in the Dublin Bay. The average RMSE (Root mean Square Error) for wave height (Hm0) over the storm conditions selected for calibration is about 0.2 m with a bias of about 0.0 m.

Hourly time series of nearshore wave data are extracted at regular intervals at approximately every 1 km. The seabed level at the nearshore extraction points along the Project is approximately -6 m Mean Sea Level. The nearshore wave roses show that waves along this frontage are from northeast clockwise to southeast. The largest waves are from east-northeast to east. The hourly wave height exceeded 1% of the year is about 1.85 m (1.75m to 1.92m) and the median annual wave height is about 0.30 m (0.24m to 0.34m) for present day wave conditions (wave climate simulated for the period Jan 1988 to Dec 2021). The modelled wave heights for future conditions (including climate change) are higher. The hourly wave height exceeded 1% of the year is about 2.10 m (1.81m to 1.99m) for 2022-2055 and 2.05m (1.93m to 2.12m). The modelled hourly nearshore wave time series is used as input for the sediment transport and shoreline evolution modelling.

Joint probability analysis was carried out to determine extreme offshore wave and water level conditions for 22.5 deg wave direction sectors. Two joint probability analysis methods were used, namely: 1) Desk study method which uses correlation coefficients to determine the dependence of the two variables (wave height and water level) and 2) The simplified method which considers astronomical tide are fully independent from the wave height while surge is considered fully dependent to wave height. The results that give the more conservative joint probability pairs are used as boundary conditions for the nearshore transformation modelling. The selected joint probability pairs were transformed to the nearshore using the wave model.

Extreme nearshore wave and water level data are extracted at regular intervals at approximately every 1 km. The nearshore wave extraction points, sample nearshore wave roses and joint probability curves are shown in Appendix A. The modelled extreme wave and water level conditions are used as input for design of the coastal structures and for storm-induced cross-shore sediment transport modelling.

3.2 Cross-shore modelling

Cross-shore modelling of storm response in the unprotected area between section B and C2 was undertaken using XBeach-G; this model is used for simulating storm impacts on shingle beaches. A cross-section from the survey data was extracted extending from the -6mODM contour to the railway corridor; two representative sediment sizes were adopted: 2.5mm and 12.4mm. The model was run for a 48-hour storm applying 1 in 200 return period wave and water level conditions for 2025, 2050 and 2075. Sensitivity analysis applying two back-to-back storms was also undertaken.

The model results predict that beach levels could draw down by up to 1.8m and up to 10m of beach retreat could occur under the back-to-back storm scenario (see Figure 3-1). As the unprotected area at Clonmannon is more than 40m wide, there is sufficient space to accommodate this storm response without the railway being at risk.

It is recommended that further cross-shore modelling is carried out at detailed design to quantify the impact of storm induced cross-shore sediment transport and associated shoreline changes along the proposed defences. This will help to improve accuracy and reduce uncertainty.

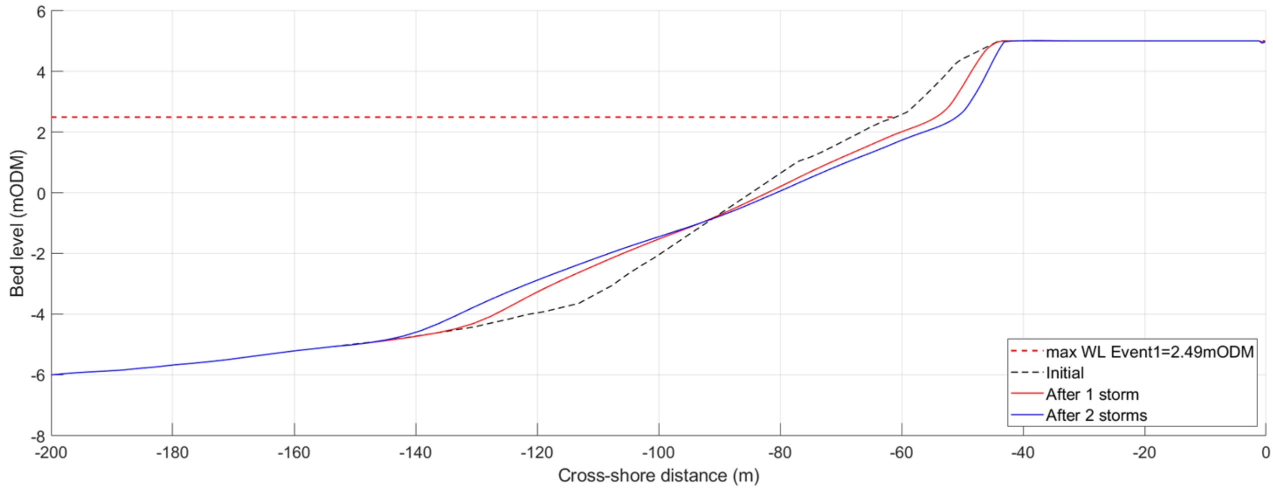

Figure 3-1. Cross-shore beach response under two back-to-back 1 in 200 RP storms in 2075

3.3 Shoreline modelling

Shoreline change modelling in LITLINE has been undertaken in Phase 3 to estimate the impact of the Project on the shoreline between Newcastle and Wicklow Murrough. The modelling exercise aimed to identify any differences in the shoreline before and after the implementation of the proposed defences. The shoreline in the “with Project” model is now largely defended throughout (see Figure 3-2), with the exception of 2km between sections B and C2. The baseline modelling indicated less than 20m of erosion in this area by 2075; as the railway corridor is at least 40m from the back of the beach, no works are proposed in this area under the Project.

The baseline model set-up for Phase 2 including extent and wave conditions was adopted as the proposed interventions would not be expected to change these inputs. The model was run for 50 years (2025 to 2075).

Figure 3-2. Extent of proposed defences (red dashed line) within the model area

The shoreline modelling shows that the Project produces similar trends to the baseline model (Figure 3-3):

- Erosion of the shoreline around A2 to reach the revetment;
- Accretion of up to 20m around Killoughter (Section B),
- Confirmation that erosion impacts at Clonmannon (section C1) remain limited to less than 20m.
- Predicted erosion for 25 years is the same as the baseline for the southern extent of the Project area, although the model predicts some recovery from 2050 onwards and the 2075 shoreline position is approximately 5m landward of the present day.

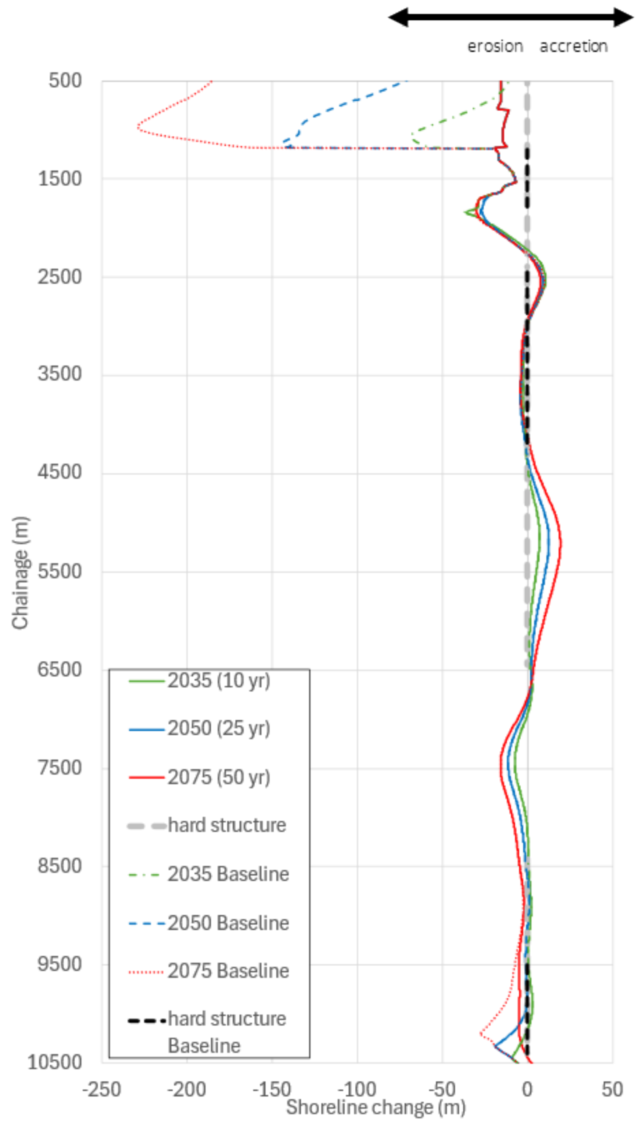

Figure 3-3. Predicted shoreline change comparing baseline and with Project model scenarios

3.4 CFD (not applicable)

No CFD modelling was undertaken for Newcastle to Wicklow Murrough under Phase 3 of the Project. During detailed design, it is recommended that CFD modelling of the proposed defences be undertaken to identify if the rock revetment design can be further refined.

3.5 Justification of areas where no works are proposed

Approximately 2km of frontage between sections B and C2 has no works proposed under the Project and will remain undefended. This area was identified in the Option Selection Report (7694-CCA6_2-P2-ENG-CV-JAC-0001) as having a reasonably large buffer back to the railway corridor and therefore, not requiring interventions under ECRIPP.

The shoreline modelling predicts that this area will erode approximately 20m over the next 50 years and the cross-shore modelling predicts a possible additional 10m of beach crest retreat under a back-to-back storm scenario. There is a wide vegetated area at the back of the beach (40-80m wide) and therefore this area is not expected to need defences during this timeframe. Monitoring of the beach is recommended to inform when interventions might be needed in the future.

4. Coastal processes assessment

The Newcastle to Wicklow Murrough frontage sits within the ESE-facing bay between Six Mile Point and Wicklow Head and comprises two principal units. The northern unit, between Six Mile Point and Clonmannon is a gravel barrier beach that fronts a low-lying hinterland of reclaimed intertidal alluvium with occasional low hills formed in glacial sediment. The southern unit comprises a gravel barrier beach that fronts a network of tidal lagoons (e.g. Broad Lough, Wicklow), brackish lakes and freshwater channels that are fringed with reclaimed alluvial marshes and backed by low lying hills in glacial sediment. The railway embankment is constructed on the gravel barrier and is locally defended with stretches of rock revetment near Newcastle, Five Mile Point and Wicklow.

The barrier beach formed during the Holocene marine transgression, as rising sea-levels reworked glacial sediment from the bed of the Irish Sea. Under current stable sea-levels and with negligible sediment supply, the barrier experiences periodic erosion in storms, but overall, it is ‘fixed’ in place by defences that protect the railway.

Tidal currents are low along this frontage at all stages of the tide and sediment movement is largely wave-driven and towards the north. Since Wicklow Head inhibits sediment supply from the south, beaches in the south of the frontage, particularly at The Murrough, experience erosion in winter storms as sediment is cannibalised to nourish beaches further north.

Analysis of historical mapping and aerial photographs dating from 1830 to the present day demonstrate negligible net change in the shoreline position for most of the frontage. However long term average rates of up to c. 0.3m/yr are recorded in the south, at The Murrough. The long term average rates of change mask the impact of episodic storms, which Irish Rail’s monitoring shows can lead to severe localised shoreline retreat and the need for defences to protect the railway. The affected stretches of coast subsequently recover, with no net change apparent over a time period of several years. Historical map evidence from The Murrough indicates that at least 50m erosion has occurred since 1830. Documentary evidence at the site shows that a coast guard rocket post, known locally as the Monkey Pole, has been moved inland several times in response to shoreline retreat.

Increasing erosion of the whole frontage is expected under projected sea-level rise because the barrier beach will be unable to naturally respond by the process of roll-back. Erosion will be a particular problem in the southern part of the frontage because of the net movement of sediment to the north and an absence of a supply of sediment from the south or offshore. It is likely that the area experiencing erosion will progressively expand towards the north as beach depletion continues.

A detailed assessment of the coastal processes will be undertaken to support the EIAR.

5. Design methodology and results

5.1 Approach

All proposed structures are designed to a minimum of 1 in 200-year return period for the year 2075 (incorporating 50-yrs of predicted sea level rise). The overall design approach is summarised below and in Figure 5-1.

The waves were transformed to the proposed structure toe using the closest wave point to the structures, the initial toe and nearshore slope (determined using a combination of UAV survey data, bathymetric data and recent LIDAR data). Offshore Joint Probability Analysis (JPA) used in the wave transformation was determined based on shoreline orientation and the wave direction. Shore-normal waves were used in all cases unless an obliquity either side of the shore-normal wave conditions provided a significantly larger wave.

From the nearshore wave determined, a suitable rock size has been calculated based on its stability in relation to the wave energy, the crest level determined based on EurOtop II (2018) and the toe detail based on scour. Where the revetment slope has been updated to provide greater rock stability, a further iteration of the wave overtopping assessment is needed to revise the proposed defence crest level. Wave loads on wave walls have been estimated where required for application in the structural design of the walls. The combined revetment and wave wall cross-section was then analysed by the geotechnical team and any further changes to the geometry to satisfy the bearing or global stability checks were made.

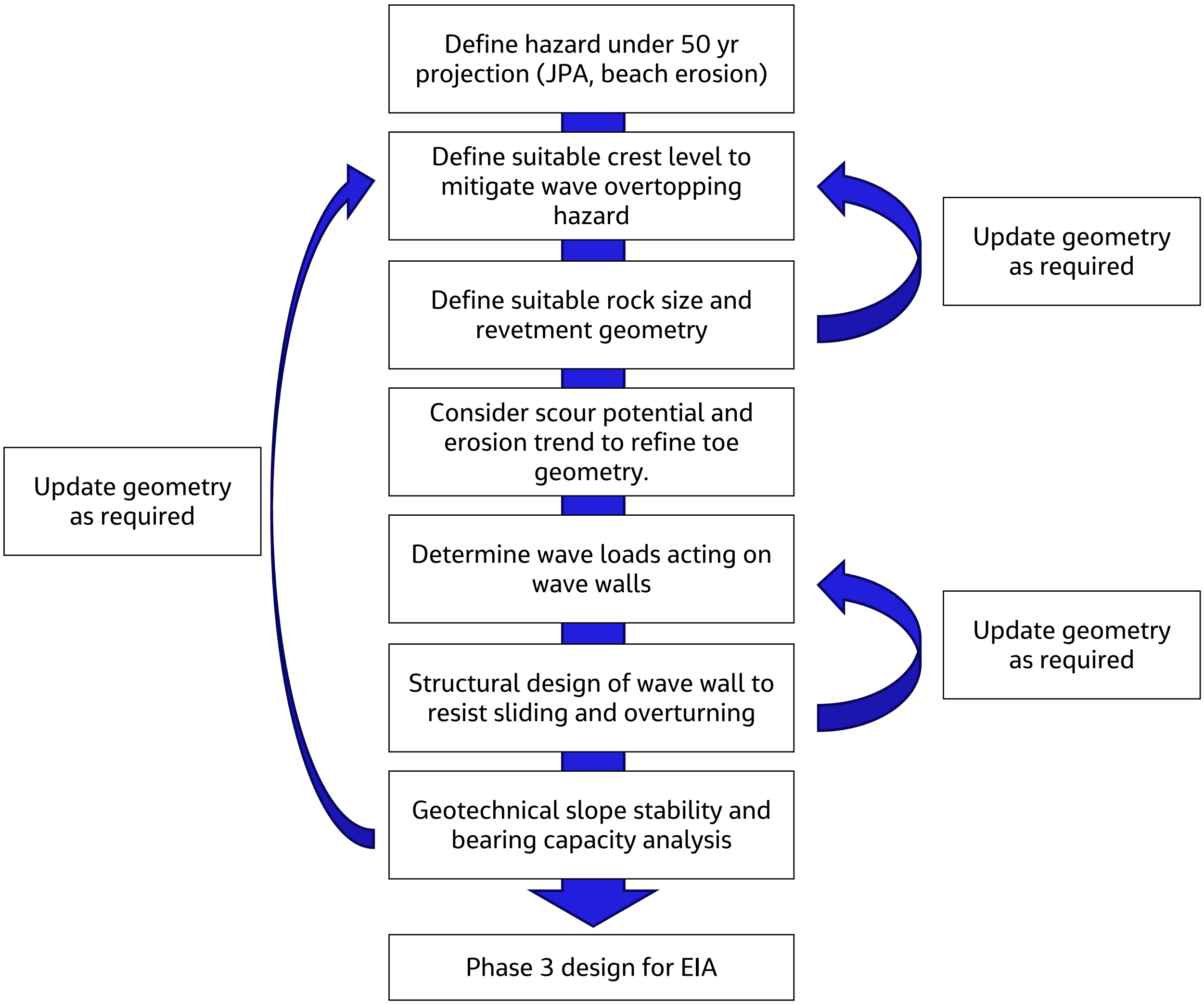

Figure 5-1 Design methodology

5.2 Key design parameters

All structures proposed shall be designed to recognised and proven current codes, standards, or regulations. Key design assumption used in the design of CCA5 are shown in Table 5-1.

Table 5-1. Key design parameters

Design Assumption	Value	Reference
Rock Density	2650kg/m³	Typical Value
Water Density	1025kg/m³	Typical Value
Storm Duration	6 Hours	Typical Value for a semi-diurnal tide
Coefficient of Gravity	9.81m/s2	Typical Value
Plunging Coefficient	6.2	CIRIA C683 (2007)
Surging Coefficient	1.0	CIRIA C683 (2007)
Nominal Permeability	0.1	CIRIA C683 (2007)
Wave Obliquity	0 degrees	Assumed for conservativism
Damage Number	2	CIRIA C683 (2007)

5.2.1 Tide levels

Reference tide levels for Dublin North Wall and Wicklow are tabulated below.

Table 5-2. Reference tide levels

Reference level	Dublin North wall (mODM)	Wicklow (mODM)
Highest Astronomical Tide, HAT	1.99	
Mean High Water Springs, MHWS	1.59	0.19
Mean High Water Neaps ,MHWN	0.89	-0.21
Mean Sea Level, MSL	-0.11	
Mean Low Water Neaps, MLWN	-1.01	-1.41
Mean Low Water Springs, MLWS	-1.81	-1.81
Lowest Astronomical Tide, LAT	-2.61	

5.3 Coastal engineering design

5.3.1 Assessment of scour

For all of the frontages included in the Project, rock revetments are proposed. As limited detailed beach modelling has been undertaken, a conservative assumption regarding the beach drawdown has been considered. The beach level at each rock revetment cross-section has been lowered by 1.5m based on the application of the Mean Sea Level contour retreating onshore due to shoreline erosion, the beach level at each cross-section has been lowered by 1.5m. It is assumed that maximum scour has already occurred within this beach lowering. It is assumed that if any scour was to occur at the toe of the structure the rock toe will be able to fall into the scour hole. As the beach level reduction already is adopted as the design condition, a three-rock wide toe with two layers of rock armour is considered to be sufficient. This shall be re-assessed at detailed design.

5.3.2 Rock armour sizing

The sizing of the armour has been based on the wave action of 200-year Return Period (RP) waves in accordance with the Van der Meer (1988) for non or marginally overtopped structures and Van Gent et al. (2004) as presented in The Rock Manual (CIRIA, 2007). The result from this analysis is shown in Table 5-3.

Table 5-3. Rock armour sizing results

Location	Rock Grading Adopted
A2	3-6t
B	3-6t
C2	6-10t

5.3.3 Wave overtopping assessment

Wave overtopping discharges and volumes were calculated at the initial crest level adopted from Phase 2 at each revetment structure, following EurOtop II (2018) guidance. The wave overtopping discharge limit (q) considered in this analysis is 20 l/s/m for structural damage. Maximum wave volume (Vmax) has also been considered, with a limit of 2000 l/m. Where EurOtop does not provide a single method to accurately parametrise the defence and calculate the required minimum crest level, multiple methods have been applied. This is recommended to be confirmed at detailed design using CFD.

Table 5-4 shows the range of minimum required crest level for q and Vmax determined in the analysis as well as the adopted crest levels for design.

Table 5-4. Wave overtopping results

Location	Calculate minimum crest level requirement (mODM)	Crest Width of the Rock Armour (m)	Adopted Rock Crest Level (mODM)
A2	5.56	4.30	5.50
B	4.7 to 6.20	4.30	5.50
C2	5.13 to 7.91	5.10	5.50

The calculated value for A2 is based on a crest width of 3 rocks wide of 3-6t. Widening the crest width to align with the other crest widths in the scheme will reduce the required minimum crest level. For ease of interfacing and construction along the scheme the crest at this location will be retained at 5.50mODM, this may be revisited at detailed design for further optimisation.

5.3.4 Wave loading assessment

Phase 2 proposed crown walls behind the revetment crests in Sections A2 and B; therefore, wave loading was initially considered during the Phase 3 analysis. Based on initial empirical formulae results from a range of methods, very high wave pressures were calculated. High-level structural and geotechnical review of these pressures indicated that a very large wave wall requiring piled foundations would be needed to withstand the wave pressures. This would introduce significant additional complexity for construction and therefore, opportunities to design out the crest wall were explored by revisiting the wave overtopping assessment.

The rock armour crest widths presented in Section 5.3.3 and consideration of the spatial distribution of wave overtopping behind the revetment (refer to Section 5.3.5 and Appendix B) allowed the wave loads to be discounted fully.

5.3.5 Review of requirements for Crest Wall

The Phase 2 design included a crest wall behind the rock revetment crest. During the design development in Phase 3, the wall was identified as potentially being subject to large wave uplift forces which would either require a wall with a very large self-weight or a piled foundation. Therefore, alternative geometries were considered to manage the predicted wave overtopping discharges and volumes: inclusion of a smaller set-back wall close to the railway corridor or amendments to the rock revetment geometry to reduce the impacts of wave overtopping.

An exercise to assess the spatial distribution of wave overtopping behind the rock crest was undertaken to identify any areas where the railway might be considered at significant risk. The approach detailed in Section 6.4.2 of EurOtop II (2016) was applied to estimate at what distance the wave overtopping volumes would reduce to acceptable levels.

By increasing the rock armour crest width to four rocks wide instead of the standard three rocks wide and extending the underlayer behind the rock crest, the impacts of wave overtopping behind the defence can be reduced. The spatial analysis identified that significant impacts on the railway are not expected where the railway corridor is more than 8m behind the proposed revetment crest alignment.

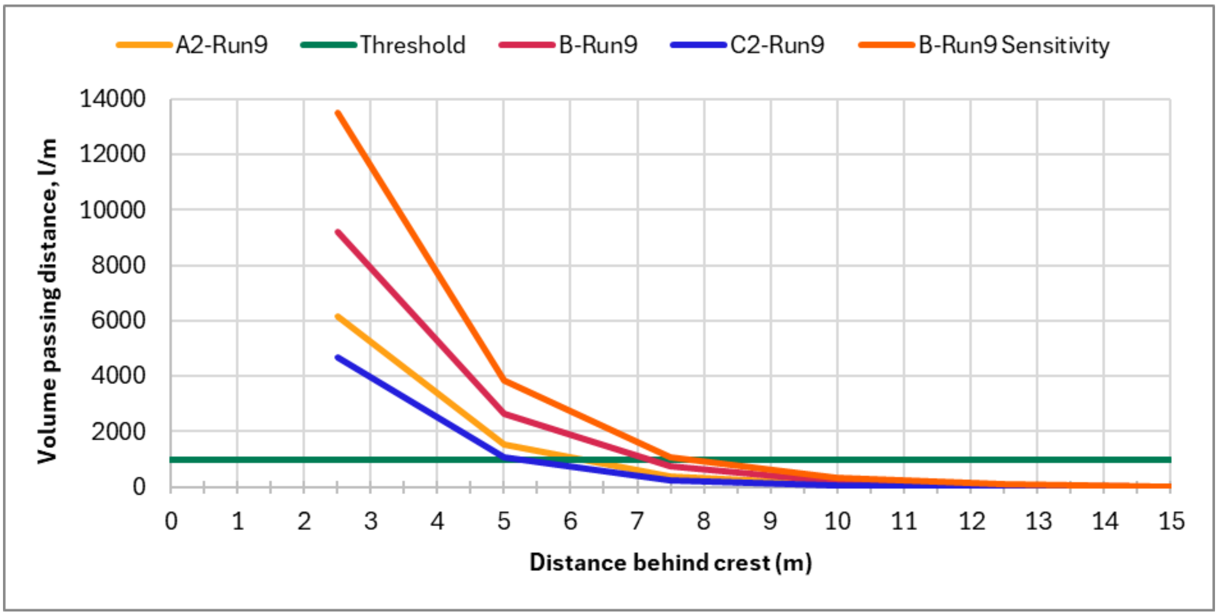

Figure 5-2. Graphical representation of the reduction in maximum wave overtopping volume with increasing distance behind the rock revetment crest

Analysis of the UAV survey data showed that the railway between Newcastle and Wicklow Murrough is typically more than 8m from the landward edge of the rock armour crest and volumes landing beyond 8m are not anticipated to cause any damage to railway infrastructure. There are some areas where the railway corridor sits at a lower level than the existing ground level and some flow of overtopping discharges and volumes towards the railway should be expected. However, any such flows are expected to be localised in nature and drain quickly as an impermeable layer is not believed to be present at or near the ground surface.

Under the conditions investigated (1 in 200 RP storm in 2075), no trains are expected to be operating and it is expected that an inspection by the permanent way team would be undertaken prior to re-opening the line to passenger or freight services. Further detail is provided in Appendix B.

5.4 Structural design

5.4.1 Wave wall design

Initial consideration of the wave loads was undertaken following methods for sliding and overturning checks as described in BS6349-1-2. Set B and Set C load factors have been adopted and resistance factors from the Irish national annex for BS EN 1997 have been applied. The minimum required wave wall geometry to withstand the wave pressures described in Section 5.3.4 and achieve utilisation less than 1 for both sliding and overturning was determined.

Where rock armour is present in front of the wall, it is assumed this acts as a soil layer. Due to the marine exposure, 100mm equivalent self-weight of the concrete wall is assumed to be lost due to abrasion.

As discussed in Section 5.3.4, the wall geometry to withstand the wave loading was considered prohibitively large. It introduced concerns about bearing pressure and was likely to need support from a sheet pile. Early discussions with the geotechnical team suggested that the piles would need to be in the region of 10m long. This in turn would lead to larger piling equipment needing access to the beach. Therefore, alternative amendments to the revetment cross-section were made to remove the need for a crest wall.

5.5 Geotechnical design

The railway is constructed on an embankment built upon a natural barrier beach system with occasional low hills of glacial sediment and is fronted by a narrow intertidal beach. The railway is widely protected by rock armour, concrete blocks and sea walls. Erosion is a particular problem at The Murrough, north of Wicklow, where rock armour has been progressively extended to the north to protect the railway. The hinterland in the north comprises low land marsh underlain by glacial sediment, while the south is characterised by the channel of the River Varty and two brackish lagoons, including Broad Lough.

Bedrock does not crop out on site and has not been encountered by ground investigations undertaken for this project. Geological Survey of Ireland data indicates the bedrock comprises predominantly hard lithologies of greywacke, shist and slate that ground investigations suggest lie at over 20m below ODM. Bedrock is overlain by a sequence of glacial sediments, including tills and sand and gravel, that crop out to form low hills in the north and reach a thickness of at least 16m. In the south, the glacial sediments are obscured by Holocene deposits. On the seaward side of the railway, glacial sediments are obscured by sand and gravel of the beach and barrier complex. On the landward side, glacial sediments are mantled by estuarine and fluvial deposits that comprise soft sandy silt alluvium and sandy gravel (to around 2m thick) that include beds of peat (to around 0.9m thick).

Ground investigations from November 2023 and May 2024 gathered information on soil, rock, and groundwater for designing coastal defences, supervised by Jacobs to ensure accurate data collection and reporting. Methods and results are summarised in the factual report (Causeway Geotech Ltd., 2025).

An engineering ground model for the site has been developed in the Geotechnical Interpretive Report (GIR) for this Project. This is supported by boreholes, dynamic probes at track level and on the beach. For interpretation of ground conditions and soil/rock parameters refer to CCA6.2- Geotechnical Interpretive Report, Doc No 7694-CCA6_2-P3-ENG-CV-JAC-0001 (Appendix C).

The geotechnical design comprised rock revetments, or structures within Sections A2, B, and C2 (Rock Revetment). The sub cells are underlain by superficial deposits. The conducted analysis confirmed that the bearing capacity and global stability of the rock revetments are acceptable if not founded on compressible soils like Alluvium or Peat. Settlements assessment of the rock revetments are acceptable at C2, whereas at A2 and B additional rock overbuild may be required post-construction. If peat is confirmed in these areas, anticipated settlements could be substantially higher, further impacting design and construction strategies. Section 5.5.1 to 5.5.3 below include summary of geotechnical results. For more details about coastal area CCA6.2 geotechnical assessment refer to Section 6 of the GIR (Appendix C).

The geotechnical risks identified at this stage of the project have been included in Section 8 of the GIR. The major geotechnical risk identified at this stage of the project comprise scour in front of the proposed structures, variable or unforeseen ground conditions which may include unexpectedly soft/loose Alluvium deposits and Peat. Key geoenvironmental risk include the potential for encountering unforeseen land contamination during construction.

Additional GI is recommended to address the risk of the potential presence of alluvium and peat within the proposed structure footprints. These materials, if present, may adversely affect the stability and performance of the structures. The removal and replacement or staged construction may be required to achieve the necessary bearing capacity and structural stability. For further details about geotechnical recommendations refer to Section 9 of the GIR.

5.5.1 Bearing capacity

A bearing check was undertaken for founding soils marine beach sands, alluvium and glacial till when surcharged by self-weight of the rock armour (unfavourable permanent loading). Maximum utilisation of 144% was achieved for alluvium in short term or undrained case, whereas bearing was satisfied in long term or drained case for alluvium. Hence bearing check for alluvium in undrained case showed ground failure in bearing. Bearing check for marine beach sands, glacial till is considered safe because the degree of utilisation was less than 100%.

It is recommended that additional ground investigation works be carried out prior to the completion of the detailed design. Should further investigations confirm the presence of alluvium or peat within the structure footprints, excavation and replacement will be necessary to meet structural bearing capacity requirements.

5.5.2 Slope stability assessment

Factor of safety (FoS) was calculated for rock armour with two internal friction angles (40 and 55 degrees) and was compared against the steepest slope with slope ratio of 1:1.5 (approx. 33.7˚). The shallow slope stability was satisfied because the minimum FoS obtained was ≥ 1.3.

Deep slope stability have shown failure in undrained conditions for alluvium (FoS obtained was < 1.0). However, as the deep slope stability is satisfied under drained conditions, it is feasible to proceed with construction using a staged approach. This method will allow alluvium to undergo consolidation and facilitate the dissipation of excess pore water pressures, thereby improving ground stability over time. Further ground investigations during the detailed design phase should check for the presence of alluvium or peat within the structure footprints. If encountered, excavation and replacement may be necessary to meet structural stability requirements.

5.5.3 Settlements assessment

Serviceability Limit State (SLS) 1D consolidation analysis was undertaken to determine likely ground settlements when founding soils of the structure are surcharged by self-weight of the rock armour. The settlement check considered the effects of immediate settlement and primary consolidation and was undertaken for the ground models present at the three rock revetments (section 6.1.6 of the GIR). Settlement in fully saturated granular materials was defined by immediate settlement, whereas settlement in cohesive material was defined by primary consolidation settlement. The results showed that majority of consolidation settlement occurs within five years after construction. Maximum obtained total settlement was in the range of 115mm. No limit on total settlements was applied as over-build of the rock armour is adopted during design life to allow settlements and to maintain the defence crest level at or above the design level.

For the current settlement levels at Sections A2 and B, additional rock overbuild may be required post-construction. If peat is confirmed in these areas, anticipated settlements could be substantially higher, further impacting design and construction strategies.

5.6 Landscape design

Landscape design is not needed at this stage of the project given the more rural setting of the proposed works. The proposed defences make use of natural materials (rock) and although larger in footprint are similar to existing structures along the Project frontage. Beach material excavated to construct the revetment will be placed at the rear of the crest, reducing the visual impact of the rock structure from the railway.

5.7 Access

Permanent pedestrian access through the proposed works has been considered during Phase 3 of the Project. Between Newcastle and Wicklow Murrough, pedestrian access to the frontage is via the pedestrian level crossings at Newcastle (XR015), Five Mile Point (XR016), Killoughter (XR019), Clonmannon (XR021), Pines (XR022) and via the footway from the Murrough Car Park. Currently, pedestrian access to the beach is available for much of the frontage as there are large stretches of undefended coastline. Pedestrian access steps are provided near Five Mile Point and access is possible along the frontage either at beach level or at the back of beach area.

Through the construction of rock revetments, safe access/egress to the beach becomes limited and therefore, where there are long sections of revetment, additional access points are proposed as part of the Project. Pedestrian access steps are proposed to be formed of pre-cast marine grade concrete step units with wing walls and handrails. These will be cast as two-step units to enable easier lifting.

5.8 Environmental enhancement/biodiversity design

The Phase 3 design will be further modified at detailed design having regard to the potential for environmental effects as identified by the Environmental Impact Assessment Report (EIAR) which will be produced in Phase 4 of the Project.

6. Preferred scheme

6.1 Description of preferred scheme design solution

The Phase 3 design has further developed the initial designs from concept design stage (Phase 2) that were presented in the Option Selection Report (7694-CCA6_2-P2-ENG-CV-JAC-0001). Optimisations considered include changing the structure type, flattening the slope, altering the rock grading and removal of the wave wall. Iterations of design variations, coupled with the public consultation requirements, have defined the approach taken in optimisation for each section.

6.1.1 Section A2

A rock revetment constructed of 3-6t rock armour underlain by 0.3-1t rock shall be placed offset from the railway following the railway boundary fence alignment. The crest of the revetment shall be at +5.50mODM with a crest width of 4.3m (four-rocks wide). The underlayer will extend 3.35m landward of the rock armour crest to the level of the top of the first layer of rock. The extension of the underlayer is intended to provide additional protection against erosion immediately behind the rock crest caused by wave overtopping of the structure which could ultimately lead to destabilisation of the rock armour crest. The underlayer shall be covered by beach material excavated during construction of the revetment to provide a more suitable surface for walking on. This material can also act as a sacrificial beach material for when material is drawn through the structure during extreme storm events. It may be necessary to top-up the material behind the revetment crest following major storms.

A geotextile shall be placed underneath the two layers of underlayer. The slope of the revetment shall be a 1 in 2 down to a toe crest level of +2.5mODN.

The wider rock crest and provision of additional protection against rear face erosion reduce the impact of wave overtopping on the railway. The crown wall included at Phase 2 has been removed from the cross-section following these amendments. Further design developments since Phase 2 are the reduction in revetment slope (1 in 1.5 to 1 in 2) to improve rock armour stability. The cross-section is provided in drawing 7694-CCA6_2-P3-DWG-CV-JAC-0300 and reproduced below.

The shallower 1 in 2 revetment slope, wider rock crest and extension of the underlayer increase the total volumes of rock required for this section by approximately 40% in comparison with Phase 2. Approximately 1,800m^3 of concrete are removed through the exclusion of the wave wall.

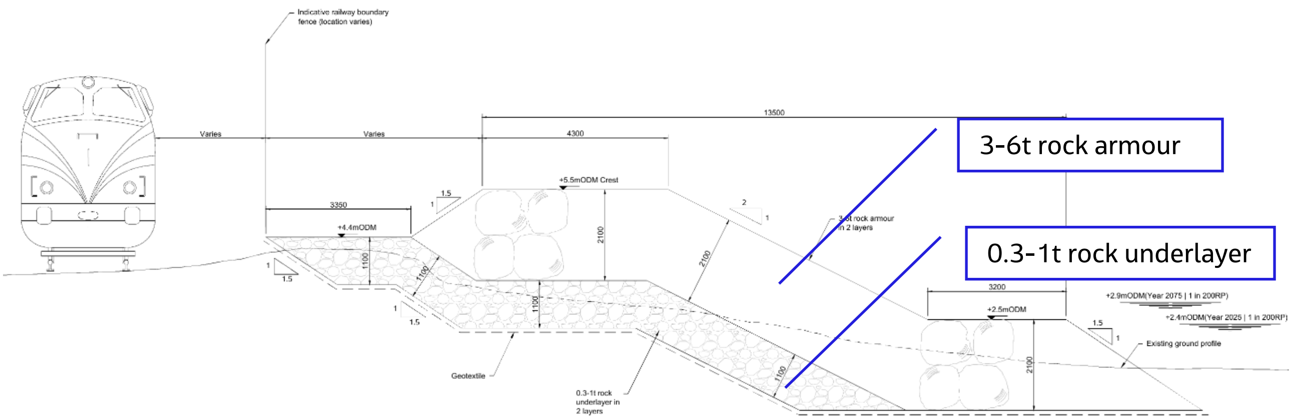

Figure 6-1. Proposed Phase 3 cross-section at A2

6.1.2 Section B

A rock revetment constructed of 3-6t rock armour underlain by 0.3-1t rock shall be placed offset from the railway along the fenced boundary. The crest of the revetment shall be at 5.50mODM with a crest width of 4.3m. The underlayer will extend 3.35m landward of the rock armour crest to the level of the top of the first layer of rock. The extension of the underlayer is intended to provide additional protection against erosion immediately behind the rock crest caused by wave overtopping of the structure which could ultimately lead to destabilisation of the rock armour crest.

A geotextile shall be placed underneath the two layers of underlayer. The slope of the revetment shall be a 1 in 2 down to a toe crest level of +3.0mODN. Where the beach will require re-profiling prior to the construction of the revetment it is recommended that the excess beach material is piled at the back of the revetment past the underlayer. This can then act as a sacrificial beach material for when material is drawn through the structure during extreme storm events. This would increase the design life of the structure.

The wider rock crest and provision of additional protection against rear face erosion reduce the impact of wave overtopping on the railway. The crown wall included at Phase 2 has been removed from the cross-section following these amendments. Further design developments since Phase 2 are the reduction in revetment slope (1 in 1.5 to 1 in 2) to improve rock armour stability. The cross-section is provided in drawing 7694-CCA6_2-P3-DWG-CV-JAC-0300 and reproduced below.

The shallower 1 in 2 revetment slope, wider rock crest, extension of the underlayer and extension of the proposed works by approximately 300m increase the total volumes of rock required for this section by approximately 40% in comparison with Phase 2. Approximately 5,400m3 of concrete are removed through the exclusion of the wave wall.

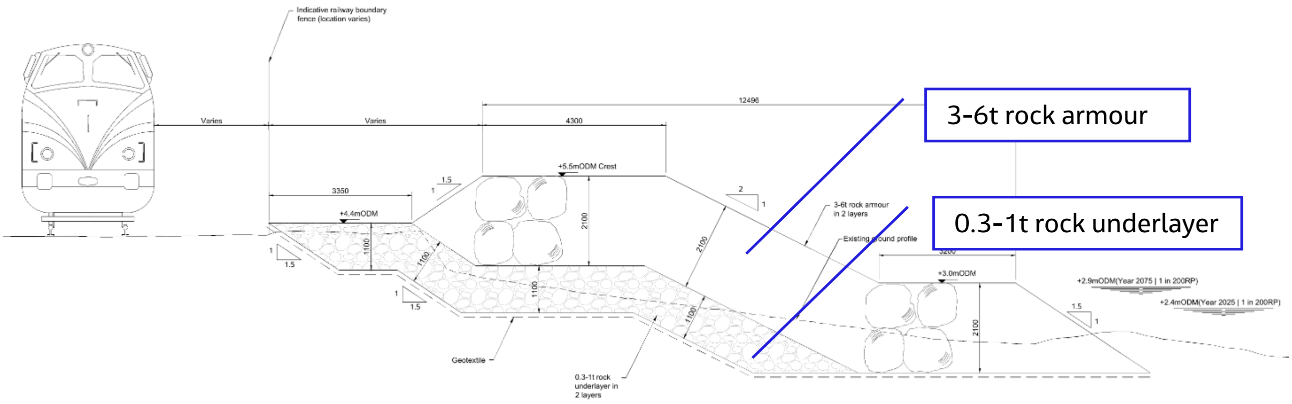

Figure 6-2. Proposed Phase 3 cross-section at B

6.1.3 Section C2

A rock revetment constructed of 6-10t armour stone underlain by 0.3-1t rock shall be placed offset from the railway along the fenced boundary. The crest of the revetment shall be at 5.50mODM with a crest width of 5.1m. The underlayer will extend 3.35m landward of the rock armour crest to the level of the top of the first layer of rock. The extension of the underlayer is intended to provide additional protection against erosion immediately behind the rock crest caused by wave overtopping of the structure which could ultimately lead to destabilisation of the rock armour crest.

A geotextile shall be placed underneath the two layers of underlayer. The slope of the revetment shall be a 1 in 2.5 down to a toe crest level of +2.0mODN. Where the beach will require re-profiling prior to the construction of the revetment it is recommended that the excess beach material is piled at the back of the revetment past the underlayer. This can then act as a sacrificial beach material for when material is drawn through the structure during extreme storm events. This would increase the design life of the structure.

The wider rock crest and provision of additional protection against rear face erosion reduce the impact of wave overtopping on the railway. Further design developments since Phase 2 are the reduction in revetment slope (1 in 1.5 to 1 in 2.5) to improve rock armour stability and the increase in rock armour grading to 6-10t. Additionally, the linear extent of C2 has been increased to tie-in with the emergency works to the south. The cross-section is provided in drawing 7694-CCA6_2-P3-DWG-CV-JAC-0301 and reproduced below.

The shallower 1 in 2.5 revetment slope, wider rock crest and extension of the underlayer increase the total volumes of rock required for this section by approximately 270% in comparison with Phase 2. The 238m extension of C2 to tie-in with the emergency works to the south adds a further 80% on the Phase 2 rock quantity estimates.

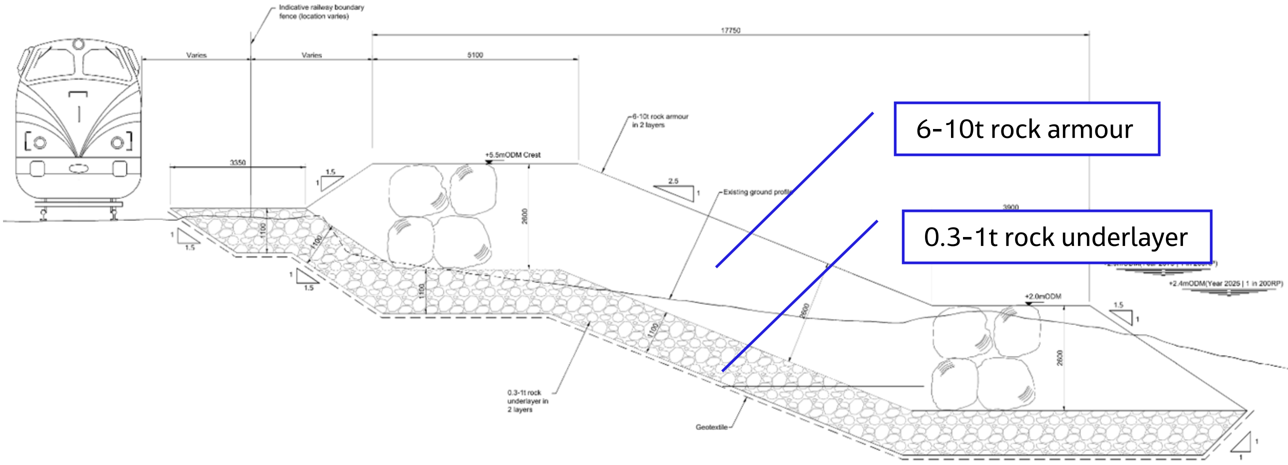

Figure 6-3. Proposed Phase 3 cross-section at C2

6.2 Future adaptability of the design

All locations within the Project can be adapted in the future to reduce wave overtopping impacts at the railway through the inclusion of a set back wall. This additional protection could be provided by a concrete wave wall or a sheet pile wall. The proposed crest alignment for the rock revetment provides a wide buffer between the railway and the proposed revetment, leaving a corridor for future works to be constructed without compromising the revetment.

6.3 Interfaces between sub-cells and existing structures

Interfaces with existing structures exist at both ends of A2 and to the south of C2; in these locations the rock armour will taper along the existing revetment, blending the proposed rock armour into the existing rock. Some reworking of existing rock may be needed to achieve a smooth transition.

Where there is no existing structure to tie into, the proposed rock revetments will taper around the crest.

6.4 Drawing list

Drawings prepared for the Project are summarised in Table 6-1.

Table 6-1. Drawing list for Newcastle to Wicklow Murrough Phase 3 Design

Drawing No.	Title	Description
7694-CCA6_2-P3-DWG-CV-JAC-0010	Site location plan	Site location plan showing linear extent of works between Newcastle and Wicklow Murrough with aerial imagery for context
7694-CCA6_2-P3-DWG-CV-JAC-0100	Location plan	Location plan showing linear extent of proposed works between Newcastle and Wicklow Murrough
7694-CCA6_2-P3-DWG-CV-JAC-0200	General arrangement plan 1 of 8	Plan view of proposed works in Section A2, Parts 1 and 2
7694-CCA6_2-P3-DWG-CV-JAC-0201	General arrangement plan 2 of 8	Plan view of proposed works in Section A2, Part 3

Drawing No.	Title	Description
7694-CCA6_2-P3-DWG-CV-JAC-0202	General arrangement plan 3 of 8	Plan view of proposed works in Section B, Parts 1 and 2
7694-CCA6_2-P3-DWG-CV-JAC-0203	General arrangement plan 4 of 8	Plan view of proposed works in Section B, Parts 3 and 4
7694-CCA6_2-P3-DWG-CV-JAC-0204	General arrangement plan 5 of 8	Plan view of proposed works in Section B, Parts 5 and 6
7694-CCA6_2-P3-DWG-CV-JAC-0205	General arrangement plan 6 of 8	Plan view of proposed works in Section B, Parts 7 and 8
7694-CCA6_2-P3-DWG-CV-JAC-0206	General arrangement plan 7 of 8	Plan view of proposed works in Section C2, Parts 1 and 2
7694-CCA6_2-P3-DWG-CV-JAC-0207	General arrangement plan 8 of 8	Plan view of proposed works in Section C2, Parts 3 and 4
7694-CCA6_2-P3-DWG-CV-JAC-0300	General arrangement cross-sections 1 of 2	Proposed cross-sections at A2 and B
7694-CCA6_2-P3-DWG-CV-JAC-0301	General arrangement cross-sections 1 of 2	Proposed cross-sections at C2
7694-CCA6_2-P3-DWG-CV-JAC-0400	Typical access details	Proposed pedestrian access steps
7694-CCA6_2-P3-DWG-CV-JAC-0500	Cross sections 1 of 5	Simplified cross-sections indicating how typical cross-section A2 varies along the frontage
7694-CCA6_2-P3-DWG-CV-JAC-0501	Cross sections 2 of 5	Simplified cross-sections indicating how typical cross-section B varies along the frontage, 1 of 3
7694-CCA6_2-P3-DWG-CV-JAC-0502	Cross sections 3 of 5	Simplified cross-sections indicating how typical cross-section B varies along the frontage, 2 of 3
7694-CCA6_2-P3-DWG-CV-JAC-0503	Cross sections 4 of 5	Simplified cross-sections indicating how typical cross-section B varies along the frontage, 3 of 3
7694-CCA6_2-P3-DWG-CV-JAC-0504	Cross sections 5 of 5	Simplified cross-sections indicating how typical cross-section C2

6.5 Buildability / Constructability

The constructability considerations for the Project are broadly similar to those presented during the Option Selection Report; however, the materials required have been simplified to rock and geotextile only, reducing the complexity of manual handling. The frontage has good accessibility for marine delivery of rock but has extremely limited road access. Therefore, it is expected that all materials and plant will need to be transported to site via rail or sea. The Project area is long (4km of proposed works within a 8.4km frontage) but due to the nature and locations of the proposed works, several work frontages could proceed at the same time, independently of each other.

The volumes of rock armour required for the scheme between Newcastle and Wicklow Murrough are very large and therefore, the procurement of rock is of key importance to the success of the Project. Ultimately the contractor will decide where the rock is supplied from but there is a high probability that it may be sourced from overseas. Norwegian rock is known within the marine construction sector to be high quality, have good availability and can be a cost-effective and low carbon way to source large volumes of rock.

The expectation at the Phase 3 design stage is that rock will arrive at the Project site via barge, will be discharged at low tide and moved up the beach for construction of the revetments by land-based plant. Two different rock gradings will be required along each section of the works – a 0.3-1t underlayer and a primary armour layer (3-6t for A2 and B, 6-10t for C2). Therefore, at each work frontage two rock stockpiles will need to be managed.

The 6-10t rock armour proposed for C2 will require an underlayer along the whole cross-section to reduce damage to the geotextile during installation. The underlayer rock is reasonably large (median rock size of around 600mm) and unlikely to be disturbed under normal tidal conditions; it may therefore be possible to construct a stretch of underlayer over several consecutive days before then placing the primary rock armour layer.

6.6 Environmental assessment

The EIA screening and scoping documents are currently being prepared. The EIA screening report will determine whether the proposed project is of the nature and scale that requires an EIA. The EIA scoping report will outline the proposed assessment to be undertaken to generate an Environmental Impact Assessment Report (EIAR) for the proposed project including details of the environmental topics to be scoped in/out, the assessment methodology and the surveys, consultation and data required for the assessment.

The Phase 3 design will inform the environmental assessment under Phase 4 of the Project. Due to the proximity of the proposed works between Newcastle and Wicklow Murrough to several designated sites (The Murrough SPA (Code 004186), the Murrough Wetland SAC (Code 002249) and the Murrough pNHA (Code 000730)), it is anticipated that a full EIAR will be required for the Project.

6.7 Health and safety

A Design Hazard Elimination & Risk Reduction Register or DEHERR, has been developed alongside the design of the preferred option during Phase 3 design. The DEHERR is presented in Appendix D and has been prepared following Jacobs' De5ign ('Five in Design') principals. The DEHERR allows the designer to determine potential risks and, where possible, design against the risks presented. Where the risk is not possible to eliminate at this stage of design, further evaluation of the risk will occur at detailed design, before the risk is transferred to the contractor for them to consider when developing their safe system of works. A table presenting the principal identified risks is provided in Table 6-2. Top five risks identified in the DEHERR.

Table 6-2. Top five risks identified in the DEHERR

Risk ID.	Activity	Potential Hazard	Design to Reduce Risk	Residual Risk	Action By	Comments
17	Handling and placement of rock armour	Death/injury to site personnel from loss of control of rocks (movement due to soft ground conditions/dropped by construction plant).	Early design of the rock structures & grading to allow delivery rock delivery to commence early in programme.	Death/injury to site personnel from loss of control of rocks (movement due to soft ground conditions/dropped by construction plant). Risk of injury to eye as a result of rock splinters.	Contractor	Contractor to prepare method statement and safe system of work. Experienced Contractor and subcontractors to be appointed.
42	Public accessing beach areas during storm conditions	Risk of drowning	Phase 3: Beach access points have been included to reduce the likelihood of becoming cut off by the tide designer to advise Client that warning signs should be installed at the access points to the coastal defence (i.e. at access points through the defence on to the beach)"	Risk of drowning	Designer / Client	Client to ensure signage is installed at visible locations along the access points. Signs should also be provided to warn pedestrians of presence of maintenance vehicles
1 / 2	Use of vehicles/plant on site – Staff / Public	Transportation over foreshore and access ramps, etc. Potential plant overturning leading to potential for injury/death to members of public with access to the foreshore.	Clear pedestrian routes within the site and fencing off of working areas to be considered during design development.	Contractor to put in sufficient safe system of works as well as sufficient temporary retaining structures to limit the chance of cliff slippages occurring when the revetment is in its most unstable (i.e. during construction).	Contractor	Contractor to put in sufficient safe system of works as well as sufficient temporary retaining structures to limit the chance of cliff slippages occurring when the revetment is in its most unstable (i.e. during construction).
7	Unstable ground conditions	Potential for site operatives or plant to become stuck in pockets of soft or loose ground. Instability of plant working in area of low soil strength. Risk of suffocation, crush injuries from sinking into ground/loss or damage to plant.	Inform contractor of risk of soft ground from GI and geotechnical analysis in detailed design.	Potential for site operatives or plant to become stuck in pockets of soft ground. Instability of plant working in area of low soil strength. Risk of suffocation, crash injuries from sinking into ground/loss or damage to plant.	Designer / Contractor	Contractor to prepare method statement and safe systems of work. Risk to be updated following completion GI and geotechnical analysis.

Risk ID.	Activity	Potential Hazard	Design to Reduce Risk	Residual Risk	Action By	Comments
27	Lifting operations	Risk of plant overturning during moving or lifting on slope.	The proposed Concept design solutions can be adjusted to reduce the risk following results of the GI and geotechnical analysis. Allowable bearing capacity of slope revetment to be checked and shared with Contractor for temporary works design.	Risk of plant overturning on slope or temporary working platform - Contractor to undertake safe working practices	Designer / Contractor	Designer to assess the bearing capacity of the existing concrete structures. Contractor to prepare method statement of lifting and safe temporary working platform.

6.7.1 Safety and maintenance plan

The safety and maintenance plan will be developed during detailed design.

As stated in Section 2.6, due to the proximity to the Irish Railway line between Newcastle and Wicklow Murrough, the safety certification and approvals will be aligned with the process stated in Iarnród Éireann (IÉ) standards and the general good practices of safety assurance and management. However, based on the consultation with IÉ stakeholders, it has been confirmed that the scoped work are non-significant in accordance with the Common Safety Method Risk Assessment (CSM-RA) and does not require Authorisation to Place in Service (APIS).

Limited maintenance of the designed engineering is proposed because the revetments are designed to respond to beach movement and toe scour. It is possible that re-profiling of the rock revetments may be necessary if a storm exceeding the design conditions occurs within the revetments design life.

6.8 Recommendations for refinement at detailed design

It is noted that the Phase 3 design has only considered one location along each section for the development of the design and that the existing beach levels, slopes and exposure varies along each section. This is particularly relevant for section B which is over 2km long. At detailed design, each section of works should be looked at in greater detail, with coastal analyses (in particular scour calculations, rock armour stability and wave overtopping assessments) and geotechnical analyses further refined to allow the Phase 3 proposals to be tailored to local topography, ground conditions and wave exposure.

Further cross-shore modelling to understand beach response to storms is also recommended. In addition, modelling of the structures in CFD could enable further refinements in the rock gradings, cross-sections and required volumes of rock armour, enabling value engineering of the proposed design to be undertaken.

The principal construction risks identified relate to the interaction of plant on site with construction workers and the public, construction in an exposed marine environment and unforeseen ground conditions.

The use of plant will be carefully planned and managed during construction to ensure the safety of workers. Working zones will be clearly marked and fenced to prevent members of the public from providing access to the works and/or areas where beach access/egress may be temporarily reduced.

Prior to construction, further ground investigation will be undertaken to ensure that ground conditions at each site are fully understood, and that the location of any buried services is understood and accounted for in the design.

7. Conclusions and Next Steps

This Phase 3 Design Report is the principal deliverable at this phase. Future Project phases to deliver the Emerging Preferred Scheme are summarised below:

- Phase 1 – Project Scope and Approval (completed);
- Phase 2 – Concept, Feasibility and Options (completed);
- Phase 3 – Phase 3 Design (current phase);
- Phase 4 – Statutory Process (next phase);
- Phase 5a- Detailed Design and Tender Issue (future phase);
- Phase 5b - Contract Award (future phase);
- Phase 6 – Construction; and,
- Phase 7 – Close out.

7.1 Design development

The next phase of design covers Statutory Process that is focussed on preparation of the environmental impact assessment report (EIAR) AA Screening reports, Natura Impact Statements and associated documentation required for a planning application.

7.2 Opportunities for consultation and engagement

The Phase 3 Design has been informed by Public Consultation 1 (PC1) undertaken in Nov/Dec 2024. The findings are summarised in the PC1 report (7694-CCA6_2-P2-PLA-EV-JAC-0010). There was generally support for the scheme and the rock revetment proposals. Continued access along the shoreline and to the beach was a key requirement from the public. Access provision has been assessed during the Phase 3 design and access behind the proposed defences has been retained and access points to the beach have been included at regular intervals.

A second round of consultation (PC2) will be undertaken in September 2025.

The Project will now undertake an environmental assessment and report it in the EIAR and other documentation in support of the statutory planning process for the Project. Stakeholders will be afforded the opportunity to engage on the Project again at this point through the statutory stakeholder engagement process. Outputs from this consultation process will be taken into consideration by the planning authority.

7.3 Consenting

The significant work streams undertaken during this phase of the project comprise the preparation of all documentation leading to a Marine Area Consent application and Planning Consent application.

An application(s) will be made to MARA for the Marine Area Consent (MAC). On receipt of a MAC a planning consent application will be made. At this stage it is considered that the application for planning will be made under the Seventh Schedule Strategic Infrastructure Development (SID) under the Planning and Development (Strategic Infrastructure) Act 2006 and Planning and Development Act, 2000 (as amended). However, the application will be made under the Planning and Development Act 2024 if the relevant sections are enacted at the time of the application.

7.4 Procurement and programme

The construction procurement will commence following the granting of the consents in Phase 5.

A high-level indicative programme of the next phases is as follows:

- Phase 3 programmed for summer 2025;
- Phase 3 completion autumn 2025; and
- Phase 4 programmed for winter 2025 and throughout 2026.

The programme for phases after planning submission (Phase 5 onwards) is subject to application durations.

8. Glossary

Term	Description
Annual exceedance probability	The probability that a given event will be equalled or exceeded in any one year
Antecedent rainfall	Cumulative rainfall totals over a given period
Beach lowering	Reduction in beach surface elevation over a timescale due to cross-shore and longshore sediment transport.
Beach nourishment	Supplementing the existing beach periodically with suitable material to increase beach volumes, reduce erosion and toe scour at flood defences and/or soft cliffs.
Breakwater	Offshore structure which dissipates wave energy due to their size, roughness and presence of voids. This reduces the wave heights at the shoreline defences
Caisson	A watertight retaining structure used as a foundation
Capital expenditure	Funds used to acquire, upgrade and maintain physical assets (e.g., construction costs)
Capping beam	Steel structures that join pile foundations together to increase their rigidity and reduce movement
Carbon management	An approach to mitigate or reduce carbon (or other greenhouse gas) emissions
Catch fence	A fence designed to catch falling debris and absorb impact
Circular economy	A system which reduces material use, redesigns materials, products, and services to be less resource intensive, and recaptures "waste" as a resource
Cliff recession	Landward retreat of the cliff profile (from cliff toe to cliff top) in response to cliff instability and erosion processes
Climate adaption plan	A plan which sets out measures that protect a community or ecosystem from the effects of climate change, while also building long-term resilience to evolving environmental conditions
Climate change	A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide
Climate resilience	Climate resilience is the capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance caused by climate change
Coastal Cell Area (CCA)	A spatial model which subdivides the coast based on the variation in physical characteristics, including the geology, geomorphology, shoreline topography and orientation, and existing defence type
Coastal erosion	Loss or displacement of land, or long-term removal of rocks and sediment along the coastline due natural impact of waves, wind, rain and tides
Coastal flooding	Submergence of normally dry and low-lying land by seawater
Coastal protection	Measures aimed at protecting the coast, assets and inhabitants from coastal flooding and erosion. Coastal protection may involve structural, non-structural or nature-based solutions
Coastal spit	A coastal landform, whereby a stretch of beach material projects out to the sea and is connected to the mainland at one end
Computational Fluid Dynamics (CFD)	Numerical modelling to analyse and solve complex fluid dynamics problems based on the application of the Navier-Stokes equations. In coastal engineering design, CFD can help refine the design of coastal structures.
Concept level design	Foundational phase of the design process which lays the groundwork for the entire project. The design work undertaken for the concept design is sufficient to confirm that the options will work from a technical perspective and will meet the Project objectives.
Concrete armour	Precast concrete units placed to form breakwaters or revetments to dissipate wave energy
Constructability	Also known as buildability. The extent to which a design facilitates the each and efficiency of construction

Term	Description
Design horizon	The period of time over which the scheme provides the required Standard of Protection (SoP) to the railway line.
Design life	The service life intended by the designer, which is the period of time after installation during which the structure meets or exceeds the performance requirements.
Dilapidation survey	A detailed survey that examines the existing state of the coastal structure
Dune regeneration	Stabilisation and enhancement of existing dune systems to deliver additional resilience
Embankment	Linear grassed earth structure providing flood protection; typically used along riverbanks
Emergency works	Works in response to an event that is unexpected and serious such that it presents a significant risk to human life, health and property or the natural environment and involves the need for immediate action to manage the risk
Feasibility study	An assessment of the practicality of a proposed project plan or method.
Flood proofing	Structural, and non-structural, solutions that can prevent or reduce flood damages to a property or its content.
Flood warning and preparedness	Measures undertaken to better prepare, respond and cope with the immediate aftermath of a flood event
Foreshore	The part of a shore between high- and low-water marks
Freeze-thaw weathering	Form of mechanical weathering whereby water enters cracks in rocks, freezes and expands, widening the cracks. Repetition of this cycle causes gradual break down of the rock.
Gabions	A basket or container filled with earth, stones, or other material
Geomorphology	The interaction between Earth's natural landforms, processes and materials
Geotextile	Permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain
Geotubes/ Geotextile Tubes	Tube shaped bags made of porous, weather-resistant geotextile and filled with sand slurry, to form artificial coastal structures such as breakwaters or levees
Groyne	Linear structure constructed perpendicular to the shoreline which helps retain beach material in place.
Hazard	A process or material that has the potential to cause harm.
High tide mark	A point that represents the maximum rise of a body of water over land
Hydrodynamic modelling	Used in the analysis of coastal hydrodynamic processes, it is employed to simulate major physical phenomena in the coastal region
Joint Probability Analysis (JPA)	Analysis combining the probability of two variables occurring at the same time to determine representative design conditions.
Maintenance burden	The level of maintenance (repair, monitoring, rebuilding) required over the design life of the structure to retain the Standard of Protection of the coastal defence structure
Managed realignment	A coastal management strategy that involves setting back the line of actively maintained defences to a new line inland and creating inter-tidal habitat between the old and new defences
Mudslides	Mass of saturated sediment that moves downslope. Typically comprises distinct source, transport and debris accumulation zones
Multi criteria analysis (MCA)	A structured approach to determine overall preferences among alternative options, where the options should accomplish multiple objectives.
Nature-based solutions	The use of natural materials and processes to reduce erosion and flood risk to coastal infrastructure
Option Selection Report (OSR)	Phase 2 deliverable documenting option selection for the Project
Pore water pressure	The pressure of groundwater within voids between sediment particles. High pore water pressures push particles part, reducing the shear strength which may trigger slope failure.

Term	Description
Residual risk	The risk that cannot be completely eliminated by engineered mitigation measures. It is generally agreed to be at an acceptable level by the client.
Return Period (RP)	Interval of reoccurrence of an event (e.g. storm, water level); indicates the expected frequency in years that an event can be typically expected to occur over the very long term.
Revetment	Sloping or stepped structure built parallel along the shoreline between the low lying beach and higher mainland to protect the coast from erosion and wave overtopping. The revetment may have a smooth or rough surface
Risk	The adverse consequence of a hazard event. Risk is typically described in financial terms, but may consider human harm, environment impact, programme delays or reputational damage.
Road Rail Vehicle (RRV)	Dual mode vehicle that can operate on tracks and road.
Rock netting	A drapery system designed to control rockfall movement by guiding falling debris to a collection point at the toe of the slope
Saltmarsh	Coastal grassland that is regularly flooded by seawater
Sea level rise	An increase in the level of the oceans due to the effects of climate change and/or land-level change
Seagrass bed	Intertidal or sub-tidal beds of sea grass. Provides ecosystem benefits including carbon sequestration.
Seawall	Vertical or near-vertical impermeable structure designed to withstand high wave forces and protect the coast from erosion and/or flooding
Shellfish reefs	Sub-tidal or intertidal reefs formed of suitable material for settlement by oysters or mussels.
Sill	A low rock structure in front of existing eroding banks to retain sediment behind.
Standard of Protection	The expected frequency or chance of an event of a certain size occurring. Defined for this project as being a 0.5% Annual Exceedance Probability, also known as a 1 in 200 year storm protection level.
Storm surge	A temporary change in sea level that is caused by a storm event, which can lead to coastal flooding
Toe scour	Occurs when the toe (bottom) of the defence is worn away by the waves and can cause defences to fail.
Unmanned Aerial Vehicle (UAV)	Drone or other unmanned aircraft used to capture high resolution topographic data through photogrammetry.
Wave exposure	The degree to which a coast is exposed to wave energy
Wave overtopping	The average quantity of water that is discharged per linear meter by waves over a protection structure (e.g., breakwater) whose crest is higher than the still water level

9. References

Causeway Geotech Ltd., 2025, East Coast Railway Infrastructure Protection Projects (ECRIPP); CCA6.2 Newcastle – Ground Investigation, Factual Ground Investigation Report

CIRIA CUR CETMEF C683, 2007, The Rock Manual – The use of rock in hydraulic engineering, 2nd Edition, C683, CIRIA, London, UK

EurOtop, 2018. Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application. Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B., www.overtopping-manual.com

Irish Rail (2020) CCE Department Technical Management Standard, CCE-TMS-391, Safety Approval of Change in CCE owned plant, Equipment, Infrastructure and Operations (PEIO), version 1.0, Date: 17 Feb 2020.

Appendix A. Modelling outputs

Figure A-1. Nearshore Points around CCA 6.2

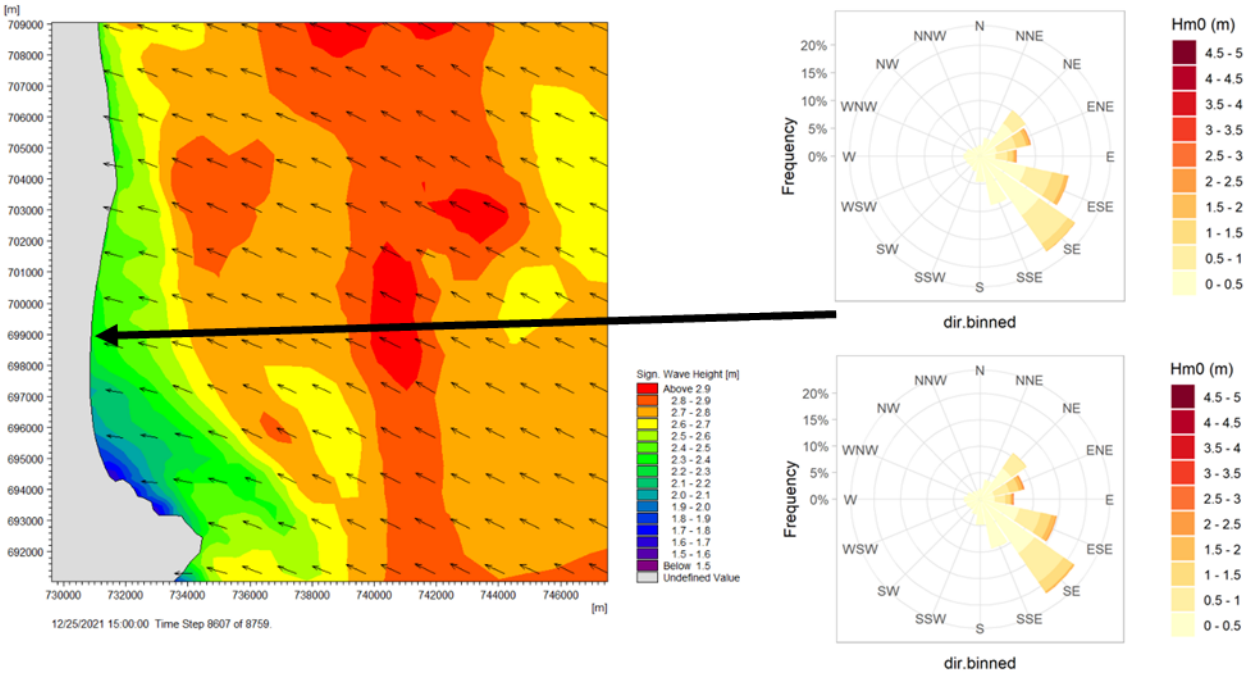

Figure A-2. CCA6.2 contour plot showing event of 25th December 2021 (left), wave height roses - Jan/1988-Dec/2021 (top right) & Jan/2056-Dec/2100 (bottom right)

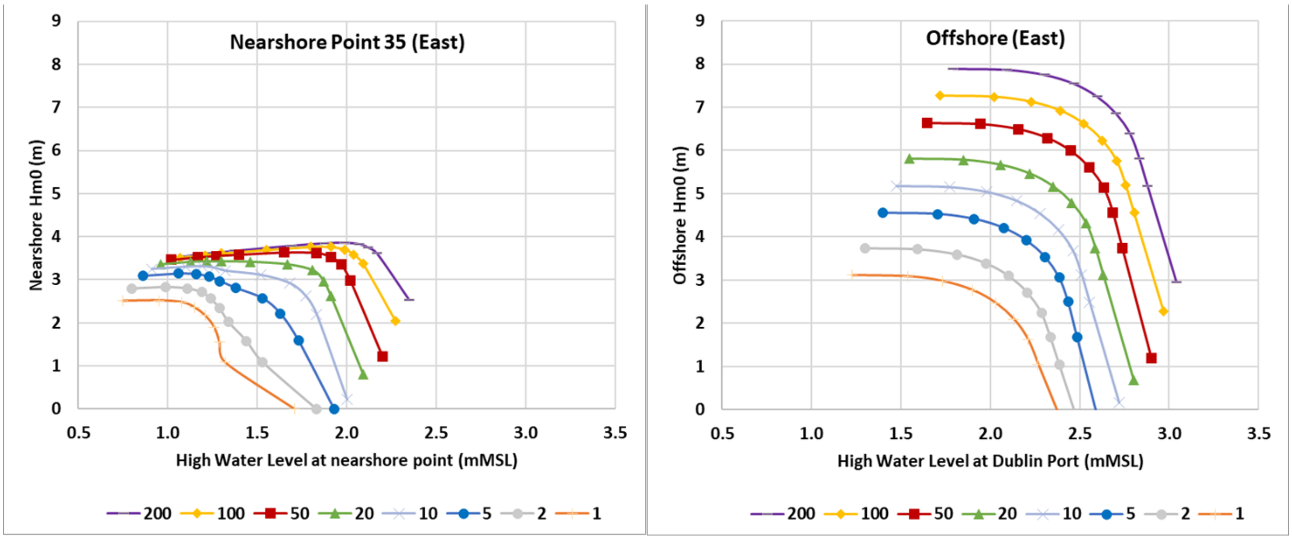

Figure A-3. Joint probability curve at nearshore point 35 in CCA6.2 (left) compared to offshore (right) for waves from the East. Nearshore wave extracted at depth of -6.0 mMSL. Note any changes in the high water levels from Dublin to the nearshore point is due to 2D variations in water level.

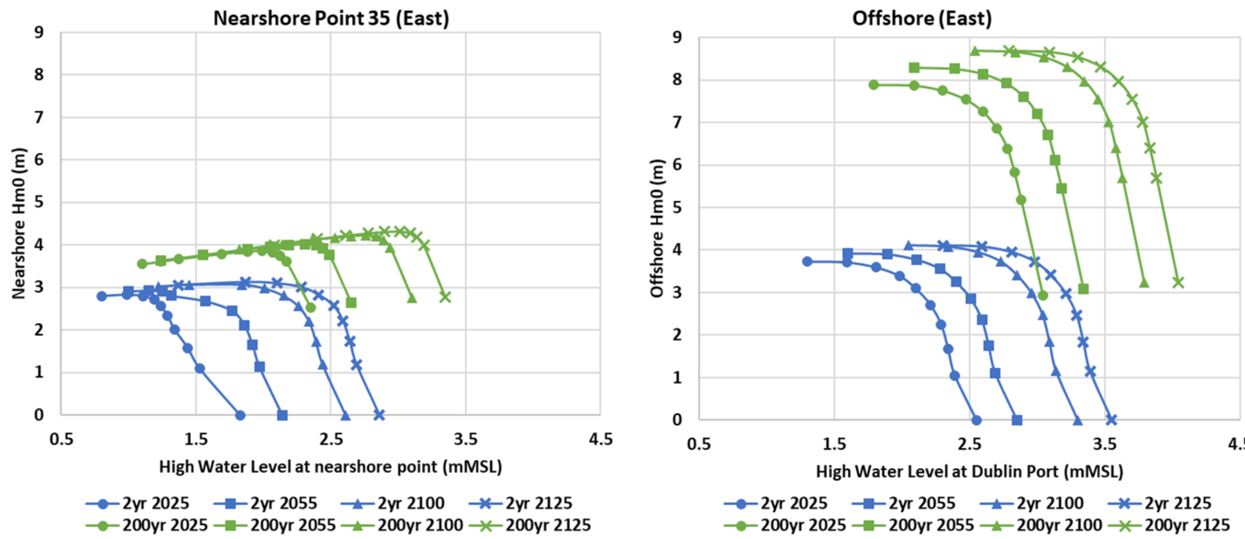

Figure A-4. Impact of climate change on joint probability curves for 1 in 2 year and 1in 200 year return periods at nearshore point 35 in CCA6.2 (left) and Offshore (right) for waves from East. Nearshore wave extracted at depth of -6.0 mMSL. Note any changes in the high water levels from Dublin to the nearshore point is due to 2D variations in water level.

Appendix B. Consideration of Need for Set Back Wall

Document Number	Document Title
7694-CCA6_2-P3-ENG-CV-JAC-0004	Phase 3 Coastal Modelling Report

Appendix C. Geotechnical outputs

Document Number	Document Title
7694-CCA6_2-P3-ENG-CV-JAC-0001	Geotechnical Interpretive Report

Appendix D. DEHERR – (designers risk assessment)

Document Number	Document Title
7694-CCA6_2-P3-REG-CV-JAC-0004	Design Hazard Elimination Risk Register