DART+ Coastal North

ANNEX 3.2

Technical Optioneering Report: Electrification of the Northern Line between Malahide and Drogheda

SECTION C

OHLE foundation solution at underbridges

ARUP

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Appendices

A.1 Detailed MCA table: Malahide Viaduct

A.2 Detailed MCA table: Rogerstown Viaduct

A.3 Detailed MCA table: Balbriggan Viaduct

A.4 Detailed MCA table: Gormanston Viaduct

Abbreviations

Abbreviation	Definition
CAF	Common assessment framework
CCE	Chief Civil Engineer's Department
CRR	Commission of Railway Regulation
GSI	Geological Survey Ireland
LAP	Local area plan
Lidar	Laser imaging, detection, and ranging
LV	Low voltage
MCA	Multi-criteria analysis
MV	Medium voltage
NIAH	National Inventory of Architectural Heritage
NTA	National Transport Authority
OHLE	Overhead line equipment
OPW	Office of Public Works
pNHA	Proposed Natural Heritage Area
RNLI	Royal National Lifeboat Institution
SAC	Special Area of Conservation
SPA	Special Protected Area
TSS	Train Service Specification
WFD	Water Framework Directive
WHS	World Heritage Site

1 Introduction

The purpose of the report is to provide the technical input to the Preliminary Option Selection Report for interventions at underbridges to facilitate Overhead Line Equipment (OHLE) as part of the works delivering an electrified railway between Malahide and Drogheda. This aspect of design is considered separately from the general adopted OHLE methodology due to the bespoke fixing arrangements required, often to assets of significant heritage and cultural value.

As explained in Section 2.2.1.1, only underbridges close to or exceeding 60m total length are materially affected by the works. The resulting list of underbridges impacted by OHLE is therefore as follows:

- UBB30 - Malahide Viaduct
- UBB36 - Rogerstown Viaduct
- UBB56 - Balbriggan Viaduct
- UBB65 - Gormanston Viaduct
- UBB72 - Laytown Viaduct
- UBB82 - Boyne Viaduct

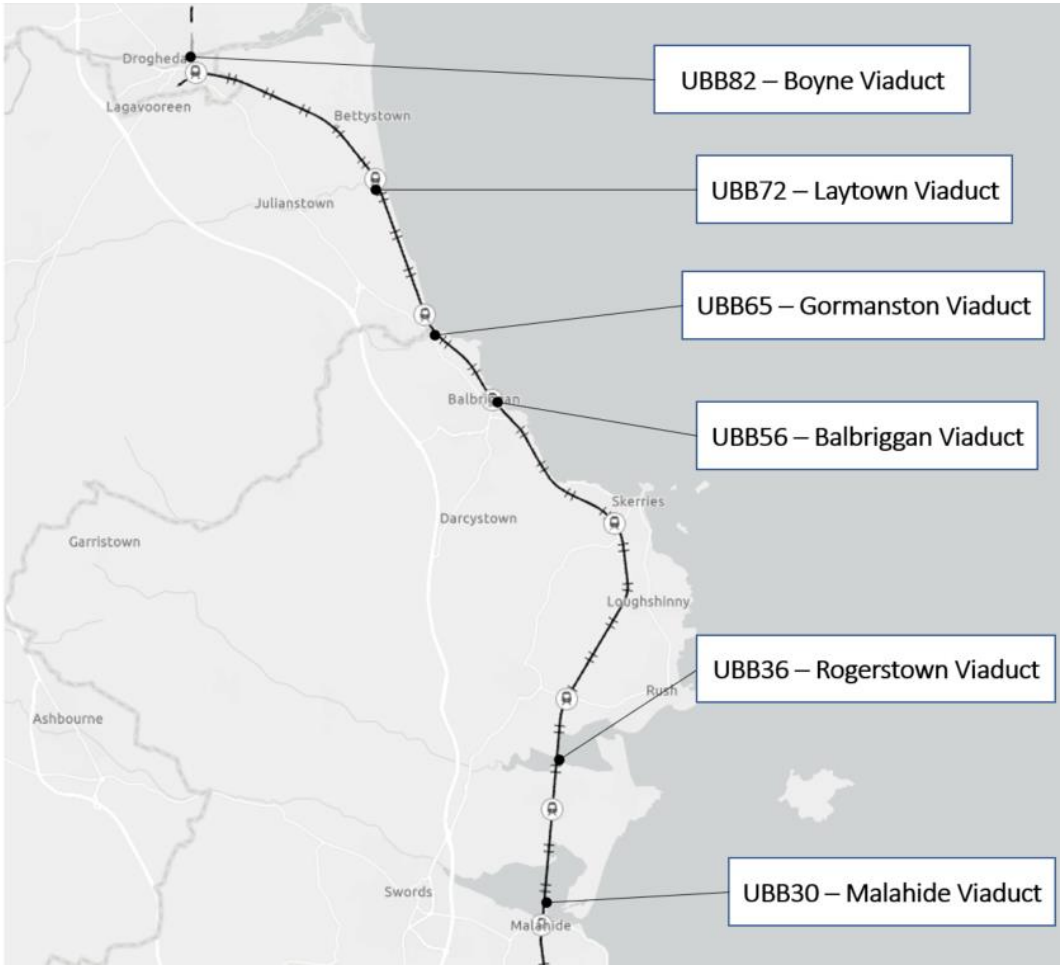


Figure 1-1: Map of underbridges impacted by OHLE mast requirements (Map data © OpenStreetMap contributors, Map layer by Esri)

This report provides the technical assessment of interventions at each of these bridges from option selection through to the Draft Emerging Preferred Option, including the options considered and how a Draft Emerging Preferred Option was chosen.

For each underbridge, the report includes:

- An introduction and description of the study;
- A summary of the option assessment approach undertaken;
- A description of the existing situation;
- The requirements;
- The relevant constraints;
- The option assessment containing:
  - Longlist of options;
  - Sifting of longlist of options;
  - Summary and details of the shortlisted options;
  - Multi-criteria analysis (MCA) (where applicable);
- The Draft Emerging Preferred Option.

1.1 Packages of work

The scope of work for DART+ Coastal North covers a wide range of interventions on the Northern Line needed in order to meet the Train Service Specification (TSS) requirements. To appropriately assess options against each other, the works have been split into separate work packages, as detailed in the relevant Annexes. Where appropriate, the works have then been further split down into sections which define the system which has been subject to the optioneering and design process.

This document is an section of the Annex 3.2: Electrification of the Northern Line. Please refer to Table 1-1 for a list of the different sections which make up the electrification package of work.

This document contains an overview of the optioneering process for interventions at underbridges required to facilitate the installation of OHLE.

Table 1-1: List of key documents associated with Electrification of the Northern Line between Malahide and Drogheda

Annex	Section	Title
3.2	A	OHLE system

Annex	Section	Title
	B	OHLE foundation solution
	C	OHLE foundation solution at underbridges
	D	Bridge parapet modifications
	E	OHLE Bridge Clearance works
	F	Traction Power Supply (will form part of Public Consultation 2)
	G	User worked level crossing south of Donabate
	H	Fencing and lineside safety

1.2 References

This report should be read in conjunction with the following related optioneering reports:

Table 1-2: List of key documents associated with this report

Annex	Title	Description
N/A	DART+ Coastal North Preliminary Option Selection Report	This is the main report which summarises the optioneering process and the different packages of proposed works on the DART+ Coastal North project.
N/A	DART+ Coastal North Preliminary Option Selection Report – Executive Summary	This report summarises the main Preliminary Option Selection Report.

Annex	Title	Description
1	Emerging Preferred Option Maps	Includes drawings for each Emerging Preferred Option, to support the Preliminary Option Selection Report.
2.1	Policy Context	This presents a detailed review of the European, National, Regional and Local policy context for the DART+ Programme and the DART+ Coastal North Project
2.2	Useful Links	Useful links to documents/websites relating to the DART+ Coastal North project.
3.1	Constraints Report	This report reviews the DART+ Coastal North constraints.
3.2	Technical Optioneering Report: Electrification of the Northern Line between Malahide and Drogheda.	The Technical Optioneering Report for the Electrification of the Northern Line between Malahide and Drogheda. The report is divided into a series of sections, as described in Table 1.
3.3	Technical Optioneering Report: Works around Drogheda MacBride Station	The Technical Optioneering Report for Works around Drogheda MacBride Station. The report addresses track and station modifications to allow for the increased number of DART services.
3.4	Technical Optioneering Report: Works around Malahide Station	The Technical Optioneering Report for Works around Malahide Station. The report addresses track modifications required to allow trains to be turned back clear of through running services.
3.5	Technical Optioneering Report: Works around Clongriffin Station	The Technical Optioneering Report for Works around Clongriffin Station. The report addresses track modifications required to allow trains to be turned back clear of through running services.
3.6	Technical Optioneering Report: Works around Howth Junction & Donaghmede Station	The Technical Optioneering Report for Works around Howth Junction & Donaghmede Station. The report addresses the addition of tracks to allow a higher frequency shuttle service.
3.7	Technical Optioneering Report: Howth Branch Level Crossings	The Technical Optioneering Report for the Howth Branch Level Crossings. The report addresses the impacts of all proposed increases in train frequency on existing level crossings on the Howth Branch.

1.3 Option Assessment Approach

The works proposed to underbridges have been assessed using the Department of Transport's Common Appraisal Framework for Transport Projects and Programmes (CAF) as the options have the potential to be geographically different from each other and have a material difference on external parties or the environment. Further details can be found in the Option Selection Process section of the Preliminary Option Selection Report.

2 Requirements

2.1 Specific Requirements

The main project objectives and requirements relating to this subsection of the overarching electrification optioneering report are as follows:

- Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead;To minimise adverse impacts on the natural and built environment associated with construction, operation and maintenance of the project;
- To minimise adverse impacts on existing rail services, road users and landowners associated with the construction, operation and maintenance of the project ;To deliver a sustainable, low carbon and climate resilient design solution including making use of existing infrastructure where possible with targeted improvement works;To design in accordance with IÉ Standards and relevant national and EU standards and guidelines;
- Designs shall comply with the Minimum Employer's Functional Requirements and meet the Train Service Specification;
- To identify cost-effective solutions from a capital, operations, and maintenance perspective.

2.2 Positioning of OHLE Supports

The longitudinal placement of masts is decided based upon technical requirements and is undertaken prior to determining the transverse positioning of the masts. This transverse positioning affects the chosen fixing methodology, from which the various options generated are put through the option selection process.

2.2.1 Longitudinal arrangement

2.2.1.1 OHLE mast spacing requirements

The maximum design spacing of OHLE masts is 63m, assuming a straight track. Track curvature can result in a reduced spacing, but only starts to have an impact for horizontal radii less than 10000m. The span reduces to approximately 60m for a track curvature of 5000m. Hence, as an initial assessment, underbridges with an overall length of less than 60m are assessed not to require OHLE frames to be placed on the structure, i.e. for bridges with an overall length less than 60m, there is no need to physically attach and support OHLE masts on the underbridge structure below.

The table below is an extract from the Functional Specification. The Specification goes on to require a reduced maximum span of 63m, to avoid later large-scale repositioning of structures.

Table 2-1: OHLE max. span versus curvature radius (Source: Electricity Functional Specifications System-Wide - MAY-MDC-ELE-DART-SP-E-0002)

Radius (m)	Span (m)
Straight	65
30000	65
20000	65
10000	65
9000	64
8000	63
7000	63
6000	61
5000	60
4000	58
3000	58

Radius (m)	Span (m)
2000	58
1000	58
850	55
800	54
600	49
550	48
500	46
450	45
400	43
300	38
200	32
100	20

Based on the current draft power study assessment, Coastal line will have multiple parallel feeder wires in some places. For Malahide-Drogheda section, the following parallel feeders per track are considered in the power study assessment:

- Interface with existing electrification to Donabate TSS: 1x240 mm2
- Donabate TSS to Rush&Lusk TSS: 2x240 mm2
- Rush&Lusk TSS to Skerries TSS: 1x240 mm2
- Skerries TSS to Laytown TSS: 2x240 mm2
- Laytown TSS to Drogheda TSS: 3x240 mm2

Final parallel feeders need still to be agreed, however, based in the current arrangement, 1x240 mm2 parallel feeder per track will be installed along Malahide viaduct and 2x240 mm2 parallel feeder per track will be installed along Rogerston, Balbriggan, Gormanston and Layotwn viaducts. For Boyne viaduct is considered parallel feeder will not be required.

Therefore, in case these parallel feeders will be installed aerial, supported on the masts, the sag of the feeder could be a constrain for the maximum span to be considered.

The Electricity FRS System-Wide indicates that the parallel feeder wire shall be preferably position on top on the OHLE structure in single track cantilever arrangements and on the upper side of the portal or twin cantilever beam to provide enough height to ensure the feeder sag will not infringe the vehicle/pantograph clearance.

According to similar situations, the sag for 1x240 mm2 Cu parallel feeder wire would be about 1.3 m for 60 m span at 40 ºC. Therefore placing the parallel feeders wires at the top of the masts (8.5 m height) the lowest point of the feeder wires would be at 7.2 m from the rail level.

2.2.1.2 Aesthetic requirements

For aesthetic requirements, the criteria below will be followed.

Bridges with lengths shorter than 60m

- Frames will be placed as far as possible from the bridge structure;
- Where possible, frames will be placed so that there is equal space either side of the bridge, to create an aesthetically pleasing symmetrical arrangement.

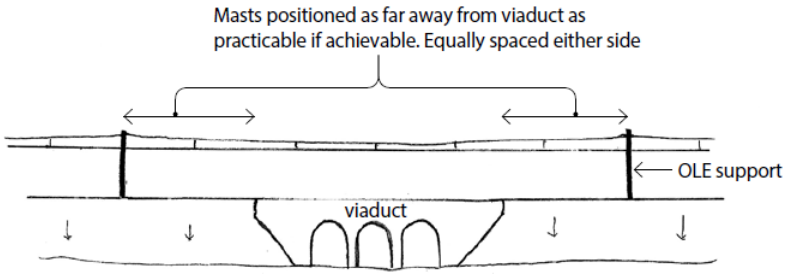


Figure 2-1: Approach to longitudinal frame arrangement for underbridges with lengths < 60m

Bridges with lengths larger than 60m

- Where possible, longitudinal frame positions will be aligned with the bridge piers;
- Where possible, a symmetric arrangement with a minimum of two frames will be provided, even if this requires placing the frames closer than what is technically required;
- Where possible, a single OHLE support positioned at the centre of the bridge will be avoided.

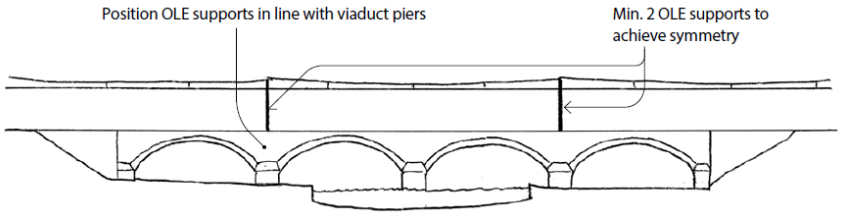


Figure 2-2: Approach to longitudinal frame arrangement for underbridges with lengths > 60m

2.2.1.3 Tensioning requirements

Overhead wires are required to be held under tension. Tensioning is achieved by means of spring devices which ensure a constant tension regardless of temperature variations. In an open route (i.e., not on bridges) a standard fixing arrangement would be as shown in Figure 2-3. According to standards, the maximum half tensioning length is 800 m. The longest overbridge in the affected route is 525m. Hence, no anchor supports are required on bridges generally.

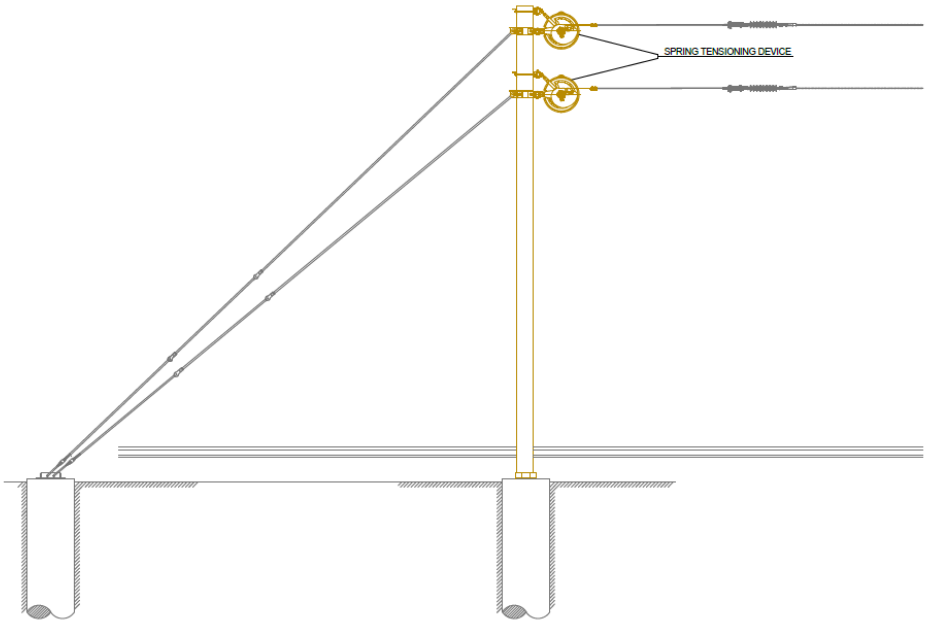


Figure 2-3: Tensioning Device

2.2.2 Transverse arrangement

Depending on the clearance available between tracks and bridge parapets, as well as the technical feasibility of the options, OHLE masts will be placed in one of the following configurations:

- Option A – Supported on superstructure;
  - Option A1 - In-board of parapets;
  - Option A2 – Aligned with parapets;
  - Option A3 – Outside of parapets.
- Option B - Supported on substructure
  - Option B1 – Supported off pier;
  - Option B2 – Supported off abutment;
- Option C - Independent supports.

The following minimum offsets from the edge of the nearest running rail to the OHLE mast shall be assumed, in accordance with I-PWY-1101 (Requirement for Track and Structures Clearances):

- 1790mm where no walkway is provided;
- 2040mm where a walkway is provided.

These clearances are minimum values associated with straight and level tracks. Additional clearances may be required to account for cant and curvature of the adjacent track.

According to the Electricity Functional Specifications System-Wide the preferred clearances from running edge to OHLE structure line in straight track will be 2.940 mm, considering cess walkway and services.

2.2.3 Determining impacted underbridges

The underbridges considered for assessment are determined using the longitudinal spacing requirements outlined above. As a result, bridges close to or exceeding 60m in length are included for assessment, the list of which is presented below:

- UBB30 - Malahide Viaduct;
- UBB36 - Rogerstown Viaduct;
- UBB56 – Balbriggan Viaduct;
- UBB65 - Gormanston Viaduct;
- UBB72 – Laytown Viaduct;
- UBB82 - Boyne Viaduct.

2.3 Design Standards

The design of any structural interventions shall be in accordance with Eurocodes and all relevant national annexes.

Design of OHLE and, in particular, spacing of masts to be in accordance with MAY-MDC-ELE-DART-SP-E-0002 Electricity Functional Specifications System-Wide.

Clearances to new/modified structures shall be provided in accordance with I-PWY-1101 (Requirement for Track and Structures Clearances).

Design of structures, including OHLE supports, to be in accordance with CCE-TMS-410 (Civil Engineering Structures Design Standard).

3 Malahide Viaduct (UBB30) optioneering selection process

3.1 Existing Situation and Constraints

3.1.1 Structure

Malahide Viaduct is a 176m long viaduct over a tidal estuary. The deck superstructure is comprised of twelve simply supported spans (4 x 12.275 m + 8 x 15.860 m).

The bridge was originally constructed in 1844 as a timber trestle structure supported on timber piles. Due to the large tidal flows at this location, the bridge experienced significant scour, resulting in large volumes of rock being placed along the line of the structure, forming a rock fill weir. The bridge was reconstructed in 1860 using masonry piers constructed on top of the rock fill. The superstructure has since been replaced over the years, with the original masonry piers retained. In 2009, Pier 4 collapsed along with the two spans bearing on it. The pier was subsequently reconstructed on a piled foundation. The remaining piers were then stabilised using micro-piles drilled through the masonry abutments and rock fill below.

The newly constructed spans (spans 4 and 5) – see Figure 3-3 and Figure 3-5 - comprise twelve prestressed concrete beams with a cast in-situ deck slab. The remaining spans comprise six post-tensioned concrete beams without the use of a deck slab.

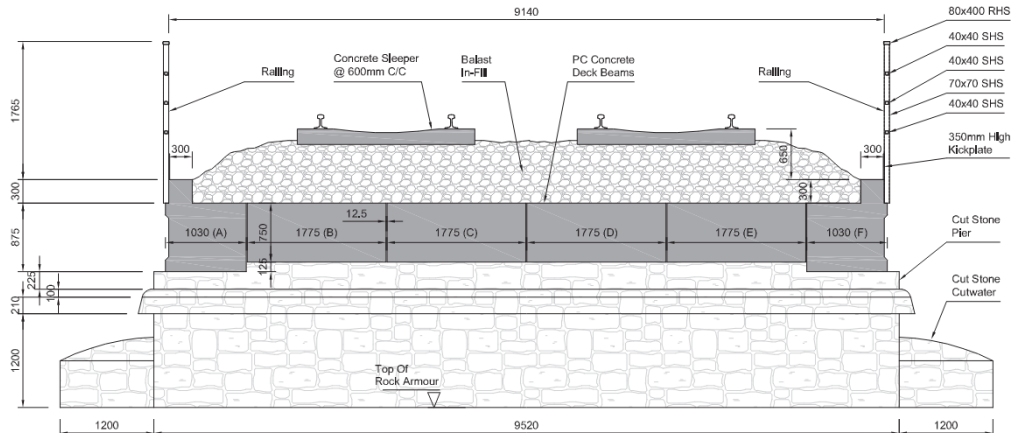


Figure 3-1: UBB30 Typical section for spans 1 and 12 (end spans)

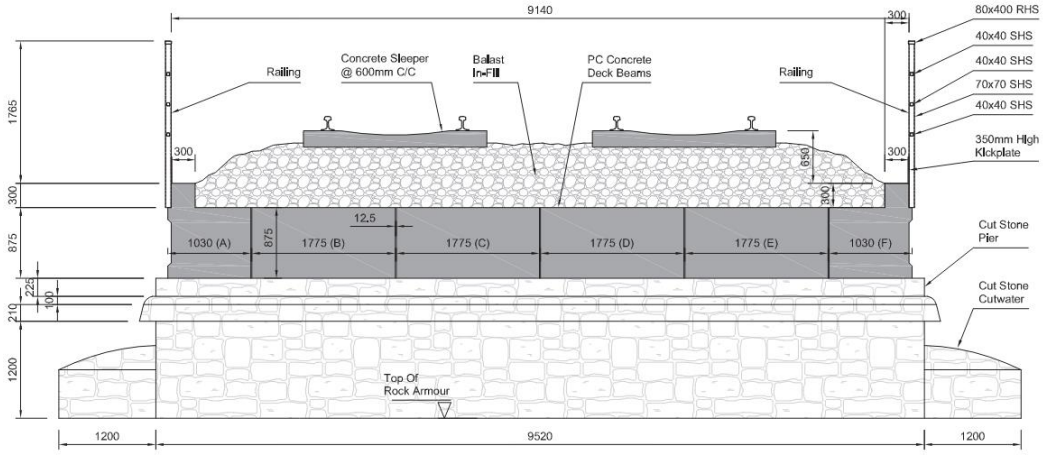


Figure 3-2: UBB30 Typical section for spans 2, 3 and 6 to 11

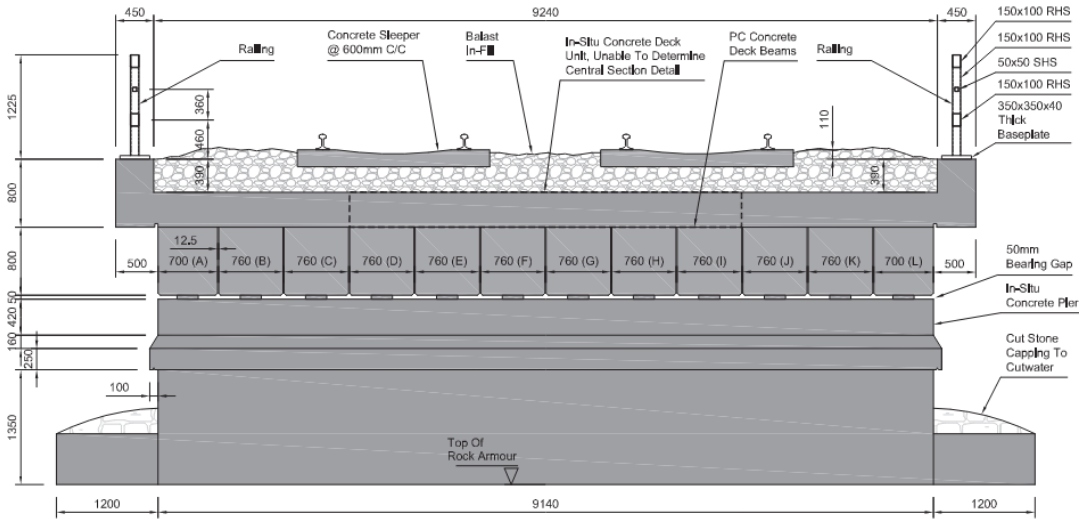


Figure 3-3: UBB30 Typical section for spans 4 and 5 (spans replaced following collapse)

Figure 3-4: UBB30 view looking at downstream edge of bridge (source: Iarnród Éireann)

Figure 3-5: UBB30 replaced spans (4 and 5) and reconstructed Pier 4 (source: Iarnród Éireann)

Figure 3-6: UBB30 side elevation photo (source: Iarnród Éireann)

Figure 3-7: UBB30 at track level looking north (source: Iarnród Éireann)

Figure 3-8: UBB30 deck soffit (source: Iarnród Éireann)

Figure 3-9: UBB30 Elevation at historical piers (source: Iarnród Éireann)

3.1.2 Permanent Ways and Tracks

The structure currently carries two tracks: the Up and Down Main Lines. Each track has two central derailment containment rails over the full length of the underbridge. The tracks have a substantially straight alignment.

3.1.3 Utilities

Within the study area there are telecommunications fibre cables running parallel alongside the railway for the extent of the Malahide Viaduct. At the southern end of the viaduct there is an Irish Water sewer outfall running parallel to the railway which outfalls from the nearby Malahide Wastewater Treatment Works. There are no utilities crossing the railway within the study area.

The various OHLE foundation options are unlikely to impact on the existing sewer. The lineside telecommunications pose potential constraints to the OHLE foundation options. As such, they have been considered in the development of options. Regardless of the option selected, it will be necessary to maintain these during construction or to minimise outage durations in consultation with the utility providers.

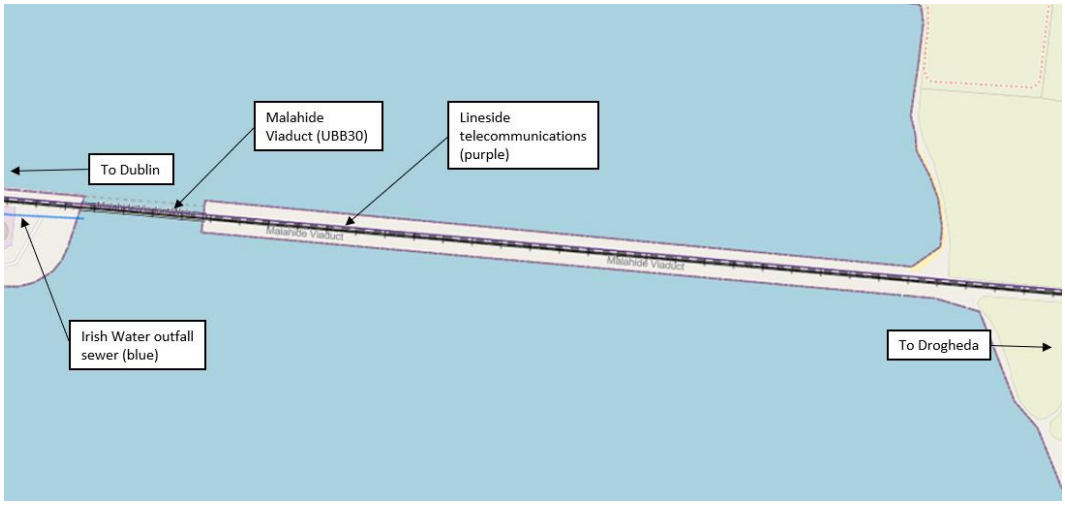


Figure 3-10: Plan of Malahide Viaduct (UBB30) showing existing utility routes (Map data © OpenStreetMap contributors, Map layer by Esri)

3.1.4 Environmental

For an overview of the existing environmental constraints for DART+ Coastal North refer to Annex 3.1 Constraints Report. The following sections provide detailed environmental description of the existing situation and constraints relevant to this specific structure.

3.1.4.1 Traffic and Transportation

The site is accessible by a local road currently providing access to the Malahide Marina Village. The road is approximately 6m wide and serves a residential area, a wastewater treatment plant and some other commercial land uses, some of which are related to the marina. The nearest road link of regional importance is the R106 Swords Road to the west, which links - through an industrial area on the west of the M1 - with Junction 3 (R125) on the M1. This road link provides the only access to the site, through the village of Malahide.

Towards the north the site access will be provided through farmland towards the west of the railway line. The farmland is accessible via local roads. The nearest road link of regional importance is the R126 to the west, which links with Junction 4 on the M1.

A planned walkway and cycleway across Malahide Estuary have been granted planning permission. The Broadmeadow Way forms part of the Fingal Coastal Way, the National Transport Authority's (NTA) Greater Dublin Area Cycle Network and East Coast Trail. It is funded by the NTA and Fingal County Council and construction is set to take place between 2022 and 2023. The route will run alongside the rail line currently crossing the estuary and will include a 280 metre long bridge on the railway viaduct.

The low speed and function of the access road to the Malahide Marina Village will need to be considered in the context of construction traffic. The road provides access to residential areas and the wastewater treatment plant. The interface with

the planed Broadmeadow Way and the watercourse to the north will also need to be considered during construction.

3.1.4.2 Landscape and visual impact

Malahide Railway Viaduct is listed by Fingal County Council as a protected structure (reference: RPS No. 0420 Appendix 2 'Record of Protected Structures' of the Fingal Development Plan 2017-2023).

The lands at the southern end of the estuary within which the viaduct is located is zoned Town and District Centre and High Amenity at the northern end in the Fingal Development Plan. The Plan also includes an objective to Preserve Views of the estuary from the southern shore (Estuary Road, Caves Strand, The Haven and Bissett's Strand and Coast Road in Malahide) and the north shore (M1 Bridge to Kilcrea and along Corballis Cottage Road). The viaduct is circa 600m north of the nearest such listing on the southern shore (The Haven), and circa 1.5km south of the nearest listing on the northern shore (the Island Golf Course end of Corballis Cottages Road).

3.1.4.3 Archaeological and cultural heritage

There are no recorded archaeological monuments or findings in and around the viaduct. However, Malahide and the estuary has been the focus for settlement and activity for thousands of years, as evidenced by the Mesolithic and Neolithic flint scatters in the wider area. The village itself was based around a Viking landing point, which survived from the eighth century until the arrival of the Anglo-Normans. The village continued as a fishing port and was also the site of several silk and poplin mills. The building of the Dublin to Drogheda railway viaduct in 1844 was largely responsible for the decline and eventual disappearance of the fishing fleet (Bennett 1991). Rocque's 1756 map of Dublin shows the estuary's oyster beds, which were removed by the railway viaduct less than a hundred years later. The estuary is considered to be of archaeological potential and an area where buried archaeological features and finds or historical supports (timber piles) associated with the original viaduct construction could be revealed by in water works.

3.1.4.4 Architectural heritage

The Malahide Viaduct is a protected structure under Fingal County Council's Development Plan (FCC RPS 0420). The original structure, erected in 1844, was first altered in 1860, with much of the superstructure replaced in subsequent years. Substantial reconstruction took place after the 2009 collapse, including replacing two spans and one of the original piers. Despite the alterations, the majority of the piers are original to the structure, and the viaduct remains of architectural and technical interest.

There is a railway bridge to the north of the viaduct, at Kilcrea townland, and a second to the south at Bissets Strand, which are also included in Fingal County Council's Record of Protected Structures (FCC RPS 0502 and 0423). These structures are also included in the NIAH where they are rated of Regional

Importance for reasons of architectural and technical interest (NIAH 11336027 and 11344015). The Malahide Historic Core Architectural Conservation Area is to the south of the viaduct (approximately 600m away).

3.1.4.5 Noise and Vibration

The existing acoustic environment at the viaduct will be predominantly dominated by train pass bys on the railway line and natural noises such as birds, wind, and the ocean. The existing acoustic environment will be positively affected by the electrification of the line, as this will reduce noise from trains.

Construction noise and vibration is expected to be audible at all locations.

The nearest sensitive receivers for the Malahide Viaduct are residents to the south of the viaduct adjacent to the station. They are approximately 500m away and will be most affected by works on the southern side of the viaduct.

Noise sensitive species in the vicinity of the viaduct will have to be considered during construction.

3.1.4.6 Air quality and climate

The nearest sensitive receivers for the Malahide Viaduct are residents to the south of the viaduct adjacent to the station. They are approximately 500m away and will be most affected by works on the southern side of the viaduct.

The Malahide Estuary is a designated Special Area of Conservation (SAC), a Special Protection Area (SPA), and a proposed National Heritage Area (pNHA). These areas are sensitive to dust impacts during the construction phase.

The proposed development will support the aims of the Climate Action Plan. However, a key constraint is the development of the proposed scheme to ensure the following:

- the use of construction materials with low embodied carbon;
- the reduction of road traffic due to modal shift.

3.1.4.7 Agricultural and Non-agricultural

There are no agricultural constraints at the location of the Malahide Viaduct and therefore this location is assessed as very low sensitivity from an agricultural perspective.

Farms in County Dublin are larger than the national average. There are fewer dairy and other livestock farms and more tillage farms. In the environs around Malahide Station there is no agricultural land.

The lands north of Malahide Estuary are agricultural. There are beef and tillage enterprises on the west side of the railway line within the study area in this area. There is also an access road along the western boundary of the railway line.

3.1.4.8 Geology and Soils

The Malahide Viaduct is underlain by recent deposits of Made Ground in areas of reclaimed land with deposits of recent estuarine fine and coarse grained sediments deposits and marine beach sands.

These, in turn, overlie various glacial deposits derived from underlying bedrock with Irish Sea tills derived from limestone to the west and south and Irish Sea till derived from siltstone and sandstone to the north. A pocket of glacial gravels is indicated by the Geological Survey Ireland (GSI) mapping to the south of the viaduct and causeway.

The underlying bedrock comprises the Carboniferous Malahide Formation described as argillaceous limestone and shale. Faulting in the bedrock occurs to the north and south of the estuary trending in a northwest – southeast direction.

The nearest Geological Heritage Area is Malahide Point (Site Code DF020), approximately 500m east of the viaduct, a County Geological Site which has been recommended for Geological National Heritage Area (NHA). It is described as dunes and a sand/shingle beach and geologically as a large dune system and beach formed by a long sand and shingle spit.

3.1.4.9 Water Resources

The Malahide Viaduct is located between the Broadmeadow Water transitional waterbody (IE_EA_060_0100) and Malahide Bay coastal waterbody (IE_EA_060_0000). Under the Water Framework Directive (WFD, 2000/60/EC) the status of the Broadmeadow Water waterbody is classified as Poor for the 2013-2018 monitoring cycle and At Risk, indicating that the waterbody may not maintain or achieve that status on the next WFD cycle. The status of the Malahide Bay coastal water body is classified as Moderate for the 2013-2018 monitoring cycle and At Risk. The minimum objectives for a water body under the WFD are to achieve at least ‘Good’ status (or ‘Good potential’ for artificial/ highly modified water bodies), and no deterioration of existing status.

The area is part of the Malahide Estuary SAC, SPA and proposed Natural Heritage Area (pNHA).

3.1.4.10 Biodiversity

The site in question is within the estuarine environment of the Malahide Estuary, and north of the urban fabric of Malahide centre. The Malahide Estuary is a designated Special Area of Conservation (SAC), a Special Protection Area (SPA), and a proposed National Heritage Area (pNHA) as indicated below.

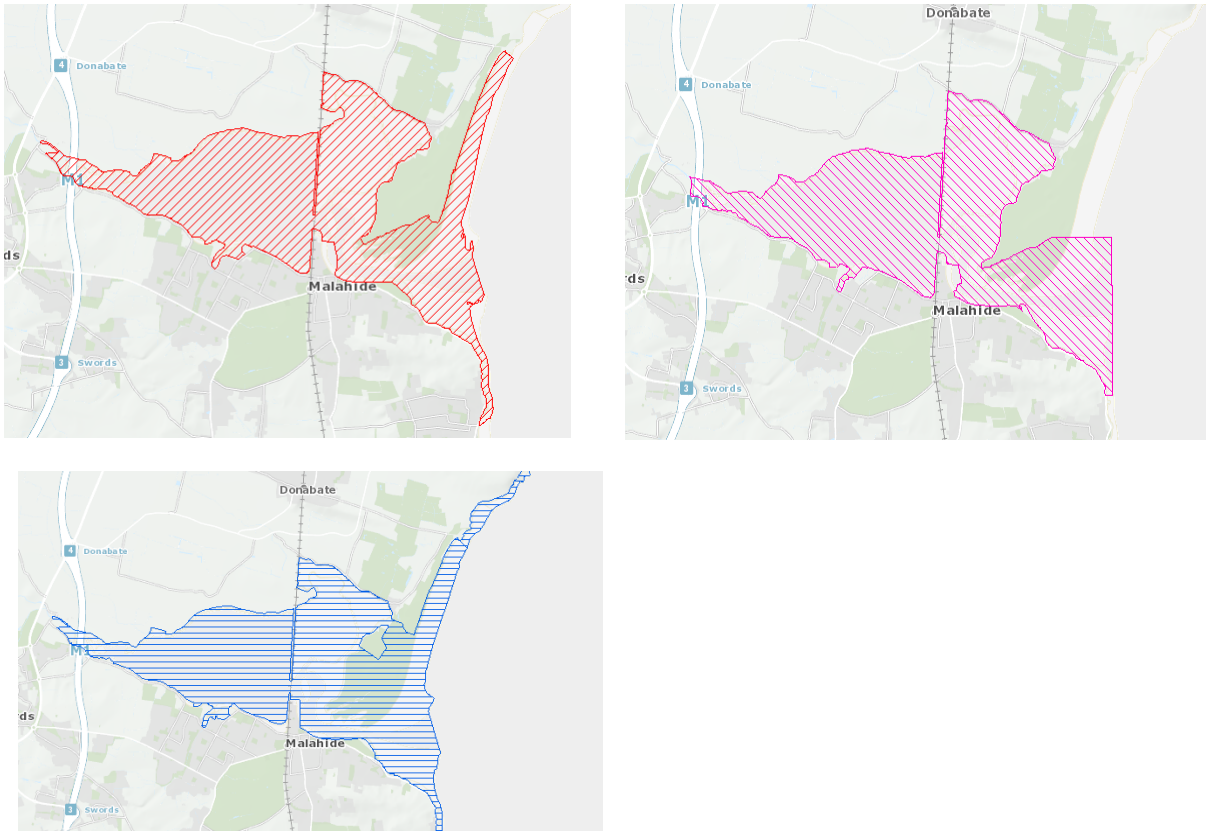


Figure 3-11: Designated sites in the vicinity of Malahide Viaduct (Map data © OpenStreetMap contributors, Map layer by Esri)

Habitats and notable species

A list of sites within the site of development have been identified and described according to their site synopsis. The key ecological constraints in this area are the Malahide Estuary SAC, Malahide Estuary SPA and the proposed Natural Heritage Area designation. These are designated for marine habitats and over wintering birds. The designated areas are of international and national biodiversity importance. The qualifying interests (reason for designation) of the Malahide Estuary SAC and SPA are as listed below.

Table 3-1: Qualifying interests of the Malahide Estuary SAC and SPA

MALAHIDE ESTUARY SAC	MALAHIDE ESTUARY SPA
Mudflats and sandflats not covered by seawater at low tide [1140] Salicornia and other annuals colonising mud and sand [1310] Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] Mediterranean salt meadows (*Juncetalia maritimi*) [1410] Shifting dunes along the shoreline with white dunes (*Ammophila arenaria*) [2120] Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]	Great Crested Grebe (*Podiceps cristatus*) [A005] Light-bellied Brent Goose (*Branta bernicla hrota*) [A046] Shelduck (*Tadorna tadorna*) [A048] Pintail (*Anas acuta*) [A054] Goldeneye (*Bucephala clangula*) [A067] Red-breasted Merganser (*Mergus serrator*) [A069] Oystercatcher (*Haematopus ostralegus*) [A130]

MALAHIDE ESTUARY SAC	MALAHIDE ESTUARY SPA
	Golden Plover (*Pluvialis apricaria*) [A140] Grey Plover (*Pluvialis squatarola*) [A141] Knot (*Calidris canutus*) [A143] Dunlin (*Calidris alpina*) [A149] Black-tailed Godwit (*Limosa limosa*) [A156] Bar-tailed Godwit (*Limosa lapponica*) [A157] Redshank (Tringa totanus) [A162] Wetland and Waterbirds [A999]

Other potential constraints include:

- Potential for the railway to support interesting flora species and habitats due to the calcareous nature of the ballast and their often relatively undisturbed nature;
- Potential for invasive species to occur along the railway line.

3.1.5 Planning

Malahide Viaduct is listed by Fingal County Council as a protected structure (reference: Appendix 2 'Record of Protected Structures' of the Fingal Development Plan 2017-2023).

Malahide Estuary is a protected site and is designated as both a Special Area of Conservation (SAC) and a Special Protected Area (SPA) by the National Parks and Wildlife Service.

Plans to construct the Broadmeadow Greenway received planning approval in 2020. The Greenway will include a pedestrian and cycle bridge which will run parallel to the existing rail viaduct over Malahide Estuary. The piers for this new bridge have already been constructed. The proposed bridge will be approximately 1.73m offset from the existing piers of the railway viaduct.

3.2 OHLE frame longitudinal arrangement

In determining the longitudinal arrangement of the masts, three separate configurations have been considered. A summary of these and their suitability to meet the basic criteria is presented in Table 3-2. Yellow indicates an unfavourable result, with red indicating a value that precludes the option.

Table 3-2: UBB30 OHLE Longitudinal arrangement appraisal matrix

	Mast at piers	Number of masts	Symmetric distribution	Mast in bridge centreline	Mast spacing < 60m	All details equal?
Arrangement 1 (Piers 3,6, 9)	Yes	3 ≥ 2	Yes	Yes	Yes	Yes
Arrangement 2 (Piers 4, 8)	Yes	2 ≥ 2	Yes	No	~63.4m	No (historic and new

	Mast at piers	Number of masts	Symmetric distribution	Mast in bridge centreline	Mast spacing < 60m	All details equal?
						piers affected
Arrangement 3 (Piers 1,3,5,7,9,11)	Yes	6 ≥ 2	Yes	No	Yes	Yes

Sketches of the various arrangements are provided in the figures below. Based upon the assessment criteria, arrangement 1 is selected as the preferred option. Arrangement 2 is discounted due to excessive mast spacing and detail complexity. Arrangement 3 is discounted due to an excessive number of masts required.

Arrangement 1 will be used in assessing the longlist options of positioning the masts on the structure. Note the sumbol in the centre of the figures below represents the central axis of the viaduct.

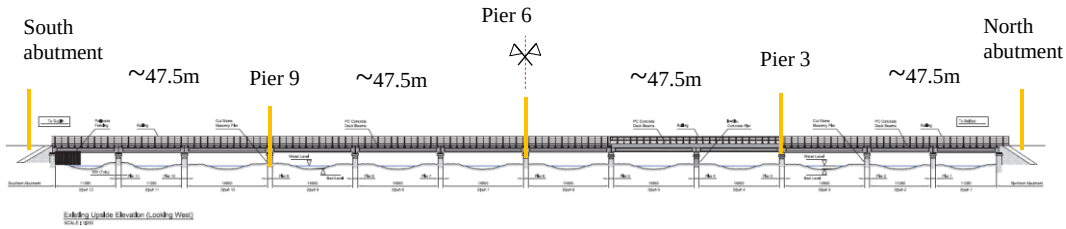


Figure 3-12: UBB 30 - Longitudinal frame arrangement 1 (preferred)

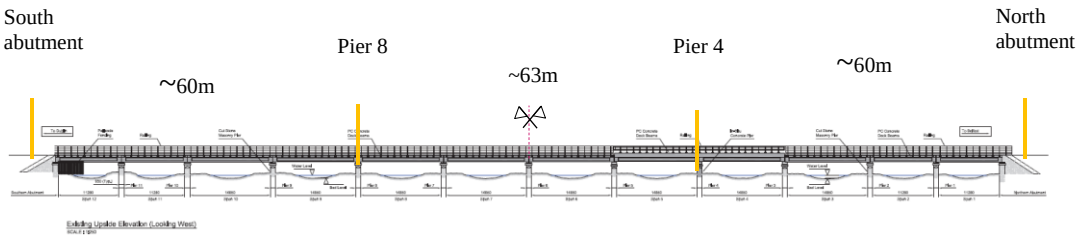


Figure 3-13: UBB 30 - Longitudinal frame arrangement 2

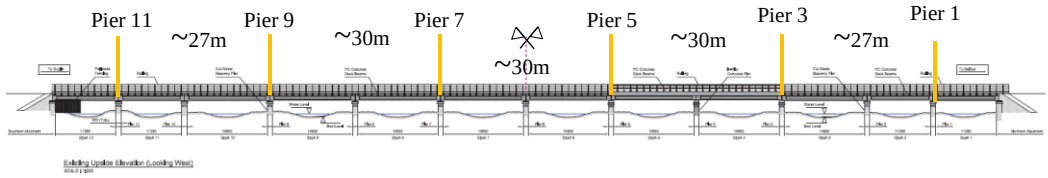


Figure 3-14: UBB 30 - Longitudinal frame arrangement 3

3.3 Longlist of options

This section describes the options which have been considered for the OHLE foundation solution at Malahide Viaduct. The discussion is limited to items which will have a bearing on the development or selection of an option.

The options which have been considered are summarised in Table 3-3 below.

Table 3-3: Longlist of options considered

Option	Description
Option 0	Do nothing
Option A	Supported on structure
Option B1.1	Supported off piers – steel collars
Option B1.2	Supported off piers - anchors
Option C	Independent supports

3.3.1 Option 0 – Do nothing

'Do-Nothing' represents a scenario where infrastructure works and interventions to meet the Project Objectives and Requirements are absent. For this option no OHLE masts would be provided.

3.3.2 Option A – Supported on structure

The minimum offset measured from the outer rail to the parapet guardrail is approximately 1.70m, which is close to the minimum required offset of 1.790m - refer to Figure 3-15 below. Hence a solution placing the posts inside the alignment of the parapets is not feasible. The posts would need to be positioned to either align with the parapets or be placed on the outside of the structure.

A potential option could be to use precast units working in gravity only with no attachment to the deck structure, placed beneath the ballast under the tracks. This is shown in Figure 3-16 and Figure 3-17. Should this option be taken forward, the solution will be developed during preliminary design to avoid unacceptable movement of the precast unit due to passing trains, and to facilitate any IÉ maintenance requirements regarding movement joints.

It is not feasible to attach masts to the side of the superstructure due to the technical risks and complexity of installing large fixings into the existing post-tensioned concrete beams, which would be required to stop the masts from overturning.

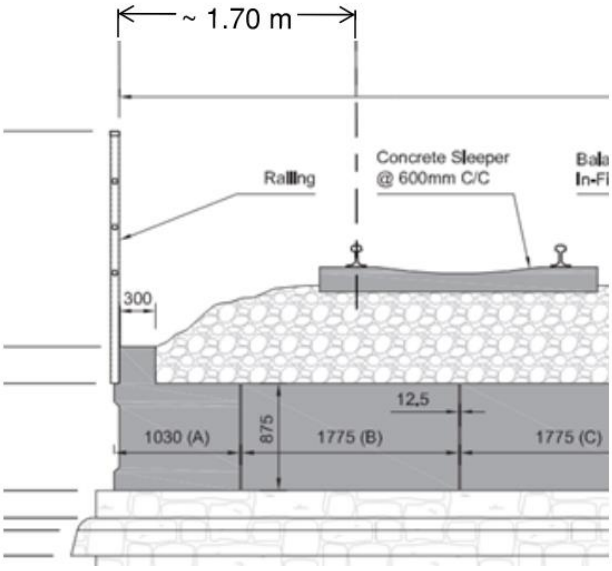


Figure 3-15: UBB30 Existing clearance to face of parapet

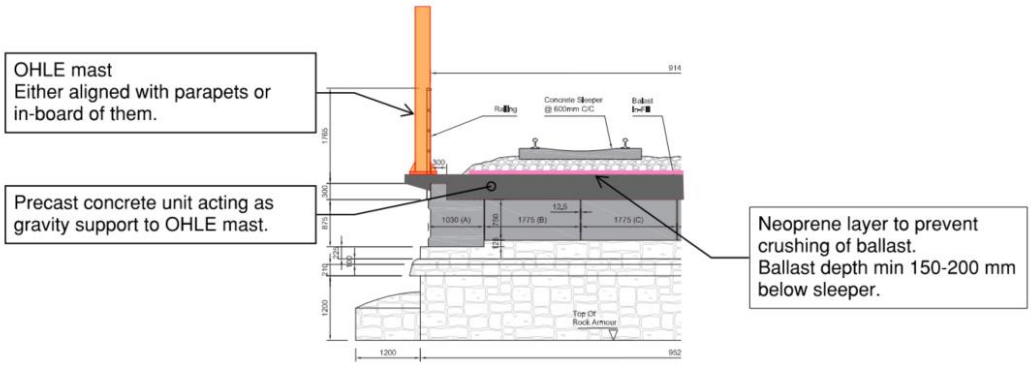


Figure 3-16: UBB30 – Proposed precast unit option (section)

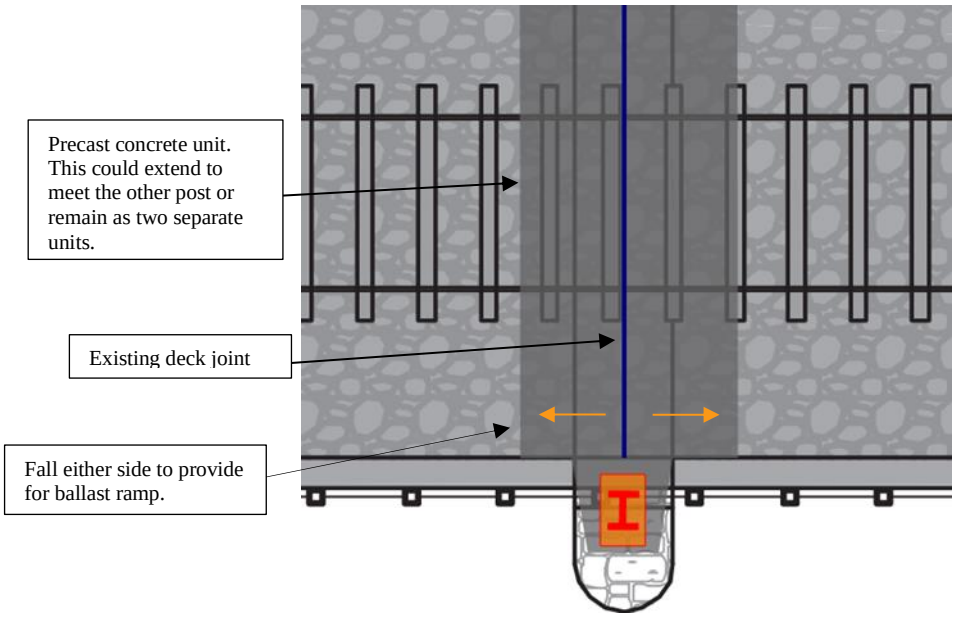


Figure 3-17: UBB30 – Proposed precast unit option (plan)

3.3.3 Option B1.1 – Supported off piers – steel collars

This option involves the construction of a new reinforced concrete plinth on top of the cutwater stone plinth, following a similar hydrodynamic shape.

The new reinforced concrete plinth will be sufficiently high to avoid direct exposure of the column base plate to water flows. Additional protection to the base plate will need to be considered.

The new concrete plinths each side of the bridge will be connected to steel rings at two levels that will partially wrap around the pier. Anchors will be installed to connect both sides of the 'collar' to the masonry pier.

Stainless steel may need to be considered due to the highly corrosive marine environment and the limited ability to inspect and maintain the connection.

Works within the tidal estuary will pose a significant risk during construction for this option.

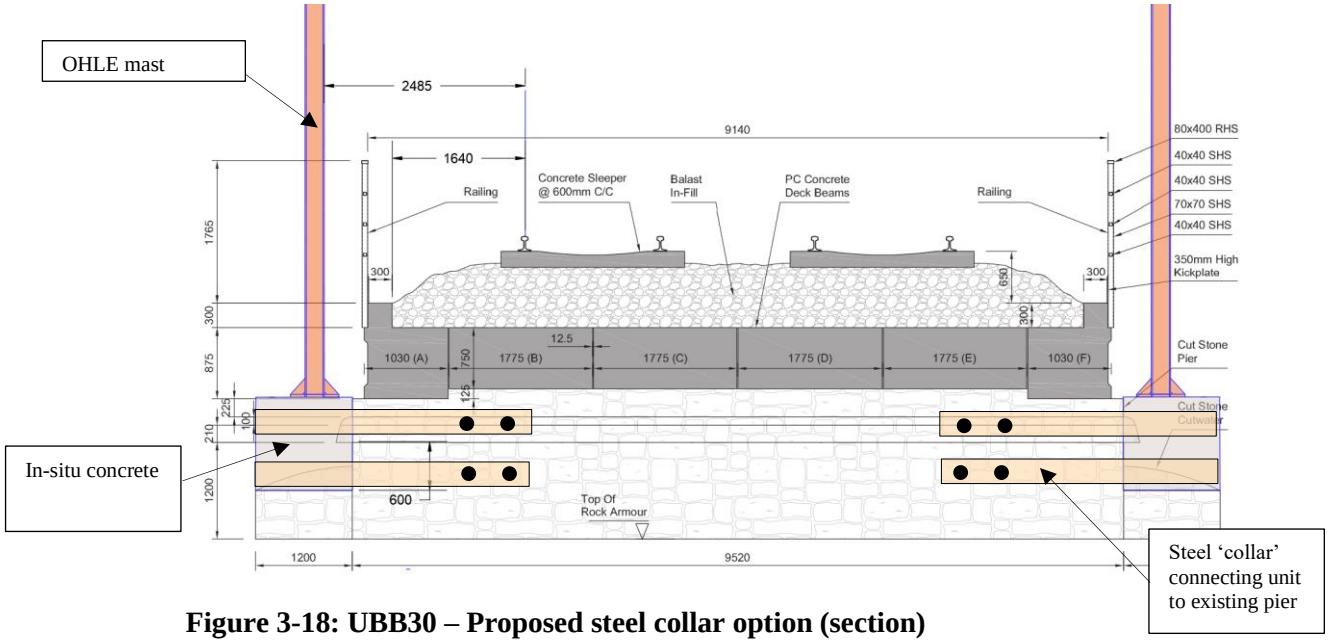


Figure 3-18: UBB30 – Proposed steel collar option (section)

Figure 3-19: Sketches of Option 1 of proposed OHLE transverse arrangement (source: Iarnród Éireann)

3.3.4 Option B1.2 – Supported off piers – anchors

This option will require anchors to be drilled through the existing masonry pier into the supporting ground.

This method will likely require a single anchor for the downstream side of the bridge. However, for the upstream side, a system of two soil anchors should be placed as there is not enough space to construct the anchor perpendicular to the bridge deck due to the presence of the foundations for the proposed greenway pedestrian and cycling crossing.

The existing piers on the bridge were stabilised using mini piles following the collapse of Pier 4 in 2009. Any proposed ground anchors will need to avoid the previous strengthening works. There is a high risk that the proposed anchors will clash with the existing stabilisiation works.

Works within the tidal estuary will pose a significant risk during construction for this option.

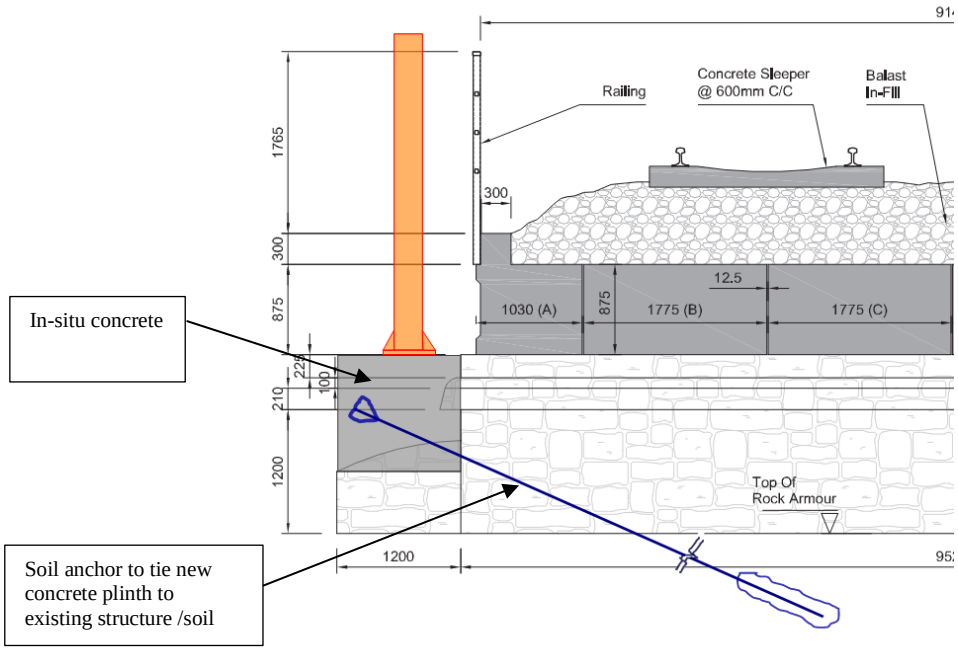


Figure 3-20: UBB30 - Ground anchors option (section)

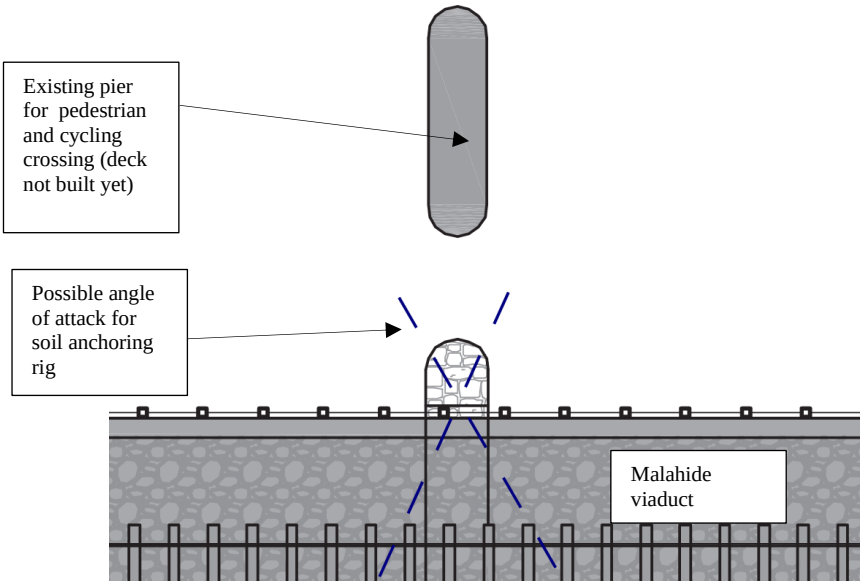


Figure 3-21: UBB30 Ground anchors option (Plan)

The offset between the proposed Broadmeadow Greenway pedestrian/cycle bridge and Malahide Viaduct is illustrated in Figure 3-22 below.

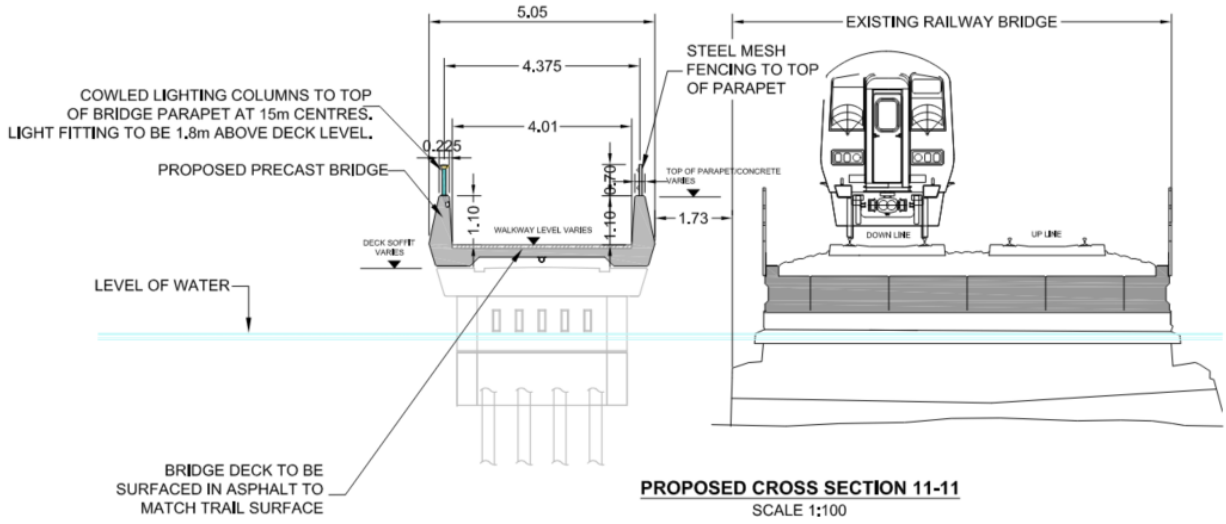


Figure 3-22: UBB30 Malahide Viaduct and proposed Broadmeadow Greenway bridge

3.3.5 Option C – Independent supports

This option involves construction of independent bases for the OHLE masts, on foundations within the estuary, separate from the bridge structure.

Figure 3-23: UBB30 Malahide Viaduct and proposed Broadmeadow Greenway bridge (source: Iarnród Éireann)

3.4 Sifting of longlist of options

Assessment of the outlined options is provided in Table 3-4 below.

Table 3-4: Assessment of longlist of options against project objectives and requirements

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure – in-board of parapets		Option B1.1 – supported off piers – steel collars		Option B1.2 – supported off piers - anchors		Option C – independent supports	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To deliver a higher frequency, higher capacity, reliable, electrified route to enable an increased DART service frequency between Drogheda and Central Dublin.	**Fail**	• Option prevents installation of OHLE over bridge	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on ballast depths (space to accommodate unit)	**Pass**	• Option enables installation of OHLE over bridge • Strength of pier stonework unknown	**Pass**	• Option enables delivery of objective by facilitating OHLE installation Unknown strength of pier stonework • Constrained execution of anchors in greenway bridge side	**Pass**	• Option enables delivery of objective by facilitating OHLE installation •
Project objective	To deliver solutions which improve the passenger experience where passenger infrastructure interventions are required to meet the Train Service Specification.	**Pass**	• No infrastructure intervention considered as part of 'do-nothing' approach	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience
Project objective	To deliver a sustainable, low carbon and climate resilient design solution including making use of existing infrastructure where possible with targeted improvement works.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Localised work making use of existing infrastructure • Small pre-cast concrete unit	**Pass**	• Longevity of solution and exposure to weathering from seawater • Additional protection to baseplates may be required • Localised work making use of existing infrastructure	**Pass**	• Longevity of solution and exposure to weathering from seawater • Additional protection to baseplates may be required • Localised work making use of existing infrastructure	**Fail**	• Fails to make use of existing infrastructure where other proposed options clearly show this is possible

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure – in-board of parapets		Option B1.1 – supported off piers – steel collars		Option B1.2 – supported off piers - anchors		Option C – independent supports	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To identify cost-effective solutions from a capital, operations, and maintenance perspective.	**Pass**	• No impact due to 'do-nothing' approach.	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of new pre-cast units • Cost of disruption to train services • Cost of installation	**Pass**	• Enables delivery of electrified route in cost effective manner • Cost of maintenance/inspection to collars working over water • No cost from disruption to services •	**Pass**	• Enables delivery of electrified route in cost effective manner • Cost of maintenance/inspection working over water • No cost from disruption to services •	**Fail**	• Large works required for construction of independent foundations, not a cost-effective option.
Project objective	To minimise adverse impacts on the natural and built environment associated with construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Avoids work in estuary	**Pass**	• Works in estuary will have some associated impact on natural environment	**Pass**	• Works in estuary to be considered	**Fail**	• Large works in estuary required associated with creating new foundations
Project objective	To minimise adverse impacts on existing rail services, road users and landowners associated with the construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• No negative operational impact • Disruption to train services during construction	**Pass**	• No negative operational impact • Less disruption to train services during construction likely	**Pass**	• No negative operational impact • Less disruption to train services during construction likely	**Pass**	• Could be installed away from track

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure – in-board of parapets		Option B1.1 – supported off piers – steel collars		Option B1.2 – supported off piers - anchors		Option C – independent supports	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To provide efficient and cost-effective integration of systems with the other DART+ projects	**Fail**	• Failure to provide fully electrified route between Malahide and Drogheda precludes effective integration with DART route.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.
Project requirement	To design in accordance with IÉ Standards and relevant national and EU standards and guidelines	**Pass**	• No intervention	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Proposed option does not contradict guidelines.
Project requirement	Designs shall comply with the Minimum Employer's Functional Requirements and meet the Train Service Specification	**Fail**	• Non-compliant • No OHLE masts installed on viaduct would create spans in excess of that allowed in standards	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Proposed option does not contradict guidelines.
Project requirement	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	**Fail**	• No electrification possible over viaduct with 'do-nothing' approach	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification
Project requirement	Provision of an appropriate number of substations to support electrification.	**Pass**	• 'Do-nothing' approach does not preclude installation of substations elsewhere to support electrification	**Pass**	• No impact on substations	**Pass**	• No impact on substations	**Pass**	• No impact on substations	**Pass**	• No impact on substations

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure – in-board of parapets		Option B1.1 – supported off piers – steel collars		Option B1.2 – supported off piers - anchors		Option C – independent supports	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project requirement	Undertake necessary infrastructure change to achieve the clearances required for electrification at bridges and structures.	**Pass**	• No clearance issues associated with 'do-nothing' approach	**Pass**	• Approx. 1.9m (1.7m in Lidar survey) between outer rail and parapet wall. OHLE could be place slightly in-board of parapet. Inconsistency between Lidar survey and drawings.	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved
Project requirement	Undertake safety improvements resulting from the introduction of 1500V DC Overhead.	**Pass**	• No safety impact from 'do-nothing' approach.	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations

3.4.1 Summary of longlist sifting

Table 3-5: Summary of longlist sifting

Option	Screening Result	Summary
'Do-Nothing'	**FAIL**	• Does not meet requirements. • Prevents installation of OHLE over viaduct. Spans for OHLE wires would be in excess of that allowed in system. • Failure to electrify the viaduct prevents effective integration with rest of DART+ route
Option A	**PASS**	Meets project objectives and requirements
Option B1.1	**PASS**	Meets project objectives and requirements
Option B1.2	**PASS**	Meets project objectives and requirements
Option C	**FAIL**	• Fails to identify cost-effective solution and utilise existing infrastructure since support can be achieved using the existing viaduct, as opposed to creating independent foundations • Fails to consider adverse natural impacts during construction since requires large groundworks in estuary to create mast foundations.

3.5 Shortlisted options

The following options have been taken forward as the shortlisted options:

- Option A - Supported on structure
- Option B1.1 – Supported off piers – steel collars
- Option B1.2 – Supported off piers – anchors

For a description of options, refer back to Section 3.3.

3.6 Multi-criteria analysis

3.6.1 Methodology

For each individual entity an assessment has been made against the MCA criteria. Each option has been relatively compared against the others based on the five-point colour coded ranking scale in Table 3-8.

3.6.2 MCA summary table

A multi-criteria analysis table is presented in this section. This has been developed to reflect the relative rankings for all sub-criteria for each of the options assessed and is presented as a summary of the key issues considered.
A more detailed table is provided in the appendix to this report with the full detailed rationale behind the scoring of each criteria and option.

Table 3-6: MCA sub-criteria summary table

Criteria	Sub-Criteria	Option A	Option B1.1	Option B1.2
		Supported on structure	Supported off piers – steel collars	Supported off piers – anchors
Economy	CAPEX			
	OPEX			
	Train Operations Functionality/Economic Benefit			
	Traffic functionality and associated economic activities and opportunities			
Safety	Employer's Safety			
	Public safety			
Environment	Landscape and Visual Quality			
	Biodiversity			
	Noise and Vibration			
	Water resources			
	Archaeology, Architectural and Cultural Heritage			
	Geology and Soils (includes waste)			
	Agricultural and non-agricultural			
	Air Quality & Climate Change			
Accessibility & Social Inclusion	Accessibility			
	Social Inclusion			
Integration	Adaptability in the future			
	Transport Integration			
	Land Use Integration			
	Government policy integration			
	Geographical integration			
Physical Activity	Walking/cycling opportunities			

Table 3-7: Overall criteria MCA summary table

Criteria Summary	Option A	Option B1.1	Option B1.2
	Supported on structure	Supported off piers - steel collars	Supported off piers - anchors
Economy			
Safety			
Environment			
Accessibility & Social Inclusion			
Integration			
Physical Activity			

Table 3-8: Legend for MCA Summary Tables

Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

3.6.3 Economy

Economy has been divided into four sub-criteria which are considered below.

CAPEX

Option A involves more disruption to trains during construction due to lifting tracks to install concrete footings which will impact costs. Works in the waterway are avoided, along with the cost of providing a working platform in an environmentally sensitive and highly tidal waterway.

Options B1.1 and B1.2 involve less disruption during construction as tracks can remain in place during construction. Much of the work would still need to be carried out during possessions. Access to the piers in the waterway would be required, along with setting up a working platform in a highly tidal zone. This would likely present a considerable constraint.

OPEX

Option A can be inspected and maintained with relative ease from track level. Any maintenance to the concrete footing may involve track possessions, although this is likely to be limited over the lifespan. Options B1.1 and B1.2 have the comparative disadvantage as inspection and maintenance are constrained by the waterway. Whilst this reduces impact on train operations during such tasks, these are still likely to prove more costly than option A.

Train operations functionality/economic benefit

All options are comparable from a train operations functionality/economic benefit perspective.

Traffic functionality and associated economic activities and opportunities

Option A has comparative disadvantage due to greater construction disruption. It should be noted that options B1.1 and B1.2 will still likely require possessions.

When operational, the scheme will have no visible impacts on the prevailing traffic conditions in the surrounding road networks.

Option B1.1 and B1.2. involve construction and maintenance in the estuary which may also impact the planned Broadmeadow Greenway. Option A has disruption to trains during construction. Mitigation measures for the construction impact will be required.

Construction activities on all options considered are expected to generate a relatively low number of additional vehicular journeys and therefore will, at most, have a minor temporary impact on the traffic conditions of the local road network.

3.6.4 Safety

Safety has been divided into two sub-criteria which are considered below. It should be noted that all options are safe, but some will have the potential for greater residual risks to remain. This criterion considers relative advantages of each option on the criteria of safety.

Employer's Safety

Option A has comparative advantage over the other options as it avoids works in a tidal waterway. Maintenance work alongside track is a risk but regarded as a more common environment for rail staff to work under. Construction risks are limited as works will be undertaken during track possession. Other options present greater risk for construction and maintenance as they require work within the tidal waterway.

Public Safety

All options are comparable since the public will not have access to this infrastructure.

3.6.5 Environment

Section 3.1.4 sets out a description of the existing environment, under key environmental criteria, including the key environmental constraints associated with this study area. Below is a summary of the key findings of the MCA under the various environmental criteria, with an emphasis on differentiating aspects for the options considered.

Landscape and Visual Quality

The structures are generally at a distance from viewers (except on water and on the future greenway). Option A has less visual interference with the structure and is

preferred over Options B1.1 and B1.2. There is little landscape or visual difference between Options B1.1 and B1.2.

Biodiversity

All the proposed options have potential to indirectly impact on the Malahide Estuary SAC, SPA and pNHA, and two of the three options have the potential for direct impacts on these nationally and internationally important designated sites. Potential direct impacts include works within the designated site boundaries, potentially involving habitat removal as a result of drilling and new retaining structures. Potential indirect impacts include construction related impacts (e.g., water quality impacts or disturbance to birds) and new lighting which would impact on the birds present in the estuary. The potential for these impacts is greater in Option B1.1 and B1.2 and least in Option A.

There are several other potential ecological constraints, but these are similar across all options and do not differentiate the preference between options. These include:

- The Overhead line equipment masts (OHLE) pose a hazard for birds, there are three main risks:
    - Mortality through collision with the power lines or the masts supporting them. This can occur when the bird flying across the viaduct from one side of the estuary to the other collides with the wire and is killed from the impact, from hitting the ground or from injuries sustained in the process.
    - Mortality through electrocution from the powerlines by causing a short circuit either by touching two live wires or a live and an earthed component.
    - Displacement, caused by disturbance through construction and maintenance activities. Displacement can also include barrier effects in which birds are deterred from using their normal routes to feeding or roosting grounds.
- Displacement of bats. The development has the potential to impact bats associated with waterbodies: Daubenton's bats, Nathusius' pipistrelle, soprano pipistrelle. If there are bat roosts within the existing structure, renovation works would reduce the potential satellite roosts within this well-connected habitat network for wildlife.
- All options involve some level of works on the existing tracks. Railway lines can often support interesting flora species and habitats due to the calcareous nature of the ballast and their often relatively undisturbed nature. If any such habitat is present the level of impact is likely to be similar across all options and might not be a significant differentiator between options.
- It is not known whether invasive species may occur along the railway line. If present, then there would be risk of these spreading to adjacent areas with

the adjacent Malahide Estuary SAC and SPA being particularly sensitive receptors. Even if it were the case that invasive species are present in this area, the level of impact is likely to be similar across all options and , as such, is not a significant differentiator between options.

Also of note are Fingal County Council's proposals for the Broadmeadow Greenway adjacent to the railway line, which will link Malahide and Donabate. The environmental assessments for the Broadmeadow Greenway set out specific environmental and ecological mitigation and any works in this area should be cognisant of those plans and ensure there are no conflicts between the Irish Rail works and the Broadmeadow Greenway proposals (e.g. timings of works to avoid sensitive periods for species).

Noise and Vibration

Option A will have the smallest acoustic impact for the Malahide Viaduct. Construction work for the piers and drilling for soil anchors for Options B1.1 and B1.2 respectively will be noisier than Option A, which involves very little on-site work. This makes Option A the best option from an acoustic point of view, even though there will still be construction noise associated with Option A.

There will be no negative acoustic impact during the operational phase.

Water resources

From a water resources perspective, Options A and B1.1 are similarly comparable with each other. Option B1.2 has some comparative disadvantage over other options as, depending on the construction method employed, the drilling of ground anchors within Malahide Estuary has the potential to generate pollutants with the potential to impact on the receiving waterbodies and the associated protected sites.

Archaeology, Architectural & Cultural heritage

From an archaeological viewpoint, Option A is preferable as it involves no works in the estuary. Option B1.1 and Option B1.2 are of equal preference as they both display some comparative disadvantages over option A including working and maintenance works in the estuary and alterations to the historic masonry piers and interventions to the historic structure.

Option A has advantages over Option B1.1 and B1.2 from an architectural heritage perspective since it avoids direct impact on the historic fabric and has a significantly reduced visual impact on the setting of the viaduct.

Options B1.1 and B1.2 propose alteration of and concealment of historic fabric which would have a significant negative impact. The anticipated visual impact on the viaduct is also greater than for Option A.

It is anticipated that the visual impact for Option B1.2 would be marginally less than for Option B1.1.

Geology and Soils

From a Geology and Soils perspective, Options A and B1.1 respectively are similarly comparable with each other. It is to be noted that Option B1.2 can also be considered as similarly comparable to the above options provided that the construction methodology and feasibility of ground anchors are confirmed.

Agricultural and Non-Agricultural

All options are located in non-agricultural land and therefore similarly comparable with each other. There are no agricultural constraints at the location of Option A, B.1, B.2 or Option C, and therefore this location is assessed as very low sensitivity from an agricultural perspective.

Air quality and climate

All options involve construction works that may generate dust, potentially impacting on the Malahide Estuary SAC, SPA and pNHA.

All options increase the capacity of the rail system and consequently the attractiveness for trips to be undertaken by public transport in the Greater Dublin Area. As such, it brings about positive impacts on air quality and climate during the operational phase.

3.6.6 Accessibility and social inclusion

All options are comparable from both accessibility and social inclusion perspectives. Option A is likely to have more impact on trains during construction, however this will be short term.

3.6.7 Integration

Integration is assessed using the five sub-criteria described below.

Adaptability in the future

Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway. However, this is a temporary scenario. In the permanent situation the impact is minimal in all options.

Transport integration

All options have no impact on the integration with other transport modes.

Land use integration

All options have no impact on land use.

Government policy integration

All options have no impact on government policy integration.

Geographical integration

All options have no impact on geographical integration.

3.6.8 Physical activity

Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway.

3.7 Construction Considerations

Constructability considerations for the shortlisted options are as follows:

3.7.1 Option A

This option involves more disruption to trains during construction as track needs to be lifted to install the concrete footings.

3.7.2 Options B1.1 and B1.2

These options involve less disruption to trains during construction as the track can remain in place, although much of the works will still need to be carried out during possessions. However, construction of a working platform within the estuary would be required to complete the works.

3.8 Summary and conclusions

3.8.1 Non-preferred options

Option B1.1 is not preferred due to:

- The large number of negative environmental impacts this option would result in;
- The difficulty of construction and maintenance over a tidal waterway.

Option B2.2 is not preferred due to:

- The large number of negative environmental impacts this option would result in;
- The difficulty of construction and maintenance over a tidal waterway.

3.8.2 Draft Emerging Preferred Option

Option A has been chosen as the Draft Emerging Preferred Option as it:

- Presents the most favourable option with regards to safety due to removing the need to work within a tidal waterway;
- Has significant advantages over the other options on the environmental impacts, such as landscape and visual quality, biodiversity, and archaeological, architectural and cultural heritage.

3.8.3 Key Risks/Next Steps

The following risks and next steps have been identified:

- Confirmation of ballast depths required;
- Quantification of disruption to services required to complete works;
- The need to lift and slew cable routes temporarily during construction. Note that ballast inspection pits have been included in SI works at proposed mast locations on the bridge, which will identify potential services in the cess at these locations.
- Damping of passing trains on the new slab to limit movement of the OHLE support.
- Feedback from heritage and environmental stakeholders

4 Rogerstown Viaduct (UBB36) optioneering selection process

4.1 Existing situation and constraints

4.1.1 Structure

Rogerstown Viaduct is a 58.5 m long viaduct over a tidal estuary. The deck superstructure is comprised of three spans, each 19.5m in length.

The original piers and abutments remain and are understood to be the only parts of the structure that are classified ‘protected'. Modern precast concrete beams now form the deck.

Rogerstown Estuary is a protected site and is designated as both a Special Area of Conservation (SAC) and a Special Protected Area (SPA) by the National Parks and Wildlife Service. The location of the bridge relative to these protected areas will need to be confirmed.

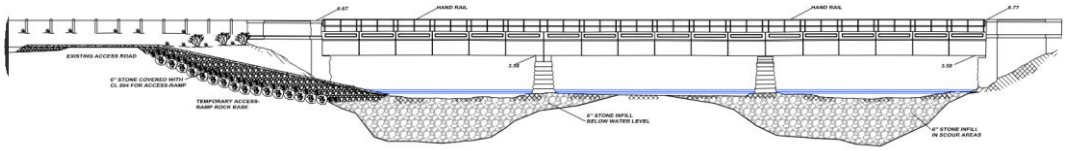


Figure 4-1: UBB36 Elevation

Figure 4-2: View of UBB36 deck (source: Iarnród Éireann)

Figure 4-3: UBB36 Abutment (source: Iarnród Éireann)

Figure 4-4: UBB36 Erection of precast beams (left) and soffit (right) (Source IÉ)

Figure 4-5: UBB36 Piers (source: IÉ)

Figure 4-6: UBB36 Protected piers and replaced deck (source: IÉ)

4.1.2 Permanent ways and tracks

The structure currently carries two tracks: the Up and Down Main Lines. No points and crossings exist on or within the vicinity of the bridge. From a preliminary measure in cad, the tracks have radius of approximately 12.000 m.

4.1.3 Utilities

Within the study area there are telecommunications fibre cables running alongside the railway for the extent of the Rogerstown Viaduct. At the northern end of the viaduct there is a stormwater culvert running parallel to the railway which discharges to the Rogerstown Estuary. There are no utilities crossing the railway within the study area.

The various OHLE foundation options are unlikely to impact on the existing stormwater culvert. The lineside telecommunications pose potential constraints to the OHLE foundation options. As such, they have been considered in the development of options. Regardless of the option selected, it will be necessary to maintain these during construction or to minimise outage durations in consultation with the utility providers.

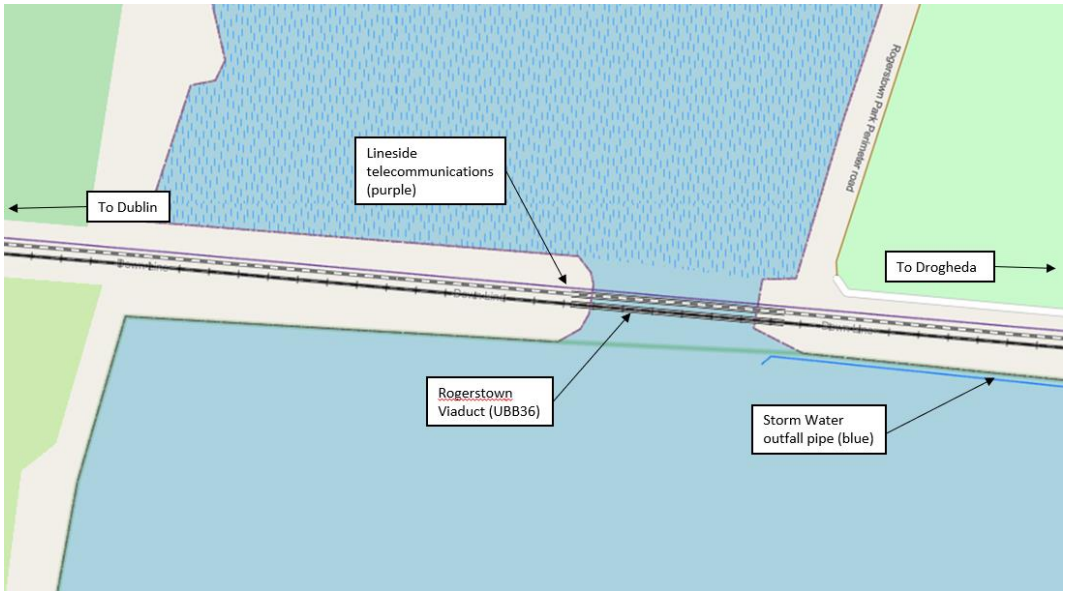


Figure 4-7: Plan of Rogerstown Viaduct (UBB36) showing existing utility routes. (Map data © OpenStreetMap contributors, Map layer by Esri)

4.1.4 Environmental

For an overview of the existing environmental constraints for DART+ Coastal North refer to Annex 3.1 Constraints Report. The following sections provide detailed environmental description of the existing situation and constraints relevant to this specific structure.

4.1.4.1 Traffic and transportation

The site is accessible from the north and the south. From the north current access is through the Rogerstown Park off Baleelly Lane (approximately 6m wide) which connects to the R127 Dublin Road and the R132 to the M1. From the south current access is through Donabate town and the Beaverstown Golf Club via Beaverstown Road. Beaverstown Road is approximately 6m wide and additional width is provided for a public walkway. The road connects to Hearse Road and the R126 which leads to the M1.

The low speed and function of the access road through Donabate town will need to be considered in the context of construction traffic. The road provides access to residential areas, schools and a golf club. The interface with the park and the estuary to the north will also need to be considered during construction.

4.1.4.2 Landscape and visual impact

Rogerstown Viaduct is listed by Fingal County Council as a protected structure (reference: RPS No. 0516 Appendix 2 ‘Record of Protected Structures’ of the Fingal Development Plan 2017-2023).

The lands at either end of the viaduct are zoned High Amenity / Open Space in the Fingal Development Plan. The Plan also includes an objective to Preserve Views

of the estuary from the northern end of Beaverstown Road on the southern shore. The viaduct is circa 325m north of the nearest extent of the listing on Beaverstown Road.

4.1.4.3 Archaeological and cultural heritage

Rogerstown Viaduct spans Rogerstown estuary north of Donabate where the wetlands and saltwater marsh are an important habitat for birds. A large number of Mesolithic flint artefacts have been collected along the coast from Howth to Balbriggan and the estuary would have been ideal for Mesolithic hunting and gathering activities. Permanent settlement was established early in this landscape, with a Neolithic house dating to 3640-3520 cal. BC having been identified in Rogerstown overlooking the estuary (SMR DU008-110; Licence no.: 10E0121). Archaeological sites dating to the Bronze Age, early medieval period and the medieval period have been identified on both sides of this estuary, with a cluster of monuments occurring in Rogerstown c. 1km northeast of the viaduct.

The resources of the estuary likely remained important to the local population following the early settlement, and a Bronze Age fulacht fiadh from Rogerstown (SMR DU008-109; Licence no.: 10E0121; McQuade 2011) suggests the practice of outdoor cooking which may have been associated with hunting. There was likely a continuity of activity in the Bronze Age, with monuments from this period including a ring-ditch (SMR DU008-078) in Rogerstown and a cist burial in Whitestown containing a skeleton and Food Vessel (SMR DU008-085).

The discovery of 20-30 burials, one of which was radiocarbon dated to AD 618-675, in Rogerstown suggests further settlement in this area in the early medieval period (SMR DU008-108001; Licence no.: 11E0235; Mullins 2011; Mullins 2012). On the southeast side of the estuary at Burrow, a holy well and chapel site are associated with St. Mochuda, a 6th / 7th century saint who travelled to Burrow to pray in solitude (RMP DU008-028, DU008-029).

St. Maur's Church in Whitestown (RMP DU008-021001) is thought to be associated with crusaders, with local tradition recording that a group of Breton mariners were saved from a storm at sea by praying to St. Maur, a 6th century follower of St. Benedict in Gaul. Indeed, Rogerstown is noted in medieval records as having been a 'haven' or 'harbour' (Mullins 2011).

A number of rectilinear field systems and curvilinear enclosures with associated trackways have been identified through aerial photography and archaeological investigations around the estuary, particularly within the cluster of sites at Rogerstown (SMR DU008-077001/2/3, DU008-079, DU008-080, DU008-081, DU008-089, DU008-108002;3; Licence 11E0235). Some of these features may date to as early as the Bronze Age, but it appears that a number of associated ditches to the east and west of the burials at Rogerstown (SMR DU008-001) were intended to demarcate the burials (Mullins 2011). The discovery of medieval pottery throughout in the excavation of an enclosure and a roadway also indicates the use of these features in the medieval period (SMR DU008-108002, DU008-108003; Licence 11E0235).

Post medieval features include Rogerstown House which dates to circa 1780 and an 18th century windmill at Rahillion (RMP DU008-027). The viaduct itself is actually a replacement of the original timber and masonry structure which was dismantled and replaced with the existing iron structure in the 1880s (Rynne 2006).

4.1.4.4 Architectural heritage

The Rogerstown Viaduct is a protected structure (FCC RPS 0516) spanning the tidal causeway at the Rogerstown Estuary. It comprises original mid-nineteenth century dressed stone abutments and piers with a replacement modern deck and railed parapets. Despite modern alterations, the viaduct retains original fabric, and is of architectural and technical interest.

Rogerstown Pier is located approximately 700m to the north-west of the viaduct. It is included in the NIAH where it is rated of regional importance for reasons of social and technical interest. Beaverstown House (FCC RPS 515) is a protected structure situated approximately 900m to the south east, and there is a cluster of buildings at Rogerstown House (NIAH 11329017) approximately 1.2km to the north east.

4.1.4.5 Noise and vibration

The existing acoustic environment at the viaducts will be predominantly dominated by passing trains on the railway line and natural noises such as birds, wind, and the ocean. The existing acoustic environment will be positively affected by the electrification of the line, as this will reduce noise from trains. Construction noise and vibration is expected to be audible at all locations.

Nearby sensitive receivers for the Rogerstown Viaduct include the park to the north-west, the golf club to the south, and residents to the south (approximately 500 m south of the viaduct). The nearest receivers (i.e. the park and golf course) are amenity receivers rather than residential, which makes them less sensitive to noise disturbance.

Noise sensitive species in the vicinity of the viaduct will also have to be considered during construction.

4.1.4.6 Air quality and climate

Nearby sensitive receivers for the Rogerstown Viaduct include the park to the north-west, the golf club to the south, and residents to the south (approximately 500m south of the viaduct).

The works location is on the Rogerstown viaduct within the Rogerstown estuary. The Rogerstown Estuary is designated as Special Area of Conservation (SAC), Special Protection Area (SPA) and proposed Natural Heritage Area (pNHA).

The proposed development will support the aims of the Climate Action Plan 2019. However, a key constraint is the development of the proposed scheme to ensure the following:

- the use of construction materials with low embodied carbon;

- the reduction of road traffic due to modal shift.

4.1.4.7 Agricultural and non-agricultural

There are no agricultural constraints at the location of Rogerstown Viaduct and therefore this location is assessed as very low sensitivity from an agricultural perspective

4.1.4.8 Geology and soils

The Rogerstown Estuary is underlain by recent soft estuarine sediments overlying glacial deposits of Irish Sea Till. The underlying bedrock is comprised of the Carboniferous Malahide Formation described the GSI as argillaceous bioclastic limestone and shale. The GSI mapping for the area indicates bedrock faulting trending in a northwest to southeast direction to the north and south of the estuary.

There are no Geological Heritage Areas in the location. The site history indicates a significant portion of reclaimed land to the northwest of the viaduct previously in use as the Balleally Landfill and restored to its current use as Rogerstown Park. The landfill restoration included the installation of a subsurface perimeter barrier wall. The viaduct foundations have undergone a number of improvements including pier replacement and retrofitting of pile foundations.

4.1.4.9 Water Resources

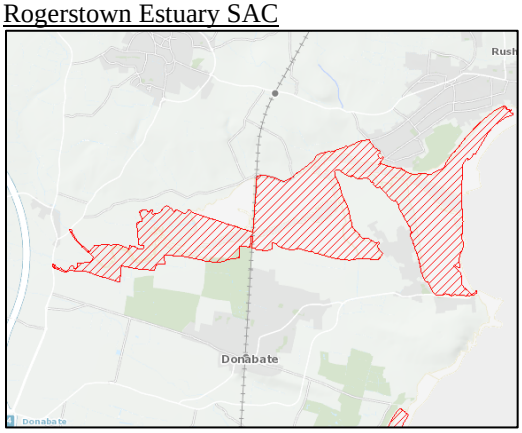
The Rogerstown Viaduct transects the Rogerstown Estuary transitional waterbody (IE_EA_050_0100). Under the Water Framework Directive (WFD, 2000/60/EC) the status of the Rogerstown Estuary waterbody is classified as Bad for the 2013-2018 monitoring cycle and At Risk. The minimum objectives for a water body under the WFD are to achieve at least ‘Good’ status (or ‘Good potential’ for artificial/ highly modified water bodies), and no deterioration of existing status.

The area is part of the Rogerstown Estuary SAC, SPA and pNHA.

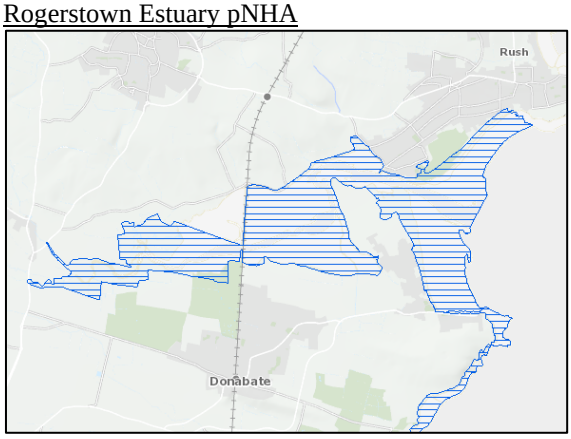
4.1.4.10 Biodiversity

The works location is on the Rogerstown Viaduct within the Rogerstown Estuary. This estuarine environment is also just north of the Malahide Estuary, and of the urban fabric of Malahide centre. The Rogerstown Estuary is designated as Special Area of Conservation (SAC), Special Protection Area (SPA) and proposed Natural Heritage Area (pNHA) as indicated below.

Rogerstown Estuary SAC



Rogerstown Estuary pNHA



Rogerstown Estuary SPA

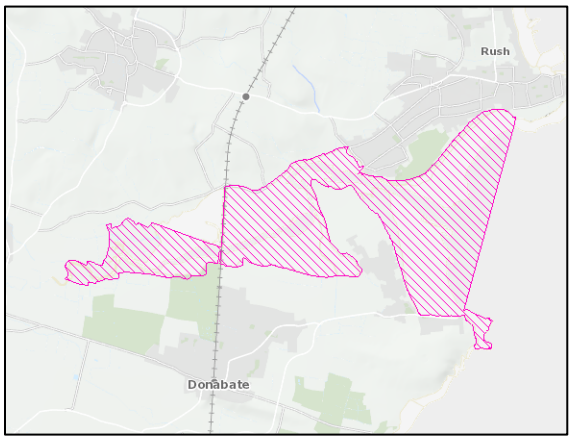


Figure 4-8: Rogerstown Estuary extents of designated areas

Habitats and notable species

A list of sites within the site of development have been identified and described according to their site synopsis. The key ecological constraints in this area are the Rogerstown Estuary SAC, Rogerstown Estuary SPA and the proposed Natural Heritage Area designation. These are designated for marine habitats and over wintering birds. The designated areas are of international and national biodiversity importance. The qualifying interests (reason for designation) of the Rogerstown Estuary SAC and SPA are as listed below.

Table 4-1: Qualifying interests of the Rogerstown Estuary SAC and SPA

ROGERSTOWN ESTUARY SAC	ROGERSTOWN ESTUARY SPA
Estuaries [1130] Mudflats and sandflats not covered by seawater at low tide [1140] Salicornia and other annuals colonising mud and sand [1310]	Greylag Goose *Anser anser [A043]* Brent Goose *Branta bernicla hrota [A046]* Shelduck *Tadorna tadorna [A048]* Shoveler *Anas clypeata [A046]* Oystercatcher *Haematopus ostralegus* [A130]

Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] Mediterranean salt meadows (Juncetalia maritimi) [1410] Shifting dunes along the shoreline with white dunes (Ammophila arenaria) [2120] Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]	Ringed Plover *Charadrius hiaticula* [A137] Grey Plover *Pluvialis squatarola* [A141] Knot *Calidris canutus* [A143] Dunlin *Calidris alpina alpina* [A149] Black-tailed Godwit *Limosa limosa* [A156] Redshank *Tringa totanus [*A162*]* Wetlands [A999]

Other potential constraints include:

- Potential for the railway to support interesting flora species and habitats due to the calcareous nature of the ballast and their often relatively undisturbed nature;

- Potential for invasive species to occur along the railway line.

4.1.5 Planning

The viaduct is located within the functional area of Fingal County Council. Rogerstown Estuary is unzoned. However, approximately two thirds of the southern portion of the viaduct is on lands that are zoned HA - High Amenity: 'Protect and enhance high amenity areas'. The northern abutment is located on or adjoining lands zoned Open Space: 'Preserve and provide for open space and recreational amenities'.

As noted above the viaduct is also located within the Rogerstown Estuary which is designated as both a Special Protection Area (SPA), Special Area of Conservation (SAC) and a proposed Natural Heritage Area (pNHA).

The abutments and supporting piers are also designated as protected structures.

Given the sensitivity of the zoning, the location within European designated environmental sites, and the protected structure status of parts of the structure, careful consideration will have to be considered in relation to the design of any works to the viaduct.

4.2 OHLE frame longitudinal arrangement

In determining the longitudinal arrangement of masts, two separate configurations have been considered. A summary of these and their suitability to meet the basic criteria is presented in Table 4-2. Yellow indicates an unfavourable result, with red indicating a value that precludes the option.

Table 4-2: UBB36 OHLE Longitudinal arrangement appraisal matrix

	Mast at piers / abutments	Number of masts	Symmetric distribution	Mast in bridge centreline	Mast spacing < 60m	All details equal?
Arrangement 1 (frames connected to abutments	Yes	2 ≤ 2	Yes	No	Yes	Yes
Arrangement 2 (frames connected to piers)	Yes	2 ≤ 2	Yes	No	Yes	Yes, but more complicated details at piers

Sketches of the various arrangements are provided in the figures below. Based upon the assessment criteria, Arrangement 1 is selected as the preferred option. Arrangement 2 is discounted due to detail complexity and risk of damage to historic piers.

Arrangement 1 will be used in assessing the longlist options of positioning the masts on the structure.

Arrangement 1

Arrangement 1 comprises two masts attached very close to the front face of the bridge abutments, almost reaching the limit for OHLE spans (~60m).

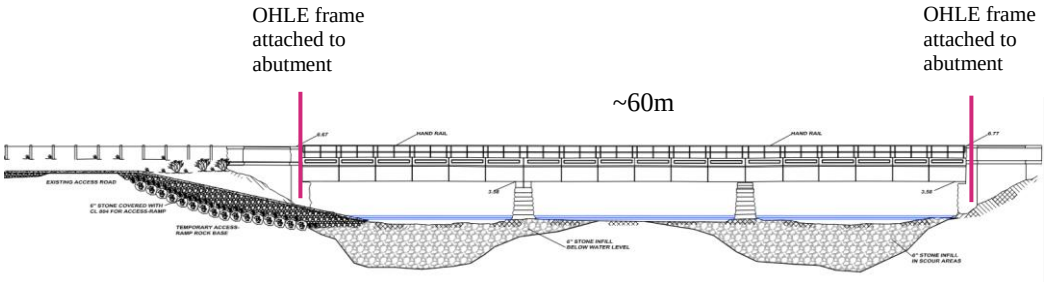


Figure 4-9: UBB36 OHLE longitudinal arrangement - Arrangement 1

Arrangement 2

Arrangement 2 comprises two masts attached to the piers, with a span of 19.5m, and two more masts placed as far as possible from these, towards the ends of the bridge, to avoid any clash with the bridge structure.

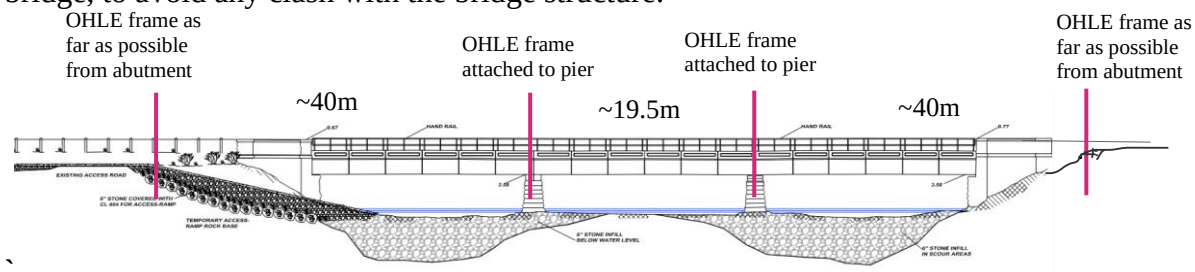


Figure 4-10: UBB36 OHLE longitudinal arrangement – Arrangement 2

4.3 Longlist of options

This section describes the options which have been considered for the OHLE foundation solution at Rogerstown Viaduct. The discussion is limited to items which will have a bearing on the development or selection of an option.

The options which have been considered are summarised in Table 4-3 below.

Table 4-3: Longlist of options considered

Option	Description
Option 0	Do nothing
Option A	Supported on structure
Option B2.1	Supported off abutment – top fixing
Option B2.2	Supported off abutment – side fixing
Option B2.3	Supported off abutment – top fixing with precast unit
Option C	Independent supports

4.3.1 Option 0 – Do nothing

No masts provided.

4.3.2 Option A – Supported on structure

Based on the available Lidar survey, there is approximately 1.90m from the outer track to the edge of the bridge. This implies an inboard option aligned with the parapets may be viable.

A potential option could be to use precast units working in gravity only (no attachment to deck structure placed under the tracks, a similar detail to UBB30). However, existing information available (drawings and photos) suggests that the amount of ballast beneath the tracks on this bridge is limited to approximately 400mm, making this option on the limit of being feasible.

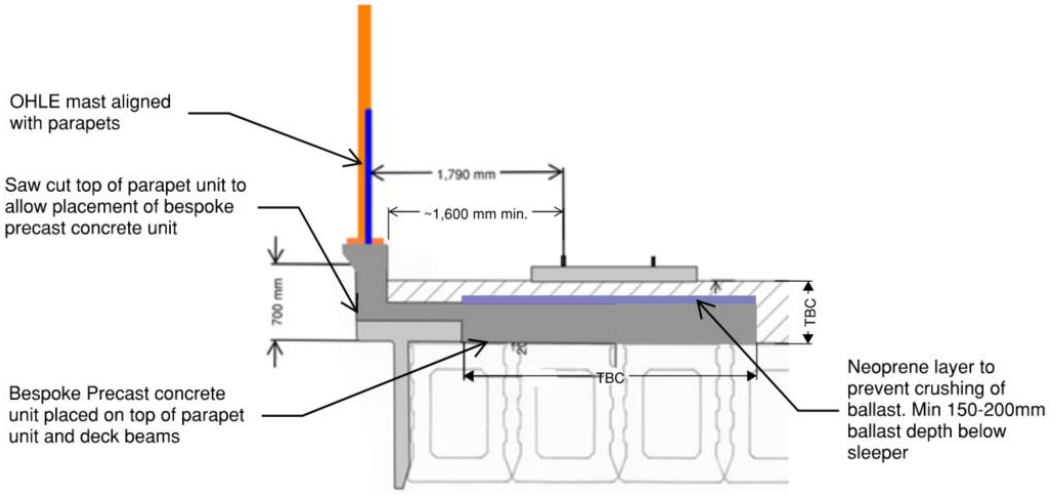


Figure 4-11: UBB36 Proposed Option A

Figure 4-12: UBB36 @ 12mls 1035yds Dublin-Belfast – View facing towards Belfast (source: Iarnród Éireann)

Figure 4-13: UBB36 @ 12mls 1035yds Dublin-Belfast – View facing towards Dublin (source: Iarnród Éireann)

4.3.3 Option B2.1 – Supported off abutment – top fixing with anchors

This option encompasses partial demolition of the protected abutment wall and installation of precast concrete walls which are stressed down onto the abutment walls. Ground anchors are installed through the sides of the abutment to laterally strengthen the walls. The masts are then attached to the top of these walls. It is proposed to restore the original state of the protected abutment wall with a stone facing to the visible face of the wall.

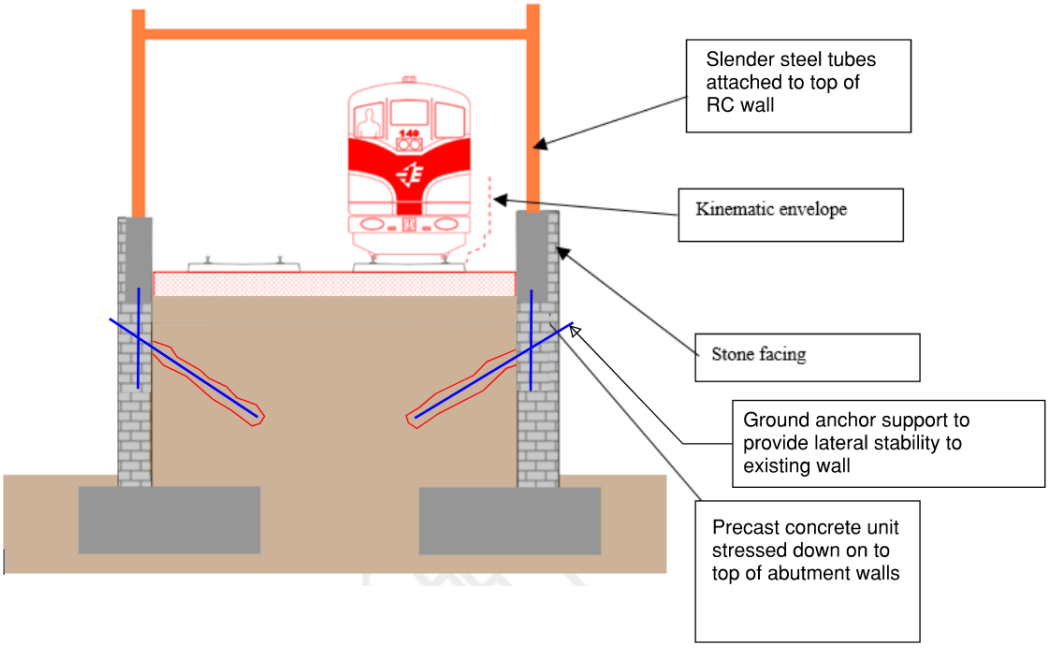


Figure 4-14: UBB36 - Option B2.1 sketch

4.3.4 Option B2.2 – Supported off abutment – side fixing

This option encompasses the attachment of the parapet posts to the side of the abutment walls. Steel ties may need to be drilled to the abutment wall connecting both walls.

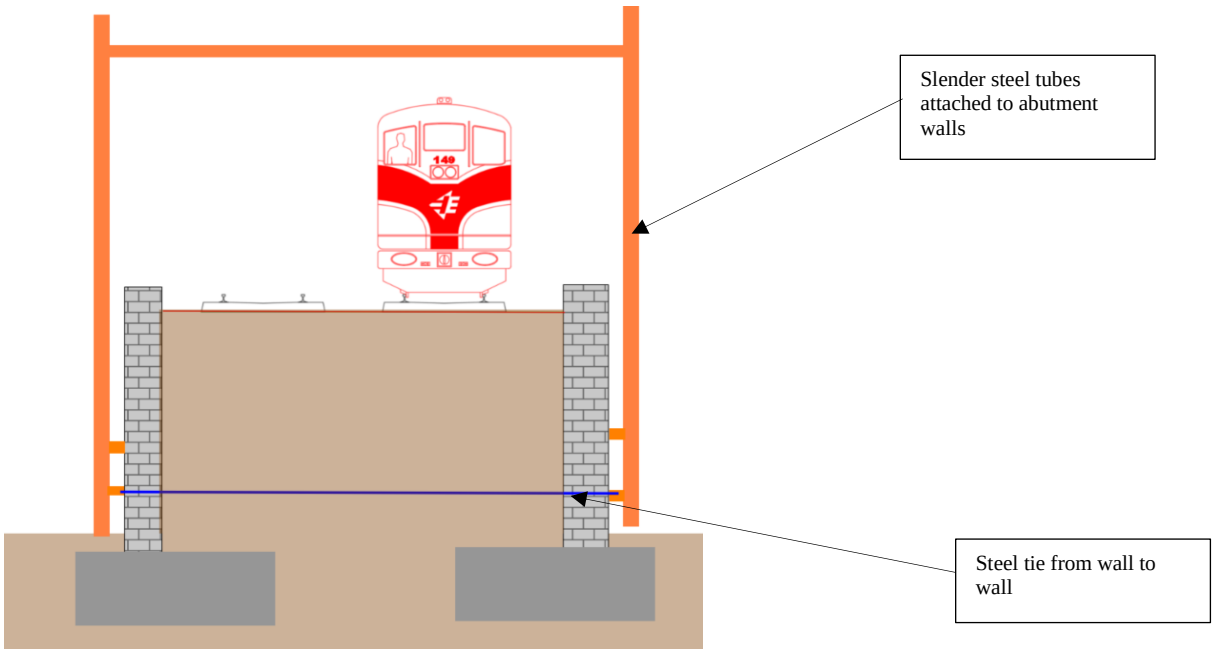


Figure 4-15: UBB36 - Option B2.2

4.3.5 Option B2.3 – Supported off abutment – top fixing with precast unit

This option requires partial demolition of the protected abutment wall to place a precast concrete 'U-shaped' unit or alternatively two 'L-shaped' units. OHLE masts will be bolted to the top of the concrete units. It is proposed to restore the original state of the protected abutment wall with a stone facing to the visible face of the wall.

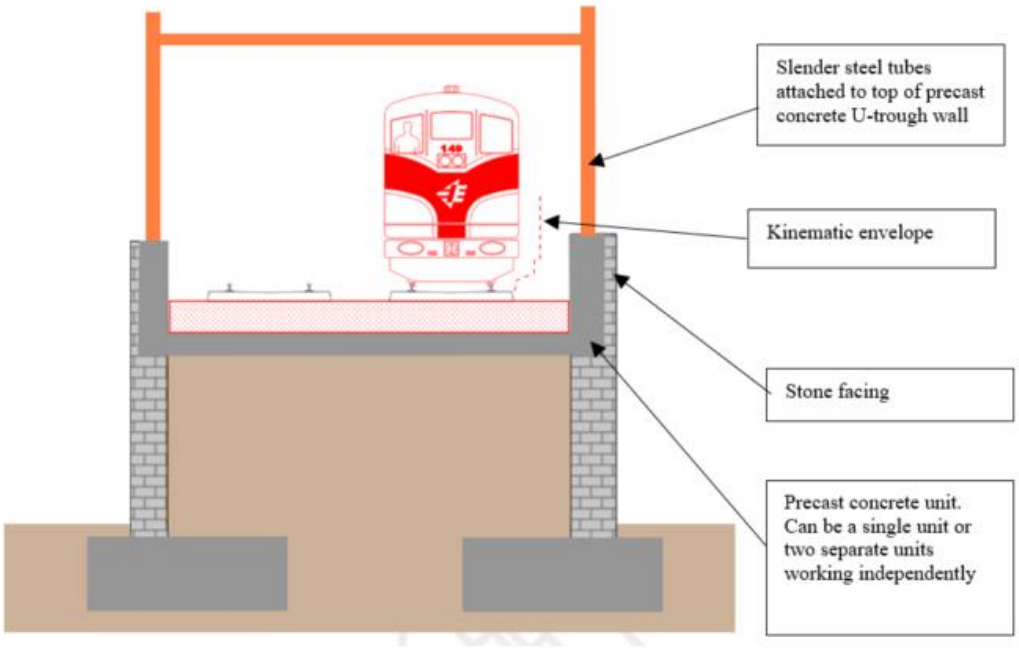


Figure 4-16: UBB36 - Option B2.3

This option requires the slab to be place in behind the abutment walls. Confirmation on the positioning of the abutment walls is required as they are close to the limit of the allowable longitudinal spacing of the posts (63m).

4.3.6 Option C – Independent supports

This option involves construction of independent bases for the OHLE masts, on foundations within the estuary, separate from the bridge structure.

Figure 4-17: UBB36 Option C sketch (source: Iarnród Éireann)

4.4 Sifting of longlist of options

Assessment of the outlined options is provided in Table 4-4 and Table 4-5 below.

Table 4-4: Assessment of longlist of options against project objectives and requirements (Options 'do nothing' – B2.2)

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure		Option B2.1 – supported off abutments – top fixing with anchors		Option B2.2 – supported off abutments – side fixing	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ Fail	Rationale
Project objective	To deliver a higher frequency, higher capacity, reliable, electrified route to enable an increased DART service frequency between Drogheda and Central Dublin.	**Fail**	• Option prevents installation of OHLE over bridge	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on ballast depths (space to accommodate unit)	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on strength of existing masonry walls	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on makeup of abutment wall and potential impact on ability to drill holes for through-ties • Pier stonework strength unknown
Project objective	To deliver solutions which improve the passenger experience where passenger infrastructure interventions are required to meet the Train Service Specification.	**Pass**	• No infrastructure intervention considered as part of 'do-nothing' approach	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience
Project objective	To deliver a sustainable, low carbon and climate resilient design solution including making use of existing infrastructure where possible with targeted improvement works.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Localised work making use of existing infrastructure • Small pre-cast concrete unit	**Pass**	• Localised work making use of existing infrastructure • Larger pre-cast concrete unit and intervention requiring some demolition	**Pass**	• Localised work making use of existing infrastructure • Longevity of mast structure and fixings due to exposure

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure		Option B2.1 – supported off abutments – top fixing with anchors		Option B2.2 – supported off abutments – side fixing	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ Fail	Rationale
Project objective	To identify cost-effective solutions from a capital, operations, and maintenance perspective.	**Pass**	• No impact due to 'do-nothing' approach.	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of new pre-cast units • Cost of disruption to train services • Cost of installation	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of new pre-cast units • Cost of disruption to train services • Cost of complex installation	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of disruption to train services • Cost of works on/near water for side fixings and future inspection • Exposure of steelwork to water, consider stainless steel
Project objective	To minimise adverse impacts on the natural and built environment associated with construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Avoids work in estuary	**Pass**	• Avoids work in estuary • Some loss of historic fabric	**Pass**	• Avoids specific work on estuary but may require construction from estuary •

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure		Option B2.1 – supported off abutments – top fixing with anchors		Option B2.2 – supported off abutments – side fixing	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ Fail	Rationale
Project objective	To minimise adverse impacts on existing rail services, road users and landowners associated with the construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• No negative operational impact • Disruption to train services during construction	**Pass**	• No negative operational impact • Disruption to train services during construction	**Pass**	• No negative operational impact • Less disruption to train services during construction likely
Project objective	To provide efficient and cost-effective integration of systems with the other DART+ projects	**Fail**	• Failure to provide fully electrified route between Malahide and Drogheda precludes effective integration with DART route.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.
Project requirement	To design in accordance with IÉ Standards and relevant national and EU standards and guidelines	**Pass**	• No intervention	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure		Option B2.1 – supported off abutments – top fixing with anchors		Option B2.2 – supported off abutments – side fixing	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ Fail	Rationale
Project requirement	Designs shall comply with the Minimum Employer's Functional Requirements and meet the Train Service Specification	**Fail**	• Non-compliant • No OHLE masts installed on viaduct would create spans in excess of that allowed in standards, since span (including abutment zones) is in excess of 65m limit.	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	Compliant clearance achieved
Project requirement	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	**Fail**	• No electrification possible over viaduct with 'do-nothing' approach	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification
Project requirement	Provision of an appropriate number of substations to support electrification.	**Pass**	• 'Do-nothing' approach does not preclude installation of substations elsewhere to support electrification	**Pass**	• No impact on substations	**Pass**	• No impact on substations	**Pass**	• No impact on substations

Project objectives and requirements	Description	Option 'do-nothing'		Option A – supported on structure		Option B2.1 – supported off abutments – top fixing with anchors		Option B2.2 – supported off abutments – side fixing	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ Fail	Rationale
Project requirement	Undertake necessary infrastructure change to achieve the clearances required for electrification at bridges and structures.	**Pass**	• No clearance issues associated with 'do-nothing' approach	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved
Project requirement	Undertake safety improvements resulting from the introduction of 1500V DC Overhead.	**Pass**	• No safety impact from 'do-nothing' approach.	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations

Table 4-5: Assessment of longlist of options against project objectives and requirements (Option B2.3 and Option C)

Project objectives and requirements	Description	Option B2.3 – supported off abutments – top fixing with precast unit		Option C – independent supports	
		Pass/fail	Rationale	Pass/ fail	Rationale
Project objective	To deliver a higher frequency, higher capacity, reliable, electrified route to enable an increased DART service frequency between Drogheda and Central Dublin.	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on positioning of back of abutment walls as they are on the limit of the 63m longitudinal spacing of the OHLE masts.	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty of ground conditions
Project objective	To deliver solutions which improve the passenger experience where passenger infrastructure interventions are required to meet the Train Service Specification.	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience
Project objective	To deliver a sustainable, low carbon and climate resilient design solution including making use of existing infrastructure where possible with targeted improvement works.	**Pass**	• Localised work making use of existing infrastructure • Larger pre-cast concrete unit and intervention requiring some demolition	**Pass**	• Requires new structure
Project objective	To identify cost-effective solutions from a capital, operations, and maintenance perspective.	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of new pre-cast units • Cost of disruption to train services • Cost of complex installation	**Pass**	• Enables delivery of electrified route in cost effective manner • Cost of works on/near water and future inspection • No cost from disruption to services • Exposure of steelwork to water, consider stainless steel •
Project objective	To minimise adverse impacts on the natural and built environment associated with construction, operation and maintenance of the project.	**Pass**	• Avoids work in estuary • Some loss of historic fabric	**Pass**	• Works in estuary required associated with creating new foundations
Project objective	To minimise adverse impacts on existing rail services, road users and landowners associated with the construction, operation and maintenance of the project.	**Pass**	• No negative operational impact • Disruption to train services during construction	**Pass**	• No negative operational impact • Less disruption to train services during construction likely

Project objectives and requirements	Description	Option B2.3 – supported off abutments – top fixing with precast unit		Option C – independent supports	
		Pass/fail	Rationale	Pass/ fail	Rationale
Project objective	To provide efficient and cost-effective integration of systems with the other DART+ projects	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.
Project requirement	To design in accordance with IÉ Standards and relevant national and EU standards and guidelines	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved
Project requirement	Designs shall comply with the Minimum Employer's Functional Requirements and meet the Train Service Specification	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved
Project requirement	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification
Project requirement	Provision of an appropriate number of substations to support electrification.	**Pass**	• No impact on substations	**Pass**	• No impact on substations
Project requirement	Undertake necessary infrastructure change to achieve the clearances required for electrification at bridges and structures.	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved
Project requirement	Undertake safety improvements resulting from the introduction of 1500V DC Overhead.	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations

4.4.1 Summary of longlist sifting

Table 4-6: Summary of Longlist Sifting

Option	Screening Result	Summary
"Do-Nothing"	**FAIL**	• Does not meet requirements. • Prevents installation of OHLE over viaduct. Spans for OHLE wires would be in excess of that allowed in system. • Failure to electrify the viaduct prevents effective integration with rest of DART route
Option A2	**PASS**	Meets project objectives and requirements
Option B2.1	**PASS**	Meets project objectives and requirements
Option B2.2	**PASS**	Meets project objectives and requirements
Option B2.3	**PASS**	Meets project objectives and requirements
Option C	**PASS**	Meets project objectives and requirements

4.5 Shortlisted options

The following options have been taken forward as the shortlisted options:

- Option A2 - Supported on structure – aligned with parapets;
- Option B2.1 – Supported off abutments – top fixing with anchors;
- Option B2.2 – Supported off abutments – face fixing;
- Option B2.3 – Supported off abutments – top fixing with precast units;
- Option C – Independent supports.

For a description of each of the options, refer back to Section 4.3.

4.6 Multi-criteria analysis

4.6.1 Methodology

For each individual entity an assessment has been made against the MCA criteria. Each option has been relatively compared against the others based on the five-point colour coded ranking scale in Table 4-9.

4.6.2 MCA summary table

A multi-criteria analysis table is presented in this section. This has been developed to reflect the relative rankings for all sub-criteria for each of the options assessed and is presented as a summary of the key issues considered.
A more detailed table is provided in the appendix to this report with the full detailed rationale behind the scoring of each criterion and option.

Table 4-7: MCA sub-criteria summary table

Criteria	Sub-Criteria	Option A2	Option B2.1	Option B2.2	Option B2.3	Option C
		Supported on structure – aligned with parapets	Supported off abutments – top fixing with anchors	Supported off abutments – face fixing	Supported off abutments – top fixing with precast units	Independent supports
Economy	CAPEX					
	OPEX					
	Train operations functionality/economic benefit					
	Traffic functionality and associated economic activities and opportunities					
Safety	Employer's Safety					
	Public safety					
Environment	Landscape and Visual Quality					
	Biodiversity					
	Noise and Vibration					
	Water resources					
	Archaeology, Architectural and Cultural Heritage					
	Geology and Soils (includes waste)					
	Agricultural and non-agricultural					
	Air Quality & Climate Change					
Accessibility & Social Inclusion	Accessibility					
	Social Inclusion					
Integration	Adaptability in the future					
	Transport Integration					
	Land Use Integration					
	Government policy integration					
	Geographical integration					
Physical Activity	Walking/cycling opportunities					

Table 4-8: Overall criteria MCA summary table

Criteria Summary	Option A2	Option B2.1	Option B2.2	Option B2.3	Option C
	Supported on structure – aligned with parapets	Supported off abutments – top fixing with anchors	Supported off abutments – face fixing	Supported off abutments – top fixing with precast units	Independent supports
Economy					
Safety					
Environment					
Accessibility & Social Inclusion					
Integration					
Physical Activity					

Table 4-9: Legend for MCA summary tables

Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

4.6.3 Economy

Economy has been divided into four sub-criteria which are considered below.

CAPEX

Options A and B2.3 involve some disruption to trains during construction as tracks would need lifting. This may be limited to weekend working. Negligible temporary works are required.

Option B2.1 will involve some disruption to trains due to track lifting required, dependent upon the extent of the precast concrete unit design.

Option B2.2 requires access to the abutment faces and so will require works in the estuary, with associated cost. It will have limited disruption to trains during construction.

Similarly, Option C will involve limited disruption to trains but will require installation of foundations on a steep slope, with access likely requiring a working platform to be constructed in the estuary.

OPEX

All options have a similar level of operational costs and maintenance impacts.

Infrastructure options adjacent the track are more easily accessed. They may require track possession for substantial repair works.

Options at the sides of the abutment wall do not have an impact on the track but are more difficult to inspect down the sides of a steep rock embankment.

Options requiring anchors or stress bars may have a higher level of maintenance depending on quality of construction but are not considered to have an overwhelming relative impact.

Options exposed to tidal conditions (e.g. option C) within the splash zone will have some increased maintenance requirements.

Train operations functionality/economic benefit

All options are comparable from a train operations functionality/economic benefit perspective.

Traffic functionality and associated economic activities and opportunities

Options A and B2.3 likely present the greatest disruption to trains during construction. B2.1 would disrupt trains to a magnitude dependent upon the extents of the precast concrete units. Option B2.2 would likely present a similar level of disruption, with option C disrupting trains least since work would be away from tracks.

Construction activities on all options considered are expected to generate a relatively low number of additional vehicular journey and therefore will, at most, have a minor temporary impact on the traffic conditions of the local road network.

4.6.4 Safety

Safety has been divided into two sub-criteria which are considered below. It should be noted that all options are safe, but some will have the potential for greater residual risks to remain. This criterion considers relative advantages of each option on the criteria of safety.

Employer's Safety

Options score similar for construction and maintenance risks. There are similar levels of risk associated with works adjacent the rail and works down the side of a steep rock embankment leading to an estuary.

Public Safety

All options are comparable since the public will not have access to this infrastructure.

4.6.5 Environment

Section 4.1.4 sets out a description of the existing environment, under key environmental criteria, including the key environmental constraints associated with this study area. Below is a summary of the key findings of the MCA under the various environmental criteria, with an emphasis on differentiating aspects for the options considered.

Landscape and Visual Quality

Option A has less visual interference with the structure and is preferred over other options. Options B2.1 and B2.3 are comparable to Option A. Options B2.2 and C have the greatest visual clutter and are least preferable.

Biodiversity

All the proposed options have potential to indirectly impact on the Rogerstown Estuary SAC, SPA and pNHA. Four of the five options have direct impacts on these nationally and internationally important designated sites. Potential direct impacts include works within the designated site boundary of the Rogerstown Estuary, potentially involving habitat removal as a result of drilling and new foundation structures. Potential indirect impacts include construction related impacts (e.g. potential for water quality impacts or disturbance to birds) and new lighting which would impact on the birds. The potential for these impacts is least in Option A, greater in options B2.1, B2.2 and B2.3 and greatest in Option C.
There are several other potential ecological constraints, but these are similar across all options and do not differentiate the preference between options. These include:

- The Overhead line equipment masts (OHLE) pose a hazard for birds, there are three main risks:
    - Mortality through collision with the power lines or the masts supporting them. This can occur when the bird flying across the viaduct from one side of the estuary to the other collides with the wire and is killed from the impact, from hitting the ground or from injuries sustained in the process.
    - Mortality through electrocution from the powerlines by causing a short circuit either by touching two live wires or a live and an earthed component.
    - Displacement, caused by disturbance through construction and maintenance activities. Displacement can also include barrier effects in which birds are deterred from using their normal routes to feeding or roosting grounds.
- Displacement of bats. The development has the potential to impact bats that may be roosting within the viaduct or commuting and foraging in the area. If there are bat roosts within the existing structure renovation works would reduce the potential satellite roosts within this well-connected habitat network for wildlife. Additional lighting and noise associated with the

construction of the OHLE may also cause disturbance and/or displacement of bat species.

- All options involve some level of works on the existing tracks. Railway lines can often support interesting flora species and habitats due to the calcareous nature of the ballast and their often relatively undisturbed nature. If any such habitat is present the level of impact is likely to be similar across all options and might not be a significant differentiator between options.

- It is not known whether invasive species may occur along the railway line. If present, then there would be risk of these spreading to adjacent areas with the adjacent Rogerstown Estuary SAC and SPA being particularly sensitive receptors. Even if it were the case that invasive species are present in this area, the level of impact is likely to be similar across all options and might not be a significant differentiator between options.

Noise and Vibration

Options A and B2.3 will have the smallest acoustic impact as very little construction works will have to be undertaken on site. Options B2.1, B2.2, and C will all have similar acoustic impacts. All options will cause some noise disturbance during the construction phase.

There will be no negative acoustic impact during the operational phase.

Water resources

From a water resources perspective, Options A2, B2.1, B2.2 and B2.3 are similarly comparable with each other. Option C has some comparative disadvantage over other options as, depending on the construction method employed, invasive works associated with the foundation construction has the potential to generate pollutants which could impact on Rogerstown Estuary and its associated protected sites.

Archaeology, Architectural & Cultural heritage

From an archaeological viewpoint, Option A is preferable as it involves no works in the estuary. Options B2.1 and B2.3 are the next preferred options as works in the estuary are limited and Options B2.2 and Option C are the least preferred as there are works and ongoing maintenance works planned for the estuary and both options alter the aesthetics of the existing bridge. Works within the estuary have the potential to reveal buried archaeological remains and historic features associated with the original timber and masonry viaduct structure.

Option A has advantages over Option B2.1, B2.2 and B2.3 from an architectural heritage perspective, since it avoids direct impact on the historic fabric and has a significantly reduced visual impact on the setting of the viaduct.

Options B2.1 and B2.3 propose taking down and rebuilding the parapet walls including some loss of historic fabric. This would have a significant, negative and irreversible impact on the protected structure. The anticipated visual impact is similar to the impact for Option A.

Option B2.2 would have a lesser impact on the historic fabric. The anticipated visual impact of the new structures fixed to the face of the historic masonry would have a moderate negative impact which would be greater than the impact for Option A.

Option C avoids impact on the historic fabric. There would be a negative visual impact, similar to the anticipated visual impact for Option B1.2.

Geology and Soils

From a Geology and Soils perspective, Options A, B2.2 and B2.3 are comparatively advantageous since the proposed works are on the existing structure only with no impacts on the geology and soils. Option B2.1 can also be considered as similarly comparable to the above two options once provided that the construction methodology and feasibility of ground anchor are confirmed.

However, Option C appears to be more disadvantageous than the other options since it comprises intrusive works at and adjacent to the estuary and as such, there is potential to encounter made ground and possible contaminated land.

Agricultural and Non-Agricultural

All options are located in non-agricultural land and therefore similarly comparable with each other. There are no agricultural constraints at the location for all the options and therefore this location is assessed as very low sensitivity from an agricultural perspective.

Air quality and climate

Option A is preferred due to the minimal construction work required. All options involve construction works that may generate dust, potentially impacting on the Rogerstown Estuary SAC, SPA and pNHA.

All options increase the capacity of the rail system and consequently the attractiveness for trips to be undertaken by public transport in the Greater Dublin Area. As such, it brings about positive impacts on air quality and climate during the operational phase.

4.6.6 Accessibility and social inclusion

All options are comparable from both accessibility and social inclusion perspectives. Options A, B2.1 and B2.3 would have more impact on trains during construction, however this would be short term.

4.6.7 Integration

Integration is assessed using the five sub-criteria described below.

Adaptability in the future

No future transport schemes will be significantly impacted by access to the site during construction or operation.

Transport integration

All options have no impact on the integration with other transport modes.

Land use integration

All options have no impact on land use.

Government policy integration

All options have no impact on government policy integration.

Geographical integration

All options have no impact on geographical integration.

4.6.8 Physical activity

All options have no significant impact on walking and cycling opportunities.

4.7 Construction Considerations

Constructability considerations for the shortlisted options are as follows:

4.7.1 Option A

Option A would involve some disruption to trains during construction as tracks would need lifting. This may be limited to weekend working. Negligible temporary works would be required.

4.7.2 Option B2.1

Option B2.1 would involve some disruption to trains during construction as works would be located directly adjacent to the tracks. The magnitude of this depends upon the precast unit design and working space required to install stress bars.

4.7.3 Option B2.2

Option B2.2 would involve limited disruption to trains during construction; no trackwork would be needed but works would be required in the estuary.

4.7.4 Option B2.3

Option B2.3 would involve some disruption to trains during construction as tracks would need lifting. This may be limited to weekend working. Negligible temporary works would be required.

4.7.5 Option C

Option C would involve very limited disruption to trains during construction, however new foundations would be needed on a steep slope likely requiring a working platform to be constructed in the estuary.

4.8 Summary and conclusions

4.8.1 Non-preferred options

Option A is not preferred due to:

- Risk of insufficient ballast depth;
- Significant disruption to rail services required for works.

Option C is not preferred due to:

- The large number of negative environmental impacts this option would result in. In particular - heritage, water and biodiversity;
- Construction complexity of installing the required foundations on a slope within an estuary, resulting in increased CAPEX.

4.8.2 Draft Emerging Preferred Option

Option B has been chosen as the Draft Emerging Preferred Option (inclusive of B2.1, B2.2 and B2.3) as it:

- Presents a favourable CAPEX;
- Does not have an unacceptable negative environmental impact.

4.8.3 Key Risks/Next Steps

The following risk and next steps have been identified:

- Coring data from structural investigations to inform the decision between B2.1, B2.2 and B2.3.
- Confirmation of make-up of the abutment walls and their distance apart to inform feasibility of B2.3.
- Feedback from heritage and environmental stakeholders

5 Balbriggan Viaduct (UBB56) optioneering selection process

5.1 Existing situation and constraints

5.1.1 Structure

Balbriggan Viaduct is a 100m long viaduct adjacent to Balbriggan Harbour. The bridge is comprised of eleven spans, each of approximately 9.15m in length.

The viaduct is a repeating masonry arch structure with concrete walkways either side of the deck, added in 2002 as renewal works for public access. The structure carries a twin track arrangement. Construction began in 1840 and completed in 1845, with designs undertaken by Sir John MacNeill. The bridge is a protected structure and listed in the National Inventory of Architectural Heritage.

Figure 5-1: UBB56 Aerial photo (source: Iarnród Éireann)

Figure 5-2: UBB56 Side photo (source: Iarnród Éireann)

Figure 5-3: UBB56 Side photo (source: Iarnród Éireann)

Figure 5-4: UBB56 Walkway photo from bridge soffit (source: Iarnród Éireann)

Figure 5-5: UBB56 Deck (source: Iarnród Éireann)

5.1.2 Permanent ways and tracks

The structure currently carries two tracks: the Up and Down Main Lines. There are points and crossings on the southern approach to the bridge. The tracks have a substantially straight alignment.

5.1.3 Utilities

Within the study area there are lineside telecommunication fibre cables running parallel to the railway for the extent of the Balbriggan Viaduct.

At street level there are underground medium voltage electrical cables, Irish Water watermains, foul and stormwater drainage networks pipelines running parallel to the railway for the extent of the Balbriggan Viaduct. There are two main utility crossing points, one at George's Hill and the other at Harbour Road. At George's Hill there are medium voltage power cables and Irish Water pipes crossing the rail and at Harbour Road there is a low-pressure gas pipe, low and medium voltage power cables, and telecommunications fibre cables within the streets going under the viaduct.

The existing utilities in the streets below the viaduct are not a constraint to the OHLE foundation options. However, the lineside telecommunications pose potential constraints. As such, they have been considered in the development of options. Regardless of the option selected, it will be necessary to maintain these during construction or to minimise outage durations in consultation with the utility providers.

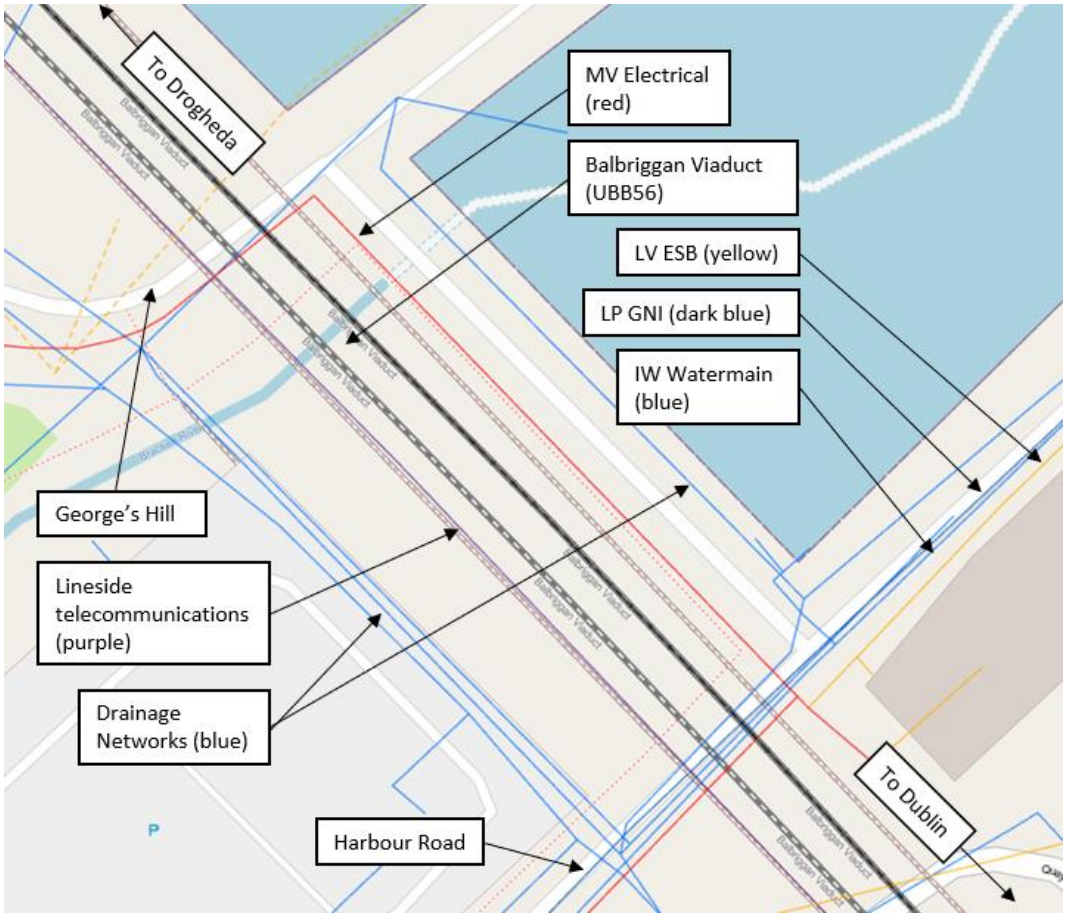


Figure 5-6: Plan of Balbriggan Viaduct (UBB56) showing existing utilities. (Map data © OpenStreetMap contributors, Map layer by Esri)

5.1.4 Environmental

For an overview of the existing environmental constraints for DART+ Coastal North refer to Annex 3.1 Constraints Report. The following sections provide detailed environmental description of the existing situation and constraints relevant to this specific structure.

5.1.4.1 Traffic and transportation

The site is accessible by local roads from both the north and the south. From the north the site can be accessed through a one-way system along Quay Street and Mill Street. From the south the site can be accessed through a one-way system along Quay Street and High Street. These roads also provide access to the Balbriggan marina, town centre and car parks (Town Car Park and Quay Street Car Park). The nearest road link of regional importance is the R132 Dublin Road that connects Balbriggan in the north-east with the M1 in the south-west.

The low speed and function of the access road through Balbriggan town will need to be considered in the context of construction traffic. The interface with the residential areas east of the rail line will also need to be considered during construction to ensure accessibility for all modes.

5.1.4.2 Landscape and visual impact

Balbriggan Viaduct is listed by Fingal County Council as a protected structure (reference: RPS No. 0036 Appendix 2 'Record of Protected Structures' of the Fingal Development Plan 2017-2023). The former RNLI Boathouse which is located beneath one of the arches of the viaduct is also a protected structure (No.0035).

The lands to either side of the viaduct are zoned Town and District Centre in the Fingal Development Plan. The viaduct is a prominent feature close to Balbriggan Harbour in the town centre.

5.1.4.3 Archaeological and cultural heritage

The Balbriggan Viaduct crosses the mouth of the Bracken River at Balbriggan Harbour where the site of a ford is indicated in the First Edition 6-inch Ordnance Survey map. There are no recorded monuments in proximity to the structure. The Dublin coast was exploited by hunter-gatherers in the Mesolithic period and several shell middens which have been identified on the coast to the north of the viaduct in the townland of Bremore may be of Mesolithic date (Deery and Goucher 2008). There was certainly activity along this part of the coast in the Neolithic period, and a passage tomb cemetery in Bremore (RMP DU002-001001/2/3/4/5) would have been the focus of funerary activity in this area. An extensive ploughzone flint assemblage was recovered along at Isaac's Bower, c. 800m southeast of the viaduct, which was thought to represent a localised flint knapping site (Licence 01E0951; Shanahan 2001).

Balbriggan was a small fishing village until the 18th century, with the 1659 census showing only 30 inhabitants. It became more of an industrial centre in the 18th century, thanks in large part to the development of the harbour in 1761. An historical assessment of an extensive area of open ground between Mill Street and George's Hill indicated industrial activity from the late 18th century onwards (Swan 2000; Licence 99E0727). The pier and cove at Balbriggan were important strategic locations on the coastline and this was one of a number of areas which was defended during the Napoleonic Wars of 1803-1815 with the construction of a Martello tower (RMP DU002-004). In 1837, Balbriggan contained 3,016 inhabitants in 600 houses, many of which were well built. Hot baths along the coastline were constructed for the many visitors who came there during the bathing season. The introduction of the railway to this area in 1843 attracted further development and visitors. Industrial features were constructed at this time to support the railway, including coke ovens on the west side of the viaduct to supply fuel and tramlines which linked the ovens to the quay and the railway (Scally 2004).

5.1.4.4 Architectural heritage

Balbriggan Viaduct is a protected structure (FCC RPS 0036) which is also included in the NIAH, where it is rated of Regional importance for reasons of architectural, social and technical interest. It is described therein as an eleven-arch limestone railway viaduct over harbour, built 1843-4 and renovated circa 1990 when footpaths

were added and iron railings were replaced. W. Dargan is noted as the builder, and Sir John MacNeill engineer.

A lifeboat station was housed within an arch below the viaduct in 1889. This structure is also included in Fingal's Record of Protected Structures (FCC RPS 0035) and in the NIAH where it is rated of Regional importance for reasons of architectural, historical, artistic and historical interest.

There are a large number of historic structures within the vicinity of the viaduct, associated with Balbriggan Harbour to the northeast, and with Balbriggan Historic Town Core to the southwest.

Balbriggan Harbour and light house, to the east of the viaduct, were built c.1760. They are also included in the RPS (FCC RPS 0038 and FCC RPS 0037) and are rated of Regional interest by the NIAH for reasons of architectural, social and technical interest.

Balbriggan Historic Town Centre is a designated Architectural Conservation Area.

5.1.4.5 Noise and vibration

The existing acoustic environment at the viaducts will be predominantly dominated by train pass bys on the railway line and natural noises such as birds, wind, and the ocean, as well as by contributions from the surrounding townland. The existing acoustic environment will be positively affected by the electrification of the line, as this will reduce noise from trains. Construction noise and vibration is expected to be audible at all locations.

At Balbriggan, residential receivers overlook the viaduct in 3 out of 4 directions and will be affected by construction noise. Construction noise will have to be limited during sensitive time periods (i.e., at night and on weekends) to minimise disruption to the surrounding community.

Noise sensitive species in the vicinity of the viaduct will also have to be considered during construction.

5.1.4.6 Air quality and climate

A number of sensitive receptors are located in proximity to the viaduct. There is the potential for dust impacts to occur during the construction phase.

The proposed development will support the aims of the Climate Action Plan. However, a key constraint is the development of the proposed scheme to ensure the following:

- the use of construction materials with low embodied carbon;
- the reduction of road traffic due to modal shift.

5.1.4.7 Agricultural and non-agricultural

There are no agricultural constraints at the location of the Balbriggan Viaduct and therefore this location is assessed as very low sensitivity from an agricultural perspective

5.1.4.8 Geology and soils

The Balbriggan Viaduct is underlain by recent deposits of Made Ground in modified areas and alluvial sediments deposited by the Bracken River. The Bracken River flows through an old glacial meltwater channel comprised of undifferentiated glacial sediments (and adjacent Irish Sea Tills) underlying the more recent deposits.

The bedrock at depth is described by the GSI as Ordovician Volcanics comprised of basalt of andesite, tuff, slate and mudstones.

There are no Geological Heritage Areas in this location. Previous land-use adjacent to the viaduct include a gas works to the west of the viaduct and salt works to the east.

5.1.4.9 Water resources

Surface water bodies

The Balbriggan Viaduct crosses the Bracken River which is part of the Matt_010 river sub basin (IE_EA_08M010900). Under the Water Framework Directive (WFD, 2000/60/EC) the status of Matt_010 is unassigned and is classified as At Risk, indicating that the waterbody may not maintain or achieve that status on the next WFD cycle. The minimum objectives for a water body under the WFD are to achieve at least ‘Good’ status (or ‘Good potential’ for artificial/ highly modified water bodies) and no deterioration of existing status.

The Bracken River discharges into the Northwestern Irish Sea (HA 08) coastal waterbody (IE_EA_020_0000) located directly east of the viaduct. Under the WFD the status of the Northwestern Irish Sea (HA 08) is ‘High’ and considered ‘Not at Risk’.

There are no protected water dependant ecological sites in the vicinity of the Balbriggan Viaduct.

Groundwater

The site is underlain by Ordovician Volcanics which are part of the Belcamp Formation. The aquifer is classified as a Locally Important (Lm) Aquifer which is Moderately Productive. The groundwater vulnerability at the site is classified as high. There are no significant karst features identified near the site.

There are no high yielding water supply springs and wells i.e., public water supplies or group water scheme supplies within the site. No Source Protection Zones associated with public or group groundwater supply schemes are located within the site.

The study area lies within the Balbriggan groundwater body (IE_EA_G_039). The groundwater body is currently at 'Good' WFD Status for the 2013-2018 monitoring cycle and currently 'Not at Risk' with regard to achieving its WFD objectives

Flooding

Historical flooding has been assessed by examining reports and maps from the OPW's National Flood Hazard mapping. There are no records of flood events within the site area. According to the OPW predictive flood maps (floodinfo.ie), the site is located adjacent to areas at risk of fluvial flooding.

5.1.4.10 Biodiversity

The works locations are on the existing Balbriggan Viaduct, which is set in the urban centre of Balbriggan. The Boyne Viaduct crosses the Bracken River, with Balbriggan Harbour adjacent to the viaduct. All of the options located on the viaduct.

There are no designated sites in the vicinity of the viaduct, with the closest being the River Nanny Estuary and Shore SPA, located circa 5km north.

The key ecological constraints for this area are the potential for bat roosts in the masonry of the viaduct, and the potential for bird strike due to the installation of the OHLE across the viaduct. There is also the potential for water quality impacts on the Bracken River, below the Viaduct.

There is no potential for direct or indirect impacts on any designated sites.

5.1.5 Planning

The viaduct is located within the functional area of Fingal County Council. It immediately adjoins lands that are zoned Major Town Centre: Protect, provide for and/or improve major town centre facilities".

The viaduct is a protected structure, as is the former RNLI Boathouse, located within one arches of the viaduct.

The abutments and supporting piers are also designated as protected structures.

Given the protected structure of the structure, careful consideration will have to be considered in relation to the design of any works to the viaduct.

5.2 OHLE frame longitudinal arrangement

Only one suitable arrangement for longitudinal frame positioning exists. This encompasses the placement of frames in the structure, at approximately 46m distance, in a symmetric fashion.

Other symmetric options would still require placing frames in the structure, with at least two frames. Hence there is no other alternative better arrangement.

Asymmetric arrangements are not considered for aesthetic reasons, and they would also require 2 masts attached to the structure.

This arrangement will be used in assessing the longlist options of positioning the masts on the structure.

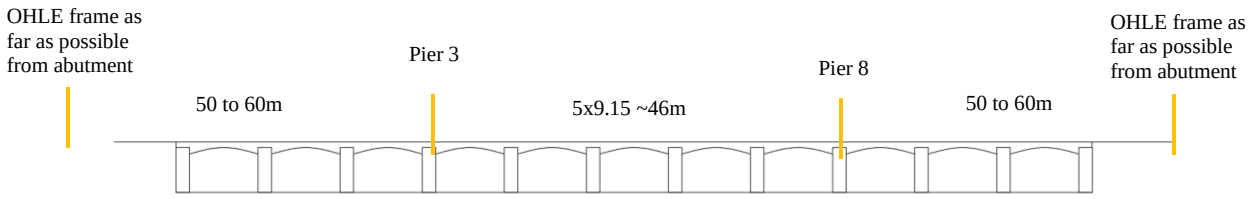


Figure 5-7: UBB56 proposed longitudinal framing arrangement

5.3 Longlist of options

This section describes the options which have been considered for the OHLE foundation solution at Balbriggan Viaduct. The discussion is limited to items which will have a bearing on the development or selection of an option..

The options which have been considered are summarised in Table 5-1 below.

Table 5-1: Longlist of options considered

Option	Description
Option 0	Do nothing
Option A2.1	Supported on structure – aligned with parapets – dowelled
Option A2.2	Supported on structure – aligned with parapets – precast 'U'
Option B1	Supported off pier

5.3.1 Option 0 – Do nothing

No masts provided.

5.3.2 Option A2.1 – Supported on structure – aligned with parapets – dowelled

This option involves cutting off a section of the parapet brick wall to place a precast beam which is then anchored to the existing brick parapet wall via 'Cintec' anchor bars or similar. The OHLE mast is then bolted down onto precast unit.

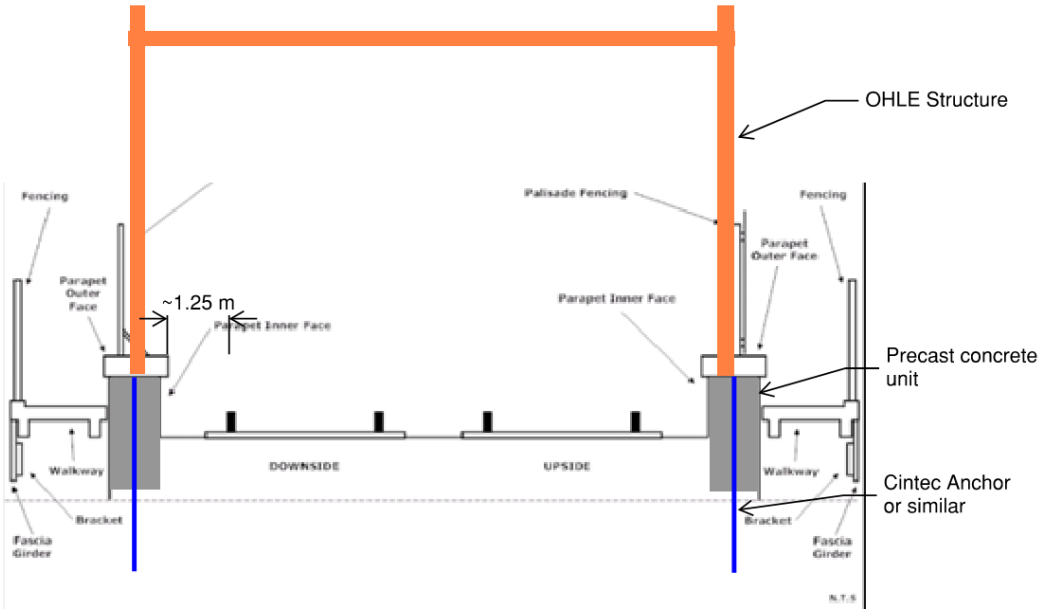


Figure 5-8: UBB56 Option A2.1 sketch

5.3.3 Option A2.2 – Supported on structure – aligned with parapets – precast 'U'

This option involves cutting of a section of the brick parapet wall to place a precast concrete 'U-shaped' unit (or 2 'L-shaped units' if feasible) acting in gravity. The OHLE mast is then bolted down onto the precast unit.

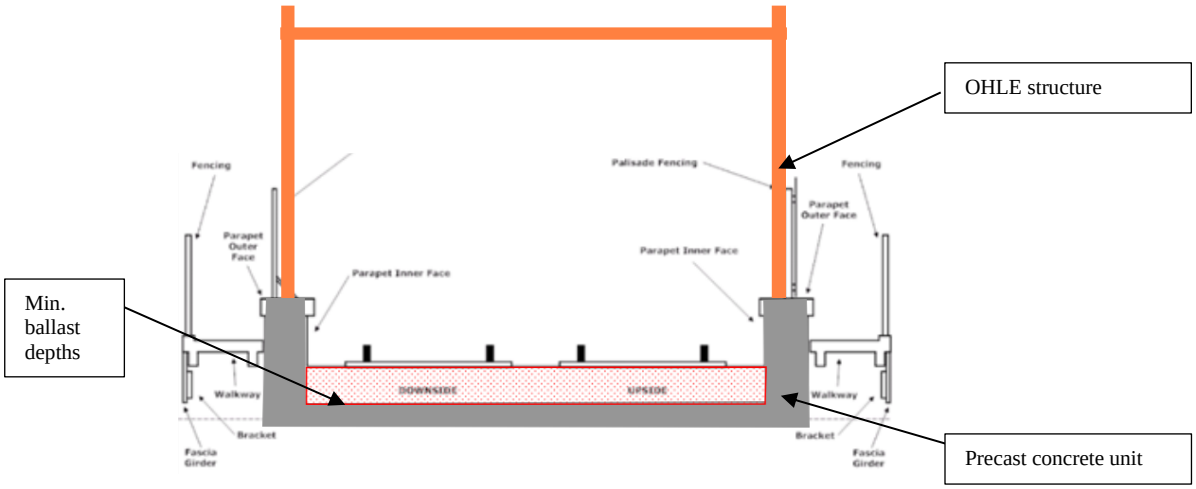


Figure 5-9: UBB56 Option A2.2 sketch

5.3.4 Option B1 – Supported off pier

This option encompasses the attachment of the OHLE frame to the side of the piers.

Figure 5-10: UBB56 Option B1.2 sketch (source: Iarnród Éireann)

5.4 Sifting of longlist of options

Assessment of the outlined options is provided in Table 5-2 below.

Table 5-2: Assessment of longlist of options against project objectives and requirements

Project objectives and requirements	Description	Option 'do-nothing'		Option A2.1 – supported on structure – aligned with parapets - dowelled		Option A2.2 – supported on structure – aligned with parapets – precast 'U'		Option B1 – supported off pier	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To deliver a higher frequency, higher capacity, reliable, electrified route to enable an increased DART service frequency between Drogheda and Central Dublin.	**Fail**	• Option prevents installation of OHLE over bridge	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on ability of masonry walls to support posts. Will likely require strengthening.	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on ability of masonry walls to support posts. Will likely require strengthening.	**Pass**	• Option enables installation of OHLE over bridge
Project objective	To deliver solutions which improve the passenger experience where passenger infrastructure interventions are required to meet the Train Service Specification.	**Pass**	• No infrastructure intervention considered as part of 'do-nothing' approach	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience
Project objective	To deliver a sustainable, low carbon and climate resilient design solution including making use of existing infrastructure where possible with targeted improvement works.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Localised work making use of existing infrastructure • Small pre-cast concrete unit	**Pass**	• Localised work making use of existing infrastructure • Larger pre-cast concrete unit and intervention requiring some demolition	**Pass**	• Localised work making use of existing infrastructure

Project objectives and requirements	Description	Option 'do-nothing'		Option A2.1 – supported on structure – aligned with parapets - dowelled		Option A2.2 – supported on structure – aligned with parapets – precast 'U'		Option B1 – supported off pier	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To identify cost-effective solutions from a capital, operations, and maintenance perspective.	**Pass**	• No impact due to 'do-nothing' approach.	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of new pre-cast units • Cost of disruption to train services • Cost of installation	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of new pre-cast units • Cost of disruption to train services • Cost of complex installation	**Pass**	• Enables delivery of electrified route in cost effective manner • Less cost from disruption to services • Cost of maintenance/inspection of face fixings at height
Project objective	To minimise adverse impacts on the natural and built environment associated with construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Some loss of historic fabric	**Pass**	• Greater loss of historic fabric	**Pass**	• Visual consideration of face fixing into historic structure
Project objective	To minimise adverse impacts on existing rail services, road users and landowners associated with the construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• No negative operational impact • Disruption to train services during construction	**Pass**	• No negative operational impact • Disruption to train services during construction	**Pass**	• No negative operational impact • Less disruption to train services during construction likely • Support portal would need to span over pedestrian walkway • More accessible to public during operation

Project objectives and requirements	Description	Option 'do-nothing'		Option A2.1 – supported on structure – aligned with parapets - dowelled		Option A2.2 – supported on structure – aligned with parapets – precast 'U'		Option B1 – supported off pier	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To provide efficient and cost-effective integration of systems with the other DART+ projects	**Fail**	• Failure to provide fully electrified route between Malahide and Drogheda precludes effective integration with DART route.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.
Project requirement	To design in accordance with IÉ Standards and relevant national and EU standards and guidelines	**Pass**	• No intervention	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved
Project requirement	Designs shall comply with the Minimum Employer's Functional Requirements and meet the Train Service Specification	**Fail**	• Non-compliant • No OHLE masts installed on viaduct would create spans in excess of that allowed in standards, since span (including abutment zones) is in excess of 65m limit.	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved

Project objectives and requirements	Description	Option 'do-nothing'		Option A2.1 – supported on structure – aligned with parapets - dowelled		Option A2.2 – supported on structure – aligned with parapets – precast 'U'		Option B1 – supported off pier	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project requirement	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	**Fail**	• No electrification possible over viaduct with 'do-nothing' approach	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification
Project requirement	Provision of an appropriate number of substations to support electrification.	**Pass**	• 'Do-nothing' approach does not preclude installation of substations elsewhere to support electrification	**Pass**	• No impact on substations	**Pass**	• No impact on substations	**Pass**	• No impact on substations
Project requirement	Undertake necessary infrastructure change to achieve the clearances required for electrification at bridges and structures.	**Pass**	• No clearance issues associated with 'do-nothing' approach	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved
Project requirement	Undertake safety improvements resulting from the introduction of 1500V DC Overhead.	**Pass**	• No safety impact from 'do-nothing' approach.	**Pass**	• Earthing and bonding considerations • Anti-trepass measures due to adjacent walkways	**Pass**	• Earthing and bonding considerations • Anti-trepass measures due to adjacent walkways	**Pass**	• Earthing and bonding considerations • Anti-trepass measures due to adjacent walkways, pier fixing and support portal may be more accessible to public

5.4.1 Summary of longlist sifting

Table 5-3: Summary of Longlist Sifting

Option	Screening Result	Summary
"Do-Nothing"	**FAIL**	• Does not meet requirements. • Prevents installation of OHLE over viaduct. Spans for OHLE wires would be in excess of that allowed in system. • Failure to electrify the viaduct prevents effective integration with rest of DART route
Option A2.1	**PASS**	Meets project objectives and requirements
Option A2.2	**PASS**	Meets project objectives and requirements
Option B1.2	**PASS**	Meets project objectives and requirements

5.5 Shortlisted options

The following options have been taken forward as the shortlisted options:

- Option A2.1 – Supported on structure – aligned with parapets – dowelled;
- Option A2.2 – Supported on structure – aligned with parapets – precast 'U';
- Option B1 – Supported off piers.

For a description of each of the options, refer back to Section 5.3.

5.6 Multi-criteria analysis

5.6.1 Methodology

For each individual entity an assessment has been made against the MCA criteria. Each option has been relatively compared against the others based on the five-point colour coded ranking scale in Table 5-6.

5.6.2 MCA summary table

A multi-criteria analysis table is presented in this section. This has been developed to reflect the relative rankings for all sub-criteria for each of the options assessed and is presented as a summary of the key issues considered.
A more detailed table is provided in the appendix to this report with the full detailed rationale behind the scoring of each criterion and option.

Table 5-4: MCA sub-criteria summary table

Criteria	Sub-Criteria	Option A.21	Option A2.2	Option B1
		Supported on structure – aligned with parapets – dowelled	Supported on structure – aligned with parapets – precast 'U'	Supported off piers
Economy	CAPEX			
	OPEX			
	Train operations functionality/economic benefit			
	Traffic functionality and associated economic activities and opportunities			
Safety	Employer's Safety			
	Public safety			
Environment	Landscape and Visual Quality			
	Biodiversity			
	Noise and Vibration			
	Water resources			
	Archaeology, Architectural and Cultural Heritage			
	Geology and Soils (includes waste)			
	Agricultural and non-agricultural			
	Air Quality & Climate Change			
Accessibility & Social Inclusion	Accessibility			
	Social Inclusion			
Integration	Adaptability in the future			
	Transport Integration			
	Land Use Integration			
	Government policy integration			
	Geographical integration			
Physical Activity	Walking/cycling opportunities			

Table 5-5: Overall criteria MCA summary table

Criteria Summary	Option A.21	Option A2.2	Option B1
	Supported on structure – aligned with parapets - dowelled	Supported on structure – aligned with parapets – precast 'U'	Supported off piers
Economy			
Safety			
Environment			
Accessibility & Social Inclusion			
Integration			
Physical Activity			

Table 5-6: Legend for MCA Summary Tables

Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

5.6.3 Economy

Economy has been divided into four sub-criteria which are considered below.

CAPEX

Option A2.1 has comparable advantage over Option A2.2 as all work can be constructed adjacent to the track with minimal disruption to the train services. Good access is available from trackside and walkway, though works will still require possessions.

Option A2.2 has the least technical complexity but would require tracks to be lifted while slab trough is constructed. The impact should be minimised by using precast concrete elements but would still require removal and reinstatement of tracks.

Option B1 would not impact tracks but would require substantial temporary works to install anchors into the side of the viaduct piers. Some possessions would still be needed. Some highway closures would be required, either at night or weekends.

OPEX

Option A2.1 has elements which are easily accessible for inspection and maintenance. The stress bars however add an additional level of complexity. Hence this option is assessed to be relatively similar to Option A2.2.

For Option A2.2, the concrete U-trough would be located beneath the tracks and would not be easily accessible for inspection and maintenance. However, the nature of this element is relatively simple and would require minimal maintenance over its lifespan and is hence assessed to be relatively similar to Option A2.1.

The connection for Option B1 involves a ground anchor located in the side of the pier high up off the ground. Hence any maintenance associated with this option would require extensive scaffolding and working at heights and so has comparative disadvantage.

Train operations functionality/economic benefit

All options are comparable from a train operations functionality/economic benefit perspective.

Traffic functionality and associated economic activities and opportunities

Option A2.1 has comparable advantage as there will only be some disruption to trains during construction. Option A2.2 and B1 are deemed comparable since Option A2.2 involves the most disruption to trains during construction and although Option B1 presents the least disruption to trains, it will likely significantly disrupt roads.

When operational, the scheme will have no visible impacts on the prevailing traffic conditions in the surrounding road networks.

Option A2.2 has greater disruption to public walkways during construction compared to Option A2.1. Mitigation measures for the construction impact will be required.

Construction activities on all options considered are expected to generate a relatively low number of additional vehicular journeys and therefore will, at most, have a minor temporary impact on the traffic conditions of the local road network.

5.6.4 Safety

Safety has been divided into two sub-criteria which are considered below. It should be noted that all options are safe, but some will have the potential for greater residual risks to remain. This criterion considers relative advantages of each option on the criteria of safety.

Employer's Safety

Options A2.1 and A2.2 have comparable advantage since they are both relatively easily accessible form track level. Option B1 would involve high level access issues and risk for inspection and maintenance.

Public Safety

All options are comparable since the public will not have access to the infrastructure. Although the OHLE masts would span over the public walkway for Option B1, the poles would be behind suitable fencing and the overhead mast well out of reach.

5.6.5 Environment

Section 5.1.4 sets out a description of the existing environment, under key environmental criteria, including the key environmental constraints associated with this study area. Below is a summary of the key findings of the MCA under the various environmental criteria, with an emphasis on differentiating aspects for the options considered.

Landscape and Visual Quality

Option A2.1 has less visual interference with the structure and is preferred over other options. Option A2.2 has slightly greater visual interfaces with the structure than A2.1, however this is seen as minimal and has comparatable advantages over option B1. Option B1 has the greatest visual clutter and is least preferable.

Biodiversity

Options A2.1, A2.2 and B1 all include either demolishing, covering or amendments of some description to the existing masonry on the parapet of the Balbriggan Viaduct. The viaduct has high bat roosting potential with numerous features across all spans, located mainly in cracks and crevices between the masonry. The bridge also has winter bat hibernation potential, therefore any amendments to the masonry on the bridge would require very strict and costly mitigation. This may only allow works to commence outside of summer roosting, and winter hibernation period, i.e. works would only be able to occur in March/April, and October/November (outside of sensitive periods). Whilst surveys are being carried out to determine if bats are roosting and/or hibernating within the bridge, due to the height and complexity of the bridge and safety issues with working on a live railway line, it would be very difficult to determine with confidence that bats are or are not roosting within the structure. Even if no roosts are identified during surveys, mitigation will be required to ensure bats will not be harmed during works. If roosts are identified within the areas where works are occurring, a bat derogation licence will be required from NPWS. This impact is comparable across all options.

Additional lighting that may be required during construction and/or operation, and noise and vibration from the works, has the potential to disturb and/or displace roosting and commuting and foraging bats in the area. This impact is comparable across all options.

The installation of the OHLE across the viaduct, has the potential to cause direct injury or mortality to birds from the lines that may be flying over the viaduct. This is as currently there are no lines at height that may cause an impact on bird species. This impact is comparable across all options.

The Bracken River flows under one span of the Viaduct (between Pier 3 and 4). Pier three will have a mast installed on it, and therefore there is potential for debris or other material to fall into the watercourse below and affect the water quality of the watercourse and the habitats and species within. This impact is likely to be minimal however as works are only required on the structure and would be comparable across all options.

Noise and Vibration

All options are expected to have a similar acoustic impact during the construction phase of the project. There is a slight disadvantage to Option B1, as works will happen on the side of the pier and in plain sight of nearby residential receivers, however, the duration of this work is expected to be so short that the impact will be minimal.

There will be no acoustic impact during the operational phase.

Water resources

From a water resources perspective, all options are similarly comparable with each other since the proposed works are on the existing structure only with imperceptible impacts on the water receptors.

Archaeology, Architectural & Cultural heritage

From an archaeological viewpoint there will be no works outside the viaduct structure, thereby minimising the potential to reveal previously undetected archaeological features and finds. Option A2.2 is the least preferred as it will result is the most loss to original historic fabric, the other two options are similar in comparison with Option A2.1 having some loss of historic fabric and Option B1 will result in a change to the aesthetics of the viaduct and localised intervention to the structure.

It is anticipated that Option A2.1 would have a moderate negative impact from an architectural heritage perspective, as some disruption of historic fabric is proposed (the legibility of the historic parapet walls has previously been impacted by the provision of the walkway). This option would have a low visual impact on the setting of the structure.

It is anticipated that Option A2.2 would have a significant negative impact on the historic fabric. More disruption of historic fabric is proposed relative to Option A2.1. This option would have a low visual impact on the setting of the structure.

It is anticipated that Option B.1 would have a moderate negative impact from an architectural heritage perspective. The disruption of historic fabric is reduced relative to Options A2.1 and A2.2 but the visual impact is greater. This option would have a medium visual impact on the setting of the structure.

Geology and Soils

From a Geology and Soils perspective, all options are similarly comparable with each other since the proposed works are on the existing structure only with no impact on the underlying geology and soils.

Agricultural and Non-Agricultural

All options are located in non-agricultural land and therefore similarly comparable with each other. There are no agricultural constraints at the location for all the options and therefore this location is assessed as very low sensitivity from an agricultural perspective

Air quality and climate

All options are comparable from an air quality and climate perspective during the construction phase.

All options increase the capacity of the rail system and consequently the attractiveness for trips to be undertaken by public transport in the Greater Dublin Area. As such, it brings about positive impacts on air quality and climate during the operational phase.

5.6.6 Accessibility and social inclusion

All options are comparable from both accessibility and social inclusion perspectives. Options A2.1 and A2.2 would have more impact on trains during construction, however this would be short term.

5.6.7 Integration

Integration is assessed using the five sub-criteria described below.

Adaptability in the future

No future transport schemes will be significantly impacted by access to the site during construction or operation.

Transport integration

Option A2.2 has greater disruption to public walkways during construction. Option B1 has an impact on walkways below during construction, along with the operational hazard of OHLE structure spanning over public walkway (although easily mitigated).

Land use integration

All options have no impact on land use.

Government policy integration

All options have no impact on government policy integration.

Geographical integration

All options have no impact on geographical integration.

5.6.8 Physical activity

Option A2.2 has greater disruption to public walkways during construction. Option B1 has an impact on walkways below during construction, along with the operational hazard of OHLE structure spanning over public walkway (although easily mitigated).

5.7 Construction Considerations

Constructability considerations for the shortlisted options are as follows:

5.7.1 Option A2.1

Good access is available from trackside and walkway, though all works will need possessions.

5.7.2 Option A2.2

This option will be significantly disruptive to trains as tracks will need to be lifted to install precast units. Additionally, much of the existing structure will need to be cut to install the new works.

5.7.3 Option B1

This option will be less disruptive to trains (some possessions still needed) but more disruptive to roads and footpaths below. Some highway closure would be needed, either at night or weekends.

5.8 Summary and conclusions

5.8.1 Non-preferred options

Option A2.2 is not preferred due to:

- The CAPEX associated with carrying out works under the tracks and disrupting trains;
- The disruption to train functionality during construction.

Option B1 is not preferred due to:

- The visual impact to the structure;
- The difficulty in accessing the connection for inspection and maintenance;
- Impacts to the road environment below during construction, adversely affecting transport integration.

5.8.2 Draft Emerging Preferred Option

Option A2.1 has been chosen as the Draft Emerging Preferred Option as it:

- Presents the best overall economy option;
- Has least visual impact on the structure;
- Minimises disruption to train operations and road environment below during construction.

5.8.3 Key Risks/Next Steps

The following risks and next steps have been identified:

- Uncertainty on ability of masonry walls to support posts. Coring data from the structural investigations will be used to inform composition and strength of existing spandrel walls.Feedback from heritage and environmental stakeholders

6 Gormanston Viaduct (UBB65) optioneering selection process

6.1 Existing situation and constraints

6.1.1 Structure

Gormanston Viaduct is a 45m long viaduct over the Delvin River adjacent to Gormanston beach. The bridge comprises three spans, with edge spans measuring 12.65m in length and a central span of 19.5m.

The viaduct is a steel structure, supported off hollow steel circular columns. For the central span, the deck is comprised of a lattice truss. Edge spans are supported on steel girders.

The bridge is listed as a ‘protected’ structure.

Figure 6-1: UBB65 View 1 (source: Iarnród Éireann)

Figure 6-2: UBB65 View 2 (source: Iarnród Éireann)

Figure 6-3: UBB65 at 23mls 1300yds Dublin-Belfast – View from Down Side (source: Iarnród Éireann)

C

Figure 6-4: UBB65 at 23mls 1300yds Dublin-Belfast – View from Up Side (source: Iarnród Éireann)

6.1.2 Permanent ways and track

The structure currently carries two tracks; the Up and Down Main Lines. No points and crossings exist on or within the vicinity of the bridge. From a preliminary measure in cad, the tracks have radius of approximately 13.000 m.

6.1.3 Utilities

Within the study area there are telecommunications fibre cables and other lineside services cables for Irish Rail. The lineside services and telecoms fibre runs parallel to the railway and usually within the cess. There are no utility crossing points within the area of study. The various OHLE foundation options should not drastically affect the utilities within the study area. Cognisance of the utilities should be taken during construction phase to ensure that no disruptions to the utilities are caused.

The lineside services and telecommunications pose potential constraints to the OHLE foundation options. As such, they have been considered in the development of options. Regardless of the option selected, it will be necessary to maintain these during construction or to minimise outage durations in consultation with the utility providers.

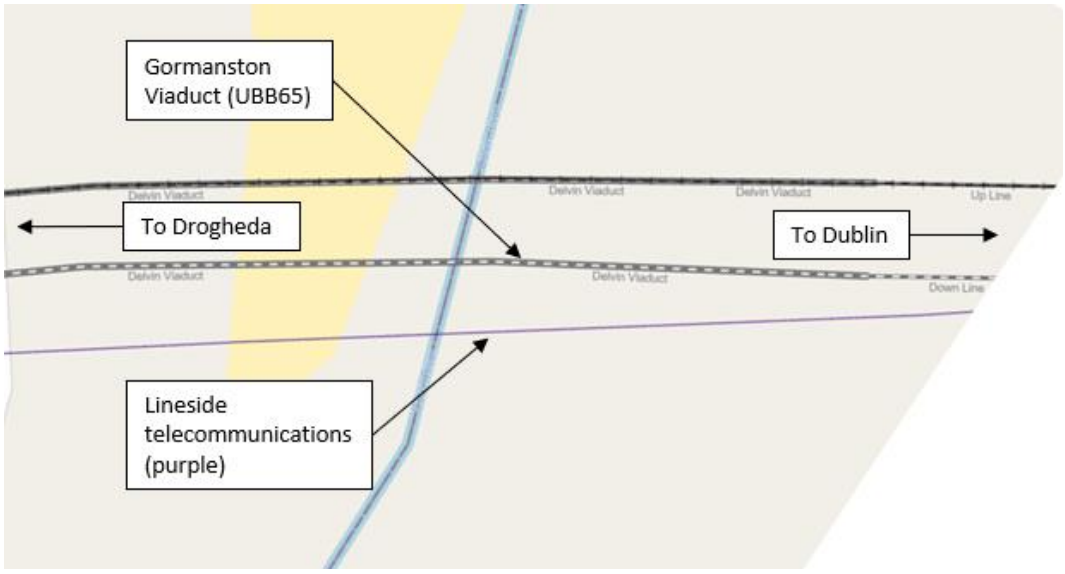


Figure 6-5: Plan of Gormanston Viaduct (UBB65) showing existing utilitiy routes (Map data © OpenStreetMap contributors, Map layer by Esri)

6.1.4 Environmental

For an overview of the existing environmental constraints for DART+ Coastal North refer to Annex 3.1 Constraints Report. The following sections provide detailed environmental description of the existing situation and constraints relevant to this specific structure.

6.1.4.1 Traffic and transportation

The site is accessible by local road from the north or by farm access from the south. The roads are narrow at approximately 3m width. The local road to the north provides access to the coast and a private property. The nearest road link of regional importance is the R132 Dublin Road that connects with the M1 in the north-west.

The access roads are narrow and may require additional traffic management measures or temporary access roads to accommodate two-way construction traffic volumes. Access to the private property to the north needs to be maintained.

6.1.4.2 Landscape and visual impact

Gormanston (Knocknagin) Viaduct is listed by Fingal County Council as a protected structure (reference: RPS No. 0001 Appendix 2 ‘Record of Protected Structures’ of the Fingal Development Plan 2017-2023).

The Delvin River forms the boundary between Fingal (Dublin) to the south and Meath to the north. The lands on the south side of the Delvin River are zoned High Amenity in the Fingal Development Plan.

6.1.4.3 Archaeological and cultural heritage

Shell middens, the passage tomb cemetery, a barrow and fulacht fiadh at Bremore suggest activity from the Mesolithic period to the Bronze Age in this area (RMP DU002-001001/2/3/4/5/6, DU002-013). Further passage tombs in Knocknagin and Gormanston townlands frame the mouth of the Delvin River (RMP DU002-010, ME028-020, ME028-021), suggesting that it formed an important routeway in the Neolithic period.

According to Hartnett (1957) the Bremore/Gormanston group of tombs represent the point of entry at a 'natural landing point' of the 'Fourknocks Group' and mark the western expansion of this culture along the Delvin River. The river would have been navigated using dugout logboats, and one Bronze Age example dating to 1132-1013 cal BC was discovered during dredging activity 300m from Gormanston Beach, demonstrating that such vessels were also used along the coast (Licence no.: 02E0467, 02E0948; ADCO 2021).

The funerary tradition was continued along the river in the Bronze Age with ring-ditches recorded in Knocknagin and Gormanston (SMR DU001-019, ME028-077). A habitation site which was found to date to 2050-1880 BC was discovered in Gormanston in the same field as the ring-ditch (SMR ME028-051; Licence no.: 02E0122, 02E0194, 02E0326; Tobin 2003). An enclosure and possible field system which were identified through aerial photography of the same field may be related to the habitation (SMR ME028-078, ME028-079).

There is no significant settlement recorded at this location in the medieval period, although the construction of a harbour at 'New Haven' on Bremore Head in 1562 would have attracted settlement to the south of the river.

The original viaduct was a timber and masonry structure and was replaced in the 1880s with the present steel structure (Rynne 2006).

6.1.4.4 Architectural heritage

Gormanston Viaduct is a protected structure listed in both the Fingal and Meath County Council Records of Protected Strictures (FCC RPS 001 and MH028-114). The wrought iron structure replaced the original timber c.1880. The bridge is of architectural and technical interest.

Knocknagin Lodge is situated approximately 200m to the south west of the viaduct. It is included in the NIAH where it is rated of Regional importance for reasons of architectural, social and technical interest. The cottage may have served as a gate lodge to Knocknagin House, which is situated a further 170m south of the lodge. The house dates from the mid seventeenth century and is included in Fingal County Council's RPS (FCC RPS 002). It is rated of National importance by the NIAH for reasons of architectural, artistic ad social interest.

6.1.4.5 Noise and vibration

The existing acoustic environment at the viaducts will be predominantly dominated by train pass bys on the rail line and natural noises such as birds, wind, and the

ocean. The existing acoustic environment will be positively affected by the electrification of the line, as this will reduce noise from trains. Construction noise and vibration is expected to be audible at all locations.

There is a detached house just to the north of the viaduct at Gormanston that is the nearest sensitive receiver. Construction noise will have to be controlled during the night and on weekends to minimise disruption to the resident.

Noise sensitive species in the vicinity of the viaduct will also have to be considered during construction.

6.1.4.6 Air quality and climate

The nearest sensitive receiver to the Gormanston Viaduct is a detached house just to the north of the viaduct.

The proposed development will support the aims of the Climate Action Plan. However, a key constraint is the development of the proposed scheme to ensure the following:

- the use of construction materials with low embodied carbon;
- the reduction of road traffic due to modal shift.

6.1.4.7 Agricultural and non-agricultural

There are no agricultural constraints at the location of the Gormanston Viaduct and therefore this location is assessed as very low sensitivity from an agricultural perspective

6.1.4.8 Geology and soils

Gormanston Viaduct traverses the Delvin River and is underlain by recent deposits of alluvium associated with the Delvin River and nearby marine beach sands. These are underlain by glacial deposits predominantly comprising gravels derived from the underlying bedrock with limestone dominant gravels to the north and sandstone and siltstone dominant gravels to the south of the viaduct.

The underlying bedrock is comprised of the Silurian Denhamstown Formation described by the GSI as blue-grey greywacke sandstones and siltstones at the base and metabentonites toward the top of the formation. A fault in the underlying bedrock is indicated by the GSI beneath the viaduct.

The Gormanston Viaduct is located with the Geological Heritage Area of Laytown to Gormanston (Site Code MH008) which is a County Geology Site described as a coastal plain including sea cliffs which is significant geologically as a flat to gently undulating glacial outwash plain of sandur gravels.

The railway is contained on an embankment on either side of the viaduct.

6.1.4.9 Water resources

Surface water bodies

The Delvin River is part of the Devlin_040 river sub basin (IE_EA_08D010400). Under the Water Framework Directive (WFD, 2000/60/EC) the status of Delvin_040 is 'Poor' and is classified as 'At Risk', indicating that the waterbody may not maintain or achieve that status on the next WFD cycle. The minimum objectives for a water body under the WFD are to achieve at least 'Good' status (or 'Good potential' for artificial/ highly modified water bodies), and no deterioration of existing status.

The Delvin River discharges into the North-western Irish Sea (HA 08) coastal waterbody (IE_EA_020_0000). Under the WFD the status of the Northwestern Irish Sea (HA 08) is High and considered Not at Risk.

There are no protected water dependant ecological sites in the vicinity of the Gormanston Viaduct.

Groundwater

The site is underlain by Silurian Metasediments and Volcanics which are part of the Denhamstown Formation. The aquifer is classified as a Poor Aquifer (Pu) which is Generally Unproductive. The groundwater vulnerability at the site is classified as high. There are no significant karst features identified near the site.

There are no high yielding water supply springs and wells i.e. public water supplies or group water scheme supplies within the site. No Source Protection Zones associated with public or group groundwater supply schemes are located with the site.

The study area lies within the Duleek groundwater body (IE_EA_G_012). The groundwater body is currently at Good WFD Status for the 2013-2018 monitoring cycle and currently Not at Risk with regard to achieving its WFD objectives

Flooding

Historical flooding has been assessed by examining reports and maps from the OPW's National Flood Hazard mapping. There are no records of flood events within the site area. According to the OPW predictive flood maps (floodinfo.ie), the site is located adjacent to areas at risk of fluvial and coastal flooding.

6.1.4.10 Biodiversity

The works locations are set in the estuarine environment of Gormanston, on the Meath – Dublin County Borders, between Laytown and to the north, and Balbriggan to the south. The works locations are located on or directly adjacent to the Gormanston Viaduct which crosses the Delvin River adjacent to Gormanston Beach.

There are no designated sites within the vicinity of the works area, with the closest being the River Nanny Estuary and Shore SPA, located c. 2km north of the works areas, and the Laytown Dunes/Nanny Estuary pNHA, located c. 3.4km north. All

options involve the installation of an OHLE frame on both sides of the viaduct, placed close to or in the bridge abutment walls.

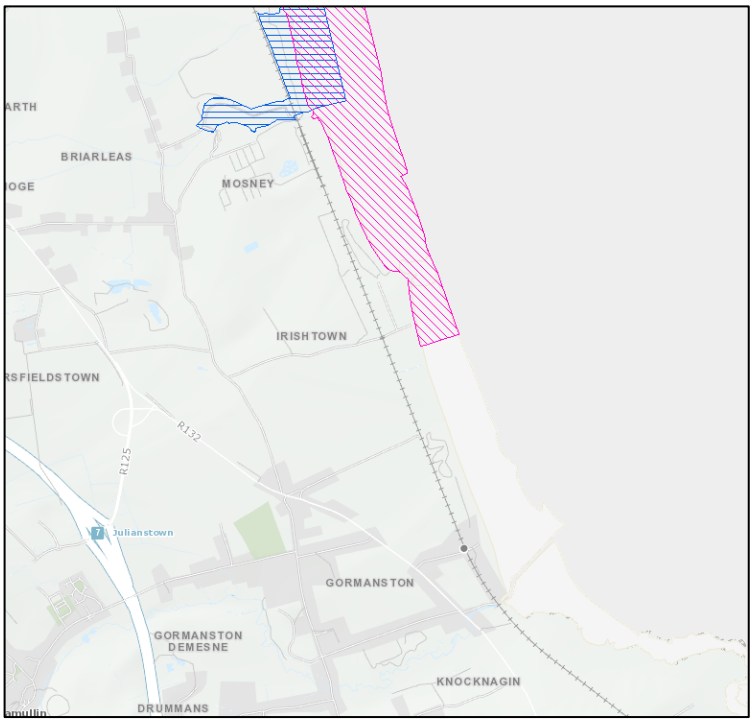


Figure 6-6: River Nanny Estuary and Shore SPA and Laytown Dunes/Nanny Estuary pNHA (Map data © OpenStreetMap contributors, Map layer by Esri)

The key ecological constraints in this area are the Delvin River, which flows beneath the Viaduct, and any potential bat roosts within the structure.

Other potential ecological constraints include:

- Vegetation (scrub) which may provide foraging and nesting for fauna species (e.g. birds, bats, small mammals)
- Potential for invasive species to occur adjacent to or along the railway line
- Potential for bird strike caused by the overhead lines

6.1.5 Planning

The viaduct is located within the functional area of Meath County Council. It is located on unzoned lands as it is outside the town envelope of Gormanston.

It is a protected structure.

Given the protected structure status of the structure, careful consideration will have to be considered in relation to the design of any works to the viaduct.

6.2 OHLE frame longitudinal arrangement

The bridge is 45m long, which means that no OHLE frames will need be placed in the bridge itself. However, as the maximum OHLE frame spacing is 60m, frames

may need be placed close or in the abutments, potentially requiring a modification of the structure.

Figure 6-7: UBB65 Aerial photo with deck (highlighted yellow and potential OHLE mast locations (red dots) at 60m spacing (Source: Google Earth)

Arrangement 1

Maximum OHLE span to avoid frames on deck structure

- Advantages: No intervention to deck structure, no works in height;
- Disadvantages: OHLE frames to be placed close to the abutment front face (~7.5m) and may require intervention to the wingwalls.

Figure 6-8: Proposed OHLE frame location – arrangement 1 (source: Iarnród Éireann)

Arrangement 2

Shorter OHLE span to avoid frames on abutments with masts attached to superstructure

- Advantages: No intervention to abutment/abutment wingwalls;
- Disadvantages: OHLE frames to be attached to deck structure. Works in height.

Figure 6-9: Proposed OHLE frame location – arrangement 2 (source: Iarnród Éireann)

Table 6-1 provides a summary of the criteria against which the arrangements have been assessed. It has been chosen to proceed with arrangement 1 due to the comparative detail simplicity. Yellow indicates an unfavourable result, with red indicating a value that precludes the option.

Table 6-1: UBB65 OHLE Longitudinal arrangement appraisal matrix

	Mast at piers / abutments	Number of masts	Symmetric distribution	Mast in bridge centreline	Mast spacing < 60m	All details equal?
Arrangement 1 (frames connected to abutments	Yes	2 ≤ 2	yes	No	yes	yes
Arrangement 2 (frames connected to piers)	Yes	2 ≤ 2	yes	No	yes	Yes, but more complicated details at piers

Arrangement 1 will be used in assessing the longlist options of positioning the masts on the structure.

6.3 Longlist of options

This section describes the options which have been considered for the OHLE foundation solution at Gormanston Viaduct. The discussion is limited to items which will have a bearing on the development or selection of an option.

The options which have been considered are summarised in Table 6-2. These are based upon the standard options as laid out in Section 2.2.2.

Table 6-2: Longlist of options considered

Option	Description
Option 0	Do nothing
Option B2.1	Supported off abutment – top fixing
Option B2.2	Supported off abutment – face fixing
Option C	Independent supports

6.3.1 Option 0 – Do nothing

No masts provided.

6.3.2 Option B2.1 – Supported off abutment – top fixing

This option requires a section of the parapet wall to be cut off to place a precast concrete 'U-shaped' unit or alternatively two 'L-shaped' units. OHLE masts will be then bolted to the top of the unit. Original stonework will be used to mask the precast concrete unit and restore the original aspect to the parapet wall.

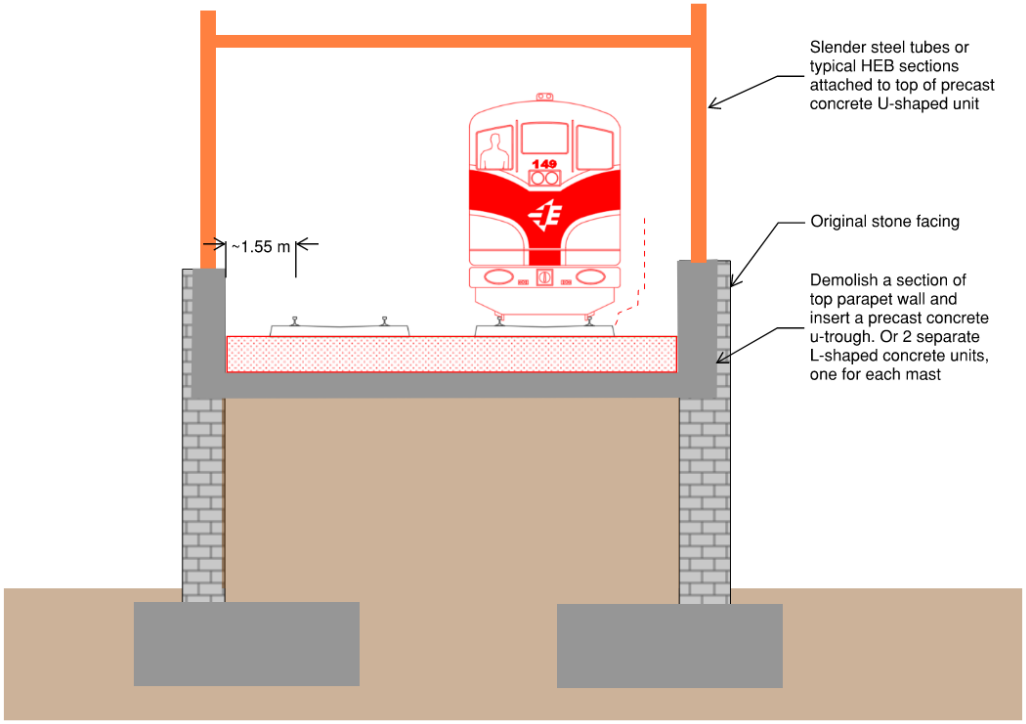


Figure 6-10: UBB65 Option B2.1 sketch

6.3.3 Option B2.2 – Supported off abutment – face fixing

This option encompasses OHLE masts attached to the abutment wing walls / retaining walls. Depending on the wall thickness and capacity, one or two ties may have to be drilled to connect both OHLE masts.

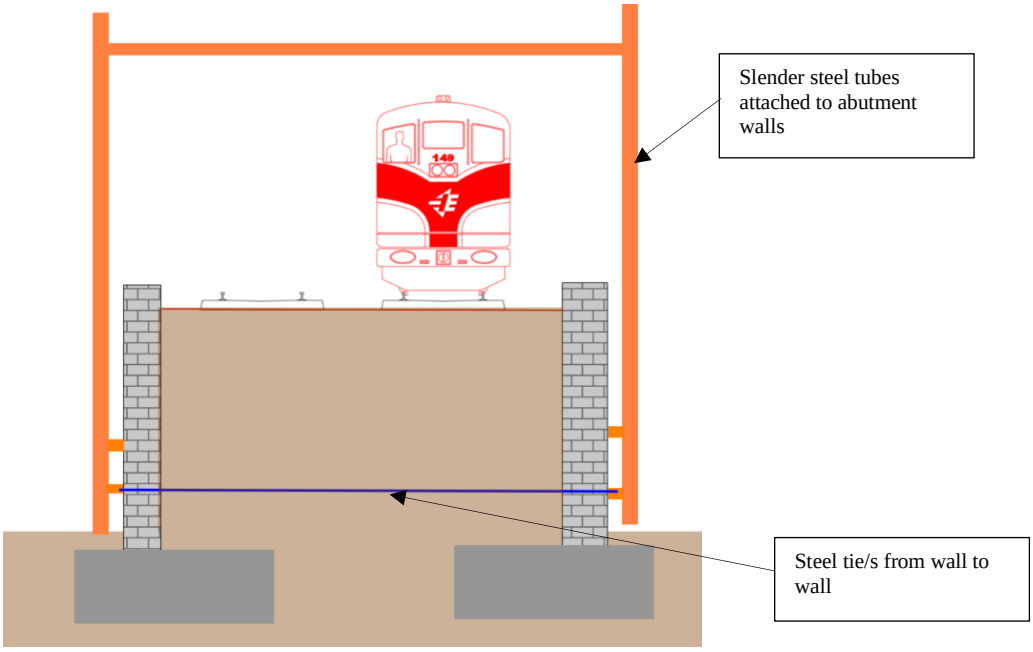


Figure 6-11: UBB65 Option B2.2 sketch

6.3.4 Option C – Independent supports

This option encompasses the construction of independent OHLE foundations at the top of the embankment on the approach to the bridge.

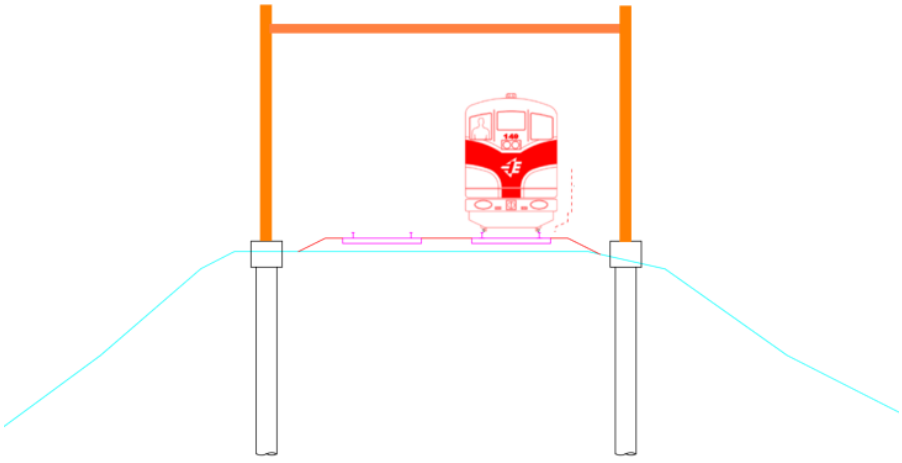


Figure 6-12: UBB65 - Option C

6.4 Sifting of longlist of options

Assessment of the outlined options is provided in Table 6-3 below.

Table 6-3: Assessment of longlist of options against project objectives and requirements

Project objectives and requirements	Description	Option 'do-nothing'		Option B2.1 – supported off abutments – top fixing		Option B2.2 – supported off abutments – face fixing		Option C – Independent supports	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To deliver a higher frequency, higher capacity, reliable, electrified route to enable an increased DART service frequency between Drogheda and Central Dublin.	**Fail**	• Option prevents installation of OHLE over bridge	**Pass**	• Option enables installation of OHLE over bridge • No reliance on existing stonework	**Pass**	• Option enables installation of OHLE over bridge • Uncertainty on ability of masonry walls to support posts.	**Pass**	• Option enables installation of OHLE over bridge • No reliance on existing stonework
Project objective	To deliver solutions which improve the passenger experience where passenger infrastructure interventions are required to meet the Train Service Specification.	**Pass**	• No infrastructure intervention considered as part of 'do-nothing' approach	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience
Project objective	To deliver a sustainable, low carbon and climate resilient design solution including making use of existing infrastructure where possible with targeted improvement works.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Localised work making use of existing infrastructure • Precast concrete unit, some demolition required	**Pass**	• Localised work making use of existing infrastructure	**Pass**	• Impact of new additional foundations

Project objectives and requirements	Description	Option 'do-nothing'		Option B2.1 – supported off abutments – top fixing		Option B2.2 – supported off abutments – face fixing		Option C – Independent supports	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project objective	To identify cost-effective solutions from a capital, operations, and maintenance perspective.	**Pass**	• No impact due to 'do-nothing' approach.	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of new pre-cast units • Cost of disruption to train services • Cost of installation	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Less cost of disruption to train services • Cost of installation	**Pass**	• Enables delivery of electrified route in cost effective manner • Less cost of disruption to train services • Cost of larger OHLE structure • Cost of installation – could be complex due to topography
Project objective	To minimise adverse impacts on the natural and built environment associated with construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Some loss of historic fabric	**Pass**	• Face-fixing into historic fabric	**Pass**	• Least invasive works • Impact on natural environment of new foundation works •
Project objective	To minimise adverse impacts on existing rail services, road users and landowners associated with the construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• No negative operational impact • Disruption to train services during construction	**Pass**	• No negative operational impact • Less disruption to train services during construction	**Pass**	• No negative operational impact • Less disruption to train services during construction likely • Potential closure of road for foundation installation
Project objective	To provide efficient and cost-effective integration of systems with the other DART+ projects	**Fail**	• Failure to provide fully electrified route between Malahide and Drogheda precludes effective integration with DART route.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.	**Pass**	• No impact on integration with systems of other DART routes.
Project requirement	To design in accordance with IÉ Standards and relevant national and EU standards and guidelines	**Pass**	• No intervention	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved

Project objectives and requirements	Description	Option 'do-nothing'		Option B2.1 – supported off abutments – top fixing		Option B2.2 – supported off abutments – face fixing		Option C – Independent supports	
		Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale	Pass/ fail	Rationale
Project requirement	Designs shall comply with the Minimum Employer's Functional Requirements and meet the Train Service Specification	**Fail**	• Non-compliant • No OHLE masts installed on viaduct would create spans in excess of that allowed in standards, since span (including abutment zones) is in excess of 65m limit.	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved	**Pass**	• Compliant clearance achieved
Project requirement	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	**Fail**	• No electrification possible over viaduct with 'do-nothing' approach	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification	**Pass**	• Enables installation of OHLE masts for electrification
Project requirement	Provision of an appropriate number of substations to support electrification.	**Pass**	• 'Do-nothing' approach does not preclude installation of substations elsewhere to support electrification	**Pass**	• No impact on substations	**Pass**	• No impact on substations	**Pass**	• No impact on substations
Project requirement	Undertake necessary infrastructure change to achieve the clearances required for electrification at bridges and structures.	**Pass**	• No clearance issues associated with 'do-nothing' approach	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved	**Pass**	• Necessary clearances can be achieved
Project requirement	Undertake safety improvements resulting from the introduction of 1500V DC verhead.	**Pass**	• No safety impact from 'do-nothing' approach.	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations	**Pass**	• Earthing and bonding considerations • Upgraded fencing would need to ensure it encompasses new supports

6.4.1 Summary of longlist sifting

Table 6-4: Summary of Longlist Sifting

Option	Screening Result	Summary
"Do-Nothing"	**FAIL**	• Does not meet requirements. • Prevents installation of OHLE over viaduct. Spans for OHLE wires would be in excess of that allowed in system. • Failure to electrify the viaduct prevents effective integration with rest of DART route
Option B2.1	**PASS**	Meets project objectives and requirements
Option B2.2	**PASS**	Meets project objectives and requirements
Option C	**PASS**	Meets project objectives and requirements

6.5 Shortlisted options

The following options have been taken forward as the shortlisted options:

- Option B2.1 – Supported off abutments – top fixing;
- Option B2.2 – Supported off abutments – face fixing;
- Option C – Independent supports.

For a description of each of the options, refer back to Section 6.3.

6.6 Multi-criteria analysis

6.6.1 Methodology

For each individual entity an assessment has been made against the MCA criteria. Each option has been relatively compared against the others based on the five-point colour coded ranking scale in Table 6-7.

6.6.2 MCA summary table

A multi-criteria analysis table is presented in this section. This has been developed to reflect the relative rankings for all sub-criteria for each of the options assessed and is presented as a summary of the key issues considered.
A more detailed table is provided in the appendix to this report with the full detailed rationale behind the scoring of each criterion and option.

Table 6-5: MCA sub-criteria summary table

Criteria	Sub-Criteria	Option B2.1	Option B2.2	Option C
		Supported off abutment – top fixing	Supported off abutment – face fixing	Independent supports
Economy	CAPEX			
	OPEX			
	Train operations functionality/economic benefit			
	Traffic functionality and associated economic activities and opportunities			
Safety	Employer's Safety			
	Public safety			
Environment	Landscape and Visual Quality			
	Biodiversity			
	Noise and Vibration			
	Water resources			
	Archaeology, Architectural and Cultural Heritage			
	Geology and Soils (includes waste)			
	Agricultural and non-agricultural			
	Air Quality & Climate Change			
Accessibility & Social Inclusion	Accessibility			
	Social Inclusion			
Integration	Adaptability in the future			
	Transport Integration			
	Land Use Integration			
	Government policy integration			
	Geographical integration			
Physical Activity	Walking/cycling opportunities			

Table 6-6: Overall criteria MCA summary table

Criteria Summary	Option B2.1 Supported off abutment – top fixing	Option B2.2 Supported off abutment – face fixing	Option C Independent supports
Economy			
Safety			
Environment			
Accessibility & Social Inclusion			
Integration			
Physical Activity			

Table 6-7: Legend for MCA Summary Tables

Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

6.6.3 Economy

Economy has been divided into four sub-criteria which are considered below.

CAPEX

Option B2.1 involves demolition of parapet walls at abutments and stressing down into historic masonry walls. It constitutes more disruption and risk compared to Option C.

For Option B2.2, connecting into the sides of the abutment walls on a steep embankment involves more disruption and risk compared to Option C.

Option C has comparative advantage as it could employ typical trackside installation of OHLE supports at the top of the embankment slope.

OPEX

Option C has comparative advantage over other options as it could be easily accessed from the cess alongside the track. Other options would require access down the sides of the embankment slope.

Train operations functionality/economic benefit

All options are comparable from a train operations functionality/economic benefit perspective.

Traffic functionality and associated economic activities and opportunities

Options B2.2 and C have comparative advantage due to their reduced disruption to trains during construction.

When operational, the scheme will have no visible impacts on the prevailing traffic conditions in the surrounding road networks.

Construction activities on all options considered, are expected to generate a relatively low number of additional vehicular journey, and therefore will, at most, have a minor temporary impact on the traffic conditions of the local road network.

6.6.4 Safety

Safety has been divided into two sub-criteria which are considered below. It should be noted that all options are safe, but some will have the potential for greater residual risks to remain. This criterion considers relative advantages of each option on the criteria of safety.

Employer's Safety

Option C has comparative advantage over other options as it could be easily accessed from the cess alongside the track. Other options would require access down the sides of the embankment slope.

Public Safety

All options are comparable since the public will not have access to the infrastructure.

6.6.5 Environment

Section 6.1.4 sets out a description of the existing environment, under key environmental criteria, including the key environmental constraints associated with this study area. Below is a summary of the key findings of the MCA under the various environmental criteria, with an emphasis on differentiating aspects for the options considered.

Landscape and Visual Quality

Option B2.1 has less visual interference with the structure and is preferred over other options. Options B2.2 and C have the greatest visual clutter and are least preferable.

Biodiversity

None of the options are likely to directly impact any designated sites i.e. River Nanny Estuary and Shore SPA, and Laytown Dunes/Nanny Estuary pNHA. There may be indirect impacts on the bird species that use the area around the viaduct for foraging and/or commuting to the estuarine/shoreline habitats and may be at risk of injury due to the height of the OHLE lines over the viaduct itself. This potential for bird strike is comparable across all options.

All of the options have the potential to affect the water quality in the adjacent watercourse, the Delvin River. Working in/or near the watercourse could produce run-off and/or debris straight into the watercourse, which has the potential to affect the habitats within, and the fauna that rely on these habitats. The potential for this impact is highest in Option C due to the construction of the independent OHLE foundations.

The abutment walls of the viaduct have bat roosting potential between cracks and crevices in the masonry and where the viaduct meets the abutment. Option B2.1 and B2.2 involve alternation/removal of masonry on the abutment walls. This could lead to direct bat roost loss. This impact is likely to be very localised however and can be easily checked for roosting bats prior to construction. Option C does not involve any works within the abutment walls itself and will therefore not have a direct impact on any potential bat roosts within the structure. However, this option is likely to create a greater level of noise and vibration than other options due to the construction of the foundations adjacent to the abutment walls, and therefore has the potential to disturb and/or displace roosting bats.

The abutment walls are currently covered in ivy and vegetation. All of the options would likely require removal of this vegetation for the works. This has the potential to disturb, displace and injure any nesting birds, roosting bats, and small mammals within this feature, if removal is undertaken in the sensitive period for these receptors. This constraint is comparable across all options.

It is not known whether invasive species may occur along or near the railway line. If present, then there would be risk of spreading to adjacent areas. Even if it were the case that invasive species are present in this area, the level of impact is likely to be similar across all options and might not be a significant differentiator between options.

Noise and Vibration

Option C will have the largest acoustic impact during the construction phase, as construction of the concrete foundations will be noisier than fixing the parapets directly to the existing piers. Options B2.1 and B2.2 are expected to have a similar acoustic impact on nearby sensitive receivers.

There will be no negative acoustic impact during the operational phase.

Water resources

From a water resources perspective, Options B2.1 and B2.2 are similarly comparable with each other. Option C has some comparative disadvantage over other options as, depending on the construction method employed, invasive works associated with the foundation construction has the potential to generate pollutants with the potential to impact on receiving waterbodies.

Archaeology, Architectural & Cultural heritage

From an archaeological perspective, Option B2.1 will result in the loss of historic fabric and is considered to be the least preferred option. The other two options are comparable but both have disadvantages in terms of they will change the aesthetic

of the viaduct and Option C will involve excavation works that may reveal buried archaeological features, deposits and finds at this sensitive location.

From an architectural heritage perspective, it is anticipated that Option B2.1 would have a negative impact as some disruption of historic fabric is proposed. This option would have a low visual impact on the setting of the structure.

It is anticipated that Option B2.2 would have a negative impact on the historic fabric. Less disruption of historic fabric is proposed relative to Option B2.1, but the anticipated visual impact is greater - this option would have a medium visual impact on the setting of the structure.

It is anticipated that Option C would have a slight negative impact from an architectural heritage perspective. No disruption of historic fabric is proposed, but a medium negative visual impact is anticipated on the setting of the structure.

Geology and Soils

From a Geology and Soils perspective, Options B2.1 and B2.2 are comparatively advantageous since the proposed works are on the existing structure only with no or minimal impacts on the geology and soils.

Option C has a comparative disadvantage over the other options as it involves the installation of foundations into the existing railway embankment and may cause instability to the existing slopes and will generate a requirement for earthworks material. However, the OHLE foundations will be similar to other locations where foundations are required on embankments.

Agricultural and Non-Agricultural

All options are located in non-agricultural land and therefore are similarly comparable with each other. There are no agricultural constraints at the location for any of the options and therefore this location is assessed as very low sensitivity from an agricultural perspective

Air quality and climate

All options increase the capacity of the rail system and consequently the attractiveness for trips to be undertaken by public transport in the Greater Dublin Area. As such, it brings about positive impacts on air quality and climate during the operational phase.

There is the potential for dust impacts during the construction phase, with all options comparable.

6.6.6 Accessibility and social inclusion

All options are comparable from both accessibility and social inclusion perspectives. Option B2.1 would have greatest impact on trains during construction, however this is short term. All options involve some train disruption during construction.

6.6.7 Integration

Integration is assessed using the five sub-criteria described below.

Adaptability in the future

No future transport schemes will be significantly impacted by access to the site during construction or operation.

Transport integration

All options have no impact on the integration with other transport modes.

Land use integration

All options have no impact on land use.

Government policy integration

All options have no impact on government policy integration.

Geographical integration

All options have no impact on geographical integration.

6.6.8 Physical activity

All options have no significant impact on walking and cycling opportunities.

6.7 Construction Considerations

Constructability considerations for the shortlisted options are as follows:

6.7.1 Option B2.1

Option B2.1 will cause disruption to trains during construction as track lifting will be needed. The magnitude of this depends upon the precast unit design/extent.

6.7.2 Option B2.2

Option B2.2 will involve limited disruption to trains during construction. No trackwork is needed but works in the estuary will be required.

6.7.3 Option C

Option C involves new foundations on an embankment . These will likely be installed from trackside and may disrupt train operations . The OHLE foundations will be installed in a similar way to other locations where foundations are required on embankments.

6.8 Summary and conclusions

6.8.1 Non-preferred options

Option B2.1 and B2.2 are not preferred due to:

- Increased OPEX associated with access via a steep embankment slope;
- Safety risks associated with construction on steep embankment slope;
- Increased CAPEX due to construction complexity and train disruption.

6.8.2 Draft Emerging Preferred Option

Option C has been chosen as the Draft Emerging Preferred Option as it:

- Incurs the least CAPEX and OPEX costs;
- Has comparable safety advantages over other options for both construction and maintenance;
- Avoids physical alterations to a protected structure.

6.8.3 Key risks/next steps

The following risks have been identified:

- Confirm distance between abutments and extent of bridge abutment wingwalls;
- Confirmation of topography and identify risks of any underground services in the location of the proposed mast foundations.
- GI investigations to determine ground parameters for pile design.

7 Laytown Viaduct (UBB72) optioneering selection process

7.1 Existing situation and constraints

7.1.1 Structure

Laytown Viaduct is a 74m long viaduct over the River Nanny. The structure comprises five. spans, with side spans measuring 9.5m long and central spans at 18.3m long. A separate pedestrian footbridge runs parallel to the viaduct.

Side spans are riveted steel girders with solid webs. Central spans are riveted steel girders with latticed webs. It is believed that the material is likely early steel.

The bridge is a 'protected' structure and is listed on the National Inventory of Architectural Heritage as making a dramatic and notable contribution to the local streetscape. Constructed in 1896-7 by the Cleveland Bridge & Engineering Co. Ltd., the viaduct replaced an earlier iron bridge from 1859, which in turn replaced the original 1844 timber viaduct.

The cross-section is formed of three longitudinal girders with bracing at regular centres. There is no bottom flange diaphragm member at piers, as opposed to intermediate bracing.

Transverse members are placed at regular centres above the longitudinal girders, riveted down to the top flange of the girder, and bolted to a steel plate above (which spans between transverse members). Plan bracing, which was likely only required only during erection, is also present

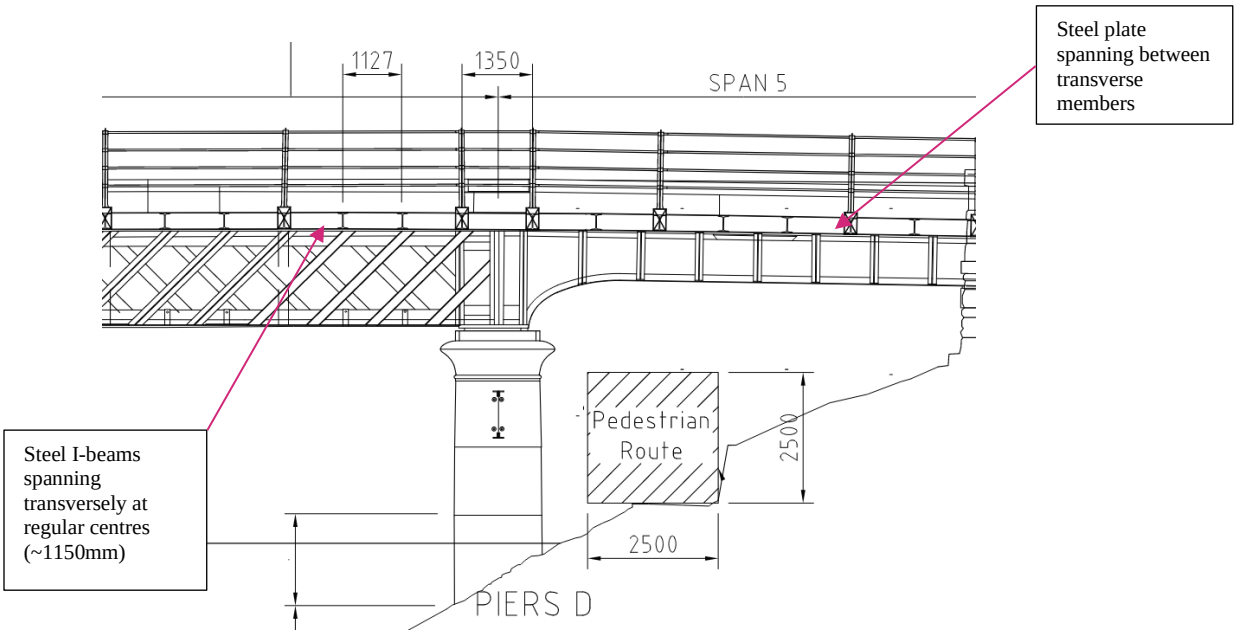


Figure 7-1: UBB72 Side elevation drawing

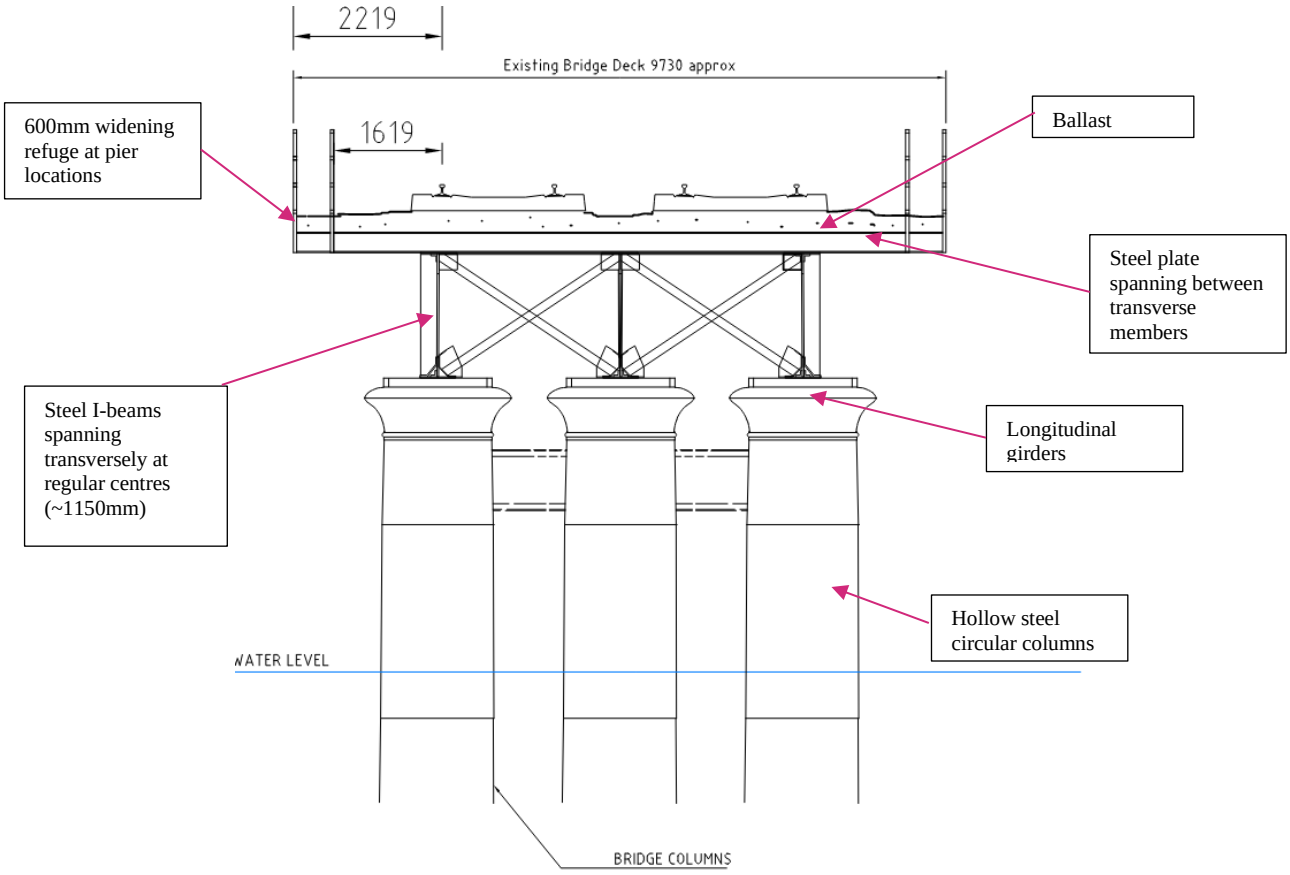


Figure 7-2: UBB72 Cross-section

Figure 7-3: UBB72 deck steelwork arrangement (source: Iarnród Éireann)

Figure 7-4: Bridge aerial view (source: Iarnród Éireann)

Figure 7-5: Bridge elevation (source: Iarnród Éireann)

Figure 7-6: Details at Pier A (source:)

Figure 7-7: Intermediate pier diaphragm with plan bracing (source: Iarnród Éireann)

7.1.2 Permanent ways and tracks

The structure currently carries two tracks: the Up and Down Main Lines. No points and crossings exist on or within the vicinity of the bridge. The tracks have a substantially straight alignment.

7.1.3 Utilities

Within the study area there is telecommunications fibre cables and other lineside services cables for Irish Rail. The lineside services and telecoms fibre run parallel to the railway across the Laytown Viaduct, usually within the cess.

To the north of the viaduct there is an Irish Water watermain crossing the railway. At the southern end of the viaduct there is an Irish Water watermain, telecommunications fibre cables (Not shown in figure) and a medium pressure gasmain running within the road that crosses underneath the Laytown Viaduct.

The existing utilities in the streets below the viaduct are not a constraint to the OHLE foundation options. However, the lineside telecommunications pose potential constraints. As such, they have been considered in the development of options. Regardless of the option selected, it will be necessary to maintain these during construction or to minimise outage durations in consultation with the utility providers.

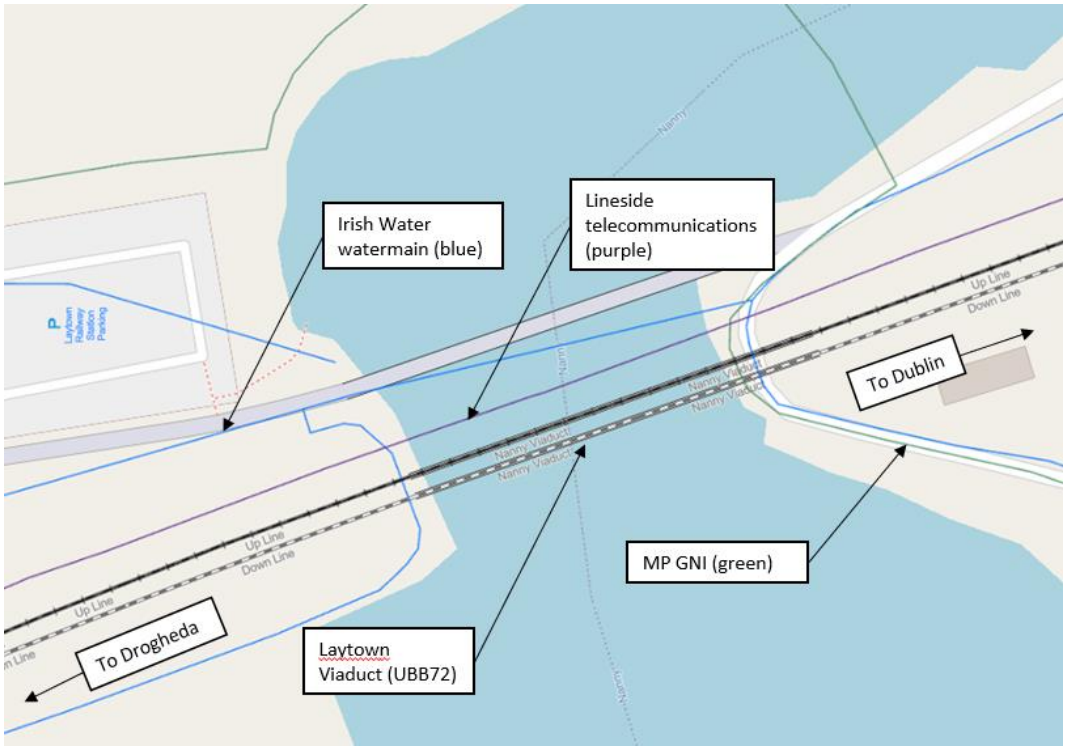


Figure 7-8: Plan of Laytown Viaduct (UBB72) showing existing utilities. (Map data © OpenStreetMap contributors, Map layer by Esri)

7.1.4 Environmental

For an overview of the existing environmental constraints for DART+ Coastal North refer to Annex 3.1 Constraints Report. The following sections provide detailed environmental description of the existing situation and constraints relevant to this specific structure.

7.1.4.1 Traffic and transportation

The site is accessible by regional road (R150) from the north or by local road from the south. The regional road is approximately 6m wide and the local road is narrow at approximately 3m width. The regional road to the north connects Julianstown and Laytown villages. The nearest road link of regional importance is the R132 Dublin Road that connects with the M1 in the south-west. The R150 provides access

to an existing pedestrian walkway across the river and the River Nanny Car Park to the east of the viaduct. The parking area serving the Laytown Rail Station to the west of the viaduct is also accessed from the R150.

The local access road is narrow and may require additional traffic management measures or temporary access roads to accommodate two-way construction traffic volumes. Access to the villages, parking areas and pedestrian walkway need to be maintained.

7.1.4.2 Landscape and visual impact

The Nanny River and Estuary is a protected site and is designated as a Special Protected Area (SPA) and proposed Natural Heritage Area (pNHA).

The lands on the south side of the viaduct are zoned Community Infrastructure, while the lands on the northern side are zoned High Amenity in the East Meath Local Area Plan (LAP) 2014-2020. The LAP includes objective ROS OBJ 1:

"*To relocate commuter parking from the Laytown seafront and from Alverno Terrace to the west of Laytown Train Station to enable the reinstatement of the public amenity lands at Laytown, subject to available funding. All aspects of the proposal will undergo screening for AA in the context of impacts on the River Nanny and Shore SPA."*

7.1.4.3 Archaeological and cultural heritage

The historic core of Laytown, which is located to the north east of the viaduct, has seen substantial expansion and development in modern times. A vernacular house, located approximately 185m to the north east of the viaduct, and which was part of the historic settlement is included in the RPS. This is Off-Shore Bookmakers (M028-304). Alverno Hotel, situated just to the north of the bookmakers is also protected (MH028-305). The Coast Tavern is a modern Public House which has been included in the NIAH, for reasons of architectural, social and technical interest. It is located approximately 245m to the northeast of the viaduct.

7.1.4.4 Architectural heritage

Laytown Viaduct is a protected structure listed in Meath County Council's Record of Protected Strictures (MH028-303). It is included in the NIAH where it is rated of Regional importance for reasons of architectural and technical interest. It is described therein as a multiple-span cast iron railway bridge build 1896-7 by Cleveland Bridge & Engineering Co. Ltd.

The current bridge is the third on the site, replacing an iron bridge built in 1859, which replaced the original timber structure erected in 1844. The NIAH notes that the viaduct makes a dramatic and notable contribution to the streetscape of Laytown, and dominates the surrounding landscape.

There is a strong relationship between the viaduct and Laytown Station, which is also included in Meath County Council's Record of Protected structures (MH028-302). The station is located approximately 250m north of the viaduct. It is included

in the NIAH where it is rated of Regional importance for reasons of architectural and technical interest.

7.1.4.5 Noise and vibration

The Laytown Viaduct spans over the River Nanny, with residential and farmland to the north and south of the river. North of the river, there is farmland and detached housing to the north-west, and the suburban area of Laytown, including Laytown Station, to the north and north-east, which is bounded by Laytown Beach to the east.

To the south of the River Nanny, is farmland, detached housing, and the Laytown Sports Club.

The acoustic environment in the area is likely to be dominated by train passbys and traffic on the R150 and Coastview Cottages Road to the south and north-west. The acoustic environment is likely to be more lively in the settlement of Laytown to the north-east, with more traffic noise, noise from the various establishments (bars, hotels, cafes, supermarkets, etc.) in the area. Traffic and train passbys are still expected to be the dominant noise sources in the early morning and later at night.

This information is based on desktop review. More detailed information will become available as on-site surveys are undertaken.

7.1.4.6 Air quality and climate

A number of residential receptors are located to the south of the viaduct.

The Nanny River and Estuary is a protected site and is designated as a Special Protected Area (SPA) and proposed Natural Heritage Area (pNHA).

The proposed development will support the aims of the Climate Action Plan. However, a key constraint is the development of the proposed scheme to ensure the following:

- the use of construction materials with low embodied carbon;
- the reduction of road traffic due to modal shift.

7.1.4.7 Agricultural and non-agricultural

There are no agricultural constraints at the location of the Laytown Viaduct and therefore this location is assessed as very low sensitivity from an agricultural perspective

7.1.4.8 Geology and soils

Laytown Viaduct traverses the Nanny River and is underlain by recent deposits of alluvium associated with the Nanny River and nearby marine beach sands. These are underlain by glacial deposits predominantly comprising gravels derived from

the underlying limestone bedrock. Made Ground is expected around the viaduct foundations, approach embankments and built-up areas nearby such as the car park to the northeast and houses to the southwest.

The underlying bedrock is comprised of the Carboniferous Tullyallen Formation described by the GSI as pale micritised grainstone-wackestone.

The Laytown Viaduct is located with the Geological Heritage Area of Laytown to Gormanston (Site Code MH008) which is a County Geology Site described as a coastal plain including sea cliffs which is significant geologically as a flat to gently undulating glacial outwash plain of sandur gravels.

7.1.4.9 Water resources

Surface water bodies

The Laytown Viaduct crosses the Nanny Estuary (IE_EA_030_0100). Under the Water Framework Directive (WFD, 2000/60/EC) the status of Nanny Estuary is unassigned and is classified as in review.

The Nanny Estuary discharges into the Northwestern Irish Sea (HA 08) coastal waterbody (IE_EA_020_0000). Under the WFD the status of the Northwestern Irish Sea (HA 08) is High and considered Not at Risk.

The Nanny Estuary is part of the River Nanny Estuary and Shore SPA and the Laytown Dunes/Nanny Estuary pNHA. A conservation objective of the River Nanny Estuary and Shore SPA is to maintain the favourable conservation condition of the wetland habitat.

Groundwater

The site is underlain by Dinantian Pure Bedded Limestones which are part of the Tullyallen Formation. The aquifer is classified as a Regionally Important Aquifer (Rkd) - Karstified (diffuse). The groundwater vulnerability at the site is classified as low to high. There are no significant karst features identified near the site.

There are no high yielding water supply springs and wells i.e. public water supplies or group water scheme supplies within the site. No Source Protection Zones associated with public or group groundwater supply schemes are located with the site.

The study area lies within the Bettystown groundwater body (IE_EA_G_016). The groundwater body is currently at Poor WFD Status for the 2013-2018 monitoring cycle and currently At Risk with regard to achieving its WFD objectives

Flooding

Historical flooding has been assessed by examining reports and maps from the OPW's National Flood Hazard mapping. According to the OPW predictive flood maps (floodinfo.ie), the site is located adjacent to areas at risk of fluvial and coastal flooding. The viaduct is adjacent to an area which has recorded recurring flooding from coastal/estuarine waters.

7.1.4.10 Biodiversity

The works location is located on the Laytown Viaduct, which crosses the intertidal habitat of the River Nanny Estuary, south of Laytown.

The River Nanny Estuary is designated as a Special Protection Area, and as a Proposed Natural Heritage Area, both of which extend along the coast north and south of the Viaduct.

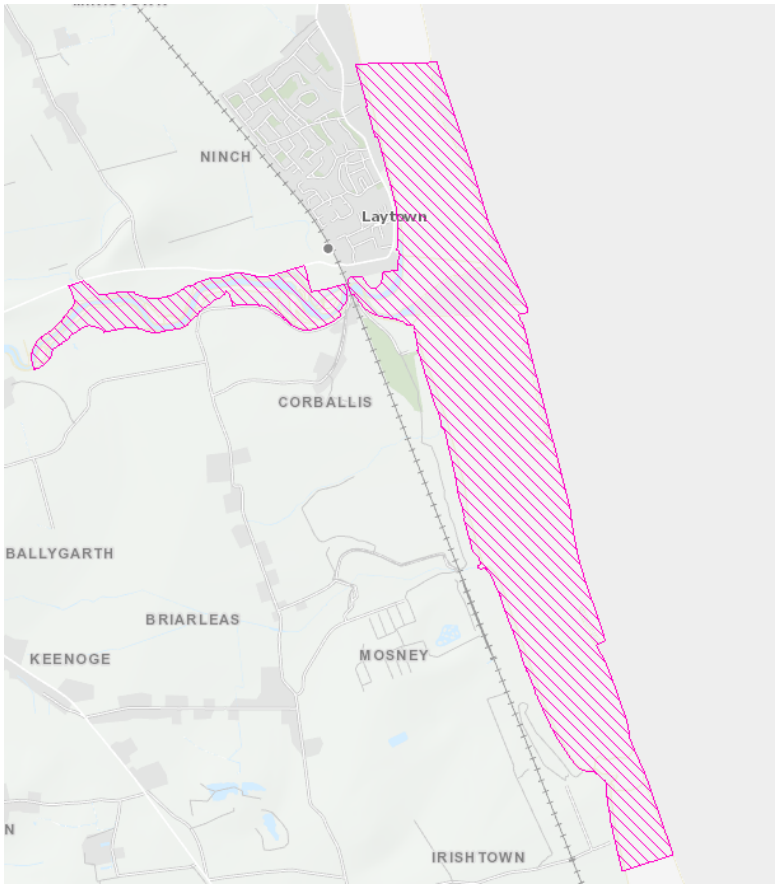


Figure 7-9: River Nanny Estuary and Shore SPA (Map data © OpenStreetMap contributors, Map layer by Esri)

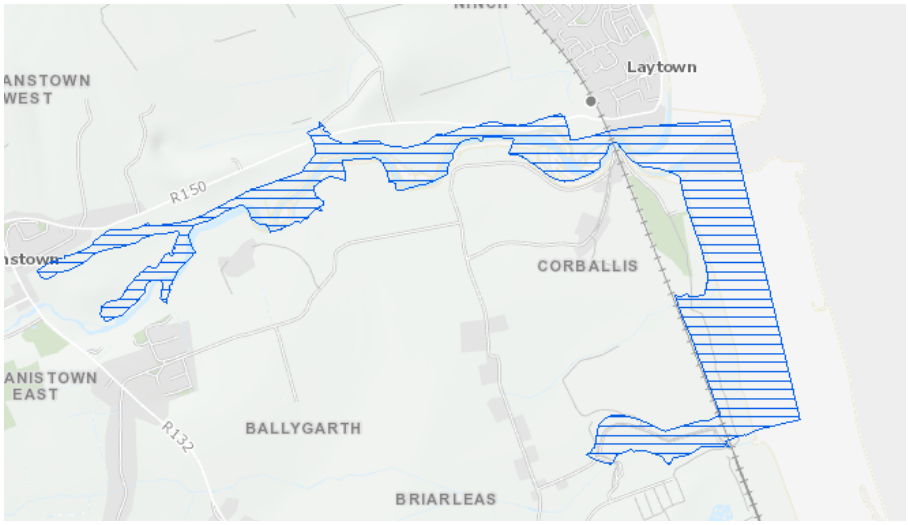


Figure 7-10: Laytown Dunes/Nanny Estuary pNHA (Map data © OpenStreetMap contributors, Map layer by Esri)

The key ecological constraints in this area are the River Nanny Estuary and Shore SPA, which is designated for overwintering birds, and the overlapping Laytown Dunes/Nanny Estuary pNHA, also designated for its estuarine and shoreline habitats. These designated areas are of international and national biodiversity importance.

The Special Conservation Interests (SCI) of the River Nanny Estuary and Shore SPA are listed below:

Table 7-1: Special Conservation Interests

River Nanny Estuary and Shore SPA
• A130 Oystercatcher (*Haematopus ostralegus)* • A137 Ringed Plover *(Charadrius hiaticula*) • A140 Golden Plover (*Pluvialis apricaria*) • A143 Knot (*Calidris canutus*) • A144 Sanderling (*Calidris alba*) • A184 Herring Gull (*Larus argentatus*) • A999 Wetland and Waterbirds

Other potential ecological constraints include:

- Potential for roosting bats in the Laytown Viaduct (UBB72)
- Potential for the railway to support interesting flora species and habitats due to the calcareous nature of the ballast and their often relatively undisturbed nature
- Potential for invasive species to occur along the railway line

7.1.5 Planning

The viaduct is located within the functional area of Meath County Council. It is located on unzoned lands and is a protected structure.

It is located within the River Nanny Estuary and Shore SPA Special Protection Area.

Given the location within European designated environmental sites, and the protected structure status of the structure, careful consideration will have to be considered in relation to the design of any works to the viaduct.

7.2 OHLE frame longitudinal arrangement

In determining the longitudinal arrangement of masts, three separate configurations have been considered. A summary of these and their suitability to meet the basic criteria is presented in Table 7-2. Yellow indicates an unfavourable result, with red indicating a value that precludes the option.

Table 7-2: UBB72 Longitudinal arrangement appraisal matrix

	Mast at pier?	Number of masts	Symmetric distribution	Mast in bridge centreline	Mast spacing < 60m	All details equal?
Arrangement 1 (Piers A & D)	yes	2 ≥ 2	yes	No	yes	Yes
Arrangement 2 (Piers A,B,C,D)	No	4 ≥ 2	yes	No	yes	No
Arrangement 3 (Midspan)	Yes	1< 2	yes	yes	yes	yes

Sketches of the various arrangements are provided in the figures below. Based upon the assessment criteria, Arrangement 1 is selected as the preferred option. Arrangement 2 is discounted due to excessive number of masts and detail complexity. Arrangement 3 is discounted due to lack of masts and masts at midspan.

Arrangement 1 will be used in assessing the longlist options of positioning the masts on the structure

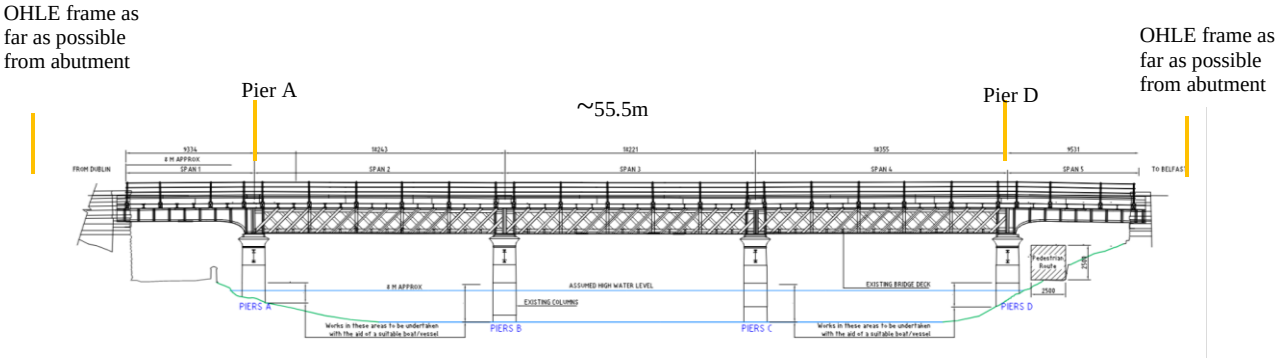


Figure 7-11: Arrangement 1 sketch

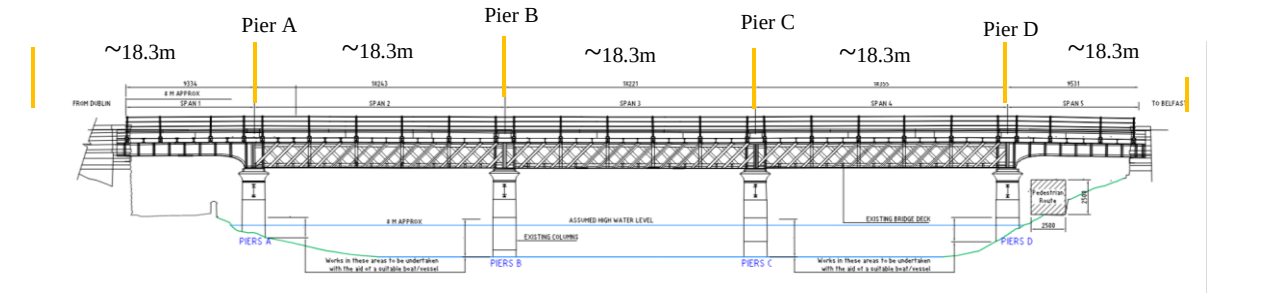


Figure 7-12: Arrangement 2 sketch

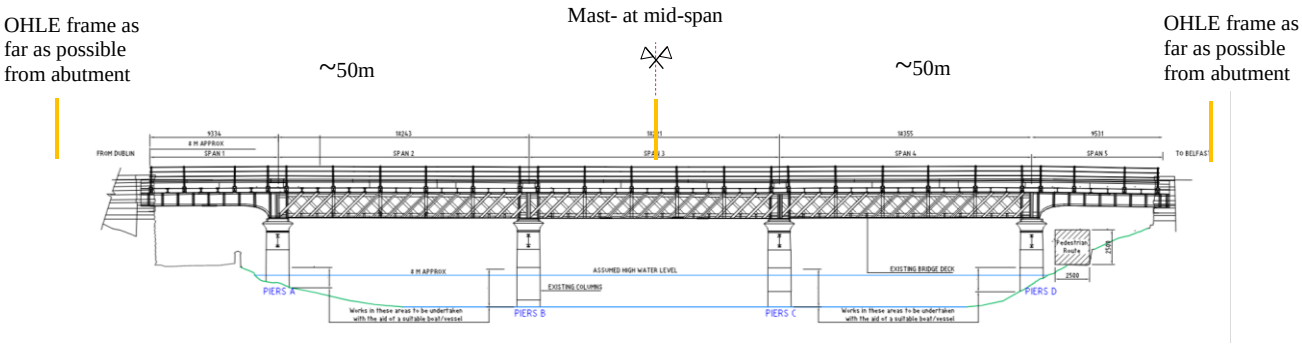


Figure 7-13: Arrangement 3 sketch

7.3 Longlist of options

This section describes the options which have been considered for the OHLE foundation solution at Laytown Viaduct. The discussion is limited to items which will have a bearing on the development or selection of an Option.

The options which have been considered are summarised in Table 7-3 below. These are based upon the standard options as laid out in Section 2.2.2. It should be noted that clearances on the bridge deck preclude Options A1 and A2 and support off piers is ruled out due to unfeasible fixing to hollow steel/cast iron piers. Independent supports are not considered due to safety, environmental, topographical and aesthetic impacts associated with constructing very tall supports in the waterway.

Table 7-3: Longlist of options considered

Option	Description
Option 0	Do nothing
Option A3	Supported on structure – outside of parapets

7.3.1 Option 0 – Do nothing

No masts provided.

7.3.2 Option A3 – Supported on structure – outside of parapets

This option proposes to use steel members connected to the crossbeams and then down to the bottom of girder level. The bottom flanges at the pier locations are then connected via horizontal steel members, creating a fully triangulated planar truss.

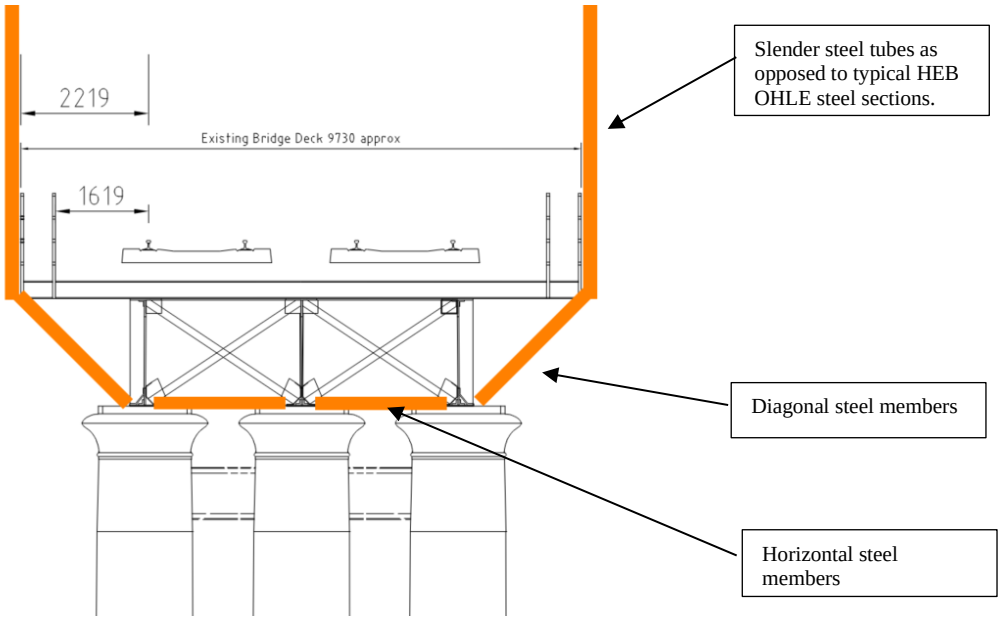


Figure 7-14: Proposed OHLE option - cross-section

7.4 Sifting of longlist of options

Assessment of the outlined options is provided in the table below.

Table 7-4: Assessment of longlist of options against project objectives and requirements

Project objectives and requirements	Description	Option 'do-nothing'		Option A3 – supported on structure – outside of parapets	
		Pass/ fail	Rationale	Pass/fail	Rationale
Project objective	To deliver a higher frequency, higher capacity, reliable, electrified route to enable an increased DART service frequency between Drogheda and Central Dublin.	**Fail**	• Option prevents installation of OHLE over bridge	**Pass**	• Option enables installation of OHLE over bridge • Attachment to historic metalwork will require assessment
Project objective	To deliver solutions which improve the passenger experience where passenger infrastructure interventions are required to meet the Train Service Specification.	**Pass**	• No infrastructure intervention considered as part of 'do-nothing' approach	**Pass**	• Electrification of Northern Line, new rolling stock and increased service frequency improves passenger experience
Project objective	To deliver a sustainable, low carbon and climate resilient design solution including making use of existing infrastructure where possible with targeted improvement works.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Localised work making use of existing infrastructure
Project objective	To identify cost-effective solutions from a capital, operations, and maintenance perspective.	**Pass**	• No impact due to 'do-nothing' approach.	**Pass**	• Enables delivery of electrified route in cost effective manner, along with access for general operations and maintenance. • Cost of limited disruption to train services • Cost of installation
Project objective	To minimise adverse impacts on the natural and built environment associated with construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• Works over estuary – consideration to methodology for construction and maintenance/inspection • Fixing into historic fabric
Project objective	To minimise adverse impacts on existing rail services, road users and landowners associated with the construction, operation and maintenance of the project.	**Pass**	• No impact due to 'do-nothing' approach	**Pass**	• No negative operational impact • Limited disruption to train services during construction
Project objective	To provide efficient and cost-effective integration of systems with the other DART+ projects.	**Fail**	• Failure to provide fully electrified route between Malahide and Drogheda precludes effective integration with DART route.	**Pass**	• No impact on integration with systems of other DART routes.

Project objectives and requirements	Description	Option 'do-nothing'		Option A3 – supported on structure – outside of parapets	
		Pass/ fail	Rationale	Pass/fail	Rationale
Project requirement	To design in accordance with IÉ Standards and relevant national and EU standards and guidelines	**Pass**	• No intervention	**Pass**	• Compliant clearance achieved
Project requirement	Designs shall comply with the Minimum Employer's Functional Requirements and meet the Train Service Specification	**Fail**	• Non-compliant • No OHLE masts installed on viaduct would create spans in excess of that allowed in standards	**Pass**	• Compliant clearance achieved
Project requirement	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	**Fail**	• No electrification possible over viaduct with 'do-nothing' approach	**Pass**	• Enables installation of OHLE masts for electrification
Project requirement	Provision of an appropriate number of substations to support electrification.	**Pass**	• 'Do-nothing' approach does not preclude installation of substations elsewhere to support electrification	**Pass**	• No impact on substations
Project requirement	Undertake necessary infrastructure change to achieve the clearances required for electrification at bridges and structures.	**Pass**	• No clearance issues associated with 'do-nothing' approach	**Pass**	• Achieves necessary clearances
Project requirement	Undertake safety improvements resulting from the introduction of 1500V DC Overhead.	**Pass**	• No safety impact from 'do-nothing' approach.	**Pass**	• Earthing and bonding considerations

7.4.1 Summary of longlist sifting

Table 7-5: Summary of Longlist Sifting

Option	Screening Result	Summary
"Do-Nothing"	**FAIL**	• Does not meet requirements. • Prevents installation of OHLE over viaduct. Spans for OHLE wires would be in excess of that allowed in system. • Failure to electrify the viaduct prevents effective integration with rest of DART route
Option A3	**PASS**	Meets project objectives and requirements

7.5 Summary and conclusions

Only one option passes the longlist sifting process as feasible and hence a multi-criteria analysis is not required. As a result, the proposed fixing arrangement outside of the parapets is taken forward as the Draft Emerging Preferred Option.

7.5.1 Key Risks/Next Steps

The following risks and next steps have been identified:

- A photogrammetry survey of the superstructure and pier steelwork at the at the pier locations is recommended;
- A survey of the existing structural members is required to determine the element sizes, plate thicknesses and existing connection details.
- Feedback from heritage and environmental stakeholders
- Aesthetic impacts on the structure will be considered and mitigated at subsequent design stages

8 Boyne Viaduct (UBB82) optioneering selection process

8.1 Existing situation and constraints

8.1.1 Structure

Boyne Viaduct is a 526m long viaduct over the River Boyne in Drogheda, north of the railway station. The structure is comprised of eighteen spans, with a three-span lattice truss of 168.75m total length and repeating masonry arches 20.8m long.

The structure was originally opened in 1855 and reconstructed in 1932 with the ironwork still in place today.

The bridge is a ‘protected’ structure and listed in the National Inventory of Architectural Heritage. Note is given to the detailing visible on voussoirs and quoins, with decorative touches to cornices and piers.

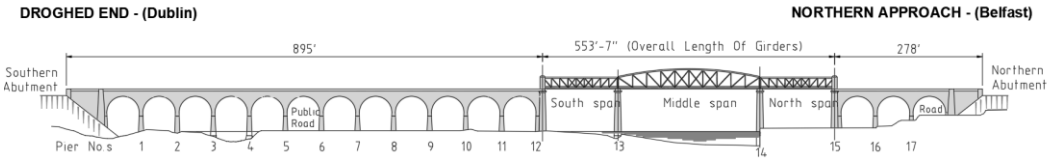


Figure 8-1: Boyne Viaduct general arrangement

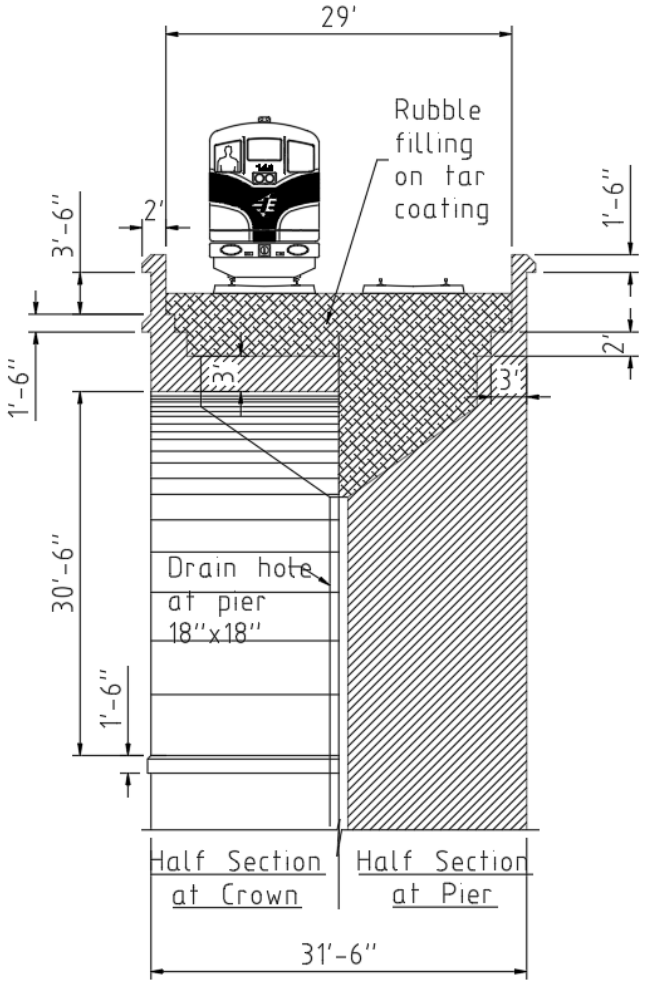


Figure 8-2: Boyne Viaduct typical cross-section

Figure 8-3: UBB82 Aerial view (source: Iarnród Éireann)

Figure 8-4: UBB82 Aerial view (arches) (source: Iarnród Éireann)

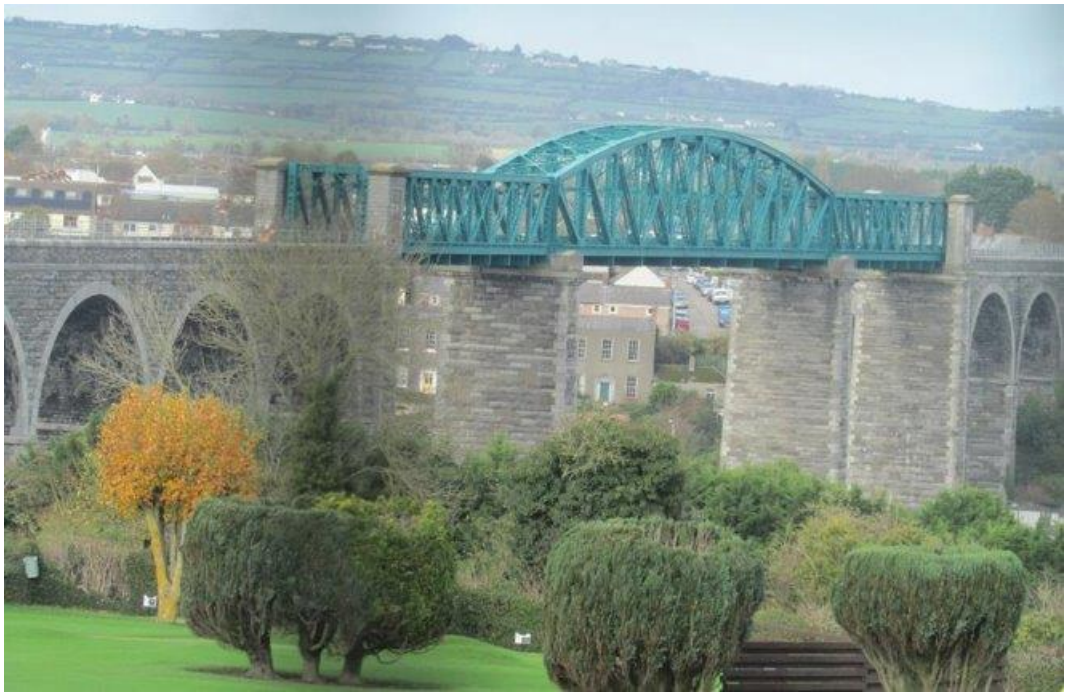


Figure 8-5: UBB82 Aerial view of truss (source: Iarnród Éireann)

Figure 8-6: UBB82 View of deck arrangement (source: Iarnród Éireann)

8.1.2 Permanent ways and track

The majority of the viaduct carries a single track with guard rails. The twin track arrangement from Drogheda MacBride Station is reduced via points and crossings over the masonry-arch portion of the southern end of the bridge. At the northern end, the switch from single to twin track occurs at the beginning of the abutments.

The twin track arrangement from Drogheda station enters into the viaduct with a curved alignment with approximately 250 m radius (from a preliminary measure in cad). The single track section has different curvature radius along the viaduct, having measured approximately 500 m radius as the minimum value.

8.1.3 Utilities

Within the study area there are telecommunications fibre cables, lineside services cables for Irish Rail, LV and MV electrical cables, and a medium pressure gas main.

The lineside services and telecommunication fibre cables run parallel to the railway and usually within the cess, crossing the railway on the southern end of the viaduct.

To the south of the viaduct, within the Drogheda MacBride Station complex, there are MV electrical cables, a low pressure gas main and a storm water pipe crossing under the railway.

There are several existing utilities located within the R167 North Strand Road to the north of the River Boyne and the R150 Marsh Road to the south of the River Boyne, both of which cross perpendicularly under the Boyne Viaduct. However, as these are located under the viaduct these utilities are not a constraint to the OHLE foundation options.

The existing utilities in the streets below the viaduct are not a constraint to the OHLE foundation options. However, the lineside telecommunications pose potential constraints, as do the MV electrical cables crossing the railway within Drogheda MacBride Station. As such, they have been considered in the development of options. Regardless of the option selected, it will be necessary to maintain these during construction or to minimise outage durations in consultation with the utility providers.

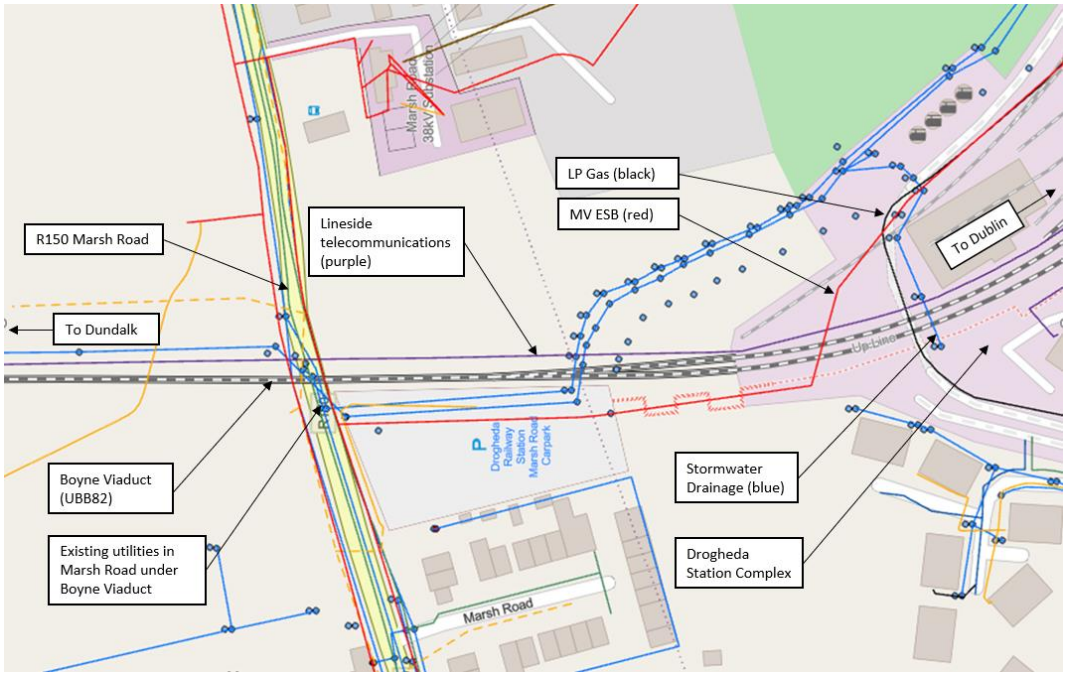


Figure 8-7: Location of utilities close to Boyne Viaduct (UBB82), south of River Boyne (Map data © OpenStreetMap contributors, Map layer by Esri)

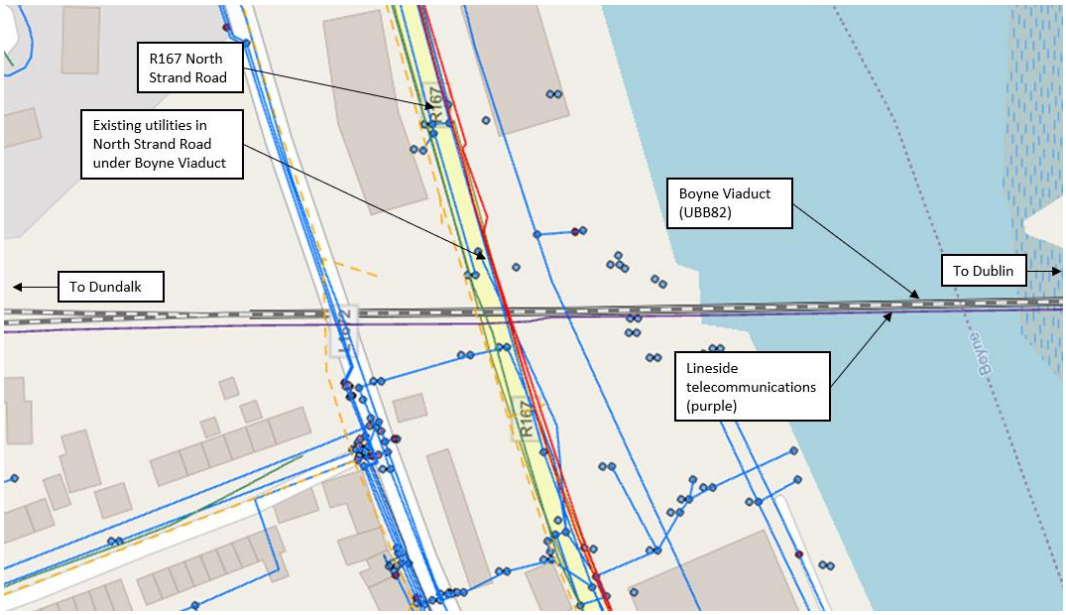


Figure 8-8: Location of utilities close to Boyne Viaduct (UBB82), north of River Boyne (Map data © OpenStreetMap contributors, Map layer by Esri)

8.1.4 Environmental

For an overview of the existing environmental constraints for DART+ Coastal North refer to Annex 3.1 Constraints Report. The following sections provide detailed environmental description of the existing situation and constraints relevant to this specific structure.

8.1.4.1 Traffic and transportation

The site is accessible by local road from both the north and the south. From the north the current access is through the Drogheda Port via the R167. This road is more than 7m wide and additional width is provided for a public walkway. From the south the current access is through vacant land that can be accessed off the R150 March Road. This road is also more than 7m wide and additional width is provided for a public walkway. The R150 links to the M1 via R132 and Donore Road towards the south-west. Regional linkage is slightly more complicated from the R167 as traffic need to either cross the River Boyne or travel through Drogheda town centre to reach the M1.

The low speed and function of the access road through Drogheda town via the R167 will need to be considered in the context of construction traffic.

8.1.4.2 Landscape and visual impact

The Boyne Viaduct is listed as a Protected Structure in the Drogheda Borough Council Development Plan 2011-2017 (No. DB-184).

The Boyne River is a protected site and is designated as a Special Area of Conservation (SAC). Downstream of the viaduct, the river and its estuary are also designated as a Special Protected Area (SPA) and proposed Natural Heritage Area (pNHA).

The lands to the north and south of the viaduct are zoned Docklands in the Drogheda Borough Council Development Plan. The Plan includes protected Strategic Views, which includes:

'V9: Views of the railway viaduct from the town centre, the Bridges along the Boyne and the Termonfeckin Road and from the West.'

8.1.4.3 Archaeological and cultural heritage

The Boyne Viaduct crosses the River Boyne 330m east of the Zone of Archaeological Potential for the historic town of Drogheda, Co. Louth (RMP LH024-041). The River Boyne was an important navigable river in prehistory, providing an access route inland from the east coast towards the World Heritage Site (WHS) passage tomb cemetery at Brugh na Bóinne. The materials which were used to build these tombs were transported from the coast to the WHS on the river, and dugout boats have often been found on the River Boyne. A mound in Bryanstown, 420m southwest of the viaduct is thought to have been a barrow or denuded passage tomb overlooking the river (RMP LH024-039). A barbed and tanged arrowhead was also found nearby in the course of archaeological investigations in Lagavooren (SMR LH024-061; Licence no.: 00E0629).

Drogheda developed at a fording point in the river, granting the settlement the name of Droichead Átha or 'The Bridge of the Ford'. The earliest bridge Drogheda was constructed sometime after the mid-12th century, with the Anglo-Norman medieval walled town of Drogheda developing on the banks of the river. There were two distinct boroughs on either side of the river with St. Peter's parish on the north side

in the Diocese of Armagh and St. Mary's south of the river in the Diocese of Meath. Both boroughs were merged into one town in 1412 (Bradley 1997).

Drogheda became a very busy port during the Middle Ages and attracted far more maritime traffic than its natural location (and silted estuarine approach) would suggest. The riverfront and riverbed silts, therefore, have a significant archaeological potential, and although the site of the Boyne Viaduct is outside of the medieval town, the potential remains for the discovery of vessels and artefacts related to this practice. The Drogheda charter of 1194 shows that colonists were sought to settle, farm and trade at Drogheda, and if there are medieval remains on the banks surrounding the Boyne Viaduct, it would likely be limited to the farming practices of these settlers.

The closest recorded monument to the viaduct is a church at Chord Cemetery, 140m to the west of the northern end, which was founded c. 1206 (RMP LH024-030001). It was the hospital priory of St. Laurence the Martyr and demonstrates that settlement activity continued outside of the precinct of the walled town.

Archaeological investigations on the Marsh Road on the west side of the Boyne Viaduct revealed evidence of the construction of the viaduct (Licence no.: 11E0002; O'Donovan 2011). The pond to the east of the viaduct was the quarry from which some of the stone used for the construction of the viaduct was drawn and stone chippings indicated the dressing of stone and. Burnt deposits containing oyster shells and burnt limestone was interpreted as being derived from mortar production for the construction of the viaduct. Up to 8m of deposits were identified where an embankment had been built to support the southern end of the viaduct.

8.1.4.4 Architectural heritage

The Boyne Viaduct is a protected structure, included in Louth County Council's Record of Protected Structures (RPS DB 176, 184). It is also included in the NIAH where it is rated of National importance for reasons of architectural, artistic, historical and technical interest. It is described by the NIAH as an Eighteen-span limestone and iron railway over river bridge, dated 1855. Fifteen round-headed stone arches, three north of river, twelve to south, three-span wrought-iron bolted girder trussed section crossing river 1932 with segmental-arched central section. Rock-faced ashlar limestone walling to abutments and spandrels, tooled block-and-start quoins running from base of abutments to tooled limestone stringcourse at springing line, tooled limestone voussiors to arches; tooled limestone stringcourse at deck level surmounted by rock-faced snecked limestone parapet, tooled limestone coping to parapet. Rock-faced ashlar limestone cutwaters, tooled limestone stringcourse surmounted by curved stone caps. Channelled limestone piers surmounting abutments to either side of trussed steel spans, roll-moulded rough punched cornice surmounted by saddle-backed cap, sandstone plaque to east and west elevations of piers, with inscription "Belfast and Dublin Junction Railway" the city crests and "1855". Spans Boyne River, Drogheda railway station to south.

The viaduct is appraised by the NIAH as follows: Designed by Sir John MacNeill and linking Belfast to Dublin, the Boyne Valley Viaduct dominates Drogheda. The three spans over the river were replaced in 1932 with iron trusses by the

'Motherwell Bridge Engineering Company' with G.B. Howden as the chief engineer. Due to its height the bridge creates an awesome presence which is emphasised by the sheer scale of the individual elements used in its construction. Detailing such as voussoirs and quoins are elegant in their geometrical simplicity, enhanced with decorative touches in the cornices and piers, giving the structure architectural and artistic merit in addition to its pure engineering status.

To the north of the viaduct, there are a number of houses of note which are included int Louth County Council's Record of Protected Structures and rated of Regional importance by the NIAH. These include a terrace of four houses along Cord Road which were built c.1840 (DB-016-019). Boyne Villa (DB-342) on North Strand, and Boyne Cottage (DB-341) on Greenhills Road.

To the south of the viaduct, six buildings in Drogheda MacBride Station are recognised as Protected Structures (DB-195, 055, 396, 397, 398, 399).

8.1.4.5 Noise and vibration

The existing acoustic environment at the viaducts will be predominantly dominated by train pass bys on the rail line and natural noises such as birds, wind, and the ocean, as well as contributions from the surrounding townland. The existing acoustic environment will be positively affected by the electrification of the line, as this will reduce noise from trains. Construction noise and vibration is expected to be audible at all locations.

There are residential receivers to the north and south of the Boyne Viaduct that have the potential to be affected by construction noise. Construction noise will have to be controlled during the night and on weekends to minimise disruption.

Noise sensitive species in the vicinity of the viaduct will also have to be considered during construction.

8.1.4.6 Air quality and climate

There are residential receivers to the north and south of the Boyne Viaduct that have the potential to be affected by dust impacts during the construction phase.

The Boyne River is a protected site and is designated as a Special Area of Conservation (SAC).

The proposed development will support the aims of the Climate Action Plan. However, a key constraint is the development of the proposed scheme to ensure the following:

- the use of construction materials with low embodied carbon;
- the reduction of road traffic due to modal shift.

8.1.4.7 Agricultural and non-agricultural

There are no agricultural constraints at the location of the Boyne Viaduct and therefore this location is assessed as very low sensitivity from an agricultural perspective.

8.1.4.8 Geology and soils

The Boyne Viaduct traverses the Boyne River and is underlain by recent fine and coarse grained alluvial and estuarine deposits. These are underlain by glacial deposits predominantly comprising glaciofluvial terrace gravels and gravels derived from the underlying bedrock with nearby Irish Sea Till derived from Lower Palaeozoic sandstones and shales. Made Ground is widespread with Drogheda's urban fabric on either side of the river.

The underlying bedrock is comprised of the Carboniferous Tullyallen Formation described by the GSI as pale micritised grainstone-wackestone to the north of the River Boyne and the Morningtown Formation to the south described as Dark limestone & calcareous shale. An exposure of quartz monzogranite known as the Drogheda Granite is indicated approximately 400m to the east of the viaduct.

Extraction of the limestone from the Morningtown Formation occurred to the east of the viaduct on the southern side of the Boyne River for use in building the viaduct. These quarries have since been reclaimed and infilled.

There are no Geological Heritage Areas at this location.

8.1.4.9 Water resources

The Boyne Viaduct crosses the Boyne Estuary transitional waterbody (IE_EA_010_0100). Under the Water Framework Directive (WFD, 2000/60/EC) the status of Boyne Estuary is 'Moderate' and is classified as 'At Risk', indicating that the waterbody may not maintain or achieve that status on the next WFD cycle. The minimum objectives for a water body under the WFD are to achieve at least 'Good' status (or 'Good potential' for artificial/ highly modified water bodies), and no deterioration of existing status.

The Boyne Estuary is part of the River Boyne and River Blackwater SAC.

8.1.4.10 Biodiversity

The works locations are on the existing Boyne Viaduct, which is set in the urban centre of Drogheda, south of the River Boyne, and adjacent to residential holdings and the Dublin Road (R132). The Boyne Viaduct crosses the Boyne River, with the Boyne Estuary from 800m east of the Viaduct. All of the options are at track level on the deck of the bridge/viaduct.

The River Boyne (and River Blackwater) is designated as a Special Area of Conservation. It is also designated as a Special Protection Area and proposed Natural Heritage area circa 3.7km west of the works area. The Boyne Coast and

Estuary is designated as a SAC and pNHA, circa 2km north-east of the works, and also as a SPA circa 1km north east of the works.

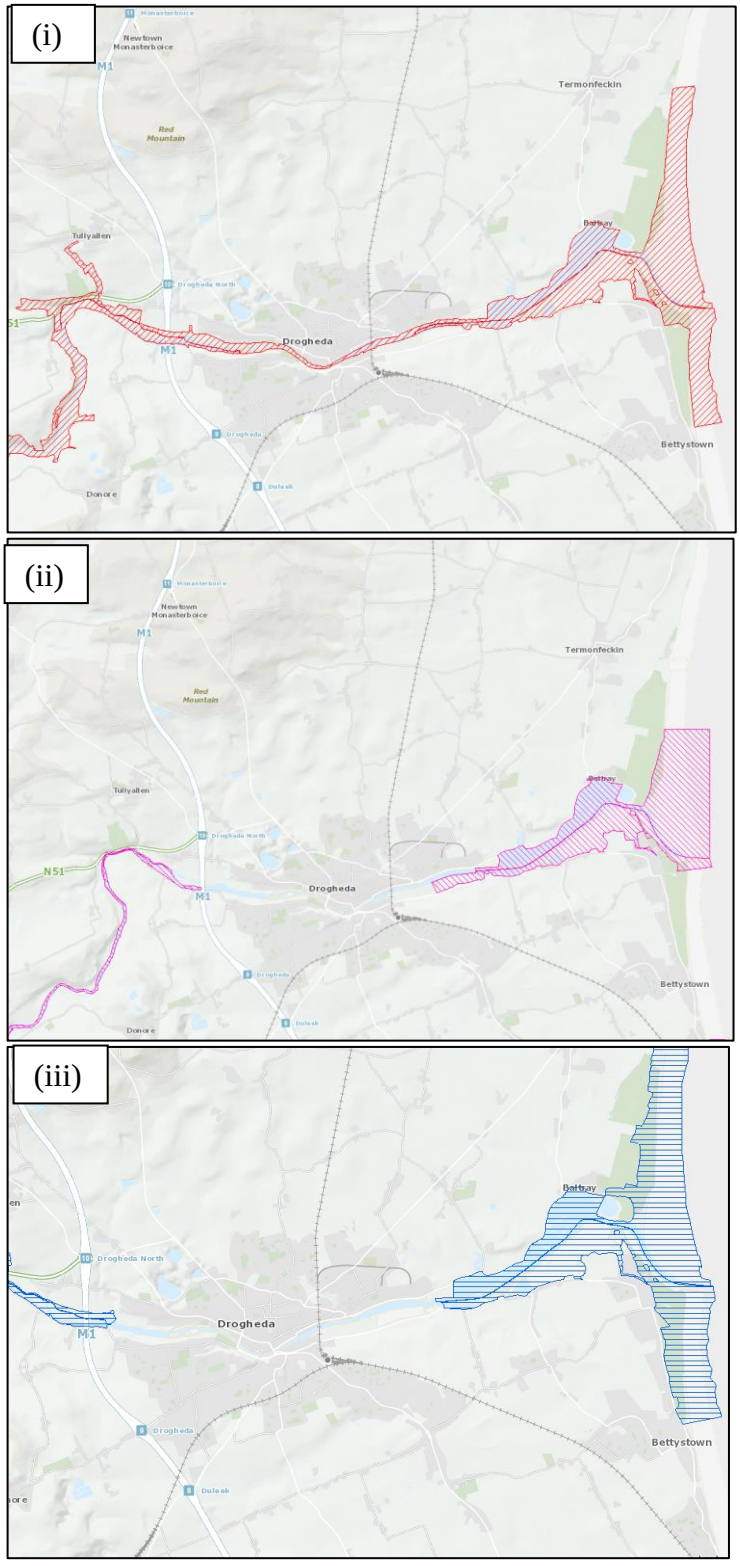


Figure 8-9: Maps showing (i) River Boyne and River Blackwater SAC and Boyne Coast and Estuary SAC, (ii) River Boyne and River Blackwater SPA and Boyne Estuary SPA, and (iii) Boyne Coast and Estuary pNHA (Map data © OpenStreetMap contributors, Map layer by Esri)

The key ecological constraints in this area are the River Boyne and Blackwater SAC, the Boyne Coast and Estuary SAC, the Boyne Estuary SPA, which are designated for riparian and marine habitats and protected species, and overwintering birds, and the overlapping pNHA designation. These designated areas are of international and national biodiversity importance. The River Boyne and Blackwater SPA is not likely to be impacted by the proposed works as it is located circa 4.1km upstream of the development, is designated for kingfisher *Alcedo atthis*, and as works will not be within the River Boyne or altering kingfisher habitat within (banks), this SPA is not considered further.

The qualifying interests (reasons for designation) of the River Boyne and Blackwater SAC, the Boyne Coast and Estuary SAC, and the Boyne Estuary SPA, are listed below.

Table 8-1: Qualifying interests of River Boyne and Blackwater SAC, Boyne Coast and Estuary SAC, and the Boyne Estuary SPA

River Boyne and Blackwater SAC	Boyne Coast and Estuary SAC	Boyne Estuary SPA
• 7230 Alkaline fens • 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae) • 1099 River lamprey *Lampetra fluviatilis* • 1106 Atlantic salmon *Salmo salar* • 1355 Otter *Lutra lutra*	• 1130 Estuaries • 1140 Mudflats and sandflats not covered by seawater at low tide • 1210 Annual vegetation of drift lines • 1310 Salicornia and other annuals colonising mud and sand • 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) • 2110 Embryonic shifting dunes • 2120 Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) • 2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)	• A048 Shelduck *Tadorna tadorna* • A130 Oystercatcher (*Haematopus ostralegus*) • A140 Golden Plover (*Pluvialis apricaria*) • A141 Grey Plover (*Pluvialis squatarola*) • A142 Lapwing (*Vanellus vanellus*) • A143 Knot (*Calidris canutus*) • A144 Sanderling (*Calidris alba*) • A156 Black-tailed Godwit (*Limosa limosa*) • A162 Redshank (*Tringa 158etanus*) • A169 Turnstone (*Arenaria interpres*) • A195 Little Tern (*Sterna albifrons*) • A999 Wetland and Waterbirds

Other potential ecological constraints include:

- Potential for roosting bats in the Boyne Viaduct (UBB82);
- Potential for the railway to support interesting flora species and habitats due to the calcareous nature of the ballast and their often relatively undisturbed nature;
- Potential for invasive species to occur along the railway line.

8.1.5 Planning

The Boyne Viaduct is located in the administrative area of Louth County Council. It is partially located on lands zoned as D1: Regeneration and is a protected structure.

It is located within the River Boyne and River Blackwater SAC.

Given the location within European designated environmental sites, and the protected structure status of the structure, careful consideration will have to be considered in relation to the design of any works to the viaduct.

8.2 OHLE frame longitudinal arrangement

The full extents of OHLE on the bridge is the subject of the optioneering for Boyne Viaduct. Being the terminus of the DART+ electrification there are a number of options regarding the exact extent of OHLE

Should OHLE be required on the viaduct over the extents required, OHLE masts will be fixed such that they align with pier centrelines. Early-stage analysis has shown that fixing to every other pier is likely the solution due to track curvature and required length to fix to every third pier.

8.2.1 Previous Arup Designs

Some example solutions for fixing arrangements to similar notable structures are provided.

Royal Border Bridge (Berwick)

Figure 8-10: Royal Border Bridge (Berwick) example OHLE masts (Source Google)

- Tie member driven through the arch fill to tie the two sides together;
- Difficult construction due to the presence of stones in the fill;
- Visually slim tubes were used as masts in place of the standard, wide H sections which are part of the standard kit for OHLE masts;
- Masts were connected with a triangulated crossbeam to provide the extra lateral stiffness required and reduce the forces at the connection with the walls;
- Arup's commission on this structure was driven by a need for a more elegant option, but the cost difference between H sections and tubes was minimal.

Wharncliff Viaduct (West London)

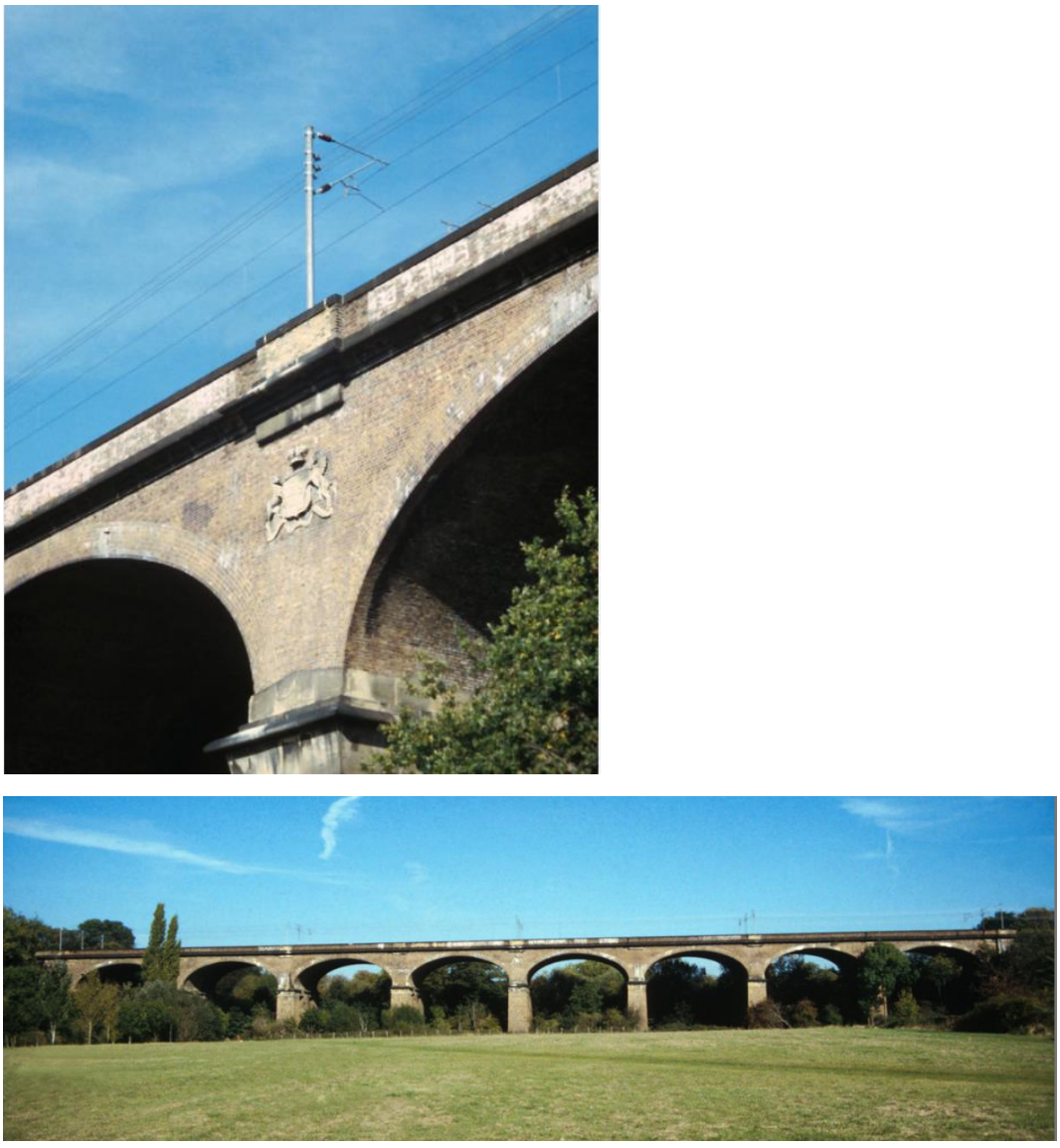


Figure 8-11: Wharncliff Vaiduct (West London) example OHLE masts (Source Google)

8.3 Longlist of options

This section describes the options which have been at Boyne Viaduct. The options considered are in the table below:

Table 8-2: Longlist of options considered for Boyne Viaduct

Option	Description
Option 1	OHLE to MP 32 ¼ as per original scope
Option 2A	No EMUs north of Drogheda platforms, Overrun Protection
Option 2B	No EMUs north of Drogheda platforms, Overrun Derogation

8.3.1 Option 1 – OHLE to MP 32 ¼

Ending the OHLE at this point allows for the reversal of the trains on the viaduct using points 209 to allow movement between Platforms 1 and 2. However, the movement blocks the mainline in both directions while the turnback operation is being completed. Hence this would not be the preferred method of completing a turnback manoeuvre if there are any through trains in the vicinity. Consequently, trains from the south would be reversed from Platform 3, 1 and 2 in that order of preference.

It is notable that points 209 are located so there is approximately 180m between the toe of the switch and the portal of the trussed section of the bridge. This is insufficient to allow the trains to comfortably reverse without extending the wires into the trussed section of the bridge. Hence OHLE would be needed throughout the trussed section if the reversing capability was required.

8.3.2 Option 2A – No EMUs north of Drogheda Platforms, Overrun Protection

The OHLE over run requirements according to the Electricity Functional Specifications System-Wide (MAY-MDC-ELE-DART-SP-E-0002) is:

DART+ OHLE over run protection shall be 7.5m per km/h line speed shall be implemented unless specified otherwise by SET IÉ department. ***[U388]***

In order to calculate the required over run distance the line speed entering the station from the south needs to be known:

It is visible in Figure 8-12 that the line speed entering the station from the south is 30km/h. Applying this to the formula from requirement [U388] results in 7.5m x 30km/h = 225m minimum OHLE over run distance requirement.

Taking the OHLE over run distance from the DA289 and DA291 platform starter signals places the required overlap onto the bridge beyond 209 points and will also include tensioning anchors on the structure.

Figure 8-12: Speed Limit Approaching Drogheda (Source Iarnród Éireann)

Figure 8-13: Overrun Distance from DA289 and DA291 (Source: Google Earth)

8.3.3 Option 2B – No EMUs north of Drogheda platforms, Overrun Derogation

To avoid placing OHLE equipment on the viaduct structure, the overlap distance will need to be reduced to approximately 116m. The risks associated with an EMU overrunning the electrified section with a reduced compared to a full overlap need to be considered. The station is a terminal requiring the driver to key off and change ends, and the approaching the viaduct is sufficiently distinctive to minimise risk of mistaking the location for elsewhere on the route.

Furthermore the majority of terminating DART EMU services are expected to use platform 3 or any new platform built as part of the DART+ programme.

Applying a derogation reducing the distance from 225m to 116m will avoid the significant complications and cost of installing the OHLE on the heritage structure, has limited impact on the operational flexibility of the terminal station and a low risk of trains overrunning the OHLE overlap due to operator error.

8.4 Summary and Conclusions

8.4.1 Draft emerging preferred option

The draft emerging preferred option is Option 2B, is to dispense with the reversal facility immediately north of the station between Platform 1 and 2 for EMUs and terminate the OHLE immediately south of the viaduct abutment and hence electric trains will not be permitted beyond the stopping mark on platforms 1 and 2.

8.4.2 Key risks/next steps

The following risks and next steps have been identified:

- Complete the risk assessment for a overrun derogation
- Apply for derogation

A.1 Detailed MCA table: Malahide Viaduct

Comparison Criteria Legend
Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

Malahide Viaduct

				Economy							
				Capital Expenditure (CAPEX): Construction, land acquisition, temporary works		OPEX:operational costs (IÉ or other entities), Technology advancements and future proofing / obsolescence		Train Operations Functionality/Economic Benefit		Traffic functionality and associated economic activities and opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of potential infrastructure costs of proposed options	Rationale	Qualitative appraisal of potential ongoing infrastructure maintenance costs of proposed options	Rationale	Qualitative appraisal of potential ongoing operational costs of proposed options	Rationale	Qualitative appraisal of potential wider benefits of proposed options	Rationale
				Estimate high level cost of construction of option Extent and type of 3rd party lands required permanently Extent and type of 3rd party land required temporarily for temporary works during construction		To offer good value for money. Cost to maintain the infrastructure over the whole life. Effects of infrastructure maintenance to services. Provision of ways of undertaking routine inspections and maintenance activities while minimising the effect on service to customers.		Potential improvement or deterioration of the operation conditions of the line (reduction or increase of the risk of interruption of service) Rolling stock & staff utilisation		Potential benefit to vehicular traffic flows in the vicinity of the works during construction and associated economic activities and opportunities in the vicinity Consideration of duration of traffic disruption and length of diversions To minimise the impacts on traffic and transportation during the construction and operational stages	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		Involves lifting tracks to install concrete footings which will impact costs. Works in the waterway are avoided, along with the cost of providing a working platform in an environmentally sensitive and highly tidal waterway.		Option A can be inspected and maintained from track level. Any maintenance works to the concrete footing may require track possession, however, the RC footing is unlikely to require much maintenance over its lifespan.		No impact - all options comparable		Option A has more disruption to trains during construction as track needs to be lifted to install the concrete footings
		B1.1	Supported off piers - steel collars		Less disruption during construction as tracks can remain in place during construction. Much of the work would still need to be carried out during possessions. Access to the piers in the waterway would be required, along with setting up a working platform in a highly tidal zone. This would likely present a considerable constraint.		B1.1 and B1.2 require access to the piers in the waterway. Inspections and maintenance are constrained by tides and access to the piers is problematic. Inspection and maintenance can occur with minimal impact on track, however, works in the waterway are still considered to be relatively more costly compared to Option A		No impact - all options comparable		B1.1 and B1.2 have less disruption to trains during construction as the track can remain in place although much of the works will still need to be carried out during possessions.
		B1.2	Supported off piers - anchors		Less disruption during construction as tracks can remain in place during construction. Much of the work would still need to be carried out during possessions. Access to the piers in the waterway would be required, along with setting up a working platform in a highly tidal zone. This would likely present a considerable constraint.		B1.1 and B1.2 require access to the piers in the waterway. Inspections and maintenance are constrained by tides and access to the piers is problematic. Inspection and maintenance can occur with minimal impact on track, however, works in the waterway are still considered to be relatively more costly compared to Option A		No impact - all options comparable		B1.1 and B1.2 have less disruption to trains during construction as the track can remain in place although much of the works will still need to be carried out during possessions.

Malahide Viaduct

				Safety			
				Employer's Safety		Public safety	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal on the safety impacts on IÉ or railway staff	Rationale	Qualitative appraisal on the safety impacts on the public (road/rail/cycle/pedestrian)	Rationale
				To reduce safety risks associated with construction maintenance and operations. To reduce the potential for incidents or near-misses for IÉ/construction staff.		To reduce safety risks associated with passengers at platforms, public adjacent to the railway and road, pedestrian and cycle users at level crossings. To reduce the potential for accidents for members of the public/passengers on railway infrastructure. To reduce the potential for conflict between rail and road users.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		Option A avoids works in a tidal waterway. There are safety concerns associated with maintenance works alongside the track, but this is regarded as a more common environment for rail staff to work under compared to a tidal waterway. Construction risks are limited as works will be undertaken during track possession.		Public will not have access to this infrastructure
		B1.1	Supported off piers - steel collars		B1.1 and B1.2 involve works in a tidal waterway and are considered to be comparatively a higher safety risk compared with the more traditional rail work alongside the tracks.		Public will not have access to this infrastructure
		B1.2	Supported off piers - anchors		B1.1 and B1.2 involve works in a tidal waterway and are considered to be comparatively a higher safety risk compared with the more traditional rail work alongside the tracks.		Public will not have access to this infrastructure

Malahide Viaduct

				Environment																	
				Landscape and Visual Qualitative		Biodiversity (Flora and Fauna)		Noise and Vibration		Water resources		Archaeology, Architectural and Cultural Heritage		Geology & Soils		Agricultural and non-agricultural		Air Quality & Climate Change	
Works Description	Summary of requirements	Option Number	Description of Option	Appraisal of landscape and visual impacts of options based on the sensitive viewpoints	Rationale	Qualitative appraisal on the impact on biodiversity	Rationale	Qualitative appraisal of the potential noise and vibration impact	Rationale	Qualitative appraisal on the potential impacts to surface ground or coastal waters	Rationale	Qualitative appraisal of the potential impacts of proposed options on potential sub surface archaeology and impact on foundations and above ground elements of architectural heritage	Rationale	Qualitative appraisal of the potential of the proposed options on waste and material resources including the reuse of site won materials.	Rationale	Qualitative appraisal of impacts on valued resources either from a human or natural origin with value arising for economic or cultural reasons. These assets can be existing utilities or non-renewable resources	Rationale	Qualitative appraisal of air quality and climate impacts both on the operational and construction phases	Rationale
				• To avoid / minimise impact on designated amenities, landscapes, protected trees or views. • To avoid / minimise visual impact on properties & amenities. • To avoid / minimise removal of trees / hedgerows. • To avoid / minimise impact from light pollution. • To provide opportunities to enhance the local amenity and green infrastructure.		•To ensure that the solution provided minimises the effects on biodiversity of the area and/or provides opportunities to enhance it.		•To provide a solution which ensures minimum levels of noise and vibration		•To minimise the impact or provide opportunities to enhance the quality of surface waters and associated floodplains, ground waters and coastal waters.		•To minimise the impact on cultural heritage such as on below ground archaeological remains, historic buildings (individual and areas), and historic landscapes and parks.		•To provide a solution which minimises total capital carbon. •To minimise waste.		To provide a solution which minimises total capital carbon.		•To provide a solution which comprises a reduction in greenhouse gas emissions. •To ensure that the chosen solution preserves or enhances the local air quality	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		The structures are generally at distance from viewers (except on water and on future greenway). Option has less visual interference with the structure.		Construction works will be located on existing structure and not in the estuary, thereby minimising the impact on biodiversity compared to the other options.		Construction methods likely have less noise and vibration impact than other options.		Works on structure only with minimal impact on water resources		No works will be located in the estuary, thereby negating the archaeological potential to reveal features or buried deposits in the estuary. Avoids disruption of historic fabric, reversible etc.		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		B1.1	Supported off piers - steel collars		The structures are generally at distance from viewers (except on water and on future greenway). Option has greater visual interference with the structure than Option A. There is little landscape or visual difference between Options B1.1 and B1.2.		Any construction/maintenance in estuary has increased likelihood of significant direct and indirect impact to designated marine habitats and overwintering birds within the works area.		Construction methods may produce more noise and vibration than Option A		Works on structure only with minimal impact on water resources		Alterations are required to the historic masonry piers and works are required in the estuary. This changes the aesthetics of the historic structure and there is a potential to reveal archaeological features and finds during the works in water. Alteration of and concealment of historic fabric proposed, more visually intrusive relative to Option A		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		B1.2	Supported off piers - anchors		The structures are generally at distance from viewers (except on water and on future greenway). Option has greater visual interference with the structure than Option A. There is little landscape or visual difference between Options B1.1 and B1.2.		Any construction/maintenance in the estuary has increased likelihood of significant direct and indirect impact to designated marine habitats and overwintering birds within the works area.		Construction methods may produce more noise and vibration than Option A		Drilling of ground anchors within Malahide Estuary has the potential to generate pollutants with the potential to impact on the receiving waterbodies and the associated protected sites.		Anchors to be drilled through the proposed concrete plinth and existing historic structure. Works will take place within the estuary during construction and ongoing maintenance. Alterations to the historic masonry piers. Alteration of and concealment of historic fabric proposed, more visually intrusive relative to Option A, but less than option B1.1		Comparative to other options, once construction methodology and feasibility of ground anchor are confirmed.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator

Malahide Viaduct

				Accessibility & Social Inclusion			
				Accessibility		Social Inclusion	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to facilitate the movement of people (either within, on to or across the rail system)	Rationale	Qualitative appraisal of capacity of options to provide ease of access for the mobility and visually impaired	Rationale
				Capacity of options to facilitate the movement of people (either within, on to or across the rail system) Impact on the wellbeing of the passenger and public. Positive impact on passenger and public experience. Improve accessibility to key facilities, such as employment, education, transport and healthcare to satisfy transport demand for all trip types.		Positive impact towards vulnerable groups Improvement of accessibility to public transport facilities, in particular from deprived geographic areas.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		All options are comparable - no permanent impact on accessibility. Option A is likely to have more impact on trains during construction but this will be short term.		All options are comparable - no impact on social inclusion
		B1.1	Supported off piers - steel collars		All options are comparable - no impact on accessibility		All options are comparable - no impact on social inclusion
		B1.2	Supported off piers - anchors		All options are comparable - no impact on accessibility		All options are comparable - no impact on social inclusion

Malahide Viaduct

				Integration									
				Adaptability in the future		Transport Integration		Land use integration		Geographical Integration		Government policy Integration	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to cater for future projects or aspirations	Rationale	Qualitative appraisal of the options and their impact on integration with other transport modes	Rationale	Qualitative appraisal of the options and their impact on integration with land use policies	Rationale	Qualitative appraisal of the options and their impact on integration with geographical polices	Rationale	Qualitative appraisal of the options and their impact on integration with geographical and government polices	Rationale
				Ability to continue to function successfully despite future changes in circumstances		Scope for and ease of interchange between modes New interchange nodes and facilities Reduce waking and wait times associated with interchanges Integration with the cycle networks Modal shifts figures during construction and operations Changes to journey times to transport nodes Impact on the operation of the other transport services both during construction and in operation stage		Consistency with land use strategies, regional and local plans		Potential to impact on external links during construction Potential to impact on external links during operations Consideration for any community severance impacts		Integration with national and international plans and policies	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway. However this is a temporary scenario. In the permanent situation the impact is minimal in all options		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		B1.1	Supported off piers - steel collars		Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway. However this is a temporary scenario. In the permanent situation the impact is minimal in all options		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		B1.2	Supported off piers - anchors		Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway. However this is a temporary scenario. In the permanent situation the impact is minimal in all options		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration

Malahide Viaduct

				Physical Activity	
				Walking / cycling opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of the options and their impact to enable walking and cycling opportunities in a safer environment for the communities along the route	Rationale
				To enable walking and cycling opportunities in a safer environment in the communities along the route To create a healthy environment conducive to active travel Connectivity to adjoining cycling and pedestrian facilities Enhanced connectivity between key attractions/trip generators related to active modes Diversions, duration and impact on journey times and potential to create a negative modal shift (e.g. people opt to drive instead of walk or cycle)	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway.
		B1.1	Supported off piers - steel collars		Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway.
		B1.2	Supported off piers - anchors		Options B1.1 and B1.2 involve construction and maintenance in the estuary which may have temporary impacts on the planned Broadmeadow Greenway.

A.2 Detailed MCA table: Rogerstown Viaduct

Comparison Criteria Legend
Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

Rogerstown Viaduct

				Economy							
				Capital Expenditure (CAPEX): Construction, land acquisition, temporary works		OPEX:operational costs (IÉ or other entities), Technology advancements and future proofing / obsolescence		Train Operations Functionality/Economic Benefit		Traffic functionality and associated economic activities and opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal off potential infrastructure costs of proposed options	Rationale	Qualitative appraisal of potential ongoing infrastructure maintenance costs of proposed options	Rationale	Qualitative appraisal of potential ongoing operational costs of proposed options	Rationale	Qualitative appraisal of potential wider benefits of proposed options	Rationale
				Estimate high level cost of construction of option Extent and type of 3rd party lands required permanently Extent and type of 3rd party land required temporarily for temporary works during construction		To offer good value for money. Cost to maintain the infrastructure over the whole life. Effects of infrastructure maintenance to services. Provision of ways of undertaking routine inspections and maintenance activities while minimising the effect on service to customers.		Potential improvement or deterioration of the operation conditions of the line (reduction or increase of the risk of interruption of service) Rolling stock & staff utilisation		Potential benefit to vehicular traffic flows in the vicinity of the works during construction and associated economic activities and opportunities in the vicinity Consideration of duration of traffic disruption and length of diversions To minimise the impacts on traffic and transportation during the construction and operational stages	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2	Supported on structure		Some disruption to trains during construction for lifting tracks. Maybe weekend working. Negligible temporary works required.		All options have a similar level of operational costs and maintenance impacts. Infrastructure options adjacent the track are more easily accessed, however may require track possession for substantial repair works. Options at the sides of the abutment wall don't have an impact on the track, but are more difficult to inspect down the sides of a steep rock embankment. Options requiring anchors or stress bars may have a higher level of maintenance depending on quality of construction, but are not considered to have an overwhelming relative impact.		No impact - all options comparable		Options A, B2.1 and B2.3 have disruption to trains during construction, option B2.2 has limited disruption to trains during construction and option C has very limited disruption to trains during construction.
		B2.1	Supported off abutment - top fixing		Some disruption to trains due to track lifting required, dependent upon the extent of the precast concrete unit design.		All options have a similar level of operational costs and maintenance impacts. Infrastructure options adjacent the track are more easily accessed, however may require track possession for substantial repair works. Options at the sides of the abutment wall don't have an impact on the track, but are more difficult to inspect down the sides of a steep rock embankment. Options requiring anchors or stress bars may have a higher level of maintenance depending on quality of construction, but are not considered to have an overwhelming relative impact.		No impact - all options comparable		Options A, B2.1 and B2.3 have disruption to trains during construction, option B2.2 has limited disruption to trains during construction and option C has very limited disruption to trains during construction.
		B2.2	Supported off abutment - face fixing		Access to the abutment faces required and so will require works in the estuary, with associated cost. It will have limited disruption to trains during construction.		All options have a similar level of operational costs and maintenance impacts. Infrastructure options adjacent the track are more easily accessed, however may require track possession for substantial repair works. Options at the sides of the abutment wall don't have an impact on the track, but are more difficult to inspect down the sides of a steep rock embankment. Options requiring anchors or stress bars may have a higher level of maintenance depending on quality of construction, but are not considered to have an overwhelming relative impact.		No impact - all options comparable		Options A, B2.1 and B2.3 have disruption to trains during construction, option B2.2 has limited disruption to trains during construction and option C has very limited disruption to trains during construction.
		B2.3	Supported off abutment top fixing with precast units		Some disruption to trains during construction for lifting tracks. Maybe weekend working. Negligible temporary works required.		All options have a similar level of operational costs and maintenance impacts. Infrastructure options adjacent the track are more easily accessed, however may require track possession for substantial repair works. Options at the sides of the abutment wall don't have an impact on the track, but are more difficult to inspect down the sides of a steep rock embankment. Options requiring anchors or stress bars may have a higher level of maintenance depending on quality of construction, but are not considered to have an overwhelming relative impact.		No impact - all options comparable		Options A, B2.1 and B2.3 have disruption to trains during construction, option B2.2 has limited disruption to trains during construction and option C has very limited disruption to trains during construction.
		C	Independent supports		Will involve limited disruption to trains but will require installation of foundations on a steep slope, with access likely requiring a working platform to be constructed in the estuary.		All options have a similar level of operational costs and maintenance impacts. Infrastructure options adjacent the track are more easily accessed, however may require track possession for substantial repair works. Options at the sides of the abutment wall don't have an impact on the track, but are more difficult to inspect down the sides of a steep rock embankment. Options requiring anchors or stress bars may have a higher level of maintenance depending on quality of construction, but are not considered to have an overwhelming relative impact.		No impact - all options comparable		Options A, B2.1 and B2.3 have disruption to trains during construction, option B2.2 has limited disruption to trains during construction and option C has very limited disruption to trains during construction.

Rogerstown Viaduct

				Safety			
				Employer's Safety		Public safety	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal on the safety impacts on IÉ or railway staff	Rationale	Qualitative appraisal on the safety impacts on the public (road/rail/cycle/pedestrian)	Rationale
				To reduce safety risks associated with construction maintenance and operations. To reduce the potential for incidents or near-misses for IÉ/construction staff.		To reduce safety risks associated with passengers at platforms, public adjacent to the railway and road, pedestrian and cycle users at level crossings. To reduce the potential for accidents for members of the public/passengers on railway infrastructure. To reduce the potential for conflict between rail and road users.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		Options score similar for construction and maintenance risks. There are similar risks associated with works adjacent the railway and works down the side of a steep rock embankment leading to an estuary.		Public will not have access to this infrastructure
		B2.1	Supported off abutment - top fixing		Options score similar for construction and maintenance risks. There are similar risks associated with works adjacent the rail and works down the side of a steep rock embankment leading to an estuary.		Public will not have access to this infrastructure
		B2.2	Supported off abutment - face fixing		Options score similar for construction and maintenance risks. There are similar risks associated with works adjacent the rail and works down the side of a steep rock embankment leading to an estuary.		Public will not have access to this infrastructure
		B2.3	Supported off abutment top fixing with precast units		Options score similar for construction and maintenance risks. There are similar risks associated with works adjacent the rail and works down the side of a steep rock embankment leading to an estuary.		Public will not have access to this infrastructure
		C	Independent supports		Options score similar for construction and maintenance risks. There are similar risks associated with works adjacent the rail and works down the side of a steep rock embankment leading to an estuary.		Public will not have access to this infrastructure

Rogerstown Viaduct

				Environment																	
				Landscape and Visual Qualitative		Biodiversity (Flora and Fauna)		Noise and Vibration		Water resources		Archaeology, Architectural and Cultural Heritage		Geology & Soils		Agricultural and non-agricultural		Air Quality & Climate Change	
Works Description	Summary of requirements	Option Number	Description of Option	Appraisal of landscape and visual impacts of options based on the sensitive viewpoints	Rationale	Qualitative appraisal on the impact on biodiversity	Rationale	Qualitative appraisal of the potential noise and vibration impact	Rationale	Qualitative appraisal on the potential impacts to surface ground or coastal waters	Rationale	Qualitative appraisal of the potential impacts of proposed options on potential sub surface archaeology and impact on foundations and above ground elements of architectural heritage	Rationale	Qualitative appraisal of the potential of the proposed options on waste and material resources including the reuse of site won materials.	Rationale	Qualitative appraisal of impacts on valued resources either from a human or natural origin with value arising for economic or cultural reasons. These assets can be existing utilities or non-renewable resources	Rationale	Qualitative appraisal of air quality and climate impacts both on the operational and construction phases	Rationale
				• To avoid / minimise impact on designated amenities, landscapes, protected trees or views. • To avoid / minimise visual impact on properties & amenities. • To avoid / minimise removal of trees / hedgerows. • To avoid / minimise impact from light pollution. • To provide opportunities to enhance the local amenity and green infrastructure.		•To ensure that the solution provided minimises the effects on biodiversity of the area and/or provides opportunities to enhance it.		•To provide a solution which ensures minimum levels of noise and vibration		•To minimise the impact or provide opportunities to enhance the quality of surface waters and associated floodplains, ground waters and coastal waters.		•To minimise the impact on cultural heritage such as on below ground archaeological remains, historic buildings (individual and areas), and historic landscapes and parks.		•To provide a solution which minimises total capital carbon. •To minimise waste.		To provide a solution which minimises total capital carbon.		•To provide a solution which comprises a reduction in greenhouse gas emissions. •To ensure that the chosen solution preserves or enhances the local air quality	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2	Supported on structure		Option has less visual interference with the structure than other options. Option is comparable to Options B2.1 and B2.3.		Construction works will be not located in the estuary, thereby minimising the impact on biodiversity.		Construction methods likely have less noise and vibration impact than other options.		works on structure only with minimal impact on water resources		No works will be located in the estuary, thereby negating the archaeological potential to reveal features or buried deposits in the estuary. No impact on the protected / historic fabric there would be a minor visual impact on the setting		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		B2.1	Supported off abutment - top fixing		Option has less visual interference with the structure than other options. Option is comparable to Options A and B2.3.		Partial demolition and potential yet limited works in estuary.		Construction methods may produce more noise and vibration than Option A		works on structure only with minimal impact on water resources		Partial demolition of protected abutment wall resulting in a loss of historic fabric. Stone facing to be added to the visible face of the wall. Potential works in the estuary to install the stone facing but limited. taking down and rebuilding historic stonework including some loss of fabric, would have an irreversible and negative impact. This option is less visually intrusive on the setting of the protected structure relative to other options		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		B2.2	Supported off abutment - face fixing		Option has greater visual interference with the structure than other options. Option is comparable to Option C.		Increased likelihood of impact on biodiversity with works in estuary.		Construction methods may produce more noise and vibration than Option A		works on structure only with minimal impact on water resources		Steel ties to be drilled to the abutment wall connecting both walls. Exposure of steelwork changing the aesthetic of the structure. Works will take place within the estuary. Requires alteration to the historic fabric, but this is reduced relative to Option B2.1. This option is more visually intrusive on the setting of the protected structure relative to other options.		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		B2.3	Supported off abutment top fixing with precast units		Option has less visual interference with the structure than other options. Option is comparable to Options A and B2.1.		Partial demolition and potential yet limited works in estuary.		Construction methods likely have less noise and vibration impact than other options.		works on structure only with minimal impact on water resources		Partial demolition of protected abutment wall resulting in a loss of historic fabric. Stone facing to be added to the visible face of the wall. Potential works in the estuary to install the stone facing but limited. taking down and rebuilding historic stonework including some loss of fabric, would have an irreversible and negative impact. This option is less visually intrusive on the setting of the protected structure relative to other options		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		C	Independent supports		Option has greater visual interference with the structure than other options. Option is comparable to Option B2.2.		Impact on biodiversity to designated marine habitats and overwintering birds within the works area due to invasive works in estuary potential pollution event.		Construction methods may produce more noise and vibration than Option A		Invasive works associated with the foundation construction has the potential to generate pollutants with the potential to impact on Rogerstown Estuary and its associated protected sites		Works required in the estuary resulting in an archaeological potential to reveal buried deposits , finds and features. The aesthetics of the bridge will be altered by the exposed, independent, steel uprights. This option avoids alteration of the historic fabric, but will have a negative impact on the setting of the viaduct.		Appears more disadvantageous from the construction related soils and geology impacts due to required invasive works at and adjacent to the estuary - potential to encounter made ground (and possible contaminated land)		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator

Rogerstown Viaduct

				Accessibility & Social Inclusion			
				Accessibility		Social Inclusion	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to facilitate the movement of people (either within, on to or across the rail system)	Rationale	Qualitative appraisal of capacity of options to provide ease of access for the mobility and visually impaired	Rationale
				Capacity of options to facilitate the movement of people (either within, on to or across the rail system) Impact on the wellbeing of the passenger and public. Positive impact on passenger and public experience. Improve accessibility to key facilities, such as employment, education, transport and healthcare to satisfy transport demand for all trip types.		Positive impact towards vulnerable groups Improvement of accessibility to public transport facilities, in particular from deprived geographic areas.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		All options are comparable - no permanent impact on accessibility. Options A and B2.1 would have more impact on trains during construction but this would be short term.		All options are comparable - no impact
		B2.1	Supported off abutment - top fixing		All options are comparable - no permanent impact on accessibility. Options A and B2.1 would have more impact on trains during construction but this would be short term.		All options are comparable - no impact
		B2.2	Supported off abutment - face fixing		All options are comparable - no permanent impact on accessibility. Options A and B2.1 would have more impact on trains during construction but this would be short term.		All options are comparable - no impact
		B2.3	Supported off abutment top fixing with precast units		All options are comparable - no permanent impact on accessibility. Options A and B2.1 would have more impact on trains during construction but this would be short term.		All options are comparable - no impact
		C	Independent supports		All options are comparable - no permanent impact on accessibility. Options A and B2.1 would have more impact on trains during construction but this would be short term.		All options are comparable - no impact

Rogerstown Viaduct

				Integration									
				Adaptability in the future		Transport Integration		Land use integration		Geographical Integration		Government policy Integration	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to cater for future projects or aspirations	Rationale	Qualitative appraisal of the options and their impact on integration with other transport modes	Rationale	Qualitative appraisal of the options and their impact on integration with land use policies	Rationale	Qualitative appraisal of the options and their impact on integration with geographical polices	Rationale	Qualitative appraisal of the options and their impact on integration with geographical and government polices	Rationale
				Ability to continue to function successfully despite future changes in circumstances		Scope for and ease of interchange between modes New interchange nodes and facilities Reduce waking and wait times associated with interchanges Integration with the cycle networks Modal shifts figures during construction and operations Changes to journey times to transport nodes Impact on the operation of the other transport services both during construction and in operation stage		Consistency with land use strategies, regional and local plans		Potential to impact on external links during construction Potential to impact on external links during operations Consideration for any community severance impacts		Integration with national and international plans and policies	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		B2.1	Supported off abutment - top fixing		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		B2.2	Supported off abutment - face fixing		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		B2.3	Supported off abutment top fixing with precast units		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		C	Independent supports		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration

Rogerstown Viaduct

				Physical Activity	
				Walking / cycling opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of the options and their impact to enable walking and cycling opportunities in a safer environment for the communities along the route	Rationale
				To enable walking and cycling opportunities in a safer environment in the communities along the route To create a healthy environment conducive to active travel Connectivity to adjoining cycling and pedestrian facilities Enhanced connectivity between key attractions/trip generators related to active modes Diversions, duration and impact on journey times and potential to create a negative modal shift (e.g. people opt to drive instead of walk or cycle)	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A	Supported on structure		No significant impact on walking and cycling opportunities.
		B2.1	Supported off abutment - top fixing		No significant impact on walking and cycling opportunities.
		B2.2	Supported off abutment - face fixing		No significant impact on walking and cycling opportunities.
		B2.3	Supported off abutment top fixing with precast units		No significant impact on walking and cycling opportunities.
		C	Independent supports		No significant impact on walking and cycling opportunities.

A.3 Detailed MCA table: Balbriggan Viaduct

Comparison Criteria Legend
Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

Balbriggan Viaduct

				Economy							
				Capital Expenditure (CAPEX): Construction, land acquisition, temporary works		OPEX:operational costs (IÉ or other entities), Technology advancements and future proofing / obsolescence		Train Operations Functionality/Economic Benefit		Traffic functionality and associated economic activities and opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal off potential infrastructure costs of proposed options	Rationale	Qualitative appraisal of potential ongoing infrastructure maintenance costs of proposed options	Rationale	Qualitative appraisal of potential ongoing operational costs of proposed options	Rationale	Qualitative appraisal of potential wider benefits of proposed options	Rationale
				Estimate high level cost of construction of option Extent and type of 3rd party lands required permanently Extent and type of 3rd party land required temporarily for temporary works during construction		To offer good value for money. Cost to maintain the infrastructure over the whole life. Effects of infrastructure maintenance to services. Provision of ways of undertaking routine inspections and maintenance activities while minimising the effect on service to customers.		Potential improvement or deterioration of the operation conditions of the line (reduction or increase of the risk of interruption of service) Rolling stock & staff utilisation		Potential benefit to vehicular traffic flows in the vicinity of the works during construction and associated economic activities and opportunities in the vicinity Consideration of duration of traffic disruption and length of diversions To minimise the impacts on traffic and transportation during the construction and operational stages	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2.1	Supported on structure - aligned with parapets - dowelled		All work can be constructed adjacent to the track with minimal disruption to the train services. Good access is available from trackside and walkway, though works will still require possessions.		Option A2.1 has elements which are easily accessible for inspection and maintenance. The stress bars however add an additional level of complexity. Hence this option is assessed to be relatively similar to Option A2.2.		No impact - all options comparable		Some disruption to trains during construction.
		A2.2	Supported on structure - aligned with parapets - precast "U"		Least technical complexity but would require tracks to be lifted while slab trough is constructed. The impact should be minimised by using precast concrete elements but would still require removal and reinstatement of tracks.		The concrete U-trough is located beneath the tracks and would not be easily accessible for inspection and maintenance. However, the nature of this element is relatively simple and would require minimal maintenance over its lifespan and is hence assessed to be relatively similar to Option A2.1		No impact - all options comparable		Most disruption to trains during construction.
		B1	Supported off pier		Would not impact tracks but would require substantial temporary works to install anchors into the side of the viaduct piers. Some possessions would still be needed. Some highway closures would be required, either at night or weekends.		The connection for this option involves a ground anchor located in the side of the pier high up off the ground. Hence any maintenance associated with this option would require extensive scaffolding and working at heights.		No impact - all options comparable		Least disruption to trains during construction but more disruption to roads

Balbriggan Viaduct

				Safety			
				Employer's Safety		Public safety	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal on the safety impacts on IÉ or railway staff	Rationale	Qualitative appraisal on the safety impacts on the public (road/rail/cycle/pedestrian)	Rationale
				To reduce safety risks associated with construction maintenance and operations. To reduce the potential for incidents or near-misses for IÉ/construction staff.		To reduce safety risks associated with passengers at platforms, public adjacent to the railway and road, pedestrian and cycle users at level crossings. To reduce the potential for accidents for members of the public/passengers on railway infrastructure. To reduce the potential for conflict between rail and road users.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2.1	Supported on structure - aligned with parapets - dowelled		Options A2.1 and A2.2 are both relatively easily accessible form track level.		Public will not have access to this infrastructure
		A2.2	Supported on structure - aligned with parapets - precast "U"		Options A2.1 and A2.2 are both relatively easily accessible form track level.		Public will not have access to this infrastructure
		B1	Supported off pier		This option involves access to high level scaffolding for inspection and maintenance.		OLE structure spanning over public walkway. However, the poles would be behind suitable fencing and the overhead mast would be well out of reach.

Balbriggan Viaduct

				Environment																	
				Landscape and Visual Qualitative		Biodiversity (Flora and Fauna)		Noise and Vibration		Water resources		Archaeology, Architectural and Cultural Heritage		Geology & Soils		Agricultural and non-agricultural		Air Quality & Climate Change	
Works Description	Summary of requirements	Option Number	Description of Option	Appraisal of landscape and visual impacts of options based on the sensitive viewpoints	Rationale	Qualitative appraisal on the impact on biodiversity	Rationale	Qualitative appraisal of the potential noise and vibration impact	Rationale	Qualitative appraisal on the potential impacts to surface ground or coastal waters	Rationale	Qualitative appraisal of the potential impacts of proposed options on potential sub surface archaeology and impact on foundations and above ground elements of architectural heritage	Rationale	Qualitative appraisal of the potential of the proposed options on waste and material resources including the reuse of site won materials.	Rationale	Qualitative appraisal of impacts on valued resources either from a human or natural origin with value arising for economic or cultural reasons. These assets can be existing utilities or non-renewable resources	Rationale	Qualitative appraisal of air quality and climate impacts both on the operational and construction phases	Rationale
				• To avoid / minimise impact on designated amenities, landscapes, protected trees or views. • To avoid / minimise visual impact on properties & amenities. • To avoid / minimise removal of trees / hedgerows. • To avoid / minimise impact from light pollution. • To provide opportunities to enhance the local amenity and green infrastructure.		•To ensure that the solution provided minimises the effects on biodiversity of the area and/or provides opportunities to enhance it.		•To provide a solution which ensures minimum levels of noise and vibration		•To minimise the impact or provide opportunities to enhance the quality of surface waters and associated floodplains, ground waters and coastal waters.		•To minimise the impact on cultural heritage such as on below ground archaeological remains, historic buildings (individual and areas), and historic landscapes and parks.		•To provide a solution which minimises total capital carbon. •To minimise waste.		To provide a solution which minimises total capital carbon.		•To provide a solution which comprises a reduction in greenhouse gas emissions. •To ensure that the chosen solution preserves or enhances the local air quality	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2.1	Supported on structure - aligned with parapets - dowelled		Option has less visual interference with the structure than other options.		Comparable to other options. There are a number of potential bat roost features within the masonry of the bridge, these cannot be checked or surveyed easily for confirmed roosts due to the height of the viaduct and safety issues with railway. Potential direct impact therefore on potential bat roosts, and potential indirect impacts from disturbance i.e. noise, lighting, vibration. Potential impacts on birds flying over viaduct from overhead lines, causing injury/mortality, comparable across all options.		Similar level of noise and vibration expected for all options		Works on structure only with minimal impact on water resources		Some loss of historic fabric. Some disruption of historic fabric (the legibility of the historic parapet walls has previously been impacted by the provision of the walkway) avoids serious visual intrusion into the setting		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		A2.2	Supported on structure - aligned with parapets - precast "U"		Option has slightly greater visual interference with the structure than Option A2.1. This is seen as minimal therefore score the same as A2.1		Comparable to other options. There are a number of potential bat roost features within the masonry of the bridge, these cannot be checked or surveyed easily for confirmed roosts due to the height of the viaduct and safety issues with railway. Potential direct impact therefore on potential bat roosts, and potential indirect impacts from disturbance i.e. noise, lighting, vibration. Potential impacts on birds flying over viaduct from overhead lines, causing injury/mortality, comparable across all options.		Similar level of noise and vibration expected for all options		Works on structure only with minimal impact on water resources		More loss to historic fabric. The loss of historic fabric is increased relative to option A2.1 the visual impact is the same as for Option A2.1		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		B1	Supported off pier		Option has greatest visual interference with the structure.		Comparable to other options. There are a number of potential bat roost features within the masonry of the bridge, these cannot be checked or surveyed easily for confirmed roosts due to the height of the viaduct and safety issues with railway. Potential direct impact therefore on potential bat roosts, and potential indirect impacts from disturbance i.e. noise, lighting, vibration. Potential impacts on birds flying over viaduct from overhead lines, causing injury/mortality, comparable across all options.		Similar level of noise and vibration expected for all options		Works on structure only with minimal impact on water resources		This option will change the aesthetics of the viaduct, with the attachment of the OHLE frame to the exterior of the piers. Where the attachments occur there will be interventions to the historic feature. This option reduces the impact on historic fabric relative to the other options. .		Works on structure only; no impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator

Balbriggan Viaduct

				Accessibility & Social Inclusion			
				Accessibility		Social Inclusion	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to facilitate the movement of people (either within, on to or across the rail system)	Rationale	Qualitative appraisal of capacity of options to provide ease of access for the mobility and visually impaired	Rationale
				Capacity of options to facilitate the movement of people (either within, on to or across the rail system) Impact on the wellbeing of the passenger and public. Positive impact on passenger and public experience. Improve accessibility to key facilities, such as employment, education, transport and healthcare to satisfy transport demand for all trip types.		Positive impact towards vulnerable groups Improvement of accessibility to public transport facilities, in particular from deprived geographic areas.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2.1	Supported on structure - aligned with parapets - dowelled		All options are comparable - no permanent impact on accessibility. Options A2.1 and A2.2 would have more impact on trains during construction but this would be short term.		All options are comparable - no impact
		A2.2	Supported on structure - aligned with parapets - precast "U"		All options are comparable - no permanent impact on accessibility. Options A2.1 and A2.2 would have more impact on trains during construction but this would be short term.		All options are comparable - no impact
		B1	Supported off pier		All options are comparable - no permanent impact on accessibility. Option B1 would have more impact on roads during construction but this would be short term.		All options are comparable - no impact

Balbriggan Viaduct

				Integration									
				Adaptability in the future		Transport Integration		Land use integration		Geographical Integration		Government policy Integration	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to cater for future projects or aspirations	Rationale	Qualitative appraisal of the options and their impact on integration with other transport modes	Rationale	Qualitative appraisal of the options and their impact on integration with land use policies	Rationale	Qualitative appraisal of the options and their impact on integration with geographical polices	Rationale	Qualitative appraisal of the options and their impact on integration with geographical and government polices	Rationale
				Ability to continue to function successfully despite future changes in circumstances		Scope for and ease of interchange between modes New interchange nodes and facilities Reduce waking and wait times associated with interchanges Integration with the cycle networks Modal shifts figures during construction and operations Changes to journey times to transport nodes Impact on the operation of the other transport services both during construction and in operation stage		Consistency with land use strategies, regional and local plans		Potential to impact on external links during construction Potential to impact on external links during operations Consideration for any community severance impacts		Integration with national and international plans and policies	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2.1	Supported on structure - aligned with parapets - dowelled		No future transport schemes will be significantly impacted by access to the site during construction or operation.		Option A2.2 has greater disruption to public walkways during construction, option B1 has an impact on walkways below during construction and operational hazard of OLE structure spanning over public walkway.		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		A2.2	Supported on structure - aligned with parapets - precast "U"		No future transport schemes will be significantly impacted by access to the site during construction or operation.		Option A2.2 has greater disruption to public walkways during construction, option B1 has an impact on walkways below during construction and operational hazard of OLE structure spanning over public walkway.		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		B1	Supported off pier		No future transport schemes will be significantly impacted by access to the site during construction or operation.		Option A2.2 has greater disruption to public walkways during construction, option B1 has an impact on walkways below during construction and operational hazard of OLE structure spanning over public walkway.		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration

Balbriggan Viaduct

				Physical Activity	
				Walking / cycling opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of the options and their impact to enable walking and cycling opportunities in a safer environment for the communities along the route	Rationale
				To enable walking and cycling opportunities in a safer environment in the communities along the route To create a healthy environment conducive to active travel Connectivity to adjoining cycling and pedestrian facilities Enhanced connectivity between key attractions/trip generators related to active modes Diversions, duration and impact on journey times and potential to create a negative modal shift (e.g. people opt to drive instead of walk or cycle)	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	A2.1	Supported on structure - aligned with parapets - dowelled		Option A2.2 has greater disruption to public walkways during construction, option B1 has an operational hazard of OLE structure spanning over public walkway
		A2.2	Supported on structure - aligned with parapets - precast "U"		Option A2.2 has greater disruption to public walkways during construction, option B1 has an operational hazard of OLE structure spanning over public walkway
		B1	Supported off pier		Option A2.2 has greater disruption to public walkways during construction, option B1 has an operational hazard of OLE structure spanning over public walkway

A.4 Detailed MCA table: Gormanston Viaduct

Comparison Criteria Legend
Significant comparative advantage over other options
Some comparative advantage over other options
Comparable to other options / neutral
Some comparative disadvantage over other options
Significant comparative disadvantage over other options

Gormanston Viaduct

				Economy							
				Capital Expenditure (CAPEX): Construction, land acquisition, temporary works		OPEX:operational costs (IÉ or other entities), Technology advancements and future proofing / obsolescence		Train Operations Functionality/Economic Benefit		Traffic functionality and associated economic activities and opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal off potential infrastructure costs of proposed options	Rationale	Qualitative appraisal of potential ongoing infrastructure maintenance costs of proposed options	Rationale	Qualitative appraisal of potential ongoing operational costs of proposed options	Rationale	Qualitative appraisal of potential wider benefits of proposed options	Rationale
				Estimate high level cost of construction of option Extent and type of 3rd party lands required permanently Extent and type of 3rd party land required temporarily for temporary works during construction		To offer good value for money. Cost to maintain the infrastructure over the whole life. Effects of infrastructure maintenance to services. Provision of ways of undertaking routine inspections and maintenance activities while minimising the effect on service to customers.		Potential improvement or deterioration of the operation conditions of the line (reduction or increase of the risk of interruption of service) Rolling stock & staff utilisation		Potential benefit to vehicular traffic flows in the vicinity of the works during construction and associated economic activities and opportunities in the vicinity Consideration of duration of traffic disruption and length of diversions To minimise the impacts on traffic and transportation during the construction and operational stages	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	B2.1	Supported off abutment - top fixing		Demolition of parapet walls at abutments and stressing down into historic masonry walls with associated disruption and risk		Requires access down the sides of the embankment slope		All options comparable		Option B2.2 and C have less disruption to trains during construction.
		B2.2	Supported off abutment - face fixing		Connecting into the sides of the abutment walls on a steep embankment with associated disruption and risk		Requires access down the sides of the embankment slope		All options comparable		Option B2.2 and C have less disruption to trains during construction.
		C	Independent supports		Could employ typical trackside installation of OHLE supports at the top of the embankment slope		Easily accessed from cess alongside track		All options comparable		Option B2.2 and C have less disruption to trains during construction.

Gormanston Viaduct

				Safety			
				Employer's Safety		Public safety	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal on the safety impacts on IÉ or railway staff	Rationale	Qualitative appraisal on the safety impacts on the public (road/rail/cycle/pedestrian)	Rationale
				To reduce safety risks associated with construction maintenance and operations. To reduce the potential for incidents or near-misses for IÉ/construction staff.		To reduce safety risks associated with passengers at platforms, public adjacent to the railway and road, pedestrian and cycle users at level crossings. To reduce the potential for accidents for members of the public/passengers on railway infrastructure. To reduce the potential for conflict between rail and road users.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	B2.1	Supported off abutment - top fixing		Requires access down the sides of the embankment slope		Public will not have access to this infrastructure
		B2.2	Supported off abutment - face fixing		Requires access down the sides of the embankment slope		Public will not have access to this infrastructure
		C	Independent supports		Easily accessed from cess alongside track		Public will not have access to this infrastructure

Gormanston Viaduct

				Environment															
				Landscape and Visual Qualitative		Biodiversity (Flora and Fauna)		Noise and Vibration		Water resources		Archaeology, Architectural and Cultural Heritage		Geology & Soils		Agricultural and non-agricultural		Air Quality & Climate Change	
Works Description	Summary of requirements	Option Number	Description of Option	Appraisal of landscape and visual impacts of options based on the sensitive viewpoints	Rationale	Qualitative appraisal on the impact on biodiversity	Rationale	Qualitative appraisal of the potential noise and vibration impact	Rationale	Qualitative appraisal on the potential impacts to surface ground or coastal waters	Rationale	Qualitative appraisal of the potential impacts of proposed options on potential sub surface archaeology and impact on foundations and above ground elements of architectural heritage	Rationale	Qualitative appraisal of the potential of the proposed options on waste and material resources including the reuse of site won materials.	Rationale	Qualitative appraisal of impacts on valued resources either from a human or natural origin with value arising for economic or cultural reasons. These assets can be existing utilities or non-renewable resources	Rationale	Qualitative appraisal of air quality and climate impacts both on the operational and construction phases	Rationale
				• To avoid / minimise impact on designated amenities, landscapes, protected trees or views. • To avoid / minimise visual impact on properties & amenities. • To avoid / minimise removal of trees / hedgerows. • To avoid / minimise impact from light pollution. • To provide opportunities to enhance the local amenity and green infrastructure.		•To ensure that the solution provided minimises the effects on biodiversity of the area and/or provides opportunities to enhance it.		•To provide a solution which ensures minimum levels of noise and vibration		•To minimise the impact or provide opportunities to enhance the quality of surface waters and associated floodplains, ground waters and coastal waters.		•To minimise the impact on cultural heritage such as on below ground archaeological remains, historic buildings (individual and areas), and historic landscapes and parks.		•To provide a solution which minimises total capital carbon. •To minimise waste.		To provide a solution which minimises total capital carbon.		•To provide a solution which comprises a reduction in greenhouse gas emissions. •To ensure that the chosen solution preserves or enhances the local air quality	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	B2.1	Supported off abutment - top fixing		Option has less visual interference with the structure than other options.		Comparable to other options. Removal/amendment of parapet has the potential to disturb bats that may be roosting within wing walls, this impact is more likely in this option and Option B2.2. However this option is likely to have less noise and vibration than Option C, so impact may be very localised. Potential for impact on water quality due to proximity of water course, less likely than Option C. Potential for bird strike due to collisions with the overhead wires comparable across all options.		Construction methods likely have less noise and vibration impact than Option C		Works on structure only with minimal impact on water resources		Loss of historic fabric in the form of the parapet wall. Taking down and rebuilding historic stonework including some loss of fabric, would have an irreversible and negative impact. This option is less visually intrusive on the setting of the protected structure relative to other options		Works on structure only; no/minimal impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		B2.2	Supported off abutment - face fixing		Option has greater visual interference with the structure than option B2.1.		Comparable to other options. Removal/amendment of parapet has the potential to disturb bats that may be roosting within wing walls, this is impact is more likely in this option and Option B2.1. However this option is likely to have less noise and vibration than Option C, so impact may be very localised. Potential for impact on water quality due to proximity of water course, less likely than Option C. Potential for bird strike due to collisions with the overhead wires comparable across all options.		Construction methods likely have less noise and vibration impact than Option C		Works on structure only with minimal impact on water resources		Supports will be affixed to the abutment wing walls and change the aesthetics of the viaduct. Requires some alteration to the historic fabric.		Works on structure only; no/minimal impacts on geology and soils.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator
		C	Independent supports		Option has greater visual interference with the structure than option B2.1.		Comparable to other options. No direct impact on potential bat roosts within wing walls, however potential for disturbance greater in this option. Construction of the OHLE foundations has greater potential to impact water quality in adjacent watercourse than other two options. Potential for bird strike due to collisions with the overhead wires comparable across all options.		Construction methods may produce more noise and vibration than Options B2.1 and B2.2		Invasive works associated with the foundation construction has the potential to generate pollutants with the potential to impact on receiving waterbodies		Independent supports have the potential to reveal archaeological buried deposits, features and finds at this sensitive archaeological area. It will change the aesthetics of the viaduct. This option avoids alteration of the historic fabric, but will have a negative impact on the setting of the viaduct.		Independent supports will require new foundations which impact on geology and soils and generate earthworks particularly during the construction phase.		Very low sensitivity – Comparable to other options		Air quality and climate not a differentiator

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				Accessibility & Social Inclusion			
				Accessibility		Social Inclusion	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to facilitate the movement of people (either within, on to or across the rail system)	Rationale	Qualitative appraisal of capacity of options to provide ease of access for the mobility and visually impaired	Rationale
				Capacity of options to facilitate the movement of people (either within, on to or across the rail system) Impact on the wellbeing of the passenger and public. Positive impact on passenger and public experience. Improve accessibility to key facilities, such as employment, education, transport and healthcare to satisfy transport demand for all trip types.		Positive impact towards vulnerable groups Improvement of accessibility to public transport facilities, in particular from deprived geographic areas.	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	B2.1	Supported off abutment - top fixing		All options are comparable - no permanent impact on accessibility. Option B2.1 would have greatest impact on trains during construction but this is short term. All options have some train impact during construction.		All options are comparable - no impact
		B2.2	Supported off abutment - face fixing		All options are comparable - no permanent impact on accessibility. Option B2.1 would have greatest impact on trains during construction but this is short term. All options have some train impact during construction.		All options are comparable - no impact
		C	Independent supports		All options are comparable - no permanent impact on accessibility. Option B2.1 would have greatest impact on trains during construction but this is short term. All options have some train impact during construction.		All options are comparable - no impact

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				Integration											
				Adaptability in the future		Transport Integration		Land use integration		Geographical Integration		Government policy Integration	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of capacity of options to cater for future projects or aspirations	Rationale	Qualitative appraisal of the options and their impact on integration with other transport modes	Rationale	Qualitative appraisal of the options and their impact on integration with land use policies	Rationale	Qualitative appraisal of the options and their impact on integration with geographical polices	Rationale	Qualitative appraisal of the options and their impact on integration with geographical and government polices	Rationale
				Ability to continue to function successfully despite future changes in circumstances		Scope for and ease of interchange between modes New interchange nodes and facilities Reduce waking and wait times associated with interchanges Integration with the cycle networks Modal shifts figures during construction and operations Changes to journey times to transport nodes Impact on the operation of the other transport services both during construction and in operation stage		Consistency with land use strategies, regional and local plans		Potential to impact on external links during construction Potential to impact on external links during operations Consideration for any community severance impacts		Integration with national and international plans and policies	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	B2.1	Supported off abutment - top fixing		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		B2.2	Supported off abutment - face fixing		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration
		C	Independent supports		No future transport schemes will be significantly impacted by access to the site during construction or operation.		No impact on integration with other modes		All options are comparable - no impact on land use		All options are comparable - no impact on geographical integration		All options are comparable - no impact on government policy integration

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				Physical Activity	
				Walking / cycling opportunities	
Works Description	Summary of requirements	Option Number	Description of Option	Qualitative appraisal of the options and their impact to enable walking and cycling opportunities in a safer environment for the communities along the route	Rationale
				To enable walking and cycling opportunities in a safer environment in the communities along the route To create a healthy environment conducive to active travel Connectivity to adjoining cycling and pedestrian facilities Enhanced connectivity between key attractions/trip generators related to active modes Diversions, duration and impact on journey times and potential to create a negative modal shift (e.g. people opt to drive instead of walk or cycle)	
Electrification of Northern Line: OLE underbridges	Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead.	B2.1	Supported off abutment - top fixing		No significant impact on walking and cycling opportunities.
		B2.2	Supported off abutment - face fixing		No significant impact on walking and cycling opportunities.
		C	Independent supports		No significant impact on walking and cycling opportunities.