Appendix A3.3 Option Selection for Overhead Line Equipment (OHLE) Intervention at OBG5, OBG11 and OBG14

DART+ West

Iarnród Éireann

Option selection for Overhead Line Equipment (OHLE) intervention at OBG5, OBG11 and OBG14

MAY-MDC-STR-OTHE-RP-Z-0004

27th May 2022

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EXECUTIVE SUMMARY

This report aims to outline the processes used for selection of the the preferred option for constructing the Overhead Line Equipment (OHLE) below the following existing historic bridges:

1. Broombridge (OBG5)
2. Castleknock (OBG11)
3. Cope Bridge (OBG14)

The potential solutions reviewed for each bridge are presented and explained in this report. The four options are as follows:

1. Reduced height OHLE
2. Vertical Track Lowering
3. Bridge reconstruction
4. Track realignment

A robust optioneering process has been undertaken to determine the preferred option for installation of OHLE at each of the three bridges.

The details of the optioneering for each of the three bridges are included in the reports listed below:

1. Technical note for OBG5 Broome Bridge: MAY-MDC-STR-OTHE-RP-Z-0002 – see APPENDIX A
2. Technical note for OBG11 Castleknock: MAY-MDC-STR-OTHE-RP-Z-0003 – see APPENDIX B
3. Technical note for OBG14 Cope Bridge: MAY-MDC-STR-OTHE-RP-Z-0001 – see APPENDIX C

Each of these reports cover the options assessed, their impacts and the outcome of the MCA process. They then conclude with the preferred option selected.

1. INTRODUCTION

1.1 Background

The DART+ West Project will introduce electrified high-capacity trains at the increased frequency for all stations between Maynooth/M3 Parkway and Dublin city centre at Connolly Station and the new Spencer Dock Station (c.40 km in length). The new DART+ trains will be similar in configuration to the current DART trains operating on the Malahide/Howth to Bray/Greystones line but with higher passenger carrying capabilities (each 8 carriage train will have a maximum capacity for 1,200 passengers per train). The project will increase services from the current 6 trains per hour per direction to 12 trains per hour per direction, increasing passenger capacity from 5,000 to 13,200 subject to passenger demand. This will be achieved through modernisation of the track infrastructure, closure of level crossings and the purchase of a new fleet of trains.

The overall scope of the DART+ West Project includes the following key elements:

- Electrification of the Maynooth & M3 Parkway lines from City Centre to Maynooth (40km approx.).
- Capacity enhancements at Connolly Station (to include modifications to junctions and the station) to facilitate increased train and passenger numbers.
- Provision of a new Spencer Dock Station, which will better serve the north Docklands area and create an improved interchange with the Luas Red Line.
- Closure of level crossings & provision of bridge crossings where required.
- Interventions at existing bridges over the rail line where there is insufficient clearance to accommodate the new overhead electrification system.
- Construction of a new DART depot facility west of Maynooth Station for the maintenance and stabling of trains.
- All civil and bridge works as necessary to accommodate electrification.

1.2 Purpose of the document

This report aims to outline the processes used for selection of the the preferred option for constructing the Overhead Line Equipment (OHLE) below the following existing historic bridges:

1. OBG5 Broome Bridge
2. OBG11 Castleknock
3. OBG14 Cope Bridge

The potential solutions reviewed for each bridge are presented and explained in this report. The four options are as follows:

1. Reduced height OHLE
2. Vertical Track Lowering
3. Bridge reconstruction
4. Track realignment

The report explains the options analysed and the decision-making process to determine the preferred option for each bridge.

2. INSTALLATION OF OVERHEAD LINE EQUIPMENT (OHLE)

2.1 Introduction

The DART+ West Project provides for the electrification and re-signalling of the existing railway. Overhead Line Equipment (OHLE) will be required to provide electrical power to the trains.

All the bridges on the Maynooth Line have been assessed to determine the most appropriate mechanism for OHLE installation.

2.2 Assessment Methodology and Hierarchy

The railway passes under a number of existing bridges and in many instances the existing bridges are too low to accommodate the required overhead lines at their current heights, hence special measures are warranted to facilitate the electrification. The proposed measures are considered on a ranked basis with an increasing scale of intervention. The measures examined, from lowest to highest degree of intervention, are as follows:

- Accept reduced wire height under an existing bridge
- Lower the railway under an existing bridge and underpin bridge as necessary
- Raise the deck of an existing bridge to provide the required clearance under the bridge or demolish the deck of an existing bridge and reconstruct it at a higher level
- Realign the railway to avoid the constraint associated with the existing bridge.

In many instances, a combination of the above options has been adopted to ensure minimal intervention.

All the existing bridges were examined and classified in respect of the height available for electrification under the bridges.

Figure 2-1 indicates the hierarchy of options examined to obtain the required minimum vertical clearance.

HIERARCHY OF ALTERNATIVE SOLUTIONS TO ACHIEVE MINIMUM VERTICAL CLEARANCE

	Options	Issues and impacts assessed
Solutions with curtailed environmental impacts	1 – REDUCED CLEARANCE OHLE	- OHLE solutions for reduced clearance - IÉ Standard derogations or risk assessments due to special OHLE solutions
	2 – VERTICAL LOWERING	- Tracks and platforms impacted - At greater depths, possibility of impact on the foundation of the structure - Drainage issues
Infrastructure interventions where 1 and 2 are not possible	3a – BRIDGE MODIFICATION	- Listed structures - Road re-alignment - Utilities
	3b – NEW ALIGNMENT	- Road diversions - Relevant construction and acquisition costs

Figure 2-1 Hierarchy of solutions

2.3 Consideration of solutions

2.3.1 Reduced clearance OHLE

Where possible, the simplest method of obtaining an appropriate solution at reduced height structures is to install OHLE with reduced clearance. **Table 2-1** and the text below describes the options available.

Table 2-1 IÉ electrical clearance categories

Clearance Category	Clearance TOR to Soffit (mm)	MDC's Categorisation	Considerations
Enhanced	≥ 5620		Standard contact wire height of 4700 mm and system height and a minimum current carrying dropper of 500 mm.
Minimum Normal	5619 – 5080		Allows contact wire height of 4700 mm but reduced system height.
Minimum Normal	5079 - 4710		Requires contact wire below 4700 mm up to 4400 mm and risk assessment. Requires MCA to explore how to gain clearance.
Special Reduced	4709 - 4495		Requires contact wire height below 4400 mm, including risk assessment and standard derogation. Requires MCA to explore how to gain clearance.

The following hierarchy of design solutions is considered for reduced OHLE clearance.

Green Structures

1. Contact wire height of 4700mm, nominal system height of 1300 mm, current carrying dropper of 500mm and enhanced electrical clearances.

Amber Structures

Where it is not possible to provide the standard OHLE solution due to mechanical or electrical clearance, the following 'Options' hierarchy has been followed for Amber structures to maintain nominal contact wire height:

1. Maintain contact wire height of 4700mm. Reduced system height, minimum current carrying dropper of 300mm and enhanced electrical clearances.
2. Maintain contact wire height of 4700mm. Reduced system height, non-current carrying dropper of 100mm and enhanced electrical clearances.
3. Maintain contact wire height of 4700mm. Reduce system height to zero and replace catenary with contenary (twin contact wire). If the bridge width is equal to or less than 8 to 9m free running solution under the bridge shall be used, if the bridge width is greater than 8 – 9m width fitted solution with bridge/elastic arms shall be applied. Enhanced electrical clearances. Limit uplift to 70mm.

When the above options are not possible, the following hierarchy has been followed and a risk assessment is required if it is the final solution to be adopted:

1. Reduce contact wire height to 4600mm. Reduced system height, minimum current carrying dropper of 300mm and enhanced electrical clearances. Reduce tamping allowance to 75mm. Maximum OHLE Span 55m unless reduction in tamping or OHLE tolerance is agreed with CCE and SET.
2. Reduce contact wire height to 4600mm. Reduced system height, non-current carrying dropper of 100mm and enhanced electrical clearances. Reduce tamping allowance to 75mm. Maximum OHLE Span 55m unless reduction in tamping or OHLE tolerance is agreed with CCE and SET.
3. Reduce contact wire height to 4600mm. Reduce system height to zero and replace catenary with contenary (twin contact wire). If the bridge width is equal or less than 8 to 9m free running solution under the bridge shall be used, if the bridge width is greater than 8 – 9m width fitted solution with

bridge/elastic arms shall be applied. Enhanced electrical clearances. Reduce tamping allowance to 75mm and limit uplift to 70mm.

4. Reduce contact wire height to 4500mm. Reduced system height, minimum current carrying dropper of 300mm and enhanced electrical clearances. Reduce tamping allowance to 50mm. Maximum OHLE Span 45m unless reduction in tamping or OHLE tolerance is agreed with CCE and SET.
5. Reduce contact wire height to 4500mm. Reduced system height, non-current carrying dropper of 100mm and enhanced electrical clearances. Reduce tamping allowance to 5mm. Maximum OHLE Span 45m unless reduction in tamping or OHLE tolerance is agreed with CCE and SET.
6. Reduce contact wire height to 4500mm. Reduce system height to zero and replace catenary with contenary (twin contact wire). If the bridge width is equal or less than 8 to 9m free running solution under the bridge shall be used, if the bridge width is greater than 8 – 9M width fitted solution with bridge/elastic arms shall be applied. Enhanced electrical clearances. Reduce tamping allowance to 50mm and limit uplift to 70mm.
7. Reduce contact wire height to 4400mm. Reduced system height, reduced current carrying dropper of 300mm, enhanced electrical clearances. Reduce tamping allowance to 50mm. Requires a maximum span of 30m to infringe the minimum contact wire position over the vehicle of 4190mm unless reduction in tamping or OHLE tolerance is agreed with CCE and SET.
8. Reduce contact wire height to 4400mm. Reduced system height, non-current carrying dropper of 100mm, enhanced electrical clearances. Reduce tamping allowance to 50mm. Requires a maximum span of 30m to infringe the minimum contact wire position over the vehicle of 4190mm unless reduction in tamping or OHLE tolerance is agreed with CCE and SET.
9. Reduce contact wire height to 4400mm. Reduce system height to zero and replace catenary with contenary (twin contact wire). If the bridge width is equal or less than 8 to 9m free running solution under the bridge shall be used, if the bridge width is greater than 8 to 9m width fitted solution with bridge/elastic arms shall be applied. Reduced electrical clearances. Reduce tamping allowance to 50mm and limit uplift to 70mm. Maximum span between bridge arms of 12m.

Red Structures

1. Reduce contact wire height to 4350mm. Reduce system height to zero and replace catenary with contenary (twin contact wire). If the bridge width is equal or less than 8 to 9m free running solution under the bridge shall be used, if the bridge width is greater than 8 to 9m width fitted solution with bridge/elastic arms shall be applied. Reduced electrical clearances. Reduce tamping allowance to 50mm and limit uplift to 50mm. Maximum span between bridge arms of 12m.
2. Reduce contact wire height to 4270mm. Reduce system height to zero and replace catenary with contenary (twin contact wire). If the bridge width is equal or less than 8 to 9m free running solution under the bridge shall be used, if the bridge width is greater than 8 – 9m width fitted solution with bridge/elastic arms shall be applied. Reduced electrical clearances. Slab track required to reduce tamping allowance to 0mm and track maintenance tolerance to 5mm. Limit uplift to 50mm. Maximum span between bridge arms of 9m.

2.3.2 Vertical lowering

Where it is not possible to achieve a reduced height OHLE solution, the next option is to examine track lowering beneath the bridge to obtain the required clearance.

This solution consists of a track lowering to reach a 4400 mm or 4700 mm contact wire height. The total length depends on the height to be lowered and the longitudinal slope of the tracks.

When it is necessary to lower the tracks more than 400 mm (800 mm ballast and trackbed + 400 mm lowering = 1200 mm), the lowering action must be carried out in two phases for each track.

When the excavation reaches the bridge foundation level, structure foundation protection is needed. For that reason, these works require several possession time throughout weekend periods.

Whilst this is an acceptable solution, the installation of this solution can pose problems depending on the site's physical characteristics.

The main problems generally associated with this type of intervention are:

Flooding issues

Lowering the level of the tracks can cause or compound flooding issues in specific areas with the consequent risk of service disruption.

In those cases, mitigations measures consist in implementing a solution to deal with the flood water removal from tracks and/or provide floodplains to store stormwater runoff.

Drainage issues

Some locations have a low point in the longitudinal profile of the track. Generally, this low point is relative and is due to the need to achieve clearance of the tracks to the overbridge.

A further lowering of the tracks accentuates this low point and requires lineside drainage implementation. Where a gravity system is not possible, a pumped drainage system requires to be considered and costed.

Impact on Stations

Lowering the tracks at overbridges that are located very close to stations can require significant construction work to existing station infrastructure.

The railway platforms provide access to trains and they must maintain a standard height to the rails.Track lowering at station locations can affect the required platform height relative to the tracks and may require lowering all platforms levels or moving them completely. This can in turn require reconstruction of footbridges, accesses, buildings, and facilities.

Structure safety

Track lowering at overbridges requires verifying that the overbridge structure, particularly its foundations, are not impacted/compromised.

2.3.3 Bridge modification

This involves either raising the deck of the existing bridge by jacking or, where raising is not possible, demolishing the existing deck and reconstructing a new deck at a raised level.

This option is generally only undertaken where the previous options (i.e. reduced OHLE clearance or track lowering) are deemed unsuitable.

The main problems generally associated with this type of intervention are:

1. Impact on historic bridge structures – a number of the bridges along the route are protected structures and the impact of bridge modifications on these structures needs to be carefully considered
2. Road diversions – during construction it may be required to divert traffic, cyclists and pedestrians
3. Utility diversions – a number of bridges contain existing utilities that may need to be diverted in order to carry out the bridge modifications.

2.3.4 Track realignment

This is generally only considered in extreme circumstances due to its high cost and impact on adjacent land. This option is generally not feasible within the urban environment.

3. OPTIONS SELECTION PROCESS

3.1 MCA methodology

The Multi-Criteria Analysis (MCA) technique used to inform the option selection process that has been applied to determine the end to end preferred option of the proposed development has been informed by the Common Appraisal Framework (CAF) for Transport Projects and Programmes (Department of Transport Tourism and Sport, March 2016 and updated October 2020). The CAF Guidelines require projects to undergo a MCA under a common set of six CAF criteria referred to as parameters. These include:

Table 3-1 CAF Parameters

CAF parameter	Summary description
Economy	Economy relates to impacts of a transport investment on economic growth and competitiveness are assessed under the economic impact and economic efficiency criteria
Integration	Integration considers the extent to which the project being evaluated promotes integration of transport networks and is compatible with Government policies, including national spatial and planning policy
Environment	Environment embraces a range of impacts, such as emissions to air, noise, and ecological and architectural impacts
Accessibility and Social Inclusion	Accessibility and social inclusion embraces the notion that some priority should be given to benefits that accrue to those suffering from social deprivation, geographic isolation and mobility and sensory deprivation.
Safety	Safety is concerned with the impact of the investment on the number of transport related accidents
Physical Activity	This relates to the health benefits derived from using different transport modes

The information required to carry out the MCA is set out below with the proposals in respect of the proposed development:

Table 3-2 Information required to carry out MCA

Information needed	Project approach
The options to be analysed	Component options are presented for each
The evaluation criteria that will be used to analyse the options	The above criteria are broken into sub-criteria each of these are used to carry out a comparative assessment of the options.
The importance of these criteria.	For individual scheme components a fully qualitative or quantitative mechanism has been used dependent on the perceived appropriateness for each component
The evaluation of the options on the different criteria. These evaluations can be given a numerical or ordinal (comparative) scale.	The evaluations are on the basis of colour coding as described in Table 3-4

The common set of six CAF parameters and criteria has been identified for the proposed development. Sub-criterion are developed under each of the distinct design elements as appropriate to meet the project objectives. The six CAF parameters and criteria are presented in Table 3-3.

Table 3-3 CAF Criteria for MCA process for DART+ West design elements

CAF Criteria	Sub - Criteria	SET Electrification	OHLE Clearance at Structures	Permanent Way	Level Crossings	Stations	Depot	Depot Access	Substations & Technical buildings	Construction Compounds
1. Economy	Construction and Land Cost		✓	✓	✓	✓	✓	✓		✓
	Long Term Maintenance costs		✓	✓	✓	✓	✓	✓		✓
	Traffic Functionality		✓		✓		✓	✓		
	Train Operation Functionality / Economic Benefit			✓		✓				
	Passenger Demand					✓				
	Passenger Journey Time Reduction			✓		✓				
	CAPEX	✓							✓	
	OPEX	✓							✓	
2. Integration	Transport Integration		✓	✓	✓	✓		✓		✓
	Adaptability in the future						✓			
	Land Use Integration		✓	✓	✓	✓	✓	✓		✓
	Geographical Integration	✓	✓	✓	✓	✓	✓		✓	✓
	Other Government Policy		✓	✓	✓	✓	✓			✓
	Integration with existing equipment	✓							✓	
	Integration with parallel projects / contracts	✓							✓	
	Buildability during operation	✓							✓	
	Obsolescence	✓							✓	
	Ownership or open technology								✓	
3. Environment	Noise and Vibration	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Air Quality and Climate		✓	✓	✓	✓	✓	✓	✓	✓
	Landscape and Visual (including light)	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Biodiversity (flora and fauna)		✓	✓	✓	✓	✓	✓	✓	✓
	Cultural, Archaeological and Architectural Heritage		✓	✓	✓	✓	✓	✓	✓	✓
	Water Resources		✓	✓	✓	✓	✓	✓	✓	✓
	Agriculture and Non-Agricultural		✓	✓	✓	✓	✓	✓	✓	✓
	Geology and Soils (including waste)		✓	✓	✓	✓	✓	✓	✓	✓
	Radiation and Stray Current	✓	✓	✓	✓	✓	✓	✓	✓	✓
4. Accessibility	Impact on Vulnerable Groups	✓	✓	✓	✓	✓			✓	✓
	Impact on the local residents						✓	✓		

CAF Criteria	Sub - Criteria	SET Electrification	OHLE Clearance at Structures	Permanent Way	Level Crossings	Stations	Depot	Depot Access	Substations & Technical buildings	Construction Compounds
& Social inclusion	Stations Accessibility		✓	✓	✓	✓				✓
	Social Inclusion		✓	✓	✓	✓	✓			✓
	Accessibility by Road									✓
5. Safety	Security						✓			
	Ease of supervision. Staff flows						✓			
	Road flows						✓			
	Rail Safety	✓	✓	✓	✓	✓			✓	✓
	Vehicular Traffic Safety		✓	✓	✓	✓		✓		✓
	Pedestrian, Cyclist and Vulnerable Road user Safety	✓	✓	✓	✓	✓		✓	✓	✓
	RAM	✓								
	Structural safety		✓							
6. Physical Activity	Connectivity to adjoining cycling facilities		✓	✓	✓	✓	✓			✓
	Permeability and local connectivity opportunity		✓	✓	✓	✓	✓	✓		
	Health benefits	✓							✓	

Sub-criterion

The criteria and sub-criterion are the measures of performance by which the options were assessed. It is appropriate that the approach should reflect the project objectives and the infrastructural element under consideration. The CAF Guidelines are used as a basis to inform the development of the respective sub-criterion which are adapted based on the individual infrastructural components under examination. For example, level crossing replacements sub-criterion may be different to the substations sub-criterion or construction compounds, etc. and are amended in the respective MCA methodology as appropriate.

This approach allows for consistency but also appropriate flexibility in the approach to the options assessment process. In some cases, some sub-criteria are scoped out - if not deemed relevant to the options assessment under examination.

Comparative assessment

The assessment undertaken is of a comparative nature (options compared against each other). This is based on the CAF criteria and based on professional judgement in respect of the items to be qualitatively evaluated, and comprehensively assessed against the key relevant criteria in accordance with good industry practice.

The assessment compared the relevant options, identifying and summarising the comparative merits and disadvantages of each alternative under all the applicable criteria and sub-criteria leading to a Preferred Option.

A comparative assessment was undertaken for each option developed, where in general, for each positively scored option there must be an opposing negatively scored option. Table 3-4 provides an overview of the comparative colour coded scale for assessing the criteria and sub-criterion. For illustrative purposes, this scale is colour coded with advantageous options graded to ‘dark green’ and disadvantaged options graded to ‘dark brown’.

Table 3-4 Comparative colour coded scale for assessing the criteria and sub-criteria

Colour	Description
Dark green	Significant comparative advantage over all other options
Light green	Some comparative advantage over all other options
Yellow	Comparable to all other options
Light brown	Some comparative disadvantage over all other options
Dark brown	Significant comparative disadvantage over all other options

For each individual assessment the parameter and associated criteria and sub criteria are considered and options are compared against each other based on the comparative scale, ranging from having ‘*significant advantages over other options’* to having ‘*significant comparative disadvantages over other options*.’ Options that are comparable were assigned ‘*comparable across all other options’*. Options were compared under each criterion, before those criterion are aggregated to give a summary score for each parameter. The aggregated assessment considers the potential impacts and significance of those impacts when compared with the other options being assessed. The aggregated scores are compared to establish the options with more advantages over other options arriving at the preferred option. The MCAs are presented in the MCA matrices contained in the individual chapters in this report.

NOTE: A degree of professional judgement was used by the specialist undertaking the assessment. For example, environmental criterion assessments take into consideration the comparative likely potential impact and the significance value of the environmental factor to be impacted which is reflected in the aggregated summary ranking of that criteria.

4. INCREASED PASSENGER DEMAND

The 'Station's Capacity Report' (MAY-MDC-ARC-RS00-RP-A-0003-2) for all stations was completed by IDOM in April 2021. Nine stations along the DART+ West route were reviewed to determine if modification was required to facilitate safe evacuation in an emergency and passenger demand through operations as a result of the increased passenger figures generated by the DART+ West project. Passenger demand figures for the suburban stations are based on the AECOM ERM modelling study and provide for a 2% annual increase to 2043.

The table below shows the results of this study, with the three historic bridges highlighted. Operationally, there are no interventions required as a result of the DART+ West project. With regards to evacuation, there are some upgrades required to ensure safe evacuation from the station with the increase in passenger demand. Given the fact that these upgrades would be required in order to facilitie the project, regardless of the OHLE solution selected, any negative impact on the infrastructure listed below has been considered in the option selection process to give a fair assessment.

Table 4-1 Stations requiring upgrade as a result of DART+ West

Station	Evacuation (Intervention Required)	Year Required by	Operation (Intervention Required)	Year Required By
Drumcondra	• Staircases at Platform 1&2 to be widened by 0.2m • Staircase between the platform and concourse area to be widened by 0.3m	2028	• 1 additional validation gate	2025
Broombridge	• Platform 1 increase of 1.23m	2028	• N/A	N/A
Ashtown	• Platform 1 ramp width to be increased from 1.1m • Platform 2 gate to be increased by 0.42m	2028	• 1 additional validation gate	2048
Castleknock	• Platform 1 door to be widened by 0.63m • Platform 2 doors to be widened by 0.45m	2028	• N/A	N/A
Coolmine	• Platform 1 access corridor to be widened by 0.7m • Platform 2 access door to be widened by 0.45m	2028	• 1 additional validation gate	2036
Clonsilla	• Access to Platform 1 to be widened by 0.83m • Access to Platform 2 to be widened by 0.44m	2028	• 1 additional validation gate • 1 additional validation gate	2022 2056
Leixlip - Confey	• Platform 1: footbridge to be widened by 0.31m • Platform 2: access gate to be widened by 0.44m	2028	• N/A	N/A
Leixlip - Louisa Bridge	• Platform 1: access ramp to be widened by 1.17m	2028	• N/A	N/A
Maynooth	• Access to Platform 2 to be widened by 0.38m	2028	• 1 additional validation gate	2055

Note there are no planned upgrades required at any of the above stations at present, regardless of the DART+ West Project, so any works to the station would be as a direct result of the DART+ West project.

5. CONCLUSION

A robust optioneering process has been undertaken to determine the preferred option for installation of OHLE at each of the three bridges.

The details of the optioneering for each of the three bridges are included in the reports listed below:

1. Technical note for OBG5 Broome Bridge: MAY-MDC-STR-OTHE-RP-Z-0002 – see APPENDIX A
2. Technical note for OBG11 Castleknock: MAY-MDC-STR-OTHE-RP-Z-0003 – see APPENDIX B
3. Technical note for OBG14 Cope Bridge: MAY-MDC-STR-OTHE-RP-Z-0001 – see APPENDIX C

Each of these reports cover the options assessed, their impacts and the outcome of the MCA process. They then conclude with the preferred option selected.

APPENDIX A. Technical Note for OBG5 Broome Bridge: MAY-MDC-STR-OTHE-RP-Z-0002

DART+ West

Iarnród Éireann

Technical note on OBG5 Broome Bridge reconstruction

MAY-MDC-STR-OTHE-RP-Z-0002

27th May 2022

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EXECUTIVE SUMMARY

The report aims to justify the option selected for constructing the Overhead Line Equipment (OHLE) below the OBG5 Broome Bridge to achieve the project's objective.

The potential options are presented and explained in this report and the four options reviewed are:

1. Reduced height OHLE.
2. Vertical Track Lowering.
3. Bridge reconstruction.
4. Track realignment.

No reduced height OHLE solution was deemed feasible due to the existing clearance from top of rail (TOR) to bridge soffit, so any potential special arrangement would need to be combined with another infrastructure intervention. For this reason, this option was not considered acceptable.

Regarding track lowering, while this option minimises the impact on the historic railway bridge and does not require road diversions during construction, the disruption to railway users and operations during construction is significant. In addition, the cost and programme impact of the construction work at the station is greater for this option. A pumped drainage solution could be installed to mitigate the risk of the track flooding due to the new low point in the tracks, but the risk of the tracks flooding remains a concern.

The conclusion of the report is that bridge reconstruction is the preferred option. This option limits the disruption to station and railway users/operators during construction. It has a shorter construction programme, reducing the impacts on residents and does not increase the track flooding risk in this location. It is also the most economical option. It is acknowledged that this option impacts significantly on the protected railway bridge (NIAH reference 50060126), however engagement with a Grade 1 Conservation Architect has taken place to ensure that the reconstruction is done sympathetically and in keeping with the historic canal structure that sits alongside it. Road diversions are required for this option during construction, but traffic assessments have been completed and the impact is deemed minimal.

The new track realignment option was considered an almost unsuitable option due to the position of the bridge in an urban environment and the considerable impact that any deviation from the railway line would have on the surrounding area. The solution involves high construction and land acquisition costs with severe social impact. The current Broombridge station would also be displaced from its current location, further increasing construction and land acquisitions costs. This option was ruled out early on in the optioneering process.

1. INTRODUCTION

1.1 Background

The DART+ West Project will introduce electrified high-capacity trains at the increased frequency for all stations between Maynooth/M3 Parkway and Dublin city centre at Connolly Station and the new Spencer Dock Station (approximately 40 km in length).

OverHead Line Equipment (OHLE) will be required to be constructed to provide electrical power to the trains. All the bridges on the Maynooth Line have been assessed to determine the most appropriate mechanism for OHLE installation.

The technical note titled ‘Option selection for Overhead Line Electrication (OHLE) intervention at OBG5, OBG11 and OBG14’ (document number MAY-MDC-STR-OTHE-RP-Z-0004) gives an overview of the option selection process followed for the installation of OHLE at three specific historic bridges along the route (OBG5 Broome Bridge, OBG11 Castleknock and OBG14 Cope Bridge).

1.2 Purpose of the document

This report aims to justify the option selected to achieve the project objective of electrifying the line and providing OHLE through the OBG5 Broome Bridge.

The report explains the options analysed and the decision-making process to determine the preferred option.

2. OBG5 BROOME BRIDGE

OBG5 Broome Bridge is located on the Maynooth line at Broombridge Station exit towards Maynooth. This arch limestone railway bridge of c.1845 is located at Dublin City County and a listed OB with a National rating. The bridge (over the Royal Canal) and the Royal Canal are dated from 1790.

Broome Bridge is a protected structure and is included in the record of protected structures for Dublin city under reference 909. While the entry in the record of protected structures implies that only the canal bridge is protected, the National Inventory of Architectural Heritage has included the railway and canal bridges under reference 50060126 and they have been assigned a National significance for their architectural, historical, social and technical interest. Both the canal bridge and the railway bridge are listed in the Dublin City Industrial Heritage Record.

Figure 2-1 OBG5 – Broome Bridge

Table 2-1 OBG5 overbridge information

OB	Description	Type of Structure	Use	PS
OBG5	Broome Bridge	Arch Bridge	Cars/Cycles/Pedestrians	No

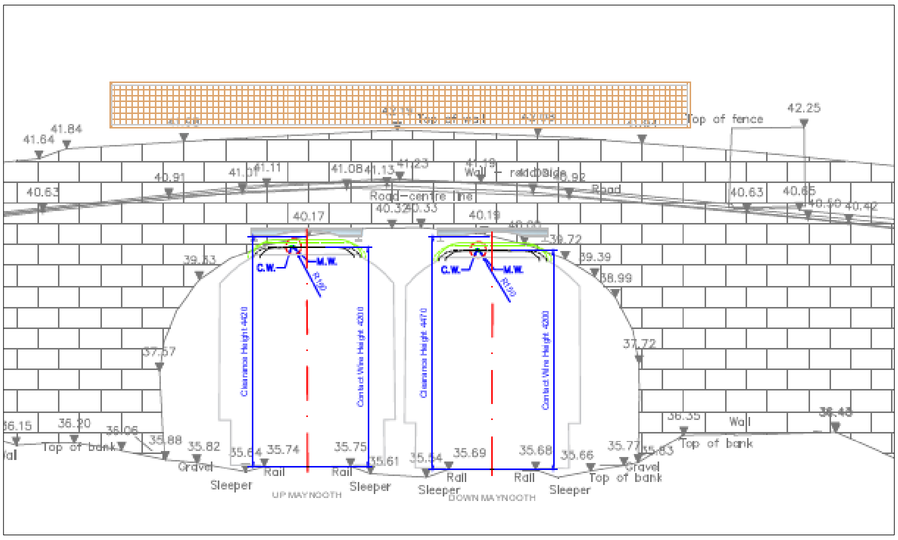

Figure 2-2 OBG5 East elevation existing

The overbridge is a two-span masonry arched bridge, incorporating a span over the railway and one over the Royal Canal. It operates a single lane shuttle traffic system and is 8.5 m wide. There is access to the Royal canal close to the bridge, which means that any road closures have impact on the mobility in the area.

The main constraints found when carrying out the optioneering to provide the required OHLE clearance are listed below:

- Heritage impact on the protected bridge: Any alterations to the bridge is a very significant loss of important historic fabric.
- Location adjacent to Broombridge Station: Options need to consider proximity of the bridge to the existing station and the impact of modifications on station infrastructure (platforms, accesses, footbridge, utilities, fences, etc.).
- Flooding: Flood risk assessments carried out indicate there is an existing risk of flooding at this location.
- Utilities: there are a number of existing services through Broome Bridge crossing over the train tracks and the existing bridge that may need to be diverted.

3. ASSESSMENT OF OPTIONS

The options assessed to construct the OHLE beneath OBG5 Broome Bridge are listed below. The three options reviewed are as follows:

Table 3-1 Options for reduced height OHLE

Options	Description
Option 1	Track lowering to allow a 4400 mm contact wire system
Option 2	Bridge deck reconstruction
Option 3	New alignment solution

The current TOR to soffit clearance of the structure (as per available data) is 4360 mm. This clearance does not allow any reduce height OHLE solution (reference technical note titled 'Option selection for Overhead Line Equipment (OHLE) intervention at OBG5, OBG11 and OBG14' (document number MAY-MDC-STR-OTHE-RP-Z-0004) for acceptable clearance). For this reason, this option was not progressed further.

3.1 Option 1. Track lowering to allow a 4400 mm contact wire system (TOR 4830 mm)

To achieve the required 4400 mm contact wire height, a track lowering was considered. This potential solution would require the vertical lowering of the tracks by approximately 528 mm below OBG5, which would result in lowering works for a length of approximately 600 m. The maximum track lowering required is 891 mm, 80 m west of the end of the platform structures. Whilst this is a technically feasible solution, some substantial issues were identified, as identified below.

3.1.1 Broombridge Station

Lowering the tracks requires extensive modifications to the existing station infrastructure, including platforms, accesses, footbridge, utilities and fences. This impact is the most problematic issue related to track lowering at OBG5 in the proximity of Broombridge Station. It would require, in effect, platform and surroundings reconstruction. These works would have a significant cost implication and would severely impact station functionality during the extensive construction period required.

Figure 3-1 Broombridge station platform and LUAS interconnection

3.1.1.1 Structural inventions required

3.1.1.1.1 Introduction

Near the OBG5 Broome Bridge, there are many existing structures, including the existing access ramp to OBG5, OBG4A footbridge, and platform structures.

With the proposed track lowering solution a maximum track lowering of 891 mm has been proposed on the west of the platforms. The platform structures must be modified to adapt to this new longitudinal alignment, thus impacting the footbridge and the access ramp structure.

The interventions on existing structures in this location have been summarised in the following list:

a) The existing access ramp to OBG5 between the Canal and the track needs to be rebuilt.
b) The platform structures on both sides of the track need to be demolished and rebuilt.
c) The existing OBG4A footbridge needs to be demolished and rebuilt to current standards.

Figure 3-2 Track lowering structural intervention – Plan view

3.1.1.2 Existing structures

The following list is the existing structural drawings received from IE, which have been used to carry out the initial structural assessment described in this report:

- OBG5-1680.372

The drawing only shows the existing railway arch bridge structure (OBG5). There is no existing structural information on the access ramp, OBG4A footbridge, and platform structures so assumptions have been made in order to assess the impact of track lowering on these structures.

3.1.1.3 Longitudinal alignment of the proposed track lowering

The figure below shows the proposed track lowering solution at this location. The maximum proposed track lowering is approximately 0.90 m at the west side of OBG5 (chainage 61+160). At OBG5 (chainage 61+090), the proposed track lowering is approximately 0.53 m, and it goes shallower toward OBG4A.

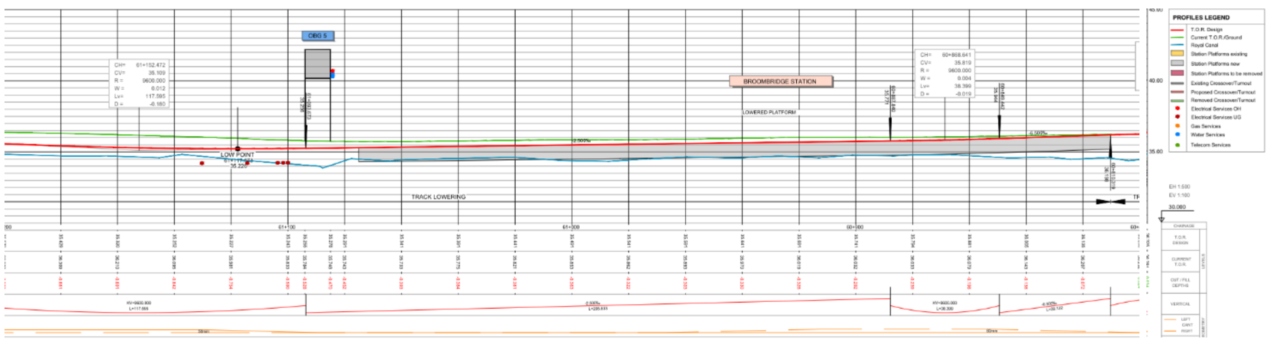

Figure 3-3 Longitudinal alignment of the proposed track lowering

3.1.1.4 Impact on the existing structures

3.1.1.4.1 Chainage 60+890 to 61+070 (existing platform structures)

The total length of the existing platforms is around 180 m. The overall depth of the track excavation is circa 1270 mm which must be done in two steps. Firstly, the track lowering work will be carried out only on one track. Secondly, the track lowering work will be carried out on another track. A temporary sheetpile will be required between the two tracks during the track lowering work.

The Up and Down track platform retaining wall structures must be demolished and rebuilt to adapt to this new longitudinal alignment.

3.1.1.4.2 Chainage 61+010 to 61+093 (railway arch bridge with the existing access ramp structure)

According to the Final GI Factual Report -DART+ OBG5, the existing foundation has not been discovered at a depth of 1.20 m measured from the existing sleeper and a horizontal distance of 0.80 m measured from the existing abutment surface. The proposed track lowering in this area is between 0.47 m to 0.53 m. However, deeper excavation is required to accommodate drainage, platform foundations and track foundations. Therefore, soil improvement is necessary around the existing foundations before any excavation work on the track.

For the existing access ramp to OBG5, the proposed track lowering at this location is between 0.38 m and 0.47 m. Besides, the proposed drainage, track, and platform design require further excavation than the proposed track lowering, significantly impacting the existing foundations. Therefore, it is assumed for the purposes of the optioneering exercise that the existing ramp wiil be demolished and rebuilt.

Figure 3-4 Existing access ramp to OBG5

In addition, steel corrosion has been noted on the beams and supports of the existing access ramp structure. Further structural assessment and additional information will be needed if the existing ramp has to be maintained.

Figure 3-5 Steel corrosion on beams and supports

3.1.1.4.3 Chainage 60+910 (existing footbridge structures)

For the existing footbridge OBG4A, the proposed track lowering at this location is around 0.30 m. The proposed drainage, track, and platform design require further excavation than the proposed track lowering level, significantly impacting the existing foundations. Therefore, it is proposed that the existing footbridge be demolished and rebuilt to current standards. Further structural assessment and additional information will be needed if the existing footbridge has to be maintained.

The access stairs to the existing tram must be modified to adapt to this new longitudinal alignment.

Figure 3-6 Existing footbridge OBG4A

3.1.2 Flooding issues

If the track lowering was to be implemented at OBG5, the tracks need to be lowered by 528 mm below OBG5. The level of the Royal Canal at this point is 35.18 m. After the lowering, the track levels (Top of Rail) would be 35.23, which (considering the depths of the rail and the sleepers, 160 mm and 200 mm, respectively) would locate the top of the ballast layout at level 34.87, which is below the canal water level.

In the early stages of the project, the MAY-MDC-ENV-ROUT-RP-D-0001 Stage 1 & 2 Site Specific Flood Risk Assessment reports a flooding episode at Broombridge Train Station on 24th October 2011. The report determined that the event appears to have been caused by extreme rainfall in combination with a series of blockages in the surface water drainage network and Royal Canal.

The subsequent MAY-ROD-ENV-ROUT_RP-D-0001 Site-Specific Flood Risk Assessment confirms the preliminary assessment and proposes the implementation of flood management measures. These include implementing flood resilient design and materials, demountable barriers, and a flood emergency response plan. At OBG5 the current track alignment already presents a low point just below the overbridge so by lowering this section further, a potential flooding issue becomes more likely due to the barrier effect of the canal, contrary to the recommendations of the assessment.

In addition, further to the generally increased risk to flooding from lowering the track, the change from diesel (DMU's) to electrically powered trains (EMU's) will reduce the vertical allowance from the distance between the rolling stock and the water surface by approximately 200 mm; meaning accepted flood levels would be an additional 20 0mm lower than they currently are.

Considering all of the above points, track lowering would increase the risk of flooding at this location and the tracks would require the implementation of a pumped drainage system in order to mitigate against this increased risk. In case of failure of the pumping system, or blockages, flooding may occur, which in turn would cause an operation closure. All of these factors would put the operational railway at increased risk.

Figure 3-7 Broombridge Station and the Royal Canal view

3.1.3 Drainage issues

Based on existing information, UBG5A, located about 530 m west of OBG5, is the closest culvert to OBG5 into which a railway lineside drainage can be discharged.

After the track lowering, the lowest point track level at OBG5 is 35.23 mOD.

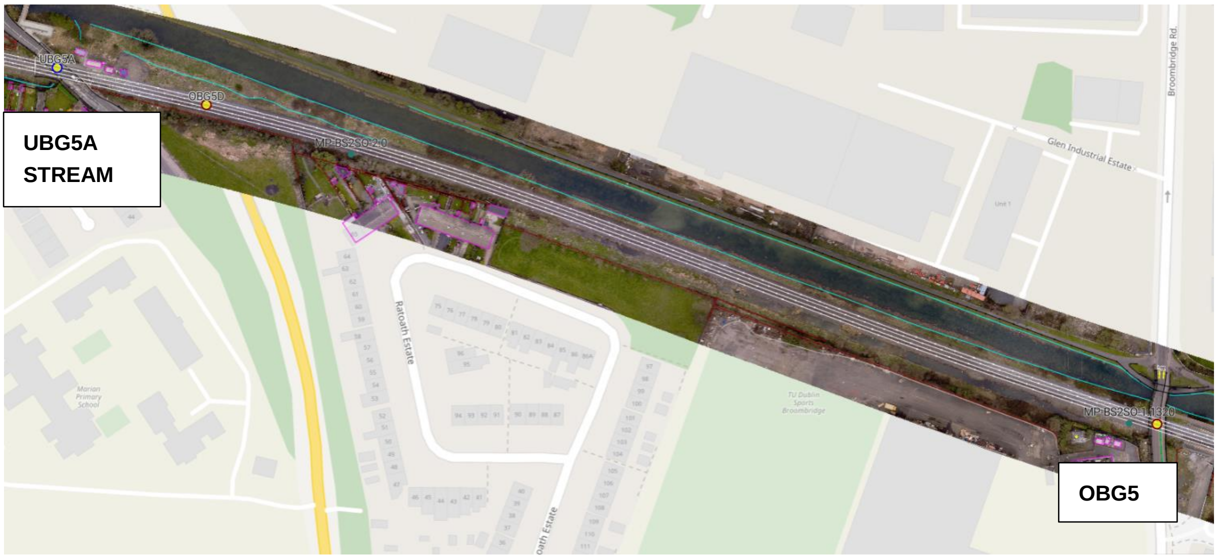

Figure 3-8 Broome Bridge UBG5A location

The invert level of the UBG5A is circa 36.5 mOD.

A gravity drainage system from OBG5 towards UBG5A is not feasible, so a pumped drainage system is required, and it has been considered and cost. This option would introduce increased operational costs and operational safety risks to the operator as a result of the regular maintenance required. Pumped drainage also has the possibility of failure and so if this failure coincided with a flood event, this would cause the railway to close.

3.1.4 Utilities

The utilities running across the tracks are listed below.

Table 3-2 Utilities across the tracks

Serial Number	Description	Location	Intervention Type	Utility	Description	Potential Diversion	Duct Type
OBG5	Broombridge Road - Stone bridge, three centres arches	Northside, Dublin	**Track Lowering**	ESB	MV/LV underground duct across rail track and Royal Canal	Yes	3x1x185 XLP
					MV/LV underground duct across rail track and Royal Canal	Yes	3x1x185 XLP
					MV/LV underground duct across rail track and Royal Canal	Yes	3x1x185 XLP
					MV/LV underground duct across rail track and Royal Canal	Yes	3x1x185 XLP
					HV underground duct across rail track and Royal Canal	Yes	3x1x630
				IW	Underground watermain pipe across rail track and Royal Canal. Referred to as ´clash pipe´.	Yes	Cast Iron 609.6mm

The track lowering impacts on 3 MV/LV ESB lines, 1 HV ESB line and 1 water main pipe.

Further surveys would be required to confirm depth of these utilities to confirm if diversions/protection of the utilities is required

Given the unknown depth of these utilities it is not possible to estimate the impact these utility diversions would have on operations, cost and programme. However this has been noted in the option assessment.

3.2 Option 2. Bridge deck reconstruction

3.2.1 Description

To achieve a sufficient vertical clearance for the catenary equipment under the bridge, the precast arch deck solution has been proposed. The new arched bridge deck shall be installed approximately 620 mm higher than the original bridge arch position.

With this bridge deck reconstruction and the lifting of the soffit of the arch, no significant impact on the connection of the existing pedestrian bridge to Broombridge Station is expected.

This structural solution may have an impact on the adjacent arch bridge above the Royal Canal; therefore, it is proposed to use a lightweight fill for the road backfill to the new elevation to reduce the additional dead load on the arch and the abutments. However, it is necessary to carry out a load test on the bridge to monitor the arch structure's movement to ensure the safety of the design.

Furthermore, after carrying out the load test, the need for strengthening of the adjacent arch barrels should be studied based on the load test result in the further stages of the project to ensure the safety of the structure.

The adjacent arch limestone canal bridge of c.1790 is a protected structure with historical value; therefore, it must be carefully protected during the bridge deck reconstruction works.

Three structural solutions were proposed to increase the vertical clearance of the bridge (the current worse clearance from TOR to soffit is 4360 mm):

- Structural solution 3A: Precast arch deck
- Structural solution 3B: Precast frame deck
- Structural solution 3C: Arch Lifting

The solution 3C was deemed the most sympathetic alteration. Nevertheless, it has a higher risk compared to solutions 3A & 3B, due to it being an innovative solution with limited experience.

The differences between the solutions 3A & 3B are the deck shape and the required lift height. Solution 3A, the precast arch shape, is maintaining the geometry of the current stone arch with a less negative aesthetic impact compared to the precast frame shape solution.

Although the solution 3B of the precast frame shape allows the height of the bridge arch to reduce its shape slightly, it has a very significant negative visual impact. Therefore, the solutions 3A has been considered as the optimal solution in terms of structural modification and a 620 mm increase in arch height is required.

One advantage to reconstructing the bridge is that the railway bridge arch would be rebuilt to current structural design standards. The existing arch is thought to have been constructed around 1845 and so rebuilding the arch to current design standards would provide a compliant structure.

The following figure shows OBG5 Broome Bridge with the precast arch deck solution.

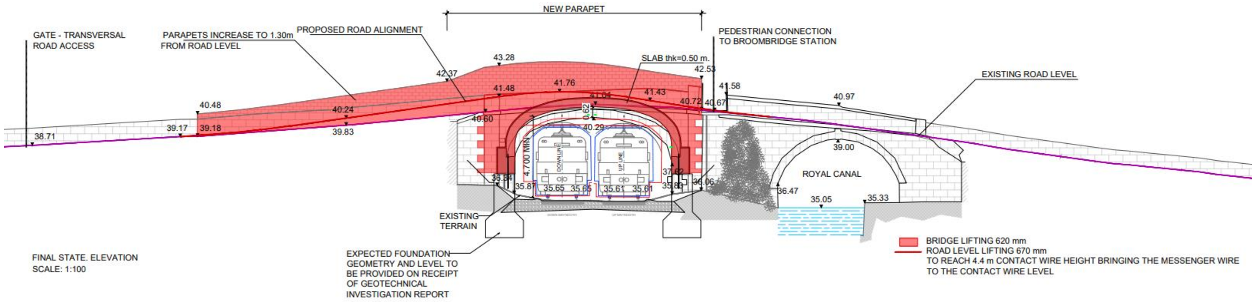

Figure 3-9 Deck reconstruction of the OBG5. Elevation

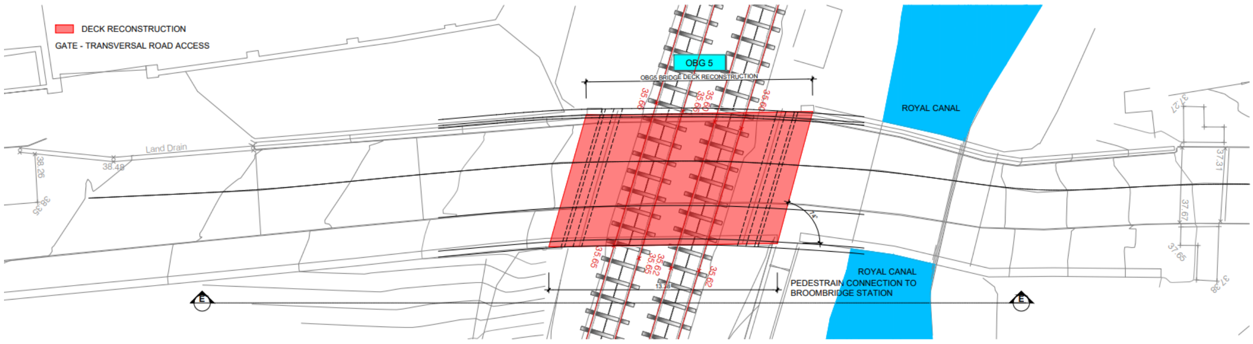

Figure 3-10 Deck reconstruction of the OBG5. Plan view

To ensure the new section of the bridge is constructed in line with heritage considerations, all of the design elements will need to be carefully considered in relation to the historic setting and, in particular, the remaining canal bridge. All junctions and interventions will need to be rigorously detailed to ensure the two bridges sit comfortably together in the landscape.

The bridge arch deck reconstruction would result in the following impacts:

- Considerable impact on the rail and canal bridges in terms of heritage.
- Closure of the road during construction would require traffic and pedestrians/cyclists to divert to other crossing locations.
- Utilities: through OBG5, there are existing utilities that would need to be diverted temporarily if the bridge deck is modified.

The above points have been considered in more detail in the following sections.

3.2.2 Heritage impact and considerations

The removal and replacement of the span of Broome Bridge over the railway line is a very significant loss of important historic fabric. This will have a considerable impact on the character of the setting, surrounding environment and the remaining canal bridge, dating from the 1790's. As this technical note identifies, the bridge could be retained but at a significant financial and programme cost. From a conservation perspective it would have been preferable to incorporate the welcomed new infrastructure into the existing setting while retaining this important historic structure.

To mitigate the loss of this historic structure as much as possible, it is essential that the replacement section of the bridge is well designed, detailed and executed. The most important consideration in the process will be to ensure that the new build element sits comfortably alongside the remaining canal bridge.

Due to the significant raising of the bridge to accommodate the OHLE and the requirement to install a precast concrete arch, it will not be possible or desirable to reconstruct the span to match the existing. Instead, a contemporary solution using modern materials will be designed to complement the proportions and style of the remaining canal bridge. The extent of demolition will be confined to the section of bridge between the stone piers to ensure that the reconstructed section will be read as an insertion rather than an entirely new bridge. The colour and texture of the concrete finish, along with the quality of the detailing and workmanship will be critical to its success. Research into materials and sample panels will be essential prior to construction to ensure the new concrete finish complements the remaining historic stonework. The junctions between old and new will need to be carefully considered, particularly the change in levels between the two spans, the parapets, and the interface between the original stonework and new concrete facing at the piers.

A number of finishes and construction methods were assessed during the design process. Initially the preferred option was to re-use the original facing stone, but it became clear that this would not be successful due to the technical constraints of the new construction. The string course is an essential element of the existing composition, but the increased height of the arch would distort its connection to the string course over the canal. The precast arch construction would reduce the existing voussoirs to cladding stones and the facing stone of the spandrels would also become cladding stones tied back to the concrete structure behind . The combination of all these factors made it very difficult to design or build stonework that would sit well with the original fabric on each side.

The use of a weathered steel facade was also explored as this material is being used on newbuild elements elsewhere in the project. After careful assessment it was decided to proceed with a concrete finish as this will sit most comfortably with the remaining original stonework. Provided a suitable colour and finish are achieved on the concrete, it should complement, not dominate the original structure.

Figure 3-11 OBG5 Broome Bridge Photomontage - Canal View West

Figure 3-12 OBG5 Broome Bridge Photomontage Canal View East

It is a safety requirement that the parapets are a minimum of 1800 mm high and the bottom 1200 mm must be solid, in the area of the OHLE. This presents a significant challenge to all of the historic bridges along the scheme, as the existing original parapet heights are lower than 1200 mm. A rigorous design process has taken place to identify a solution that will complement the historic setting and maintain a visual connection to the rail lines and surrounding landscape, when on the bridge. It was also considered essential that the parapet would not be a dominant feature while viewing the bridge from the canal. The proposed design is a contemporary, adaptable solution that can be implemented throughout, bringing a degree of uniformity to all interventions along the railway. For Broome Bridge it is proposed to provide a solid metal panel from the top of the parapet up to 1200 mm with an expanded metal mesh to continue up to 1800 mm. The fixing stays and mesh will be carefully designed to ensure the internal face of the parapet is not obscured and that the mesh allows a good visual connection to the surroundings.

To ensure the new span over the railway is successful, all elements of the design will need to be carefully considered in relation to the setting, and in particular, the remaining canal bridge. All junctions and interventions will need to be well designed and detailed to ensure the two phases of construction sit comfortably together and in the landscape.

3.2.3 Road closure and impact on the community

In order to reconstruct the bridge road closure will be required. This includes:

- 15 weeks of total road closure
- 19 weeks of partial road closure (one lane open)
- 13 weeks pedestrian/cyclist closure

For the road closure of 15 weeks, a diversion route has been proposed. The impact of this road closure has been assessed in the Traffic and Transport chapter of the EIAR, and the impact is deemed to be a minimal short term impact.

Pedestrian and cycle closure will have a bigger impact as the diversion route would be a significantly longer route for the 13 week closure. It is therefore proposed to construct a temporary pedestrian and cycle bridge over the canal as per the figure below. This cost has been included in the costing for this option.

Figure 3-13 Temporary pedestrian and cycle bridge diversion route

3.2.4 Utilities

Utilities along the bridge deck must be diverted.

Table 3-3 IDO6 utilities along the bridge deck

Serial Number	Description	Location	Intervention Type	Utility	Description	Potential Diversion	Duct Type
OBG5	Broombridge Road - Stone bridge, three centres' arches	Northside, Dublin	**Bridge Deck Reconstruction**	Electricity	ESB - MV/LV - no. 2 underground duct across bridge deck;	Yes	N/A
				Gas	None	None	None
				Water	IW - Water main - no 1 duct running across bridge deck;	Yes	Cast Iron
				Telecoms	none	None	None

In locations where bridge modification is needed, utilities within the bridge deck are proposed be temporarily diverted during the deck reconstruction.

Temporary diversions will be supported by the construction of scaffolding that will run parallel to the original deck, separated by a safe margin to ensure it remains intact during the reconstruction process. The scaffold platforms, which shall be formed above the bridge soffit level, will consist of a wooden board screwed down over netton mesh sheeting and returned vertically at the edge of the footboards, and they shall be formed above the bridge soffit level. In addition, scaffolding shall be fully enclosed with plastic sheeting, and boards shall be securely lashed together and tied down at teach end. Working surfaces on the scaffold shall only be accessed by site personnel.

Figure 3-14 Scaffold for temporary diversion

By means of the scaffolding, the affected utilities can be diverted from one side of the track to another by a temporary conduit laid on the scaffold platforms. Prior to connection to the temporary conduit, the affected utilities must be cut off behind the abutments.

In general, the disruption time of the service is mainly due to the connection of the temporary diversion. This is expected to be hours, but it will depend on the utility, the intervention and the location. To minimize the disruption time, the temporary diversion, ducting and the connections must be planned properly.

Scaffolding can be erected during night-time/weekend possessions.

3.3 Option 3. New alignment solution

This solution consists of a diversion of the track layout that avoids going through the OBG5 and thus manages to avoid the clearances issue completely.

It is an almost unsuitable option, due to the position of the bridge in an urban environment and the considerable impact that any deviation from the railway line would have on it. The solution involves a high construction and land acquisition with severe social impact. The current Broombridge station would also be displaced from its location, and it would be necessary land and acquisitions costs.

This option was ruled out early on in the optioneering process and was not progressed further.

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4. COST AND PROGRAMME IMPACTS

4.1 Track Lowering

4.1.1 Construction duration

The following table indicates the estimated duration for the track lowering option.

Table 4-1 Estimated duration of the works

Track lowering and footbridge reconstruction
15 months

Note that durations have been estimated high level at this stage of design. Note this assumes implementation of a pumped drainage system.

The construction strategy for the track lowering and station works is proposed as follows:

1. Utility diversions within the station and track lowering area.
2. Installation of track crossovers (night-time possessions) to allow for track cross overs during track lowering and platform works
3. Demolition of existing footbridge and ramps, if necessary (full weekend closure required on both tracks)
4. Platform works on the Platform 1 (180 m)
    - 4.1. Installation of temporary sheet piles between the Up and Down tracks (both tracks closed, to be done either in weeknight or weekend possessions)
    - 4.2. Demolition of existing Up track, platform, elements and RC retaining walls (Up track closed for duration)
    - 4.3. Construction of platform structures and footbridge foundations (if necessary), and new Up track elements (Up track closed for duration)
    - 4.4. Installation of drainage system and pumping station (Up track closed for duration OR weeknight or weekend possessions)
5. Platform works on the Platform 2 (180 m)
    - 5.1. Demolition of existing Down track, platform elements and RC retaining walls (Down track closure for duration)
    - 5.2. Construction of platform structures and new Down track elements (Down track closure for duration)
    - 5.3. Installation of drainage system (Down track closed for duration OR weeknight or weekend possessions)
    - 5.4. Removal of temporary sheetpiles between the Up and Down tracks (weeknight or weekend possessions)
6. Installation of the new footbridge, ramps and lifts (if necessary and deemed required by IE) (full weekend closure required on both tracks, plus night-time possessions)
7. Boundary walls fences and accesses (daytime or weeknight/weekend possessions depending on activity)

The following table shows an indicative sequence of activities:

Table 4-2 Indicative programme for track lowering

		M1				M2				M3				M4				M5				M6				M7				M8
Activity	Duration	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29
1- On site offices and welfare facilities	**2 weeks**	🟩	🟩																											
2- Utilities and existing services diversions	**8 weeks**			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																			
3 - Installation of track turnouts	**1 week**											🟧																		
4- Demolition of existing footbridge and ramp, if necessary	**1 weekend**												▨																	
5- Platform works (all the northern of 180m)	**18 weeks**																													
Installation of temporary sheetpiles between the Up and Down tracks	1 week													🟧																
Demolition of existing Up track, platform elements and RC retaining walls	4 weeks														▨	🟨	🟨	🟨												
Construction of platform structures and footbridge and ramp foundations (if necessary), and new Up track elements	12 weeks																		🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
Installation of drainage (including pumping station)	3 weeks																									🟨	🟨	🟨	
6- Platform works on southern platform of 180m	**16 weeks**																													
Demolition of existing Down track, platform elements and RC retaining walls																														
Construction of platform structures and footbridge foundations (if necessary), and new Down track elements																														
Installation of drainage	2 weeks																													
Removal of temporary sheetpiles between the Up and Down tracks	1 weekend																													
7 - Removal of track turnouts	**1 week**																													
8- Installation of the new footbridge, ramps and lifts (if necessary)	**11 weeks + 1 full weekend**																													
Construction of the new footbridge, ramps and lifts, if necessary (to be checked once the final footbridge solution is defined)	11 weeks + 1 full weekend																													
9-Boundary walls fences and accesses; making good station	**3 weeks**																													

					M9				M10				M11				M12				M13				M14				M15
Activity	Duration	W30	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57
1- On site offices and welfare facilities	**2 weeks**																												
2- Utilities and existing services diversions	**8 weeks**																												
3 - Installation of track turnouts	**1 week**																												
4- Demolition of existing footbridge and ramp, if necessary	**1 weekend**																												
5- Platform works (all the northern of 180m)	**18 weeks**																												
Installation of temporary sheetpiles between the Up and Down tracks	1 week																												
Demolition of existing Up track, platform elements and RC retaining walls	4 weeks																												
Construction of platform structures and footbridge and ramp foundations (if necessary), and new Up track elements	12 weeks																												
Installation of drainage (including pumping station)	3 weeks																												
6- Platform works on southern platform of 180m	**16 weeks**																												
Demolition of existing Down track, platform elements and RC retaining walls		▨	🟫	🟫	🟫																								
Construction of platform structures and footbridge foundations (if necessary), and new Down track elements						🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫												
Installation of drainage	2 weeks											🟫	🟫																
Removal of temporary sheetpiles between the Up and Down tracks	1 weekend																	▨											
7 - Removal of track turnouts	**1 week**																		🟧										
8- Installation of the new footbridge, ramps and lifts (if necessary)	**11 weeks + 1 full weekend**																												
Construction of the new footbridge, ramps and lifts, if necessary (to be checked once the final footbridge solution is defined)	11 weeks + 1 full weekend																		▨	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧
9-Boundary walls fences and accesses; making good station	**3 weeks**																										🟩	🟩	🟩

Note 1: From Week 13 to 29 temporary fences will be placed at th ck. 1 full weekend possesion is also required during week 13.
ck for the safety measures and to allow the operation of the Up track. 1 full weekend possesion is also required during week 30.
Note 3: From Week 11 to week 57 the footbridge is not accessible, hence the Up platform is not accessible and considered closed to passengers.
Note 4: The canal will also be closed from Week 13 to 29.

Railway operation
- 🟨 Up track railway closure
- 🟫 Down track railway closure
- 🟧 Night time possession works required
- ▨ Full weekend closure on Up & Down tracks
- 🟩 Daytime (No railway closure required)

4.1.2 Disruption of services

Road closure

For the track lowering option, the road would not be impacted. However, from week 11 to week 57 the pedestrian footbridge (labelled 'c' on the figure below) over the railway will not be accessible, meaning pedestrians will need to use the existing historic bridge to cross the railway. If the ramp (labelled 'a' on the figure below) is also required to be demolished it may not be possible to access the Up platform for this 46 week period.

A temporary bridge over the canal or some construction sequencing may be possible to keep disruption to a minimum and should be studied further at a later stage of design, should this option be taken forward.

Figure 4-1 Infrastructure elements affected

Station closure

For the track lowering option, it will require around 15 weeks of the Up-track closure to carry out the platform and foundations works. During this period (from Week 15th to 29th) temporary fences will be placed at the Up track as a safety measure and to allow the railway operation of the Down track. Once the Up-track work is finalized, the works will continue on the Down track. It will require around 15 weeks of the Down-track closure to carry out the platform and foundations works. During this period (from 31st to 45th) temporary fences will also be placed at the Down track as a safety measure and to allow the railway operation of the Up track. Considering the current constraints (i.e., site clearance and spatial limitation between the existing Up and Down tracks), it will be challenging to carry out the construction work while maintaining the operation of both the Up and Down track. During the platform demolition and foundation construction work, several weeks of night closure and weekends closure on both Up and Down track will be required. Detailed safety measures will be required in the following design stages to mitigate any possible risk on people during the construction work.

The figures below show an example of the set up required to close one track in order to complete platform reconstruction works.

Figure 4-2 Example of track closure required to complete platform works

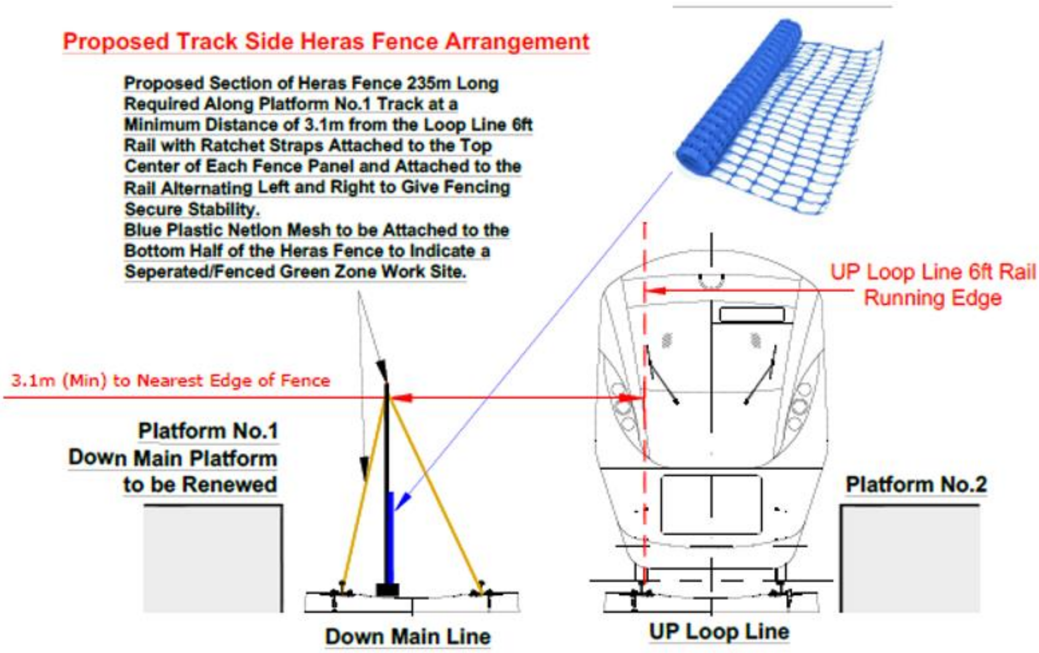

Figure 4-3 Required working space when working next to a live rail line

The closure of one track for demolition work and reconstruction of the adjacent platform means that the line needs to be operated on a single bi-directional track section.

The nearest crossovers to Broombridge Station that allows for track switching are located at Clonsilla to the west (about 8.7 km away) and to the east at Glasnevin, about 1.4 km away for left turns movements, and Dublin (Newcomen Bridge) about 3.0 km away for right turns movements. This would result in the line operating on a single bi-directional track between Clonsilla and Dublin (about 11.7 km) resulting in operational constraints for the operator.

To avoid this situation, temporary turnouts could be provided at each end of the station (beyond the track lowering area) to allow trains to pass through the station on a single track section for approximately 900 m in length.

In the first phase, while work is being done on Platform 1 and the Up track is closed, and the Down is a single track. Two provisional turnouts would allow the change from the Up to the Down and vice-versa.

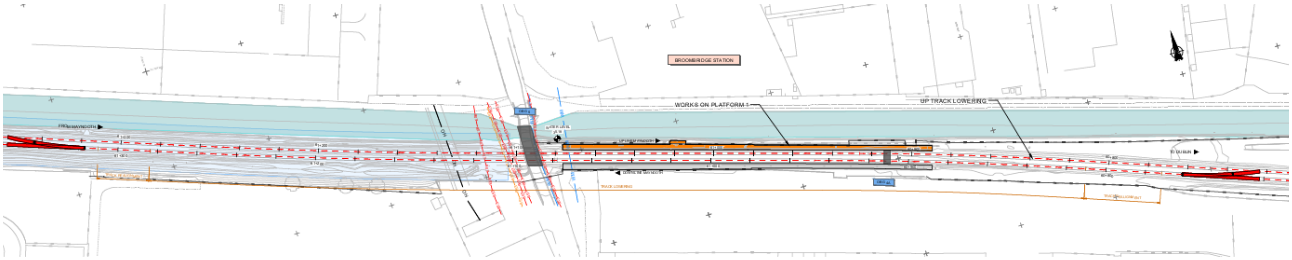

Figure 4-4 Works at Platform 1. Up track closed. Trains running through Down track

In the second phase, works are carried out at Platform 2 and the Down track is closed; meanwhile, the Up track is the single running line. For this situation, the provisional turnouts have to change sides.

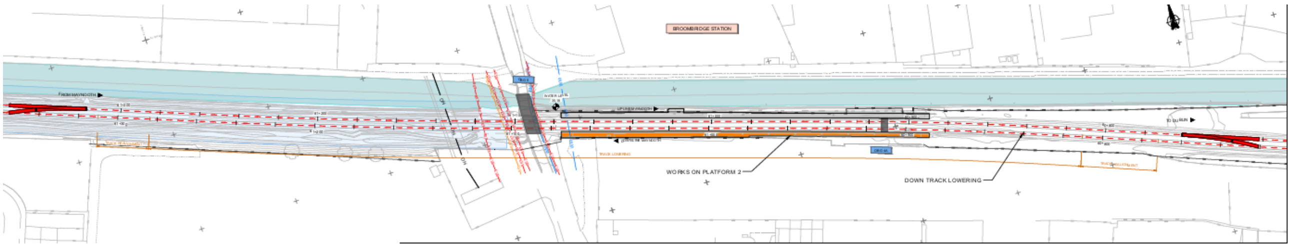

Figure 4-5 Works at Platform 2. Down track closed. Trains running through Up track

Temporary signalling works will also be required in order to implement these temporary turnouts, which adds additional cost to these works.

In summary, the Up and the Down platform would require disruptive interventions for 15 weeks each platform. Pedestrians may require to be diverted for 46 weeks if both the station footbridge and the ramp need to be demolished and reconstructed. The disruption of service to the station may need to be mitigated by provision of a shuttle bus service to bring the passengers to and from Broombridge Station. This would need to be agreed with IE operations should this option be considered.

Table 4-3 indicates the summary of the estimated time of disruption.

Table 4-3 Estimated time of disruption

Track lowering and footbridge reconstruction	
Road closure	Potential pedestrian diversion for 46 weeks (TBC)
Railway closure	15 weeks on the up track and 15 weeks on the down track;

4.1.3 Cost estimate

The table below indicates the estimated cost of the track lowering option.

Table 4-4 Estimated cost

Track lowering (*) (€ '000)
13,035

(*) Cost includes reconstruction of the station infrastructure, track lowering and drainage system. Excludes the operational costs of the pumped drainage system. Excludes transporting passengers by bus.

4.2 Bridge Reconstruction

4.2.1 Construction duration

The table below indicates the estimated duration for the bridge reconstruction option.

Table 4-5 Estimated duration of the works

Bridge modification
10 months

Note that durations have been estimated high level and can be refined during detailed design.

The construction strategy for the bridge modification is proposed as follows:

1. Traffic and utility diversions shall be carried out before the arch deck reconstruction, including site setup, accommodation works, utility diversions, earthworks, and pavement works
2. Soil improvement behind the existing wall using jet grouting
3. Excavation, deconstruction of the surface of the existing arch (existing masonry to be reused for surfacing and finishing work where applicable) and demolish the inner upper part of the existing arch structure. The pavement and backfill on the Royal Canal arch to be removed temporarily and symmetrically to avoid uneven loads on the Royal Canal arch, if necessary. A protective element should be placed to protect the parapets and the stone face of the Royal Canal arch.
   a. Underpinning of existing foundations using lateral micropiles to strengthen existing foundations, if necessary
4. Placing of the precast concrete wall blocks for arch support and anchoring to the existing walls with dowel bars
5. Placing of the precast concrete arch deck
6. Waterproofing membrane on the precast concrete arch deck and precast concrete wall blocks
7. Backfill to bedstone behind the vertical walls to consist of semi-dry mortar not less than 750 mm in width
8. Reconstruction of the road
9. Make good restoration work along the deck to integrate aesthetically with the arch bridge
10. Load test to be carried out on the adjacent canal bridge before allowing the road traffic to pass over
11. Place temporary jersey barrier (or similar) in the carriageway to allow vehicles and pedestrians to cross, reinstallation of diverted utilities
12. Repair the pavements and parapets in accordance with conservation architects' requirements.

The following table shows an indicative sequence of these activities:

Table 4-6 Indicative programme for bridge modification

		Month	1				2				3				4				5				6				7				8				9				10			
		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1. Site preparation	Traffic and utility diversions, etc.																																									
2. Soil improvement																																										
	Soil improvement behind existing wall								x	x																																
3. Excavation and deconstruction & demolition of existing structure																																										
	Excavation to the wall below springer level										x																															
	Deconstruct the surface of arch structure and arch support										x																															
	Demolish the inner part of arch structure and arch support											x																														
3a.	Foundation strengthening, if necessary																																									
4. Deck support reconstruction																																										
	Concrete wall blocks												x	x	x																											
5. Deck reconstruction																																										
	Precast arch deck												x	x	x																											
6. Deck waterproofing																																										
	Waterproofing membrane															x	x																									
7. Backfill																																										
	Backfill to bedstone behind walls																	x	x	x	x																					
8. Road modification to a new level																																										
	Road modification																			x	x	x	x	1	1	1	1															
	Finishing																											1	1	1												
9. Restoration																																										
	Restoration work																			x	x	x	x																			
10. Reinstallation of diverted utilities																																										
	Place temporary jersey barrier (or similar), utilities diversions																							1	1	1	1	1	1	1	1	1	1	1	1							
11. Deck																																										
	Parapets																																		1	1	1	1	1	1		
	Finishing, load test to be carried out on the adjacent canal bridge before allowing the road traffic to pass over																																								1	1

Total construction duration:	40 weeks
Railway closure:	4 full weekends of possession +11 weeks of night closure working on the railway + 1 weeks of total railway closure
Total road closure:	15 weeks
At least one-lane road closure:	15 weeks (total closure) +19 weeks (one-lane closure) = 34 weeks
Pedestrian total closure:	13 weeks

Road closure
- x Total road closure
- 1 One lane road closure

Railway operation
- Close to railway
- Service total closure
- Full weekend closure
- Week of night closure
- No railway closure required

Note: From 20th week the temporary jersey barrier (or similar) will be placed in the carriageway and in 20th and 21st weeks temporary pedestrian ramps will also be placed to allow pedestrian to cross.

Note: From 20th week the temporary jersey barrier (or similar) will be placed in the carriageway and in 20th and 21st weeks temporary pedestrian ramps will also be placed to allow pedestrian to cross.

4.2.2 Disruption of services

Road closure

Within the estimated time for the bridge modification:

- the road would be closed to vehicles for 15 weeks, with a one lane closure for a further 19 weeks. Note Chapter 6 Traffic and Transport of the EIAR states that the construction impact of this diversion is 'slight' and 'temporary'.
- The bridge would be closed to pedestrians for 13 weeks. However, a temporary bridge could be provided over the canal to the Up platform to allow access to the station platforms during the works, and would allow pedestrians/cyclists to cross from one side to the other (see section 3.2.3 for proposed route).

Station closure

As shown in the above design chart, the total construction duration is estimated at approximately **40 weeks.**

For the bridge modification, the station would be closed during four-weekend track possessions and 1 full week for stages 2 to 3.

The table below indicates the summary of the estimated time of disruption.

Table 4-7 Estimated time of disruption

Bridge modification	
Road closure	15 weeks total closure; further 19 weeks one lane closure; pedestrian diversion via existing station footbridge required for 13 weeks.
Station closure	4 full weekends and 1 full week

4.2.3 Cost estimate

The table below indicates the estimated cost of the bridge reconstruction option.

Table 4-8 Estimated cost

Bridge modifications (*) (€ ‘000)
1,573

(*) Cost includes the diversion of the existing utilities and temporary bridge crossing over the canal during construction.

5. SELECTION OF PREFERRED OPTION

5.1 Multicriteria Analysis (MCA)

In order to address the problem of clearance in this particular structure, a dedicated multi-criteria analysis (MCA) has been undertaken to consolidate the impacts of each option.

The feasible options included in the MCA process are listed in the table below:

Table 5-1 MCA Options

Options	Description
Option 1	Track lowering to allow a 4400 mm contact wire system
Option 2	Bridge deck reconstruction

5.1.1 Option 1. Track lowering to allow a 4400 mm contact wire system

5.1.1.1 Description

Option 1 to achieve 4400 mm contact wire height requires the lowering of the tracks approximately 528 mm directly below OBG5, as described in the previous sections.

The main advantages of this option are:

- Historic bridge is not affected by the works
- No disruption to road users using OBG5 to cross the canal and railway at this location.

The disadvantages of this option are:

- It requires extensive work in and around the station platforms, accesses, footbridges, utilities, fences, etc. requiring track closures and disruption to passengers.
- The Royal Canal is very close to the tracks and the creation of a longitudinal profile low point in the tracks increases the risk of flooding during heavy rainfall. This requires a new pumped drainage system to be installed. If a failure of the pumped drainage system occurs during a flood event, the railway could be forced to close.
- Flooding risk from the Royal Canal requires further investigation to verify this option.
- This option has increased costs and programme duration.

5.1.2 Option 2. Bridge deck reconstruction

5.1.2.1 Description

Option 2 to reconstruct the existing railway arch requires the modification of this structure to provide an additional clearance of 620 mm higher than the original bridge, as described in previous sections.

The main advantages of this option are:

- Limited disruption to station and railway users/operators
- Shorter programme reducing impacts on residents in this area during construction
- Reduced construction and maintenance costs
- No increase in flooding risk to the railway
- Railway bridge is rebuilt to current design standards

The disadvantages of this option are:

- Significant heritage impact to the historic bridge

- Disruption to road and pedestrian users in this area during the closure of the bridge

5.1.3 MCA Assessment

The options assessment summary is shown in Table 5-2 and the MCA full MCA Assessment is shown in **Table 5-3**.

The results of the MCA led to recommend Option 2, deck bridge reconstruction (precast arch deck) as the preferred option.

Table 5-2 MCA Assessment Summary

	Criteria		Sub-Criteria (Quantitative Qualitative)	Option 1. Tack lowering	Option 2. Deck bridge reconstruction
1	Economy			Significant comparative disadvantage over other options	Significant comparative advantage over other options
2	Integration			Some comparative disadvantage over other options	Some comparative advantage over other options
3	Environment			Some comparative advantage over other options	Some comparative disadvantage over other options
4	Accessibility and social inclusion			Some comparative disadvantage over other options	Some comparative advantage over other options
5	Safety			Some comparative disadvantage over other options	Some comparative advantage over other options
6	Physical Activity			Some comparative advantage over other options	Some comparative disadvantage over other options
	Chosen Option			No	Yes
	Comment			Option 1 does not impact the historic structure. Option 1 has a negative impact on Broombridge Station in terms of diruption to rail users and the operator. Option 1 increases the low point of the tracks with risk of drainage/flooding issues and installation of pumped system will impact negatively on the operator. Option 1 is the option that requires the highest construction cost.	Option 2 negatively impacts on the historic structure and the challenge of this option is to find a sympathetic solution that minimizes the impact on the historic bridge. Option 2 impacts on road users more than Option 1. Option 2 is cheaper and requires less time to construct, minimising disruption in this area. Option 2 does not increase the risk of flooding at this location.

Table 5-3 OBG5 Broome Bridge MCA Assessment

DART Maynooth & City Centre Enhancements. Draft Permanent Way Preliminary Assessment Criteria and parameters

IDO6 OBG5 MCA1 Assessment

	Parameter		Criteria	Sub-Criteria (Quantitative Qualitative)	Option 1 Tack lowering	Option 2 Deck bridge reconstruction
1	**Economy**	1.1	**Construction and Land Cost**	Assessment of cost of construction of option, land costs, acquisition costs and temporary works	**Significant comparative disadvantage over other options** This solutions requires significant lowering of both tracks below OBG5, which has increased costs when compared to Option 2. This solutions requires significant alterations to Broombridge Station (platforms, accesses, footbridges, ramp utilities, fences, etc). Requires lengthy closure of tracks and temporary infrastructure increases costs.	**Significant comparative advantage over other options** This solution requires a reconstruction of the arch bridge. This construction solution is cheaper than the track lowering and requires minimal impact on the operational railway.
		1.2	**Long Term Maintenance costs**	Maintenance and reinvestments	**Significant comparative disadvantage over other options** OB5 is in a flooding area. Lowering the tracks would increase drainage issues and maintenance costs for the pumped drainage system.	**Significant comparative advantage over other options** This solutions requires less drainage maintenance as no pumped system required. Construction of the new structure will improve bridge maintenance regime and reduce future maintenance costs as this is now a new compliant structure over the railway.
		1.3	**Train Operation Functionality / economic benefit**	Benefits to train operation through operation flexibility. Consideration of potential	**Significant comparative disadvantage over other options** Longitudinal profile low point. Risk of drainages and flooding issues (current flooding area). Risk of service interruption.	**Significant comparative advantage over other options** Option 1 introduces a risk of services interruption that Option 2 do not.
2	**Integration**	2.1	**Transport Integration**	Impact on scope for and ease of interchange between modes. Impact on	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**

	Parameter		Criteria	Sub-Criteria (Quantitative Qualitative)	Option 1 Tack lowering	Option 2 Deck bridge reconstruction
				the operation of other transport services both during construction and in operation. New interchange nodes and facilities; Reduced walking and wait times associated with interchanges. Modal shift figures during construction and operations. Changes to journey times to transport nodes.	This solution impacts on the operation of the railway during the construction works because the track lowering. This solutions impacts on Broombridge Station operation during the construction works.	This solutions impacts on OBG5 road during the works, although impacts are deemed to be minimal.
		2.2	**Land Use Integration**	Impact on land use strategies and regional and local plans. Assessment of support for land use factors local land use and planning. Inclusion of project in relevant local and regional planning documents.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the land use integration.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the land use integration.
3	**Environment**	3.1	**Noise and Vibration**	Impact on noise and vibration environment during construction and operation	**Some comparative disadvantage over other options** Construction duration is longer, impacting the public for longer. Extensive demolition work required over a longer period. There is likely to be temporary construction impacts on sensitive receptors in this location which will be the subject of further assessment.	**Some comparative advantage over other options** Construction duration shorter for this option. There is likely to be temporary construction impacts on sensitive receptors in this location which will be the subject of further assessment.
		3.2	**Air Quality and Climate**	Potential impact on air quality and climate during construction and operation	**Comparable to other options** Higher volume of infrastructure affected by this option, so higher volume of materials required and higher waste generated likely.	**Comparable to other options** Existing materials (e.g. stone parapets) planned to be reused
		3.3	**Landscape and Visual (including light)**	Key landscape characteristics affected; Effects on listed/ key views; Impact on landscape character.	**Significant comparative advantage over other options** No direct impacts on the bridge. Possible slight/moderate indirect negative impacts due to presence of overhead lines.	**Significant comparative disadvantage over other options** Direct and very significant/profound negative impacts on the bridge
		3.4	**Biodiversity (flora and fauna)**	Potential compliance/conflict with biodiversity objectives; Indirect impacts on protected species, designated sites; Overall effect on nature conservation resource.	**Comparable to other options** Works proposed in proximity to the Royal Canal pNHA. There is potential for water quality, noise and lighting impacts within the pNHA.	**Comparable to other options** Works proposed in proximity to the Royal Canal pNHA. There is potential for water quality, noise and lighting impacts within the pNHA.

	Parameter		Criteria	Sub-Criteria (Quantitative Qualitative)	Option 1 Tack lowering	Option 2 Deck bridge reconstruction
		3.3	**Cultural, Archaeological and Architectural Heritage**	Overall effect on cultural, archaeological and architecture heritage resource. Likely effects on National Monuments, RMPs, SMRs, ACAs, NIAH, RPS, demesne landscapes etc. Number of designated sites/structures (by level of designation) directly/indirectly impacted by scheme (landtake)	**Significant comparative advantage over other options** No direct impacts on RPS Broome Bridge. Possible slight/moderate indirect negative impacts due to presence of overhead lines.	**Significant comparative disadvantage over other options** Direct and very significant/profound negative impacts on the RPS Broome Bridge.
3	**Environment**	3.4	**Water Resources**	Overall potential significant effects on water resource attributes likely to be affected during construction and operation.	**Significant comparative disadvantage over other options** Broombridge station and surrounding area have history of flooding. Previous flood events appear to have been caused by extereme rainfall events in combination with surface water drainage blockages. Lowering of track at this location may increase flood depth and potential hazard.	**Significant comparative advantage over other options** Flooding issue may recur. Potential for minor impacts to water quality within Royal Canal during construction. Nonetheless, there are no significant impacts to water resources predicted during construction or operation phases.
		3.5	**Agriculture and Non-Agricultural**	Overall impact on land take & property. Number of properties to be impacted/acquired. Likely temporary or permanent severance effects, etc.	**Comparable to other options** No impact on agricultural or non-agricultural property.	**Comparable to other options** No impact on agricultural or non-agricultural property.
		3.6	**Geology and Soils (including Waste)**	Soils and Geology and likely impact on geological resources based on preliminary/likely construction details. Soil resources to be developed/removed. Existing information relating to potential to encounter contaminated land. High-level assessment based on the likely structures/ works required and the potential for ground contamination due to historic landfills, pits and quarries.	**Some comparative disadvantage over other options** No geological heritage sites. Till overlain by poorly drained grey soil. May remove passive resistance from retaining walls and abutments which are structurally significant and will require structural modifications. Likely contaminants disturbance of trackbed ballast due to operations of diesel	**Some comparative advantage over other options** No contaminants disturbance due to work being undertaken off track. However, jet grouting may be required to support existing foundations during construction.
4	**Accessibility & Social inclusion**	4.1		Impacts on low income groups, non-car owners, people with a disability.	**Significant comparative disadvantage over other options**	**Significant comparative advantage over other options**

	Parameter		Criteria	Sub-Criteria (Quantitative Qualitative)	Option 1 Tack lowering	Option 2 Deck bridge reconstruction
			Impact on Vulnerable Groups	Quantification of increased service levels to these groups ; Quantification of infrastructure and rolling stock improvements aimed at these groups; distribution of consumers surplus	Significant effect during construction when station platforms/tracks are closed, including 46 week pedestrian diversion.	Pedestrian and road diversions required during construction but impact deeemd minimal
		4.1	**Stations Accessibility**	Quantification of increased service levels to the vulnerable groups.	**Some comparative disadvantage over other options** Significant effect during construction when station platforms/tracks are closed, including 46 week pedestrian diversion. Improved in the permanent case as impaired mobility access would be provided.	**Some comparative advantage over other options** This solution does not modify the current accessibility to the station. During construction pedestrian diversions are required.
5	**Safety**	5.1	**Rail Safety**	Safety for Rail users	**Comparable to other options** Creation of low point introduces flooding risk. Some risks present working adjacent to the railway during construction.	**Comparable to other options** The tracks remain at the existing gradient. No additional flooding risk with this option. Some risks present working over the railway during construction.
		5.2	**Vehicular Traffic Safety**	Quality of Access for these road users, lengths of diversions, removal of interface with rail and other modes of transport	**Some comparative advantage over other options** No impact on road users.	**Some comparative disadvantage over other options** Diversions required during construction
		5.3	**Pedestrian, Cyclist and Vulnerable Road user Safety**	Quality of Access for these road users. removal of interfaces	**Comparable to other options** Pedestrian diversion required over historic bridge during demolition reconstruction of station footbridge/ramp (TBC) for 46 week period.	**Comparable to other options** Pedestrian diversion required via temporary bridge during 13 week period.
		5.4	**Structures safety**	Risk of reach and impact structure foundation	**Significant comparative disadvantage over other options** This solutions requires track lowering involving deep excavations and complex structural works next to a live railway. Impact on the historic railway and canal bridge also requires further investigation.	**Significant comparative advantage over other options** This solution may require jet grouting to stabilise the foundations during construction, but this solution provides a new compliant structure in line with current design standards, improving safety of the structure in the long term.

	Parameter		Criteria	Sub-Criteria (Quantitative Qualitative)	Option 1 Tack lowering	Option 2 Deck bridge reconstruction
6	**Physical Activity**	6.1	**Connectivity to adjoining cycling facilities**	Analysis of the extent that the scheme connects with cycle tracks.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option regarding the connectivity to adjoining cycling facilities.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option regarding the connectivity to adjoining cycling facilities.
		6.2	**Permeability and local connectivity opportunity**	Journey Time and lengths of diversions for active modes and numbers affected. Analysis of the connectivity with green areas/key attractions related to active mode	**Some comparative advantage over other options** No road diversions, only pedestrian/cyclist diversions during construction.	**Some comparative disadvantage over other options** Road and pedestrian diversions may affect permeability and local connectivity negatively during construction.

6. CONCLUSIONS

As stated in in Section 3, no reduced OHLE solution was deemed feasible.

Regarding track lowering, while this option minimises the impact on the historic railway bridge and does not require road diversions, the disruption to railway users and operations is significant. In addition the cost and programme impact of the construction work at the station was greater for this option. A pumped drainage solution could be installed to mitigate the risk of the track flooding due to the new low point in the tracks, but the risk of the tracks flooding remains a concern as well as the impacts identified on local residents during construction.

The option proposed given the points outlined in this report, specifically in the MCA, is a **Bridge deck reconstruction (precast arch deck)**. This option limits the disruption to station and railway users/operators significantly. It has a shorter construction programme, reducing the impacts on residents during construction and does not increase the track flooding risk in this location. It is also a more economic option. It is acknowledged that this option impacts significantly on the historic railway bridge, however engagement with a Grade 1 Conservation Architect will ensure that the reconstruction is done sympathetically and in keeping with the historic canal structure (Refer to Appendix A of this report for the Architectural Heritage Impact Assessment). Road diversions are also required, but traffic assessments have been completed and the impact is deemed minimal.

The new track realignment option was ruled out early on in the optioneering process due to the position of the bridge in an urban environment and the considerable impact that any deviation from the railway line would have on the surrounding area. The solution involves high construction and land acquisition costs with severe social impact. The current Broombridge station would also be displaced from its current location, further increasing construction and land acquisitions costs.

APPENDIX A. Broome Bridge – Architectural Heritage Impact Assessment

B L A C K W O O D   A S S O C I A T E S
A R C H I T E C T S
A N D
B U I L D I N G   C O N S E R V A T I O N   C O N S U L T A N T S
2 0 ,   S T E P H E N   S T R E E T   L O W E R ,   D U B L I N   2 .
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DART+ West

Proposed works at Broome Bridge, Cabra, Co. Dublin

Architectural Heritage Impact Assessment

June 2022

CONTENTS

1.0 INTRODUCTION

This report has been prepared by Blackwood Associates Architects to accompany the Railway Order application for the DART+ West project. The report will assess the impact of the proposed works on the existing structure and setting at Broome Bridge. The proposed works referred to in this document have been designed by IDOM, the design team lead, for the client, Iarnród Éireann.

2.0 DESCRIPTION OF STRUCTURE

Note: Much of the information below is based on the report provided by Rob Goodbody in the appendices to Chapter 21 – Architectural Heritage (Appendix A21.4 in Volume 4 of this EIAR).

Broome Bridge is a masonry road bridge, dating originally from 1790 and spanning over the Royal Canal and rail line in Cabra, Co. Dublin.

The bridge is accessed from Broombridge Road from the north and south, with both sections of road having slightly different angles of approach. The change in angle is corrected on the section of the bridge spanning the railway line, whereas the canal section crosses perpendicular to the Royal Canal. To the east of the bridge are Broombridge Train Station and Luas Station.

Originally Broome Bridge spanned over only the canal, but it was then extended in c.1846 to provide passage over the railway line, which was introduced as part of the Great Western Railway. The railway line passes directly to the south of the canal. A small bank of vegetation remains between the canal and the railway line.

The bridge is built of a mixture of rubble and squared limestone of varying sizes brought to courses in parts and laid randomly in others. It comprises two arches, one spanning over the canal and one over the railway line. When the bridge was extended over the railway the second arch was constructed with two engaged piers, one of which now sits centrally in the middle of the bridge. A continuous string course and parapet run across the bridge's hump-back shape.

The older portion of the bridge spanning over the canal is characterised by a lower semi-circular arch with keystone. The later extension of the bridge over the railway line is characterised by a higher elliptical arch.

Figure 1 – East elevation of Broome Bridge showing both arches with the railway on the left hand side and canal on the right hand side.

The bridge terminates at land to the north with wing walls that curve away from the bridge and slope down towards ground level before terminating in piers. The wing walls are capped with rounded concrete flaunchings. At the south east end of the bridge, the wing wall is in the same format and appears heavily obscured by vegetation. This wing wall appears to have retained its original coping stones.

The canal arch is decorated with an arch ring of voussoirs and a raised keystone which also drops below the soffit. Voussoirs run only as far as the arch spring. From the centre point of the canal arch, the extension to the bridge is visible in the stonework style and the orientation of the parapet and string course which continue to rise towards the crown of the bridge, over the railway line.

The vault of the canal arch is constructed in slender squared limestone, evenly coursed. Five putlog holes are visible just below the spring of the arch. Below the spring, abutments are constructed in larger pieces of squared limestone, evenly coursed and turning the corner below voussoirs.

The spandrels of the canal are faced with squared limestone laid in courses. The west face of the canal bridge contains a plaque commemorating a significant mathematical equation carved into the bridge by astronomer Sir William Rowan Hamilton in 1843.

Figure 2 – Canal spandrel with squared limestone and commemorative plaque for Sir Hamilton.

Figure 3 – West spandrel of bridge and canal arch.

The railway arch is elliptical in shape, and the vault of the arch is impressively skewed due to the angle of construction necessitated by the differing angle of Broombridge road. The railway arch is decorated by an arch ring of voussoirs, without a keystone, and flanked either side by two engaged piers. Quoins below the arch spring extend to the piers on either side.

The spandrels of the railway arch and the piers, are in the same style being of squared rubble limestone, laid in courses.

Figure 4 – Railway arch showing voussoirs of arch ring, string course, engaged pier and a wing wall curving away to the east (left hand side).

The parapet of the bridge contains a myriad of construction phases and stonework and pointing styles which contribute to its overall mixed appearance. The parapet of the bridge is generally constructed of coursed squared rubble limestone with a mixture of concrete and dressed limestone copings.

The canal section of the bridge contains the oldest coping stones. The parapet has a modern breach on the east side between the arches, providing pedestrian access from the bridge to the train platform below.

Figure 5 – Breach in east parapet wall.

On the north end of the bridge, the parapets meet directly with a lower section of wall, which has been reconstructed in a mixture of stone and blockwork. The wall is topped with a combination of rounded concrete flaunchings and block coping stones laid on edge. It continues parallel with the road before stopping short of the embankment paths down to the canal on the west and east sides.

Figure 6 – North east wall, showing reconstructed end and path to the canal on the left side.

Figure 7 – North west wall and path to the canal on the right side.

On the south end of the bridge its parapets continue parallel with the road to a point where random rubble limestone walls butt directly against the parapets and continue alongside the road at the same height. These are topped with vertically laid limestone slabs. On the east side of the road, the wall appears to be historic. On the west, the wall appears to have been reconstructed recently to match the style of the original.

Figure 8 – South west parapet end and recently reconstructed random rubble limestone wall.

Figure 9 – South east parapet end and historic random rubble limestone wall.

The east parapet wall contains various stonework styles and coping types. At the north end, it is constructed in coursed squared limestone, with courses of varying heights. The coursing angle follows the rise of the bridge. Apart from the concrete coping on the pier, this section is topped with large historic limestone copings. This continues up to the apex of the canal arch. From this point, the extension to the bridge for the railway line begins, and the rising angle of the parapet is carried through. Coping stones are then replaced with concrete slabs for a length where the breach in the parapet provides access to the pedestrian bridge. The parapet continues south with large historic limestone coping stones for the majority of the railway span before ending with a pier and a larger coping stone to cover.

Figure 10 – East parapet wall over canal with historic limestone copings.

Figure 11 –View looking south over the bridge, with historic coping stones on the parapet.

Figure 12 – East parapet and crown of bridge over railway line.

The west parapet wall also contains various stonework styles and coping types. At the north end it is constructed in randomly laid small sections of squared limestone. This section is topped with large limestone coping stones which are historic, up to the apex of the canal arch. From this point, the extension to the bridge for the railway line begins, and the rising angle of the parapet is carried through with the copings. The parapet stonework changes in style and continues south with large historic limestone copings completing the parapet, for rest of the railway span. The parapet ends with a pier and a larger coping stone to cover.

Figure 13 – Oblique view of west parapet looking south showing step where the parapet meets the adjoining wall and differing stonework styles and copings.

Figure 14 – West parapet showing section of parapet rebuilt.

3.0 STATUTORY CONTEXT

Broome Bridge is included in Dublin City Council's Register of Protected Structures (RPS) with reference number 909. The description of the bridge however, only makes reference to the section spanning the Royal Canal.

It is included in the National Inventory of Architectural Heritage (NIAH), with reference number 50060126 and has been assigned a National significance with the special interest categories architectural, historical, social and technical. However, we believe the bridge should be assigned with a Regional significance.

Broome Bridge is also documented in Dublin City Council's Industrial Heritage Record with the following description and appraisal:

''Single-arch masonry bridge, built c.1790, carrying Broombridge Road over the Royal Canal. Squared coursed limestone walls with ashlar stringcourse and dressed voussoirs to segmental-arch with central keystone. Deck is humped. Parts of parapet walls rebuilt with some replacement coping. Limestone walls flank the canal beneath the bridge. Limestone plaque to northwest of bridge''

Broome Bridge is one of a number of bridges constructed in association with the Royal Canal, whose building commenced in 1790. The bridge follows the style apparent throughout all Irish canal bridges with the simple humpbacked design enhanced by finely-executed stonework. The bridge also has a historical connotation through its being the location where Sir William Rowan Hamilton first wrote down the fundamental formula for quaternion on the 16th October 1843, making the site of historical importance with respect to mathematics.''

The description and appraisal of the extension to the bridge reads:

''Single-arch masonry bridge, built c.1847, to carry Broombridge Road over the Royal Canal. Coursed squared limestone walls with dressed stone string course. Tooled limestone voussoirs to elliptical arch. Terminating piers. Curved deck with ramped approach from south. Forms a single unit with canal bridge to north.

Built as part of the Midland and Great Western Railway project, which commenced construction in 1846, this bridge is a testament to the engineering and technological skills of the nineteenth-century builders of Ireland's railways. Its siting beside a canal bridge highlights the number of facets of Ireland's infrastructural expansion during this period, further enhancing the significance of the site within Dublin's industrial heritage.''

Broome Bridge is not in an Architectural Conservation Area (ACA).

4.0 HISTORY & DEVELOPMENT

Below is an extract taken from the conservation report provided by Rob Goodbody in the Appendix A21.4 to Chapter 21 – Architectural Heritage.

‘’Prior to the construction of the Royal Canal there was a road that ran from near the Cabra Gate of Phoenix Park along what is now Nephin Road and Broombridge Road, and the northward along Farnham Drive to Finglas. This was not a major road and there were alternative, more direct, routes to Finglas through Glasnevin and along a more westerly route that has since more or less disappeared. By the 1790s the route along what is now Broombridge Road had deteriorated and appears not to have run northward to Finglas. Nonetheless it was a local road, and it was necessary to provide a bridge over the canal so as to keep the right of way open.

The road that is now called Broombridge Road runs at an angle to the canal, though the bridge was built at right angles, necessitating the introduction of slight bends in the road at either side of the bridge. The bridge was named Broome Bridge in honour of one of the directors of the Royal Canal Company, William Broome, who served on the board from 1792 to 1801.

The most significant historical event associated with the bridge is an act of justifiable vandalism carried out in 1843 by William Rowan Hamilton. Hamilton had been appointed Andrews Professor of Astronomy and Royal Astronomer of Ireland in 1827 at the age of 21. His scientific achievements at that time were in the realm of optics, but he also had a strong interest in algebra. One problem that he wrestled with for ten or fifteen years was the possibility of using algebra in three or four dimensions and on 16th October 1843, while walking from his home at Dunsink Observatory to the Royal Irish Academy along the towpath of the Royal Canal he had a flash of inspiration, resulting in him devising the equation that he had long sought, relating to a concept he called quaternions. Conscious that he may not remember it, he used his penknife to carve the equation into one of the stones of Broome Bridge. The long-term significance of this discovery has led, among other things, to three-dimensional physics and computer technology, ranging from 3D modelling to video games.

Even as Hamilton was carving the formula on the bridge abutment the directors of the Midland Great Western Railway Company was negotiating with the directors of the Royal Canal Company for the acquisition of the canal with a view to constructing a railway along its route toward Mullingar and beyond. Work commenced on the construction of the railway in January 1846 and the line opened between Broadstone and Enfield in June 1847. In the interval between these two dates the canal bridge known as Broome Bridge was extended to include a second arch spanning the new railway line. The extension of the bridge directly southward from the canal bridge at right angles to the railway would have exacerbated the bend in the road at the southern end of the bridge and to avoid this the railway arch was built at as a skew bridge at an angle to the alignment of the canal bridge. ‘’

Map Comparison

Broome Bridge as portrayed in available historic maps generally aligns with its construction date of 1790 and its latter extension in c.1846 over the railway line.

In the OS Map below, the railway line has not yet been constructed. A clearing north of the bridge is seen, possibly indicating access to the towpath at canal level. The construction of the bridge perpendicular to the canal is clearly shown. A small structure sits to the south of the bridge. The approach roads north and south are lined with trees on one side. The map also records the level of the canal and the keystone of the bridge.

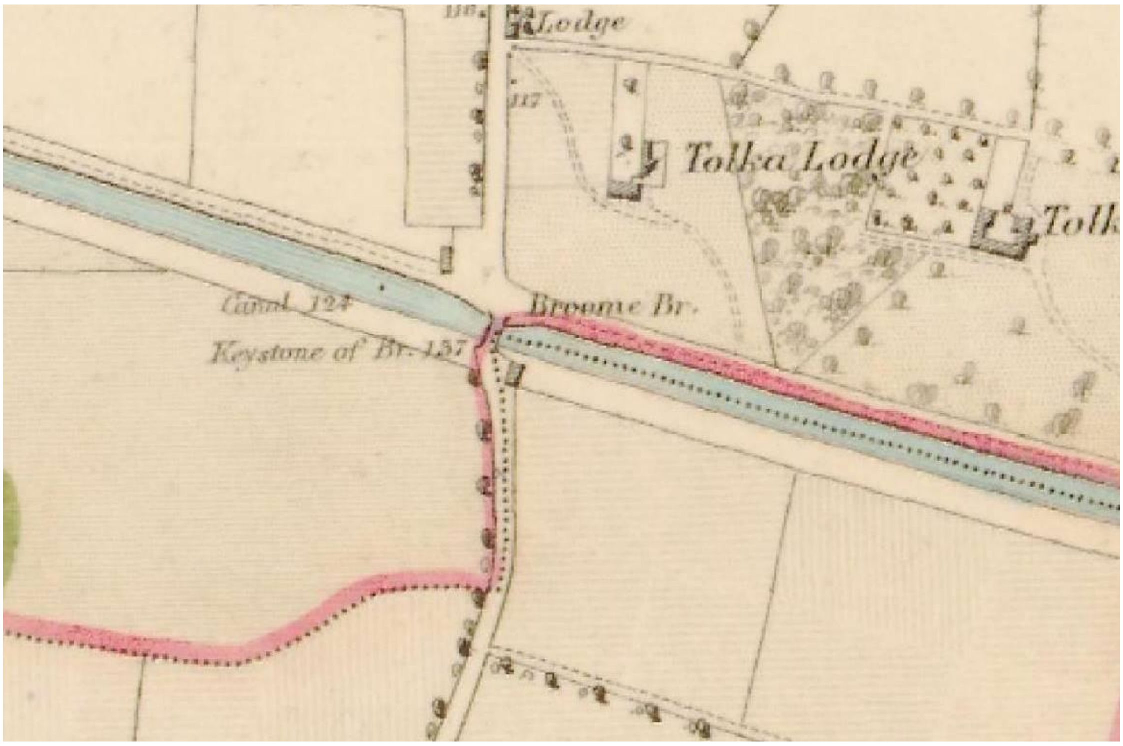

Figure 15 – 6inch OSI Map 1829 - 1841 showing Broome Bridge crossing the Royal Canal.

The 25inch OS Map (Figure 16) records the arrival of the railway line in Cabra and also documents Broome Bridge in context in greater detail. Ramped paths to the towpath at canal level are now clearly visible to the north of the bridge. The bridge is also now extended over the railway line. However, the angle of the bridge and its extension are not recorded. The paths to the north of the bridge indicate a route from the road down to the level of the canal. The towpath along the south of the canal is also visible along with train lines terminating to the south.

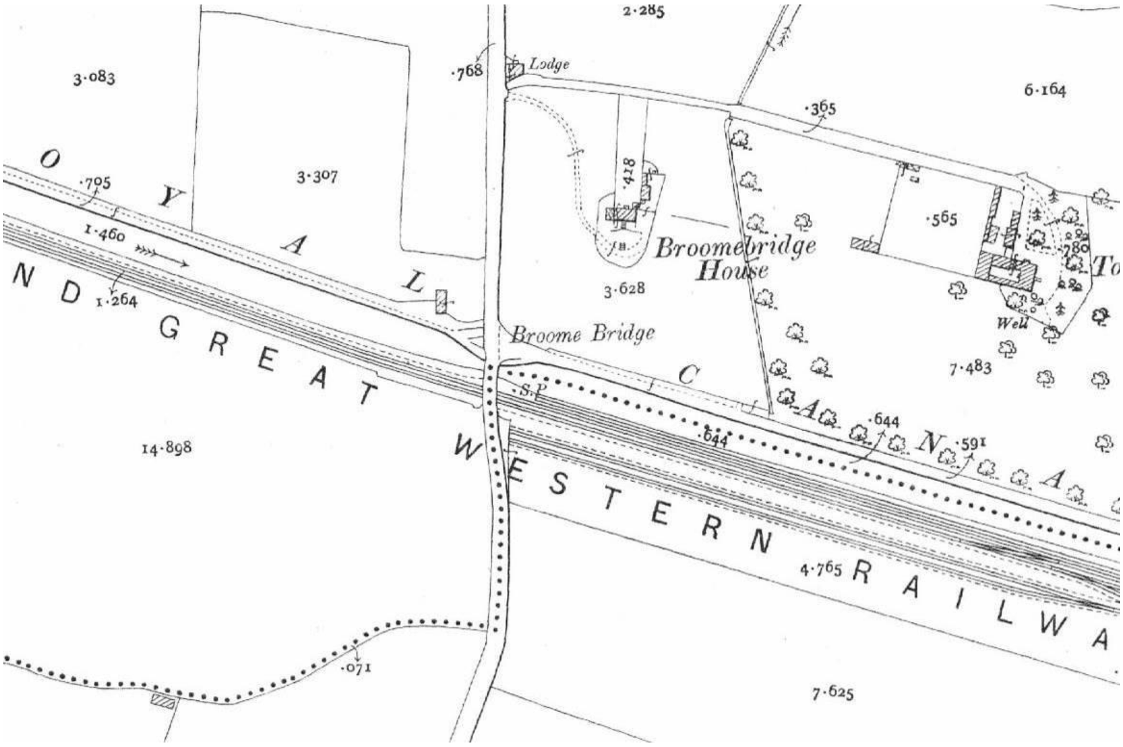

Figure 16 – 25inch OSI Map 1888-1913 showing the addition of the rail line and the extension to Broome Bridge.

Google satellite imagery from 2022 shows Broome Bridge as it is today with the train station to the east. The pedestrian access to the canal from the north is clearly visible.

Figure 17 – Screengrab taken from Google Maps, 2022.

5.0 ASSESMENT OF SIGNIFICANCE

Statement of Significance

The categories of special interest which define a Protected Structure as per the Planning and Development Act 2000 (as amended) are Architectural, Historical, Archaeological, Artistic, Cultural, Scientific, Social or Technical. These categories are not mutually exclusive, and a structure may be attributed with several of the categories. The categories identified as particular to Broome Bridge by the NIAH are Architectural, Historical, Social and Technical. The bridge has been recorded as having of National significance, but we believe it should be Regional. As noted previously, Broome Bridge is also a protected structure. The Royal Canal is also included in the Fingal County Council register of Protected Structures from locks 10 – 12 (RPS no. 944a, b, c and d), further west of Broome Bridge.

It is important to note that while the canal and railway bridges are individually a typology of their own, in this instance their compositions and significance must be read together due to their co-dependency and the fact that both are experienced as essentially one symbiotic bridge. This is due to the fact that the canal bridges in many cases were extended to span over the railway line which was constructed adjacent to the canal.

Architectural
Though Broome Bridge has undergone many alterations over time, the architectural merit of the bridge remains evident. The fine masonry craftsmanship of the bridge can be clearly seen in the decorative details, overall worksmanship and its elegant integration into the canal infrastructure. Like other canal bridges of this typology, the simple decorative features of the bridge in carved and dressed limestone contribute to the overall architectural expression of the bridge and testify to the skilled masonry craftsmanship employed in its construction. Relatively few of the railway bridges remain unchanged today, further highlighting the bridge’s importance as part of Ireland’s industrial architectural heritage.

Historical
Historically Broome Bridge carries significance for several reasons. The bridge represents two significant periods in Ireland’s transport and industrial heritage in the form of two distinct developments with the construction of The Royal Canal and The Great Western Railway. The fact that the railway was added after the canal is also important as a layer of history of the overall composition of the bridge.
In this the twin form of Broome Bridge can be read as the embodiment of the period in the history of transport in Ireland, when the canals were superseded by the railways, but continued to function in parallel.

The bridge is also associated with astronomer and mathematician Sir William Rowan Hamilton who inscribed the important quaternion formula on the bridge in 1843. This equation carries great significance even today in three-dimensional physics and is credited with leading to developments in modern day technology such as computer modelling software among others.

Social
The bridges along the Royal Canal, including Broome Bridge, carry significance as pieces of social infrastructure for a number of reasons. Bridges act as a connection point between areas previously separated by the canal and railway and often provide a sense of identity and place for the people and communities around them. Both the canal and the railway line formed a manmade boundary, where the bridges then provided essential connection points. This is especially true for pedestrian bridges as they are more directly experienced by people. Additionally, bridges often survive development around them over a long period of time, as standalone independent structures further reinforcing the sense of identity provided. Today the bridges are important architecturally as standalone features, acting as nodes of identity along the canal which extends through many towns and communities into the midlands.

The canals and some railway lines around Ireland are now important places used for walking and cycling, especially in urban settings where outdoor recreational infrastructure is limited. The Royal Canal Way is one example on the Royal Canal. The canals are also popularised with barge boating culture and disused railway infrastructure has also been converted into greenways around Ireland.

Technical

Technically, the manner in which the bridge was extended over the railway in 1846 is significant. The vault of the arch spanning over the railway was constructed with a skew. This critically allowed the arch to be constructed at an angle over the railway line which was essential due to the angle of the approaching road to the south. The skewed arch is a technically impressive feat which required skilled engineering and craftsmanship to ensure the thrust of the arch was successfully transferred either side. The execution of it in slender stone sections tying in with quoins and voussoirs either side also demonstrates exceptional craftsmanship and skill.

6.0 OUTLINE CONDITION ASSESSMENT

Broome Bridge is generally in fair condition considering its proximity to the canal and road, but there are areas where repair works are required.

The stonework of the arches, buttresses and spandrels do not appear to have major structural issues. It was not possible to get access to many areas but no structural cracks were identified. The stonework on the face and the rising wall under the arches generally appears to be in good condition apart from a number of areas on the canal side where extensive weathering is visible. This is particularly evident on the north east face near the base of the arch. There are small pockets where the stone face has broken away, especially on the canal side, but this is not widespread. The smaller stonework forming the arches appears to be more weathered and there is some evidence of moisture penetration from the road deck above. The railway side could not be properly inspected due to access constraints but it is clear that all the stone has been painted at low level, presumably to cover earlier graffiti. There appears to be a number of phases of pointing on the bridge, some of which is likely to be an inappropriate cement mortar. This pointing has been washed out or has fallen away in many areas, predominantly beneath the arches and on the spandrels of the canal span. The joints on the railway side are tighter but there is evidence of localised pointing loss there as well.

Figure 18 – Weathered facing stone visible, especially below the spring of the arch.

Figure 19 – Condition of canal arch stonework.

Figure 20 – Graffiti under railway arch.

There are three wing walls on the bridge and their condition varies. The wall to the north west is in fair condition with slightly increased weathering present on stone at low level. The original copings have been lost and replaced with concrete and a section of the wall is covered in graffiti. The stonework on the north east wall has weathered considerably in the area that adjoins the bridge face. Like the north west side, the original copings have been lost and replaced with concrete. It was not possible to inspect the south east wing wall due to the limited access and extent of growth over the wall during the inspection. It looks like the original copings are still in place and the stonework appears to be in fair condition from a distance. The painting of stonework below the arch extends onto this wing. The walls have been repointed a number of times, some more successfully than others. This pointing is failing in localised areas.

Figure 21 – North east wing wall.

Figure 22 – Original copings visible to south east wing wall.

The parapet stonework appears to be sound but there are a number of phases of rebuilding visible. It is difficult to get close to the external face of the parapets but from a distance they appear to be in fair condition with the exception of localised areas of vegetation. The ramp to the platform connects to the bridge through the parapet and these junctions are poorly executed. Original stone on the parapet was broken away to create the junction. There are a variety of coping stones on the bridge including the original canal bridge copings, original railway arch copings and several versions of replacement concrete copings. The concrete copings have hairline cracks in places and localised repairs have been carried out. There are a variety of pointing styles on the bridge including recessed pointing on the newly built stone and the pointing is buttered over the stone on the older sections. Both of these styles are inappropriate for this historic bridge and all cement mortars are detrimental to the historic stonework.

Figure 23 – Poor condition of pointing & concrete copings.

Figure 24 – Pier stone damaged.

7.0 PROPOSED WORKS

As identified in the accompanying documentation, it is proposed to demolish the section of existing historic bridge over the railway line to allow for the electrification of the rail system. The existing bridge does not provide the clearance required to allow the Overhead Line Equipment (OHLE) to run under the bridge.

A number of approaches to provide the additional clearance required were considered. These included re-directing the tracks around the bridge, lowering the tracks and demolishing the railway side of the bridge to build a new bridge at a higher level. The evaluation process is detailed in EIAR Volume 4 Appendix A3.3 Option Selection for OHLE Intervention. On completion of this assessment the design team lead and client concluded that the demolition of the existing bridge and re-building at a higher level was the most suitable approach for the overall scheme.

The removal of this section of bridge over the tracks is an irreversible loss of important historic fabric and permanently alters the historic structure and surrounding setting. This section of the bridge has significant historic value, particularly as it is a carefully designed and built extension to the 1790's bridge over the canal. As such, it is very much an important layer of history. To mitigate the loss of the historic fabric as far as possible, the construction of the new bridge arch is being carefully considered. It is essential that the replacement section of bridge is well designed, detailed and executed. The most important consideration in the process is to ensure that the new build element sits comfortably alongside the remaining canal bridge. The stonework from the dismantled railway arch will also be salvaged and used for repairs where required.

Due to the significant raising of the bridge to accommodate the OHLE and the requirement to install a precast concrete arch, it is not possible or desirable to reconstruct the span to match the existing. Instead, a contemporary solution using modern materials is being designed to complement the proportions and style of the remaining canal bridge. The extent of demolition will be confined to the section of bridge between the stone piers to ensure that the reconstructed section will be read as an insertion rather than an entirely new bridge.

A number of finishes and construction methods were assessed during the design process. Initially the preferred option was to re-use the original facing stone but it became clear that this would not be successful due to the technical constraints of the new construction. The string course is an essential element of the existing composition but the increased height of the arch would distort its connection to the string over the canal. The precast arch construction would reduce the existing voussoirs to cladding stones and the facing stone of the spandrels would also become cladding stones tied back to the concrete structure behind. The combination of all these factors makes it very difficult to design or build stonework that would sit well alongside the original fabric and there were concerns that it would very much read as modern stone cladding.

Figure 25 - Image of existing spans with string course highlighted.

The use of a weathered steel facade was also explored as this material would tie together the rebuilt bridge and new pedestrian bridges on each side. After careful assessment it was decided to proceed with a concrete structure as this has the potential to sit most comfortably with the remaining original stonework. It is proposed to use a board marked concrete finish on all faces and to select a concrete colour that best complements the original stonework.

Figure 26 – Example of a new board marked concrete insertion in an existing stone structure.

The colour and texture of the concrete finish, along with the quality of the detailing and workmanship is critical to its success. There are many examples of fine concrete work next to historic stonework across

Europe, as identified in the image above. The design team is aware that Irish conditions are generally a lot damper than elsewhere, therefore the texture and finish of the concrete will be designed to minimise algae and vegetation growth. The texture created by the board will be controlled to ensure there are no large shelves for vegetation to take root and the surface finish will be carefully specified to limit the number of bugholes present on the finished concrete. It is proposed to use hand sawn boards to provide a finish that is not too uniform. Research into materials and sample panels will be essential prior to construction to ensure the new concrete finish complements the remaining historic stonework.

The form of the new arch and its relationship to the remaining canal arch is of critical importance. The design team have decided not to replicate the original arch exactly as the geometry of that shape would require the bridge to be raised even more than the current proposal. A slightly flatter arch provides the clearance required for both lines with less elevation.

The junctions between old and new will need to be carefully considered during detail design. The presence of the piers on either side of the arch allows the new build to be contained neatly at a natural break. These junctions will still need to be skilfully detailed and executed to ensure the concrete and stonework sit comfortably together. There will be a considerable amount of stone repair and repointing on the piers following the removal of concrete shuttering. These repairs will need to be carried out with great care by a skilled stonemason.

Figure 27 – Existing bridge with engaged piers highlighted.

The new concrete parapets will extend up to the height of the original with the additional height provided by the contemporary design discussed below. The original parapet thickness will be carefully designed to ensure the new parapet sits in as neatly as possible with the original. The piers extend up through the parapet externally providing a natural break but there is no detail on the internal face. This creates a challenge that will need to be overcome with careful detailing and skilled craftspeople.

Figure 28 – Image of parapet internally with line highlighting where the junction with the new concrete parapet will be.

It is a safety requirement that the parapets are a minimum of 1800mm high, with the bottom 1200mm solid in the area of the OHLE. This presents a significant challenge for Broome Bridge and all of the historic bridges along the line, as the existing original parapet heights are lower than 1200mm. A rigorous design process has taken place to identify a solution that will complement the historic setting and maintain a visual connection to the rail lines and surrounding landscape, when on the bridge. It is also essential that the parapet is not the dominant feature while viewing the bridge from the canal. The proposed design is a contemporary, adaptable solution that can be implemented throughout, bringing a degree of uniformity to all interventions along the railway. An alternative option with the extended parapet structure fixed on top of the coping, was also assessed. Due to wind loads and the uncertain structural integrity of the parapets, a considerable amount of damage to the original fabric would be required to anchor the new structure through the existing parapet to new concrete pads below.

For Broome Bridge it is proposed to provide a solid metal panel from the top of the parapet up to 1200mm with an expanded metal mesh to continue up to 1800mm. The vertical supports and mesh will be carefully designed to ensure the internal face of the parapet is not obscured and that the mesh allows a good visual connection to the surroundings.

Figure 29 – Render of design proposal to increase the parapet height to 1800mm with mesh about 1200mm.

Repair works will be required to the existing parapet before the proposed heightening works can take place. All joints will need to be examined and raked out where the existing mortar is lost or failing. Joints will need to be repointed in a suitable lime mortar and protected until satisfactorily carbonated. These works must be carried out by a skilled mason with extensive experience with historic stonework. The existing connection for the ramp access to the platform is to remain in position and no alterations are proposed.

Figure 30 – Existing parapet requires repair and conservation works.

Figure 31 – Render of proposal on completion – West Side.

Figure 32 – Render of proposal on completion – East Side.

8.0 ARCHITECTURAL HERITAGE IMPACT ASSESSMENT

Proposed Alteration	Negative Impact	Neutral Impact	Positive Impact	Mitigating Measures
Demolition of the section of original bridge over the railway line.	Loss of important historic fabric. Partial loss of one of the few remaining original canal and railway bridges in the area. Alters the historic setting.		Allows for the train system to be electrified.	The demolition will be contained between the stone piers on each side to minimise the loss of historic fabric. A carefully designed replacement section of bridge will be constructed to sit in harmony with the original fabric on each side. The stonework will be carefully dismantled and used for repairs on the historic bridges where necessary.
Removal of original parapets from the section of bridge being removed.	Loss of important historic fabric. Removes the only visible connection to the historic bridge when crossing over.		Allows for the train system to be electrified.	The replacement parapets will be reinstated to the original level. The additional required height will be provided with a modern parapet detail. The parapets will be carefully designed to ensure they connect neatly to the remaining historic parapets on each side.
Construction of the new bridge section over the railway line.	The use of precast concrete will create a construction joint under the bridge between the arch and board marked concrete face. The concrete arch will read differently to the shuttered concrete on completion.		Concrete colour and texture will be designed to be compatible with the surrounding historic stonework. The junctions between the concrete and original stone will be carefully detailed to ensure the two phases of construction sit comfortably together.	The cast in-situ concrete will be carefully designed to ensure the precast arch is not visible while viewing the original structure in elevation. The surface finish of the concrete will be carefully considered to limit the vegetation growth as much as possible.

Proposed Alteration	Negative Impact	Neutral Impact	Positive Impact	Mitigating Measures
Increase of parapet height.	Obscures the original design intent of the existing parapets to some degree on the internal faces. Visual connection to the top of the coping stones will be lost on internal faces. The connection to the surrounding setting is compromised by increasing the parapet height to 1800mm.		Allows for the train system to be electrified. This approach allows the original parapets to be retained on each side of the rebuilt section.	The new parapet will be carefully designed to minimise the impact on the remaining historic parapets. Fixings into the historic parapets will be minimised and will be installed in the joints where required. The majority of the structural load will be transferred to the deck, decreasing the impact on the parapets. The metal mesh will be carefully selected to ensure the visual connection to the surrounding landscape is maintained as much as possible. The parapet supports will be designed to be as slender and elegant as possible to reduce the visual impact on the parapets.
Existing ramp to platform.		This ramp is not appropriate to the historic setting but it is in place and no alterations are planned.		

9.0 CONCLUSION

The demolition and replacement of the span of Broome Bridge over the railway line is a very significant loss of important historic fabric. This will have a considerable and irreversible impact on the character of the setting, the surrounding environment and the remaining canal bridge, dating from the 1790's. From a conservation perspective it would be preferable to incorporate the welcomed new infrastructure into the existing setting, while retaining this important historic structure. As identified in Appendix A3.3 Option Selection for OHLE Intervention in Volume 4 of the EIAR, the bridge can be retained, but due to significant financial, programme and technical reasons, removal and replacement has been chosen as the preferred option.

By raising the railway arch, the connection between this and the canal arch is fundamentally altered, so constructing a stone facade on the new bridge section is not considered appropriate. After carefully assessing the alternatives, it was concluded that a contemporary concrete structure would sit most comfortably with the remaining historic stonework. Considerable effort will be required during detail design and construction, to ensure the colour and texture of the concrete complement the existing stonework. Careful detailing and execution at the junctions will also be fundamental but these are all achievable and should lead to a successful outcome. Containing the re-build between the piers on each side is positive and will allow the new section of bridge to be read as an insertion into the original rather than a new bridge.

The proposed parapet heightening design provides a flexible solution that can be adapted to each historic bridge along the length of the Dart+ West project. Raising the parapet is a fundamental safety requirement when installing OHLE, so the proposal needs to incorporate these essential requirements. The use of an expanded metal mesh above 1200mm ensures that a visual connection to the surroundings is maintained while on the bridge. The positioning of the new parapet on the internal face also ensures that it reads as a secondary element when viewing the external faces of the bridge. Unfortunately, the raised parapet will obscure the top of the existing coping stones internally, but it is an essential safety requirement to remove ledges that could be used to climb up on the parapet.

It is clear from a conservation perspective that the demolition of the section of bridge over the railway is a major loss to the overall structure and surrounding setting. However, the proposal to reconstruct the arch with a carefully designed and detailed concrete finish should sit comfortably with the remaining canal bridge and reflect a high quality contemporary design. The required conservation and repair works to the existing fabric should also be incorporated into any future works on the bridge.

APPENDIX B. Technical Note for OBG11 Castleknock Bridge: MAY-MDC-STR-OTHE-RP-Z-0003

DART+ West

Iarnród Éireann

Technical note on OBG11 Castleknock bridge reconstruction

MAY-MDC-STR-OTHE-RP-Z-0003

27th May 2022

Table of contents

EXECUTIVE SUMMARY

The report aims to justify the option selected for constructing the Overhead Line Equipment below the OBG11 (next to Castleknock Station) to achieve the project's objective.

The potential options are presented and explained in this report and the four potential solutions are:

1. Reduced height OHLE.
2. Vertical Track Lowering.
3. Bridge reconstruction.
4. Track realignment.

No reduced height OHLE solution was deemed feasible due to the existing clearance from top of rail (TOR) to bridge soffit, so any potential special arrangement would need to be combined with another infrastructure intervention. For this reason, this option was not considered acceptable.

Regarding track lowering, while this option minimises the impact on the historic railway bridge and does not require road diversions during construction, the disruption to railway users and operations during construction is significant. The track lowering requires new retaining walls in the western station, impacting residential areas' boundariess. In addition, the cost and programme impact of the construction work at the station is greater for this option. A gravity drainage solution could be installed to mitigate the risk of the track flooding due to the new low point generated in the tracks, but the risk of the tracks flooding remains a concern.

The conclusion of the report is that bridge reconstruction is the preferred option. This option limits the disruption to the station and railway users/operators during construction. It has a shorter construction programme, reducing the impacts on residents and does not increase the track flooding risk in this location. It is also the most economical option. It is acknowledged that this option impacts significantly on the historic railway bridge, however engagement with a Grade 1 Conservation Architect has taken place to ensure that the reconstruction is done sympathetically and in keeping with the historic canal structure. Road diversions are also required, but traffic assessments have been completed and the impact is deemed minimal.

The new track realignment option was considered an almost unsuitable option due to the position of the bridge in an urban environment and the considerable impact that any deviation from the railway line would have on the surrounding area. The solution involves high construction and land acquisition costs with severe social impact. The current Castleknock station would also be displaced from its current location, further increasing construction and land acquisitions costs. This option was ruled out early on in the optioneering process.

1. INTRODUCTION

1.1 Background

The DART+ West Project will introduce electrified high-capacity trains at the increased frequency for all stations between Maynooth/M3 Parkway and Dublin city centre at Connolly Station and the new Spencer Dock Station (approximately 40 km in length).

OverHead Line Equipment (OHLE) will be required to be constructed to provide electrical power to the trains. All the bridges on the Maynooth Line have been assessed to determine the most appropriate mechanism for OHLE installation.

The technical note titled ‘Option selection for Overhead Line Equipment (OHLE) intervention at OBG5, OBG11 and OBG14’ (document number MAY-MDC-STR-OTHE-RP-Z-0004) gives an overview of the option selection process followed for the installation of OHLE at three specific historic bridges along the route (OBG5 Broombridge, OBG11 Castleknock and OBG14 Cope Bridge).

1.2 Purpose of the document

The report aims to justify the option selected to achieve the project objective of electrifying the line and providing OHLE through OBG11 (next to Castleknock Station).

The report explains the options analysed and the decision-making process to determine the preferred option.

2. OBG11 BRIDGE (NEXT TO CASTLEKNOCK STATION)

The OBG11 is located on the Maynooth line at 4 miles 1428 yards mileage, at Castleknock Station exit towards Dublin.

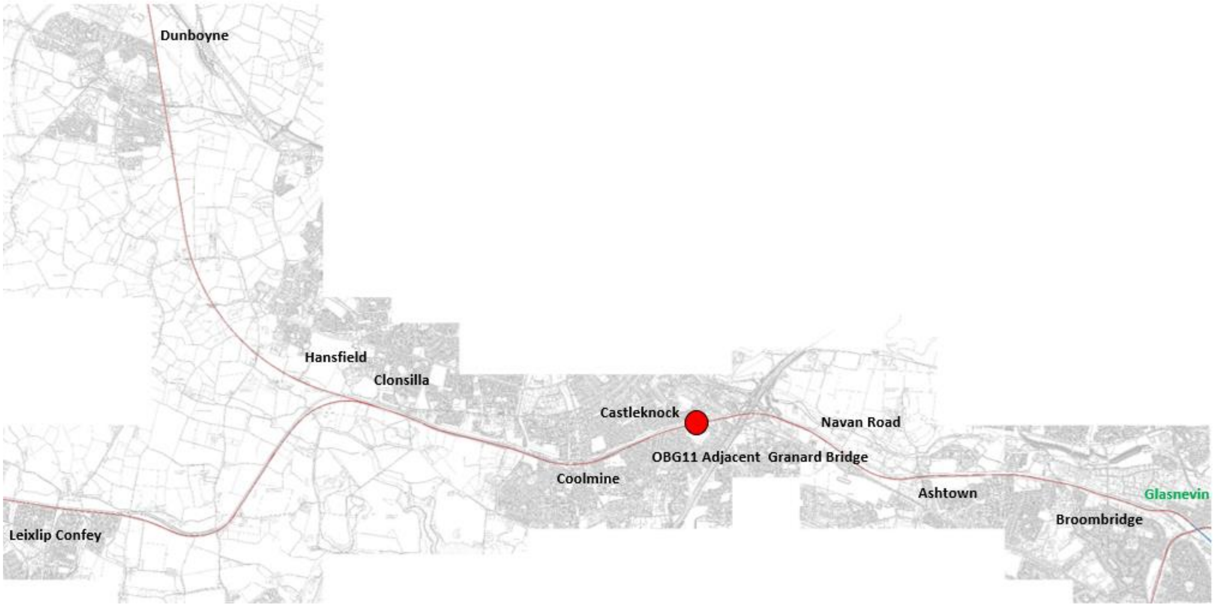

Figure 2-1 OBG11 – Location plan

Figure 2-2 OBG11 bridge next to Castleknock Station

OBG11 is a 19th-century one-span masonry arch bridge which carries the Castleknock Road over the railway. It is located in Fingal County Council's functional area, and is next to Granard Bridge, which is a protected structure (Fingal under reference 0696). The National Inventory of Architectural Heritage has included Granard bridge under reference 11354002 and has assigned a regional significance for its architectural and technical interest. The description of the bridge refers to it as a "single-arch ashlar granite humpback road bridge over canal, built c.1810."

The adjacent railway bridge OBG11 is not included in the record of protected structures or in the NIAH but is close to the canal bridge.

OBG11 is a two-lane bridge with 10.95 m wide, and there is access to the Royal Canal Greenway close to the bridge, which means that any road closures may have a negative impact on the mobility in the area.

The current TOR to soffit structure clearance (where OHLE would be installed) is 4450 mm (as per available data).

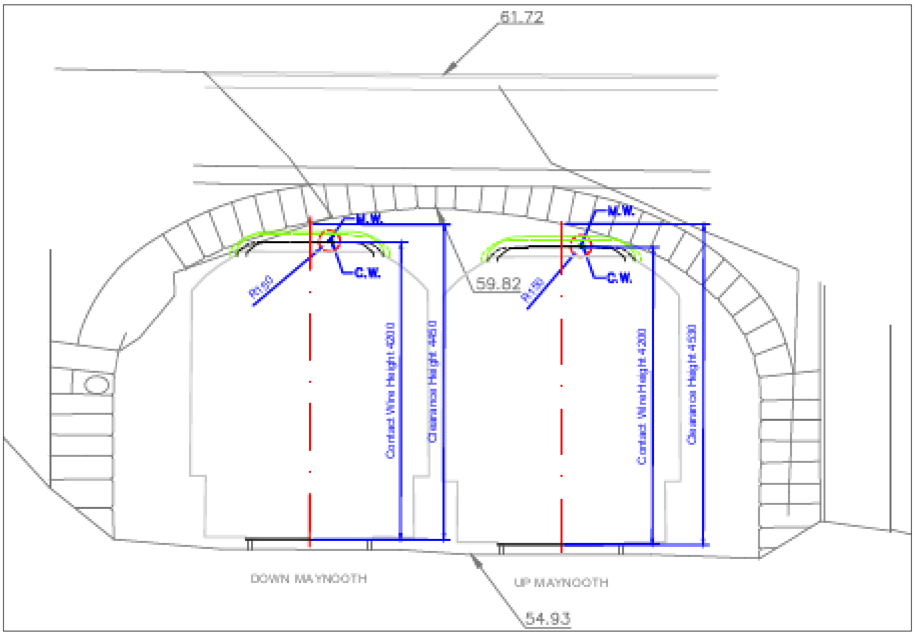

Figure 2-3 OBG11 West elevation

The main constraints found when carrying out the optioneering to provide the required OHLE clearance are listed below:

- Heritage impact on the historic bridge: Any alterations to the bridge and its location next to a protected structure is a very significant loss of important historic fabric.
- Location adjacent to Castleknock Station: Options need to consider proximity of the bridge to the existing station and the impact of modifications on station infrastructure (platforms, accesses, footbridge, utilities, fences, etc.).
- Flooding: proximity to the Royal Canal and any track lowering needs to consider potential risk of flooding.
- Utilities: there are a number of existing services through Castleknock station crossing over the train tracks and the existing bridge that may need to be diverted.

3. ASSESSMENT OF OPTIONS

The options assessed to construct the OHLE beneath OBG11 are listed below. The three options reviewed are as follows:

Table 3-1 IDO10 Options

Options	Description
IDO10 – 1	Track lowering to allow a 4400 mm contact wire system
IDO10 – 2	Bridge deck reconstruction
IDO10 – 3	New alignment solution

No reduced height OHLE solution was deemed feasible due to the existing clearance from top of rail (TOR) to bridge soffit, so any potential special arrangement would need to be combined with another infrastructure intervention. For this reason, this option was not considered acceptable.

3.1 Option 1. Track lowering to allow a 4400 mm contact wire system

To achieve the required 4400 mm contact wire height, a track lowering was considered. This potential solution would require the vertical lowering of the tracks by approximately 380 mm below OBG11, which would result in track lowering works for a length of approximately 700 m. The maximum track lowering required is 1.87 m, 40 m west of the end of the platform structures. Whilst this is a technically feasible solution, some substantial issues were identified as explained below.

3.1.1 Castleknock station

Lowering the tracks requires extensive modifications to the existing station infrastructure, including platforms, accesses, footbridge, utilities and fences. This impact is the most problematic issue related to track lowering at OBG11 in the proximity of Castleknock Station. It would require, in effect, platforms, station building and surroundings reconstruction. These works would have a significant cost implication and would severely impact station functionality during the extensive construction period required.

Figure 3-1 Castleknock platform view from OBG11

The current station gradient is 9.1 mm/m (1 in 110), and this is non-compliant with IÉ (Iarnród Éireann/Irish Rail) and TSI (Technical Specifications for Interoperability) standards.

The whole modification of the station tracks, and platforms require that the new design is compliant with relevant standards. These standards set up a maximum gradient of 2.5 mm/m (1 in 400) for new platforms on new railway lines or existing railway lines.

In order to provide this compliant gradient, the track lowering goes from 380mm below the OBG11 bridge (to provide the required clearance for OHLE) and increases along the station length, reaching a maximum value of 1.87 m (at 40 m distance from the western end of the platforms).

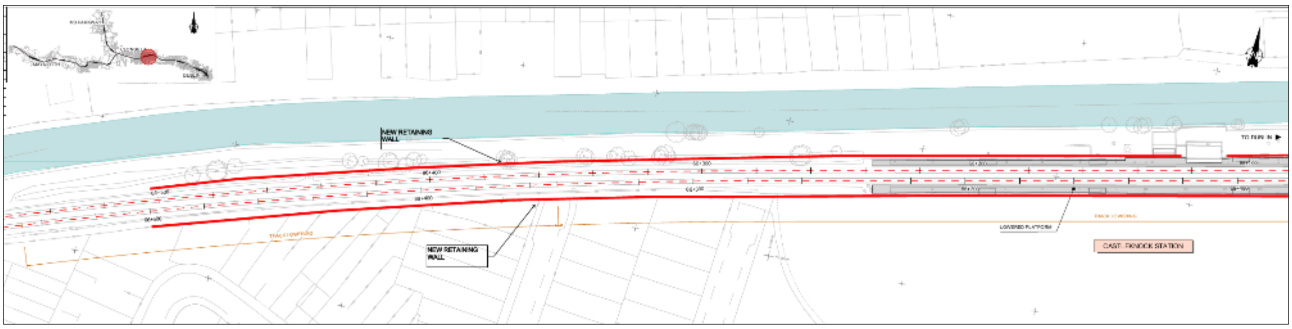

Figure 3-2 Castleknock Station's new retaining walls at the western side of the station.

3.1.2 Structural interventions required

3.1.2.1 Existing structures

The following list is the existing structural drawings sent by IE, which have been used to carry out the initial structural assessment described in this report:

- 151-1607A.
- 151-1682.
- 151-1683.

The drawing only shows the existing footbridge structure (OBG11A). There is no existing structural information on platform structures.

3.1.2.2 Longitudinal alignment of the proposed track lowering

The figure below shows the proposed track lowering solution at this location. The maximum proposed track lowering is around 1.87 m at the western end of the platforms (chainage 66+300). At OBG11 (chainage 66+030), the proposed track lowering is about 0.38 m, and it goes deeper towards OBG11A.

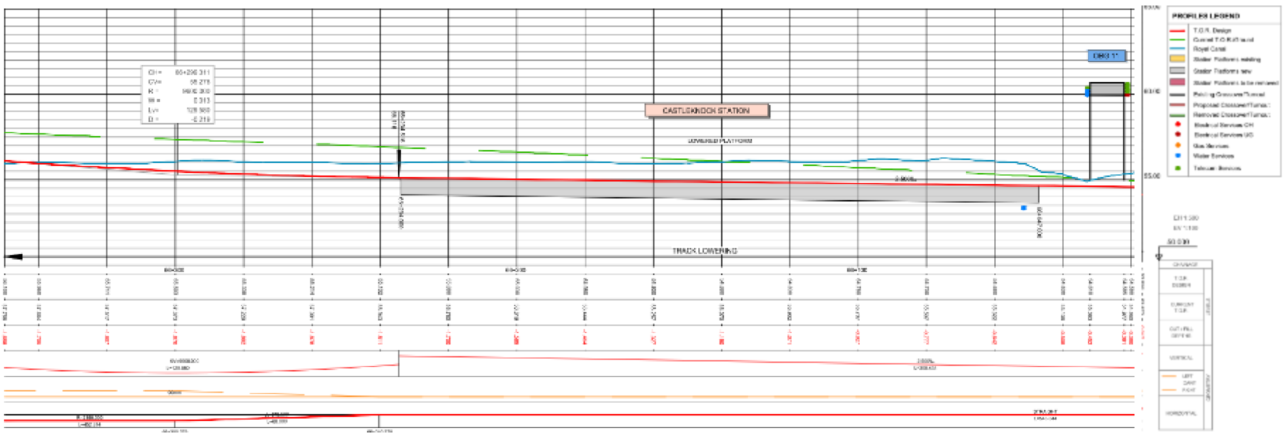

Figure 3-3 Longitudinal alignment of the proposed track lowering

3.1.2.3 Structural assessment

Near the OBG11, there are many existing station structures that require intervention, including the existing OBG11A station footbridge, station building and platform structures.

The interventions on existing structures in this location have been summarised in the following list:

a) New retaining walls are required both along the up and down track to mitigate the impact on the Royal Canal and its towpath and adjacent residential buildings.
b) The platform structures on both sides of the track need to be demolished and rebuilt.
c) The existing OBG11A footbridge needs to be demolished and rebuilt to current standards.
d) Station building to be dismantled and reassembled.

Figure 3-4 Track lowering structural intervention – Plan view

According to the Final GI Factual Report -DART+ OBG11, the existing foundation depth of the OBG11 bridge is located around 0.80 m measured from the existing sleeper. The proposed track lowering track level in this area is between 0.39 m to 0.45 m. However, the proposed drainage and track infrastructure (i.e., ballast and sub-ballast layers) require deeper excavation. Therefore, soil improvement is necessary around the existing foundations before any excavation work on the track.

New retaining walls are required both along the up and down track due to the depth of excavation required and to mitigate the impact on the Royal Canal and its towpath and adjacent buildings. In this area, the proposed track lowering is between 0.50 m and 1.90 m (from Chainage 66+047 to Chainage 66+500). Considerable excavations are required at the western end of the platforms because of new track level and gradients. N ew retaining walls are required to be constructed to support these excavations at the boundaries of the residential area of Castleknock Wood Rd and Castleknock View Rd. These works would have a significant social and cost impact and would severely impact station functionality during the extensive construction period required. Land acquisition would also be required outside of the IE ownership.

Figure 3-5 House affected by retaining wall works

The retaining wall also extends along the Laurel Lodge Park and will require temporary and potentially permanent land acquisition here. Disruption will also be seen during construction. The retaining walls along the canal bank and footpath may also cause disruption to users during construction. A number of existing trees may also be affected by these retaining wall works but further investigation would be required.

The maximum depth of the track excavation is circa 1870 mm, which must be done in two steps. Firstly, the track lowering work (including the reconstruction of one platform) will be carried out only on one track. Secondly, the track lowering work (including the reconstruction of another platform) will be carried out on the other track. A temporary sheetpile wall will be required between the two tracks during the track lowering work to ensure stability of the remaining track. These works require the closure of one track at a time while the platform and track lowering works are ongoing. Reference Section 4.1.2 for further information.

For the existing footbridge OBG11A, the proposed track lowering track level at this location is around 0.70 m. The proposed drainage, track infrastructure, and platform design require deeper excavation than the proposed track level, significantly impacting the existing foundations of OBG11A. Therefore, it is proposed that the existing footbridge be demolished and rebuilt to current standards. This will include provision for impaired mobility users (lifts and/or ramps). Further structural assessment and additional information will be needed if the existing footbridge is to be maintained.

The existing station building is also located adjacent to the Up platform. It is assumed that this structure will need to be dismantled temporarily during reconstruction of the platform structures and retaining walls and then reassembled. This has been accounted for in the cost and programme assessment.

3.1.3 Flooding issues

There are no known existing flooding issues identified at Castleknock station as per the Stage 3 Site-Specific Flood Risk Assessment. However, the new longitudinal profile places the tracks at Castleknock Station 1 m below Royal Canal water level – see figure below. The new retaining wall would need to be designed to ensure this minimises the risk of water ingress from the Royal Canal. Further investigation would be required at detailed design to ensure the risk of track flooding from the canal was minimised.

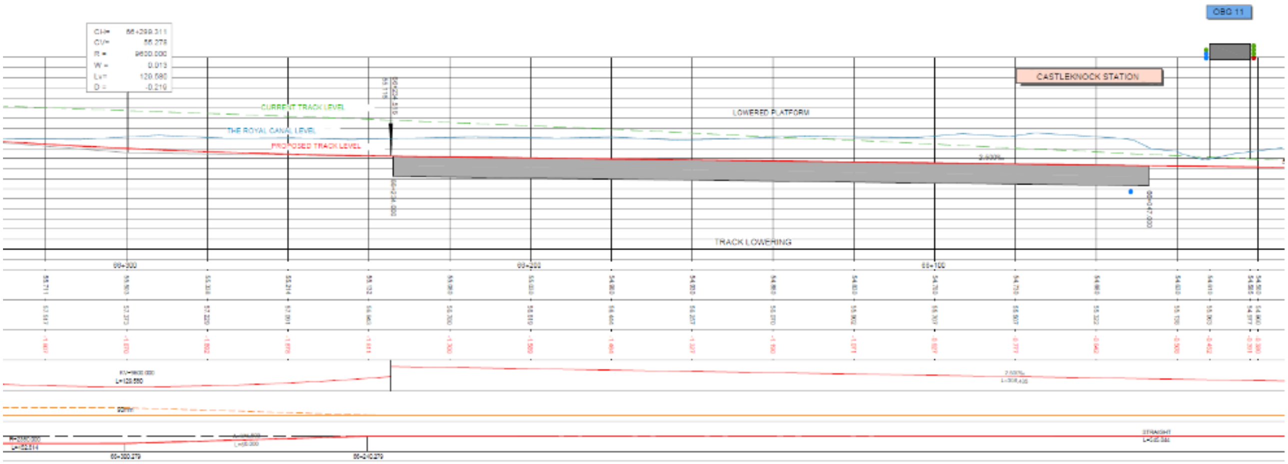

Figure 3-6 Longitudinal profile of track lowering relative to canal

3.1.4 Drainage issues

The low point of the tracks under the bridge structure is located at a height of 54.96 m (top of rail). With the proposed lowering, track rail elevation would be at 54.58 m and the formation (ballast contact with the subgrade) at 53.47 m level.

The gradient of the tracks is reduced with the track lowering option in order to comply with the current standards and tie into the station platform, and new track drainage would need to be installed.

The track longitudinal profile descends towards East, and the track lowering keeps that continuous descending gradient – see Figure 3-8 below. It is deemed feasible to install lineside gravity drainage from the track lowering low point to an outfall at UBG10, located circa 270 m from OBG11.

Figure 3-7 Plan view of OBG11 relative to UBG10 culvert

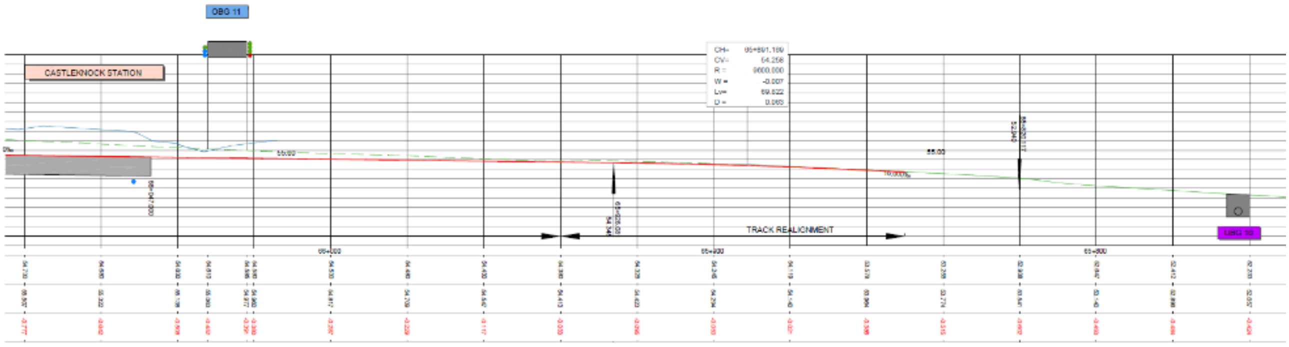

Figure 3-8 Longitudinal section of the track lowering relative to UBG10

Construction of the drainage next to the live railway will require the works to be completed at night/weekend possessions. Part of the drainage will be installed during the track closure/track lowering works, but the works to the East beyond the track lowering towards UBG10 will need to be completed during night-time/weekend possessions.

There is a hotel and residential properties at this location that would be affected by the out of hours works, adding to disruption.

3.1.5 Utilities

Utilities running across rail tracks are listed below.

Table 3-2 OBG11. Utilities along tracks

Serial Number	Description	Location	Utility	Description	Potential Diversion in case of listed intervention	Duct Type
OBG11	Castleknock Road - Stone bridge, three centres' arches	R806, Northside Dublin	IW	Gravity foul pipe underneath the tracks and Royal Canal	Track Lowering	N/A

As per current information, there is one number gravity foul pipe underneath the tracks and the Royal Canal. With current information it is believed this pipe is 5m below existing track level.

Trial holes would need to be completed to confirm the depth of this pipe to confirm this depth to allow the pipe to remain in its current position or if diversion/protection of the pipe is required. However, at present it is deemed acceptable, and no diversion is anticipated.

3.2 Option 2. Bridge deck reconstruction

3.2.1 Description

To achieve a sufficient vertical clearance for the catenary equipment under the bridge, the precast arch deck solution has been proposed. The new arched bridge deck shall be installed approximately 410 mm higher than the original bridge arch position.

The adjacent arch canal bridge is a protected structure with historical value, therefore it must be carefully protected during the bridge deck reconstruction works.

Three structural solutions were proposed to increase the vertical clearance of the bridge (the current worst case clearance from TOR to soffit is 4450 mm):

- Structural solution 3A: Precast arch deck.
- Structural solution 3B: Precast frame deck.
- Structural solution 3C: Arch Lifting.

The solution 3C is the most sympathetic alteration. However, it has a higher risk compared to solutions 3A & 3B, due to being an innovative solution with limited experience.

The differences between the solutions 3A & 3B are the deck shape and the required lift height. The solution 3A, the precast arch shape, maintains the geometry of the current stone arch with a minimised aesthetic impact compared to the precast frame shape solution. Although the solution 3B of the precast frame shape allows the height to reduce slightly to lift the bridge arch, its shape has a very significant negative visual impact.

Therefore, the solution 3A has been selected as the optimal solution in terms of structural modification and a 410 mm increase in arch height is required to achieve 4400 mm contact wire height (bringing the messenger wire to the contact wire level).

The figures below show OBG11 Castleknock Bridge with the proposed precast arch deck solution.

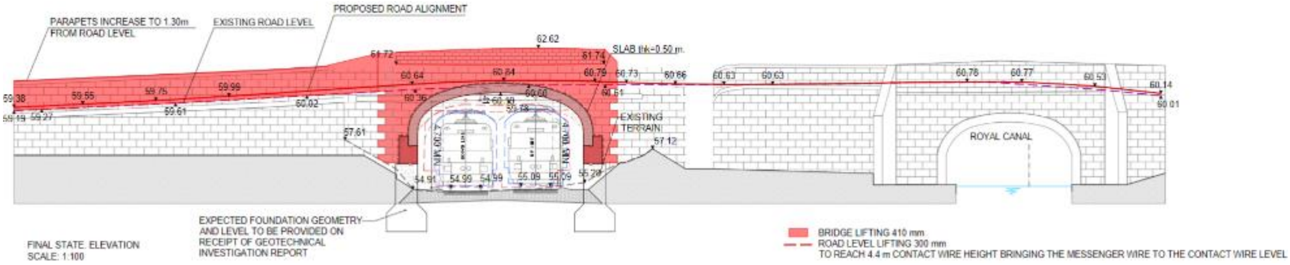

Figure 3-9 Deck reconstruction of the OBG11. Elevation

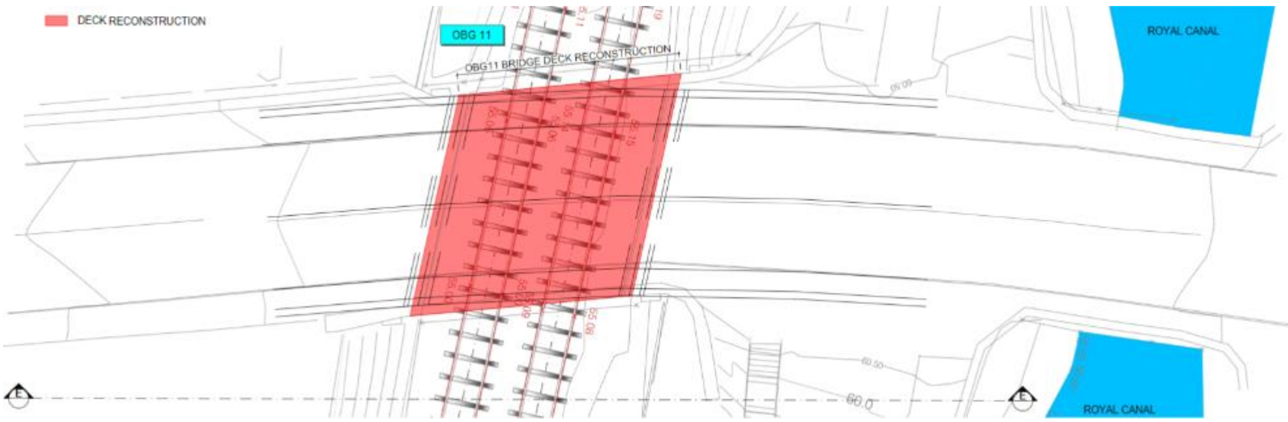

Figure 3-10 Deck reconstruction of the OBG11. Plan view

To ensure the new section of the bridge is constructed in line with heritage considerations, all of the design elements will need to be carefully considered in relation to the historic setting and, in particular, the remaining canal bridge. All junctions and interventions will need to be rigorously detailed to ensure the two bridges sit comfortably together in the landscape.

One advantage to reconstructing the bridge is that the railway bridge arch would be rebuilt to current structural design standards. The existing arch is thought to have been constructed in the 1800s and so rebuilding the arch to current design standards would provide a compliant structure.

The bridge arch deck reconstruction would result in the following impacts:

- Considerable impact on the rail and canal bridges in terms of heritage.

- Closure of the road during construction would require traffic and pedestrians/cyclists to divert to other crossing locations.
- Utilities: through OBG11, there are existing utilities that would need to be diverted temporarily if the bridge deck is modified.

The above points have been considered in more detail in the following sections.

3.2.2 Heritage impacts and considerations

The removal and replacement of the bridge on Castleknock Road over the railway line is a very significant loss of important historic fabric. Unlike the other historic bridges on the scheme being removed, this bridge stands separate, but close to Granard Bridge over the canal. The loss of the bridge span will have a considerable impact on the character of the setting, surrounding environment and the canal bridge, dating from the 1790's. As this technical note identifies, the bridge could be retained but at a significant financial and programme cost. From a conservation perspective it would have been preferable to incorporate the welcomed new infrastructure into the existing setting while retaining this important historic structure.

To mitigate the loss of this historic structure as much as possible, it is essential that the replacement section of the bridge is well designed, detailed and executed. The most important consideration in the process will be to ensure that the new build element sits comfortably alongside the remaining abutments, wing walls and nearby canal bridge.

Due to the significant raising of the bridge to accommodate the OHLE and the requirement to install a precast concrete arch, it will not be possible or desirable to reconstruct the span to match the existing. Instead, a contemporary solution using modern materials will be designed to complement the remaining features of the original stonework, including the abutments and wing walls. The extent of demolition will be confined to the section of bridge between the stone piers to ensure that the reconstructed section will be read as an insertion rather than an entirely new bridge. The colour and texture of the concrete finish, along with the quality of the detailing and workmanship will be critical to its success. Research into materials and sample panels will be essential prior to construction to ensure the new concrete finish complements the remaining historic stonework. The junctions between old and new will need to be carefully considered, particularly the change in levels, the parapets, and the interface between the original stonework and new concrete facing at the piers.

A number of finishes and construction methods were assessed during the design process. Initially the preferred option was to re-use the original facing stone, but it became clear that this would not be successful due to the technical constraints of the new construction. The string course is an essential element of the existing composition, but the increased height of the arch would distort its connection to the string course on the piers and abutment walls. The precast arch construction would reduce the existing voussoirs to cladding stones and the facing stone of the spandrels would also become cladding stones tied back to the concrete structure behind. The combination of all these factors made it very difficult to design or build stonework that would sit well with the original fabric on each side.

The use of a weathered steel facade was also explored as this material is being used on newbuild elements elsewhere in the project. After careful assessment it was decided to proceed with a concrete finish as this will sit most comfortably with the remaining original stonework. Provided a suitable colour and finish are achieved on the concrete, it should complement, not dominate the original structure.

The proposed finish is shown in Figure 3-11 below for OBG5 Broome Bridge as an example.

Figure 3-11 OBG5 Broome Bridge Photomontage - Canal View West

It is a safety requirement that the parapets are a minimum of 1800 mm high and the bottom 1200 mm must be solid, in the area of the OHLE. This presents a significant challenge to all of the historic bridges along the scheme, as the existing original parapet heights are lower than 1200 mm. A rigorous design process has taken place to identify a solution that will complement the historic setting and maintain a visual connection to the rail lines and surrounding landscape, when on the bridge. The proposed design is a contemporary, adaptable solution that can be implemented throughout, bringing a degree of uniformity to all interventions along the railway. For this bridge, it is proposed to provide a solid metal panel from the top of the parapet up to 1200 mm with an expanded metal mesh to continue up to 1800 mm. The fixing stays and mesh will be carefully designed to ensure the internal face of the parapet is not obscured and that the mesh allows a good visual connection to the surroundings.

To ensure the new span over the railway is successful, all elements of the design will need to be carefully considered in relation to the setting, and in particular, the remaining abutment and wing walls along with the nearby canal bridge. All junctions and interventions will need to be well designed and detailed to ensure the two phases of construction sit comfortably together and in the landscape.

3.2.3 Road closure and impact on the community

In order to reconstruct the bridge a road closure will be required. This includes:

- 15 weeks of total road closure.
- 19 weeks of partial road closure (one lane open).
- 13 weeks pedestrian/cyclist closure.

For the road closure of 15 weeks, a diversion route has been proposed. The impact of this road closure has been assessed in the Traffic and Transport chapter of the EIAR, and the impact is deemed to be a minimal short term impact.

For pedestrians, Castleknock station footbridge will be used, as shown in the figure below.

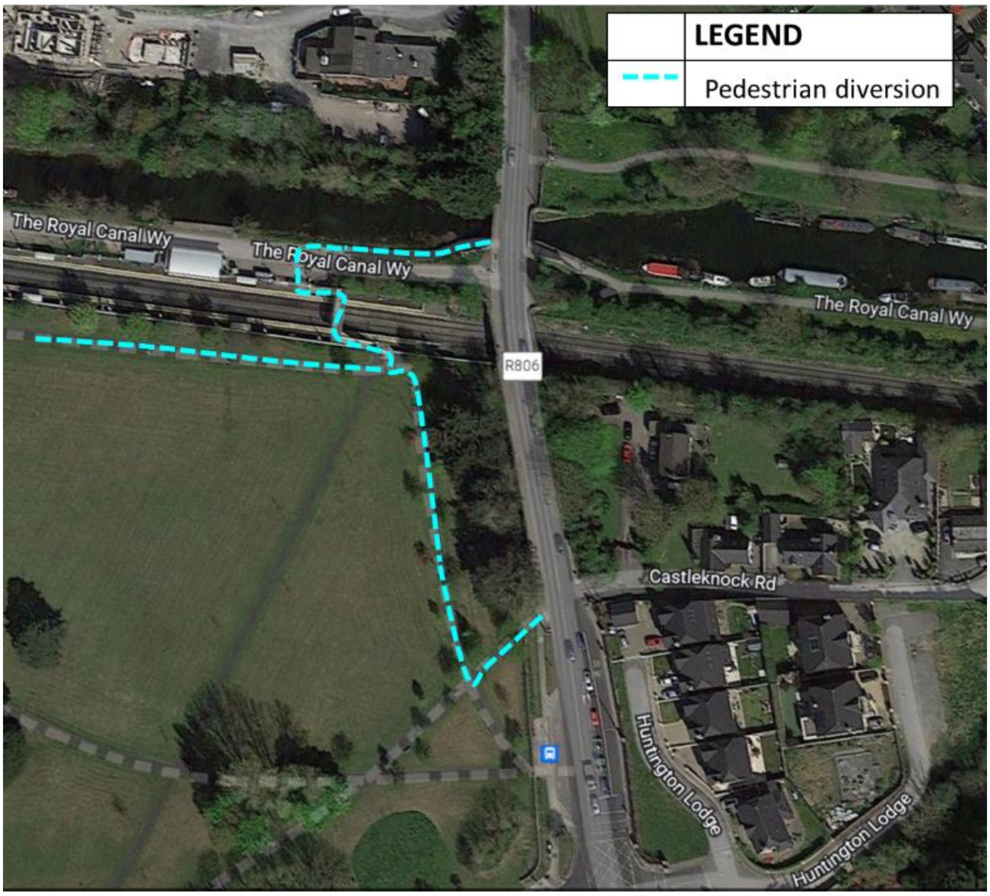

Figure 3-12 OBG11 pedestrian diversion during construction

This route is an increased distanced, and step free access if not available, so may have a negative impact on impaired mobility users using this route during the 13 week diversion.

3.2.4 Utilities

Utilities crossing over the bridge must be temporarily diverted during bridge reconstruction and then reinstated. The utilities to be diverted include MV/LV cables, watermain, and telecom ducts – see Table 3-3 below.

Table 3-3 Utilities at OBG11 Castleknock

Serial Number	Description	Location	Utility	Description	Potential Diversion in case of listed intervention	Duct Type
OBG11	Castleknock Road - Stone bridge, three centres arches	R806, Northside Dublin	ESB	MV/LV underground duct along bridge deck	Bridge Deck Reconstruction	3x1x185 XLP
			IW	Watermain pipe hanging on bridge parapet	Bridge Deck Reconstruction	228.6mm Cast Iron operating at approx. 1 Bar
			Telecoms	Eircom ducts along bridge deck	Bridge Deck Reconstruction	N/A
				Virgin ducts along bridge deck	Bridge Deck Reconstruction	1x48F / 1x144F

In locations where bridge modification is needed, utilities within the bridge deck are proposed be temporarily diverted during the deck reconstruction.

Temporary diversions will be supported by the construction of scaffolding that will run parallel to the original deck, separated by a safe margin to ensure it remains intact during the reconstruction process. The scaffold platforms, which shall be formed above the bridge soffit level, will consist of a wooden board screwed down over netton mesh sheeting and returned vertically at the edge of the footboards, and they shall be formed above the bridge soffit level. In addition, scaffolding shall be fully enclosed with plastic sheeting, and boards shall be securely lashed together and tied down at teach end. Working surfaces on the scaffold shall only be accessed by site personnel.

Figure 3-13 Scaffold for temporary diversion

By means of the scaffolding, the affected utilities can be diverted from one side of the track to another by a temporary conduit laid on the scaffold platforms. Prior to connection to the temporary conduit, the affected utilities must be cut off behind the abutments.

In general, the disruption time of the service is mainly due to the connection of the temporary diversion. This is expected to be hours, but it will depend on the utility, the intervention and the location. To minimize the disruption time, the temporary diversion, ducting and the connections must be planned properly.

Scaffolding can be erected during night-time/weekend possessions.

3.3 Option 3. New alignment solution

The option consists of a track layout diversion that avoids going through the OB11 and thus manages to avoid the clearances issue.

It is an almost unviable option due to the position of the bridge in an urban environment and the considerable impact that any deviation from the railway line would have on it.

The diversion presents significant challenges:

- 375 m east of the bridge is the M50 motorway junction, with the railway crossing above the motorway and the junction roundabout above the railway.
- The new tracks diversion alignment on the north side of the bridge would require crossing the Royal Canal twice, impacting the hotel and buildings adjacent to the Royal Canal Lock 12th. It would also impact the buildings next to the Royal Canal greenway (Roselawn Rd), and the greenway itself.

- The new track diversion alignment on the south side of the bridge would impact the buildings on Castleknock Rd before passing the bridge, impacting Laurel Lodge Park and part of the houses on Castleknock Wood Rd and Castleknock Rd View Rd past the OBG11.

The solution involves a high construction and land acquisition with severe social impact. The current Castleknock station would also be displaced from its location, and significant land acquisition costs would be incurred.

This option was ruled out early on in the optioneering process and was not progressed further.

4. COST AND PROGRAMME IMPACTS

4.1 Track Lowering

4.1.1 Construction duration

The following table indicates the estimated duration for the track lowering option.

Table 4-1 Estimated duration of the works

Track lowering and footbridge reconstruction
15 months

Note that durations have been estimated high level at this stage of design. Note this assumes implementation of a gravity drainage system.

The construction strategy for the track lowering and station works is proposed as follows:

1. Utility diversions within the station and track lowering area.
2. Installation of track crossovers (night-time possessions) to allow for track cross overs during track lowering and platform works
3. Demolition of existing footbridge and stairs (full weekend closure required on both tracks)
4. Platform works on the Platform 1 and Up track lowering (700 m)
   - 4.1. Installation of temporary sheet piles between the Up and Down tracks (both tracks closed, to be done either in weeknight or weekend possessions) from station platforms to the western ends (circa 450 m length)
   - 4.2. Demolition of existing Up track and platform elements; dismantle the existing station building (Up track closed for duration)
   - 4.3. Construction of platform structures, retaining walls, footbridge foundation, station structure, and new Up track elements (Up track closed for duration)
   - 4.4. Installation of drainage system (Up track closed for duration or weeknight or weekend possessions)
5. Platform works on the Platform 2 and Down track lowering (700 m)
   - 5.1. Demolition of existing Down track, and platform elements (Down track closure for duration)
   - 5.2. Construction of platform structures, retaining walls and new Down track elements (Down track closure for duration)
   - 5.3. Installation of drainage system (Down track closed for duration or weeknight or weekend possessions)
   - 5.4. Removal of temporary sheetpiles between the Up and Down tracks (weeknight or weekend possessions)
6. Installation of the new footbridge, ramps and lifts (if necessary and deemed required by IE) (full weekend closure required on both tracks, plus night-time possessions)
7. Boundary walls fences and accesses (daytime or weeknight/weekend possessions depending on activity)

The following table shows an indicative sequence of activities:

Table 4-2 Indicative programme for track lowering

		M1				M2				M3				M4				M5				M6				M7				M8				M9				M10				M11				M12				M13				M14				M15
Activity	Duration	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57
1- On site offices and welfare facilities	**2 weeks**	🟩	🟩																																																							
2- Utilities and existing services diversions	**8 weeks**			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																																															
3 - Installation of track turnouts	**1 week**											🟧																																														
4- Demolition of existing footbridge and ramps, station building dismantle	**1 weekend**												▨																																													
5- Platform 1 and track works (180m platforms and 700 m track lowering)	**18 weeks**																																																									
Installation of temporary sheetpiles between the Up and Down tracks	1 week													🟧																																												
Demolition of existing Up track, and platform elements	4 weeks														▨	🟨	🟨	🟨																																								
Platform structures, retaining walls, footbridge foundations, station building reassemble	12 weeks																		🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨																												
Track lowering works: Up track earthworks and track elements	12 weeks																		🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨																												
Installation of drainage and connection with UBG10A	3 weeks																										🟨	🟨	🟨																													
6- Platform 2 and track works (180m platforms and 700 m track lowering)	**16 weeks**																																																									
Demolition of existing Down track, and platform elements	4 weeks																														▨	🟫	🟫	🟫																								
Construction of platform structures and footbridge foundations, and retaining walls	12 weeks																																		🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫											
Track lowering works: Down track earthworks and track elements	12 weeks																																		🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫	🟫											
Installation of drainage	2 weeks																																								🟫	🟫															
Removal of temporary sheetpiles between the Up and Down tracks	1 weekend																																														▨											
7 - Removal of track turnouts	**1 week**																																															🟧										
8- Installation of the new footbridge, ramps and lifts (if required)	**11 weeks + 1 full weekend**																																																									
Construction of the new footbridge, ramps and lifts (if required)	weekend																																															▨	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧
9-Boundary walls fences and accesses; making good station	**3 weeks**																																																							🟩	🟩	🟩

Note 1: From Week 13 to 29 temporary fences will be placed at the Up track for the safety measures and to allow the operation of the Down track. 1 full weekend possesion is also required during week 13.

Note 2: From Week 30 to 45 temporary fences will be placed at the Down track for the safety measures and to allow the operation of the Up track. 1 full weekend possesion is also required during week 30.

Note 3: From Week 11 to week 57 the footbridge is not accessible.

Railway operation

- 🟨 Up track railway closure
- 🟫 Down track railway closure
- 🟧 Night time possession works required
- ▨ Full weekend closure on Up & Down tracks
- 🟩 Daytime (No railway closure required)

4.1.2 Disruption of services

Road closure

For the track lowering option, the road would not be impacted.

However, from week 11 to week 57 the pedestrian footbridge (labelled ‘c’ on the figure below) over the railway will not be accessible, meaning pedestrians will need to use the existing historic bridge to cross the railway between the platforms. This is an increased length of diversion for those wishing to use the station bridge to cross between platforms and is required for 46 weeks.

Figure 4-1 Track lowering structural intervention – Plan view

Figure 4-2 Proposed pedestrian diversion route during station footbridge demolition/reconstruction

Station closure

The track lowering option requires around 15 weeks of the Up-track closure to carry out the platform, track lowering, and foundations works. During this period (from Week 15th to 29th), temporary fences will be placed at the Up track for the safety measures and to allow the Down track's railway operation. Once the Up-track work is finalized, the works continue on the Down track. It requires around 15 weeks of the Down-track closure to carry out the platform, track lowering, and foundations works. During this period (from 31st to 45th), temporary fences will also be placed at the Down track for the safety measures and to allow the Up track's railway operation.

Considering the current constraints (i.e., site clearance and spatial limitation between the existing Up and Down tracks), it is challenging to carry out the construction work while maintaining the operation of both the Up and Down tracks. During the platform demolition and foundation construction work, several weeks of night closure and weekends closure on both Up and Down tracks is required. Detailed safety measures will be required in the following design stages to mitigate any possible risk to people during the construction work.

The figures below show an example of the set up required to close one track in order to complete platform reconstruction works.

Figure 4-3 Example of track closure required to complete platform works

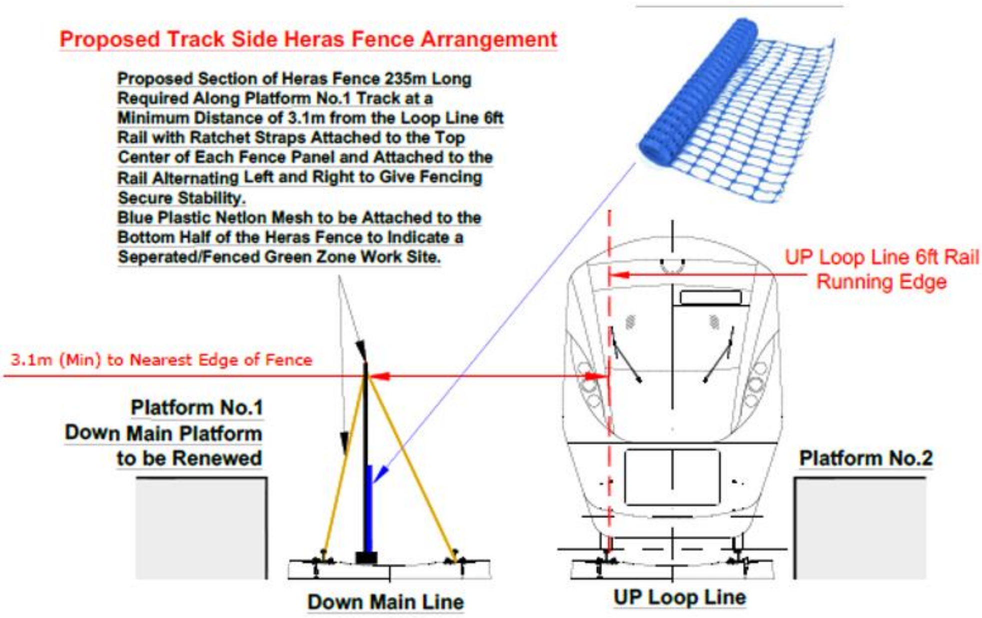

Figure 4-4 Required working space when working next to a live rail line

The closure of a track for demolition work and reconstruction of the adjacent platform means that the line needs to be operated on a single bi-directional track section.

The nearest crossovers to Castleknock Station that allows for track switching are located at Clonsilla at the West (about 3.3 km away), and at the East side, Glasnevin, about 6.4 km away for left turns movements, and Dublin (Newcomen Bridge), about 4.6 km away for right turns movements. This would result in the line operating on a single bi-directional track between Clonsilla and Dublin (about 11.7 km), resulting in operational constraints.

To avoid this situation, temporary turnouts could be provided at each end of the station (beyond the track lowering area) to allow trains to pass through the station on a single track section for approximately 900 m in length.

In the first phase, while work is being done on Platform 1, the Up track is closed, and the Down track is a single track. Two provisional turnouts allow the change from the Up to the Down and vice-versa.

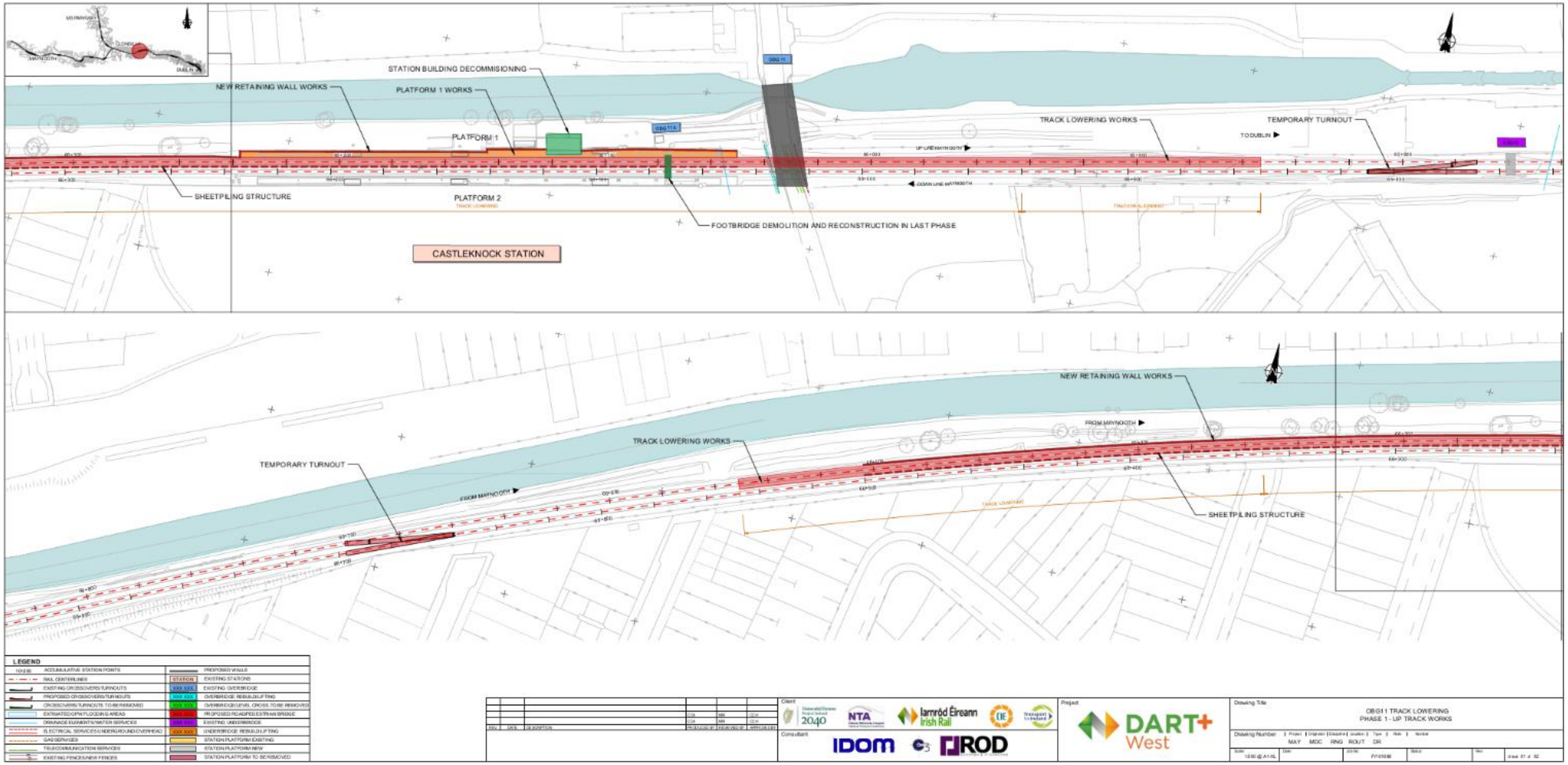

Figure 4-5 Works at Platform 1 and Up track lowering. Up track closed. Trains running through Down track

In the second phase, works are done at Platform 2, and the Down track is closed; meanwhile, the Up track is the single running line. For this situation, the provisional turnouts have to change sides.

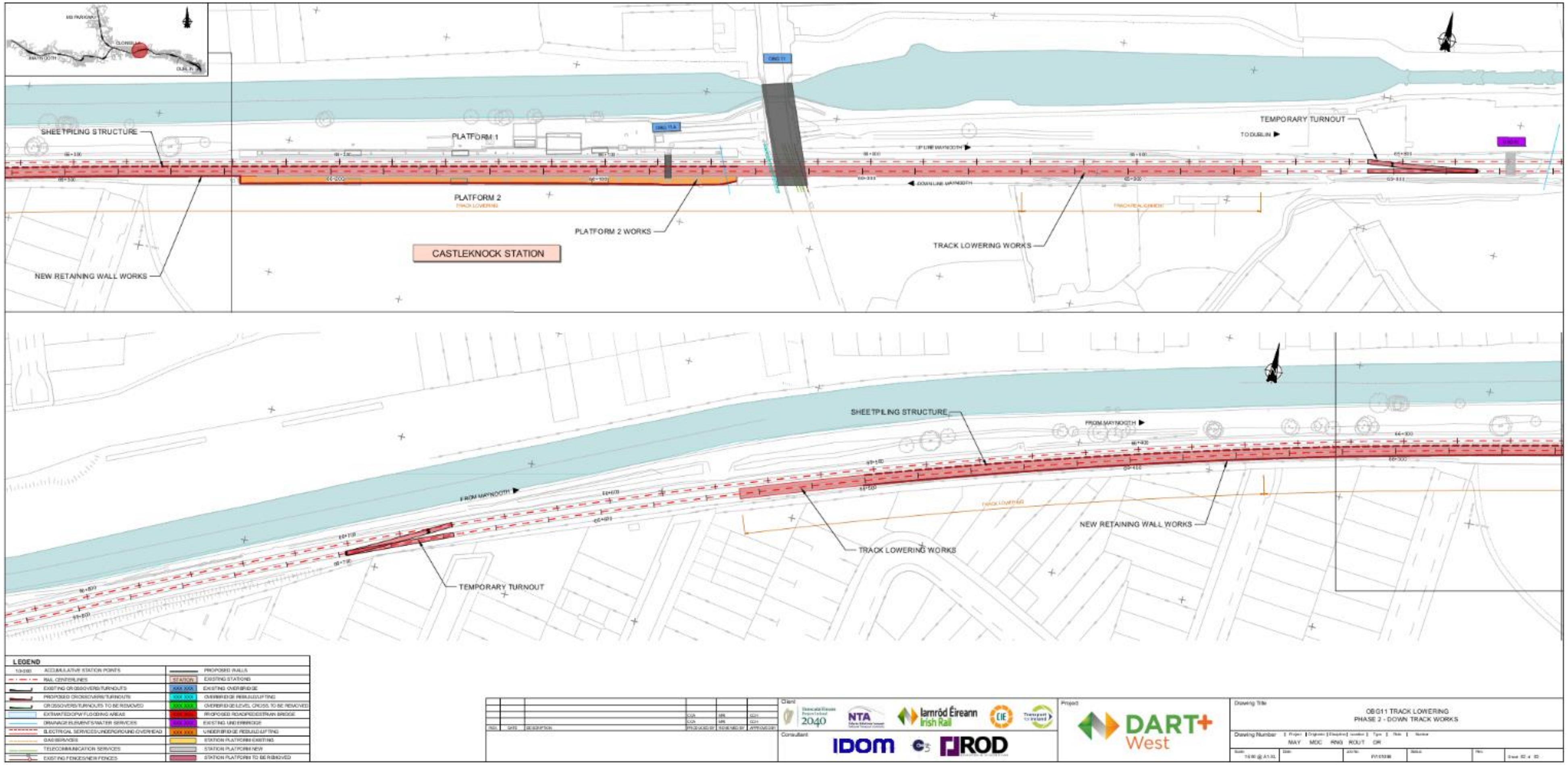

Figure 4-6 Works at Platform 2 and Down track lowering. Down track closed. Trains running through Up track

Temporary signalling works will also be required in order to implement these temporary turnouts, which adds additional cost to these works.

In summary, the Up and the Down platform would require disruptive interventions for 15 weeks each platform. Pedestrians will be required to be diverted for 46 weeks due to the station footbridge being demolished and reconstructed. The disruption of service to the station may need to be mitigated by the provision of a shuttle bus service to bring the passengers to and from Castleknock Station. This would need to be agreed with IE operations should this option be considered.

The table below indicates the summary of the estimated time of disruption.

Table 4-3 Estimated time of disruption

Track lowering and station reconstruction	
Road closure	Pedestrian diversion required for 46 weeks
Railway closure	15 weeks on the up track and 15 weeks on the down track

4.1.3 Cost estimate

The table below indicates the estimated cost of the track lowering option.

Table 4-4 Estimated cost

Track lowering (*) (€ '000)
14,677

(*) Cost includes reconstruction of the station infrastructure, track lowering and drainage system. Assumes station building can be dismantled and reused.

4.2 Bridge Reconstruction

4.2.1 Construction duration

The table below indicates the estimated duration for the bridge reconstruction option.

Table 4-5 Estimated duration of the works

Bridge modification
10 months

Note that durations have been estimated high level and can be refined during detailed design.

The construction strategy for the bridge modification is proposed as follows:

1. Traffic and utility diversions shall be carried out before the arch deck reconstruction, including site setup, accommodation works, utility diversions, earthworks, and pavement works.
2. Soil improvement behind the existing wall using jet grouting.
3. Excavation, deconstruction of the surface of the existing arch (existing masonry to be reused for surfacing and finishing work where applicable) and demolish the inner upper part of the existing arch structure. The pavement and backfill on the Royal Canal arch to be removed temporarily and symmetrically to avoid uneven loads on the Royal Canal arch, if necessary. A protective element should be placed to protect the parapets and the stone face of the Royal Canal arch.
   a. Underpinning of existing foundations using lateral micropiles to strengthen existing foundations, if necessary.

4. Placing of the precast concrete wall blocks for arch support and anchoring to the existing walls with dowel bars.
5. Placing of the precast concrete arch deck.
6. Waterproofing membrane on the precast concrete arch deck and precast concrete wall blocks.
7. Backfill to bedstone behind the vertical walls to consist of semi-dry mortar not less than 750 mm in width.
8. Reconstruction of the road.
9. Make good restoration work along the deck to integrate aesthetically with the arch bridge.
10. Load test to be carried out on the adjacent canal bridge before allowing the road traffic to pass over.
11. Place temporary jersey barrier (or similar) in the carriageway to allow vehicles and pedestrians to cross, reinstallation of diverted utilities.
12. Repair the pavements and parapets in accordance with conservation architects' requirements.

The following table shows an indicative sequence of these activities:

Table 4-6 Indicative programme for bridge modification

		Month	1				2				3				4				5				6				7				8				9				10			
		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1. Site preparation	Traffic and utility diversions, etc.																																									
2. Soil improvement																																										
	Soil improvement behind existing wall								x	x																																
3. Excavation and deconstruction & demolition of existing structure																																										
	Excavation to the wall below springer level										x																															
	Deconstruct the surface of arch structure and arch support										x																															
	Demolish the inner part of arch structure and arch support											x																														
3a.	Foundation strengthening, if necessary																																									
4. Deck support reconstruction																																										
	Concrete wall blocks												x	x	x																											
5. Deck reconstruction																																										
	Precast arch deck												x	x	x																											
6. Deck waterproofing																																										
	Waterproofing membrane															x	x																									
7. Backfill																																										
	Backfill to bedstone behind walls																	x	x	x	x																					
8. Road modification to a new level																																										
	Road modification																			x	x	x	x	1	1	1	1															
	Finishing																											1	1	1												
9. Restoration																																										
	Restoration work																			x	x	x	x																			
10. Reinstallation of diverted utilities																																										
	Place temporary jersey barrier (or similar), utilities diversions																							1	1	1	1	1	1	1	1	1	1	1	1							
11. Deck																																										
	Parapets																																		1	1	1	1	1	1		
	Finishing, load test to be carried out on the adjacent canal bridge before allowing the road traffic to pass over																																								1	1

Total construction duration:	40 weeks
Railway closure:	4 full weekends of possession +11 weeks of night closure working on the railway + 1 weeks of total railway closure
Total road closure:	15 weeks
At least one-lane road closure:	15 weeks (total closure) +19 weeks (one-lane closure) = 34 weeks
Pedestrian total closure:	13 weeks

Road closure

x	Total road closure
1	One lane road closure

Railway operation

- Close to railway
- Service total closure
- Full weekend closure
- Week of night closure
- No railway closure required

Note: From 20th week the temporary jersey barrier (or similar) will be placed in the carriageway
and in 20th and 21st weeks temporary pedestrian ramps will also be placed to allow pedestrian to cross.

Note: From 20th week the temporary jersey barrier (or similar) will be placed in the carriageway and in 20th and 21st weeks temporary pedestrian ramps will also be placed to allow pedestrian to cross.

4.2.2 Disruption of services

Road closure:

Within the estimated time for the bridge modification:

- the road would be closed to vehicles for 15 weeks, with a one lane closure for a further 19 weeks. Note Chapter 6 Traffic and Transport of the EIAR states that the construction impact of this diversion is 'slight' and 'temporary'.
- The bridge would be closed to pedestrians for 13 weeks. However, a temporary pathway could be provided to allow access to the station platforms during the works, a pathway that could also be used by pedestrians crossing from one side to the other (see section 3.2.3 for proposed route).

Station closure:

As shown in the above design chart, the total construction duration is estimated at approximately **40 weeks**.

For the bridge modification, the station would be closed during four-weekend track possessions and 1 full week for stages 2 to 3 (refer to Table 5-3 above).

The table below indicates the summary of the estimated time of disruption.

Table 4-7 Estimated time of disruption

Bridge modification	
Road closure	15 weeks; further 19 weeks one lane closure; pedestrian diversion via existing station footbridge required for 13 weeks.
Station closure	4 full weekends and 1 full week

4.2.3 Cost estimate

The table below indicates the estimated cost of the bridge reconstruction option.

Table 4-8 Estimated cost

Bridge modifications (*) (€ '000)
1,423

(*) Cost includes the diversion of the existing utilities and allowance for road closures and diversions.

5. SELECTION OF PREFERRED OPTION

5.1 Multicriteria Analysis (MCA)

In order to address the problem of clearance in this particular structure, a dedicated multi-criteria analysis (MCA) has been undertaken to consolidate the impacts of each option.

The feasible options included in the MCA process are listed in the table below:

Table 5-1 Options Assessed

Options	Description
Option 1	Track lowering to allow a 4400 mm contact wire system
Option 2	Bridge deck reconstruction

5.1.1 Option 1. Track lowering to allow a 4400 mm contact wire system

5.1.1.1 Description

Option 1 to achieve 4400 mm contact wire height requires the lowering of the tracks approximately 380 m directly below OBG11. However, as described in previous sections, the track lowering increases to the west along the platforms reaching a maximum value of 1.87 m.

The main advantages of this option are:

- Historic bridge is not affected by the works.
- Renewal of existing station tracks compliant with the standards. The report has studied a 2.5 mm/m gradient compliant with the CCE and TSI standards.
- No disruption to road users using OBG11 to cross the canal and railway at this location.

The disadvantages of this option are:

- It requires extensive work in and around the station platforms, accesses, footbridges, utilities, fences, etc., requiring long track closures and disruption to passengers. The station building located adjacent to Platform 1 and the OBG11A station footbridge need to be dismantled and reconstructed. The platforms are proposed to be lowered by circa 1 m in the building station area, and relevant building intervention is required.
- Excavations of up to 1.87 m at the western ends of the platforms require retaining walls to the solve level differences. These retaining walls impact the boundaries of the residential area of Castleknock Wood Rd and Castleknock View Rd, requiring temporary/permanent land acquisitions. Laurel Lodge Green may also be affected.
- Pedestrian diversion required for 46 weeks when crossing between platforms.
- The Royal Canal is very close to the tracks, and the position of the track below 1 m of the Royal Canal water level in the longitudinal profile may increase the risk of flooding during heavy rainfall. Flooding risk from the Royal Canal requires further investigation to verify this option.
- Lineside drainage requires to be installed for a further 270 m along the tracks.
- This option has increased costs and programme duration.

5.1.2 Option 2. Bridge deck reconstruction

5.1.2.1 Description

Option 2 to reconstruct the existing railway arch requires the modification of this structure to provide an additional clearance of 410 mm higher than the original bridge, as described in previous sections.

The main advantages of this option are:

- Limited disruption to station and railway users/operators.
- Shorter programme reducing impacts on residents in this area during construction.
- No additional land acquisition impacting local residents envisaged with this option.
- Reduced construction programme and costs.
- No increase in flooding risk to the railway.
- Railway bridge is rebuilt to current design standards.

The disadvantages of this option are:

- Significant heritage impact to the historic bridge
- Disruption to road and pedestrian users in this area during the closure of the bridge.

5.1.3 MCA Assessment

The MCA options assessment summary is shown in Table 5-2 and the full MCA Assessment is shown in Table 5-3.

The results of the MCA led to recommend **Option 2, deck bridge reconstruction** (precast arch deck) as the preferred option.

Table 5-2 MCA Summary Assessment

	Criteria	Option 1. Track lowering along all the station	Option 2. Deck bridge reconstruction
1	Economy	Significant comparative disadvantage over other options	Significant comparative advantage over other options
2	Integration	Some comparative disadvantage over other options	Some comparative advantage over other options
3	Environment	Some comparative advantage over other options	Some comparative disadvantage over other options
4	Accessibility and social inclusion	Some comparative disadvantage over other options	Some comparative advantage over other options
5	Safety	Some comparative disadvantage over other options	Some comparative advantage over other options
6	Physical Activity	Some comparative advantage over other options	Some comparative disadvantage over other options
	Chosen Option	No	Yes
	Comment	Option 1 does not impact the historic structure. Option 1 has a negative impact on Broombridge Station in terms of diruption to rail users and the operator. Option 1 negatively impact on the the boundaries of the residential area of Castleknock Wood Rd and Castleknock View Rd and requiring temporary/permanent land acquisition. Option 1 requires significant higher construction cost than Option 2. Option 1 requires a longer construction period, increasing disruption to residents in the area	Option 2 negatively impacts on the historic structure and the challenge of this option is to find a sympathetic solution that minimizes the impact on the historic bridge. Option 2 impacts on road users more than Option 1. Option 2 is cheaper and requires less time to construct, minimising disruption in this area. Option 2 improves structural safety in the long run through construction of a new structure in line with current standards.

Table 5-3 MCA Options Assessment

DART Maynooth & City Centre Enhancements. Draft Permanent Way Preliminary Assessment Criteria and parameters

OBG11 MCA1 Assessment

	Parameter		Criteria	Option 1 Track lowering along all the station	Option 2 Deck bridge reconstruction
1	**Economy**	1.1	**Construction and Land Cost**	**Significant comparative disadvantage over other options**	**Significant comparative advantage over other options**
				This solutions requires significant lowering of both tracks below OBG11, which has increased costs when compared to Option 2. This solutions requires significant alterations to Castleknock Station (platforms, accesses, footbridges, ramp utilities, fences, etc). Requires lengthy closure of tracks and temporary infrastructure increases costs. This solution requires temp/permanent acquisition of properties at Castleknock Wood Rd and Castleknock View Rd.	This solution requires a reconstruction of the arch bridge. This construction solution is cheaper than the track lowering and requires minimal impact on the operational railway.
		1.2	**Long Term Maintenance costs**	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				This solution allows a standard catenary solution. Lowering the tracks may increase drainage issues.	This solution allow a standard catenary solution and keep tracks at current level. Construction of the new structure will improve bridge maintenance regime and reduce future maintenance costs as this is now a new compliant structure over the railway.
		1.3	**Train Operation Functionality /economic benefit**	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				Tracks are now approx. 1m below Royal Canal level. Risk of flooding and service interruption.	Option 1 introduces a risk of services interruption that Option 2 do not.
2	**Integration**	2.1	**Transport Integration**	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				This solution impacts on the operation of the railway during the construction works because the track lowering. This solutions impacts on Castleknock Station operation during the construction works. Pedestrian diversions required for 46 weeks during construction	This solutions impacts on OBG11 road during the works, although impacts are deemed to be minimal. Pedestrian diverion required for 13 weeks during construction.
		2.2	**Land Use Integration**	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**

	Parameter		Criteria	Option 1 Track lowering along all the station	Option 2 Deck bridge reconstruction
				Minor impact on Laurel Lodge park during construction.	This solution does not have any impact on land use and integration.
3	Environment	3.1	Noise and Vibration	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				Construction duration is longer, impacting the public for longer. Extensive demolition work required over a longer period. There is likely to be temporary construction impacts on sensitive receptors in this location which will be the subject of further assessment.	Construction duration shorter for this option. There is likely to be temporary construction impacts on sensitive receptors in this location which will be the subject of further assessment.
		3.2	Air Quality and Climate	**Comparable to other options**	**Comparable to other options**
				Higher volume of infrastructure affected by this option, so higher volume of materials required and higher waste generated likely.	Existing materials (e.g. stone parapets) planned to be reused
		3.3	Landscape and Visual (including light)	**Significant comparative advantage over other options**	**Significant comparative disadvantage over other options**
				No direct impacts on the bridge. Possible slight/moderate indirect negative impacts due to presence of overhead lines.	Direct and very significant/profound negative impacts on the bridge
		3.4	Biodiversity (flora and fauna)	**Comparable to other options**	**Comparable to other options**
				Works proposed in proximity to the Royal Canal pNHA. There is potential for water quality, noise and lighting impacts within the pNHA.	Works proposed in proximity to the Royal Canal pNHA. There is potential for water quality, noise and lighting impacts within the pNHA.
		3.5	Cultural, Archaeological and Architectural Heritage	**Significant comparative advantage over other options**	**Significant comparative disadvantage over other options**
				No direct impacts on the bridge. Possible slight/moderate indirect negative impacts due to presence of overhead lines.	Direct and very significant/profound negative impacts on the bridge
		3.6	Water Resources	**Comparable to other options**	**Comparable to other options**
				No indication of significant flood risk at this location. Potential water quality impacts during construction. There is no foreseen advantage or disadvantage of this option with regard to Water Resources.	No indication of significant flood risk at this location. Potential water quality impacts during construction. There is no foreseen advantage or disadvantage of this option with regard to Water Resources.
		3.7	Agriculture and Non-Agricultural	**Comparable to other options**	**Comparable to other options**
				No impact on agricultural or non-agricultural property	No impact on agricultural or non-agricultural property
		3.8		**Some comparative disadvantage over other options**	**Some comparative advantage over other options**

	Parameter		Criteria	Option 1 Track lowering along all the station	Option 2 Deck bridge reconstruction
			Geology and Soils (including Waste)	No geological heritage sites. Till overlain by poorly drained grey soil. May remove passive resistance from retaining walls and abutments which are structurally significant and will require structural modifications. Likely contaminants disturbance of trackbed ballast due to operations of diesel	No contaminants disturbance due to work being undertaken off track. However, jet grouting may be required to support existing foundations during construction.
4	**Accessibility & Social inclusion**	4.1	**Impact on Vulnerable Groups**	**Significant comparative disadvantage over other options**	**Significant comparative advantage over other options**
				Significant effect during construction when station platforms/tracks are closed, including 46 week pedestrian diversion.	Pedestrian and road diversions required during construction but impact deeemd minimal
		4.2	**Stations Accessibility**	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				Significant effect during construction when station platforms/tracks are closed, including 46 week pedestrian diversion. Improved in the permanent case as impaired mobility access would be provided.	This solution does not modify the current accessibility to the station. During construction pedestrian diversions are required.
5	**Safety**	5.1	**Rail Safety**	**Some comparative advantage over other options**	**Some comparative disadvantage over other options**
				Track gradient compliant with standards post-track lowering works.	There is no foreseen advantage or disadvantage of this option in regards to the Rail Safety.
		5.2	**Vehicular Traffic Safety**	**Some comparative advantage over other options**	**Some comparative disadvantage over other options**
				No impact on road users.	Diversions required during construction
		5.3	**Pedestrian, Cyclist and Vulnerable Road user Safety**	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				Pedestrian diversion required over historic bridge during demolition reconstruction of station footbridge/ramp for 46 week period.	Pedestrian diversion required via temporary bridge during 13 week period.
		5.4	**Structures safety**	**Significant comparative disadvantage over other options**	**Significant comparative advantage over other options**
				This solutions requires track lowering involving deep excavations and complex structural works next to a live railway. Impact on the historic railway and canal bridge also requires further investigation.	This solution may require jet grouting to stabilise the foundations during construction, but this solution provides a new compliant structure in line with current design standards, improving safety of the structure in the long term.

	Parameter		Criteria	Option 1 Track lowering along all the station	Option 2 Deck bridge reconstruction
6	**Physical Activity**	6.1	**Connectivity to adjoining cycling facilities**	**Comparable to other options**	**Comparable to other options**
				There is no foreseen advantage or disadvantage of this option in regards to the connectivity to adjoining cycling facilities.	There is no foreseen advantage or disadvantage of this option in regards to the connectivity to adjoining cycling facilities.
		6.2	**Permeability and local connectivity opportunity**	**Some comparative advantage over other options**	**Some comparative disadvantage over other options**
				No road diversions, only pedestrian/cyclist diversions during construction.	Road and pedestrian diversions may affect permeability and local connectivity negatively during construction.

6. CONCLUSIONS

As stated in in this report, no reduced OHLE solution was deemed feasible.

Regarding track lowering, while this option minimises the impact on the historic railway bridge and does not require road diversions, the disruption to railway users and operations is significant during construction. In addition the cost and programme impact of the construction work at the station was greater for this option. The track lowering requires significant retaining walls structures, impacting the boundaries of the residential area of Castleknock Wood Rd and Castleknock View Rd and requiring temporary/permanent land acquisition. A gravity drainage solution could be installed to mitigate the risk of the track flooding due to the new track level, 1 m below the Royal Canal level, but the risk of the tracks flooding remains a concern.

The option proposed given the points outlined in this report, specifically in the MCA, is a Bridge deck reconstruction (precast arch deck). This option limits the disruptions to station and railway users/operators significantly during construction. It has a shorter construction programme, reducing the impacts on residents during construction and is a more economic option. It is acknowledged that this option impacts significantly on the historic railway bridge, however engagement with a Grade 1 Conservation Architect will ensure that the reconstruction is done sympathetically and in keeping with the historic canal structure (Refer to Appendix A of this report for the Architectural Heritage Impact Assessment). Road diversions are also required, but traffic assessments have been completed and the impact is deemed minimal.

The new track realignment option was considered an almost unsuitable option due to the position of the bridge in an urban environment and the considerable impact that any deviation from the railway line would have on the surrounding area. The solution involves high construction and land acquisition costs with severe social impact. The current Castleknock station would also be displaced from its current location, further increasing construction and land acquisitions costs. This option was ruled out early on in the optioneering process.

APPENDIX A. Castleknock Bridge – Architectural Heritage Impact Assessment

B L A C K W O O D A S S O C I A T E S

A R C H I T E C T S

A N D

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DART+ West

Proposed works at Castleknock Bridge, Castleknock, Co. Dublin

Architectural Heritage Impact Assessment

June 2022

CONTENTS

1.0 INTRODUCTION

This report has been prepared by Blackwood Associates Architects to accompany the Railway Order application for the DART+ West project. The report will assess the impact of the proposed works on the existing structure and setting at Castleknock Bridge. The proposed works referred to in this document have been designed by IDOM, the design team lead, for the client, Iarnród Éireann.

2.0 DESCRIPTION OF STRUCTURE

Note: Much of the information below is based on the report provided by Rob Goodbody in the appendices to Chapter 21 – Architectural Heritage (Appendix A21.4 in Volume 4 of this EIAR).

As with other bridges on the Royal Canal, the introduction of the Great Western Railway in c.1846-47 required a new road bridge to provide passage over the railway line. In some cases, this was an extension of the bridge already on the Royal Canal. In this case, a second bridge, was built in close proximity due to the embankment of land between the canal and the railway line.

Castleknock Bridge was constructed to span over the railway line. It is a masonry road bridge which spans across two train tracks below.

In close proximity to the north is Granard Bridge, a road bridge of limestone and granite dating from 1790-1820 and spanning over the royal canal. The bridges are physically separated by a raised embankment of land but are connected on their surface by the R806 road, running over the embankment.

Immediately to the west is the relatively modern Castleknock Train station. The roads leading to Granard Bridge from the north and Castleknock Bridge from the south are at slightly different angles to one another. This is corrected by Castleknock Bridge and the embankment.

Castleknock Bridge has a single elliptical arch and is bookended with engaged piers north and south. The bridge is primarily constructed with squared limestone, laid in courses. The station platforms extend nearby to the west, but do not touch the bridge. The aforementioned difference in angle is corrected by the bridge which itself is built at an angle. This is reflected in its skewed arch construction, visible in the masonry of the vault.

Figure 1 – West elevation of Castleknock Bridge over the railway line.

Figure 2 – East elevation of Castleknock Bridge, access restricted.

On the south side the bridge ends with the piers before meeting the historic boundary walls to the south, on either side of the road. On the west side the boundary wall is historic and comprises a large buttressed retaining wall upholding the road, as it rises to bridge level. It is built of limestone rubble and capped with vertical limestone slabs in the style of 'cow and calf'. On the east side, the boundary wall is shorter in length and continues on as a timber fence. The east side seems to have been recently re-built in a similar traditional style.

Figure 3 – West parapet ending with pier and historic boundary wall abutting.

Figure 4 – Junction between pier and boundary wall on left side of image. Ivy growth covering modern fencing.

On the north side, the bridge has two wing walls, one either side which curve away in the direction of the railway line. The north west wing wall runs alongside a ramp to the train station and is faced with squared limestone rubble, laid in courses. The copings are large limestone blocks. The outer face of north east wing parapet, facing the railway line, has been largely rebuilt in blockwork.

Figure 5 – North west wing wall.

Figure 6 – North east wing wall with substantial block repairs.

The bridge is decorated with a string course on both faces, and an arch ring of chamfered dressed limestone voussoirs. At the base of the bridge, below the spring, the voussoirs become quoins which meet engaged piers either side. The parapets of the bridge are built of squared, rubble limestone laid in courses and are topped with large limestone copings, also extending over the piers.

The north east parapet wall curves away and slopes down alongside a set of steps which give access to the Royal Canal Way. The copings are of modern blockwork on the curve.

Figure 7 – North east parapet with modern blockwork.

Figure 8 – North west parapet.

A service pipe travels alongside the external face of the bridge on both elevations. The pipe travels above the crown of the arch, supported by small I beams fixed back to masonry on the west and east faces. On both elevations the pipe penetrates the masonry of the wing walls to the north. On the west face the pipe also penetrates the historic boundary wall to the south as it changes direction.

Figure 9 – Canal spandrel with squared limestone.

Figure 10 –West spandrel of bridge and canal arch.

The nearby Granard Bridge spans over the canal and also has an elliptical arch. Its towpath runs to the south, and on its western side, a ramp provides access to the train station. On its eastern side a footpath provides access to the towpath and the Royal Canal Way. It is built of a mixture of rubble and squared limestone of varying sizes brought to courses in parts and laid randomly in others. It has a single arch with a continuous string course and parapet across a hump-back form.

Figure 11 –Granard Bridge west elevation.

3.0 STATUTORY CONTEXT

Granard Bridge is included in the Record of Protected Structures (RPS) (reference number 0696) in the Fingal County Development Plan 2017-2023. The Royal Canal is also included from locks 10 – 12 (RPS no. 944a ,b ,c and d). Lock 12 is approximately 300m eastwards along the canal.

The bridge also included in the National Inventory of Architectural Heritage (NIAH) with reference number 11354002. It has been assigned a regional significance and its categories of special interest are noted as Technical and Architectural.

Castleknock Bridge is neither a protected structure nor is it included in the NIAH.

A small portion of Castleknock centre is designated an Architectural Conservation Area (ACA) approximately 1km away. Recorded Monuments nearby include Talbot bridge and Saint Brigid's Catholic Church, approximately 0.3km east and 0.7km north east, respectively.

4.0 HISTORY & DEVELOPMENT

Below is an extract taken from the conservation report provided by Rob Goodbody in the Appendix A 21.4 to Chapter 21 – Architectural Heritage.

‘’Castleknock Road was part of the main road leading from Dublin to Navan and onward toward the north. The route skirted the northern side of Phoenix Park, along Blackhorse Avenue, and passed through Castleknock and Blanchardstown on its way northward. This road was of such importance that it was one of the first in the country to be declared a turnpike by act of parliament, in 1729, with the establishment of a turnpike trust charged with the responsibility for the upkeep and improvement of the road and its bridges. Funds for this purpose were to be raised by means of tolls collected from those using the route at toll gates or turnpikes, established at intervals along the route.

By the end of the eighteenth century the turnpike trust was having difficulty keeping the road between the city and Castleknock in good repair and, furthermore, it was narrow and winding. This was recognised by parliament and a new act was passed in 1796 authorising the trustees of the Navan Road to construct a new alignment of the road. Due to difficulties in raising the necessary funds this project did not go ahead for more than twenty years and finally, in 1818, the present Navan Road was laid out as a more direct, straighter and wider route. The original route was not closed off and remains in use, combined with the traffic that passes along Chesterfield Avenue through the Phoenix Park and which meets the former Navan Road, now Castleknock Road, just outside the park gates.

At the time that the Royal Canal was constructed through the Castleknock area in the 1790s Castleknock Road was still a turnpike road. The Royal Canal Company provided a new bridge to carry the road over the canal and named it in honour of the earl of Granard, who was a major shareholder in the company and who served as director from the time that the company was founded in 1789 until 1803.

The construction of the Midland Great Western Railway in 1846-47 necessitated the addition of a new bridge to the south of Granard Bridge. The road did not meet the canal at a right angle, though the difference in angle was small and the resulting bend in the road on the southern side of the canal bridge was slight. The additional of the railway bridge in line with the canal bridge would have increased the bend in the road significantly and to avoid this the railway company ran the new bridge across at an angle to the railway as a skew bridge. ‘’

Map Comparison

The bridges as portrayed in available historic maps generally align with construction dates of c.1790-1820 and its later extension in c.1846. In the 6inch OS Map, the railway line has not yet been constructed. Two small structures are recorded either side of Granard Bridge to the north where it meets land. The canal is shown narrowing as it passes below the bridge and an informal path is marked along the north of the canal.

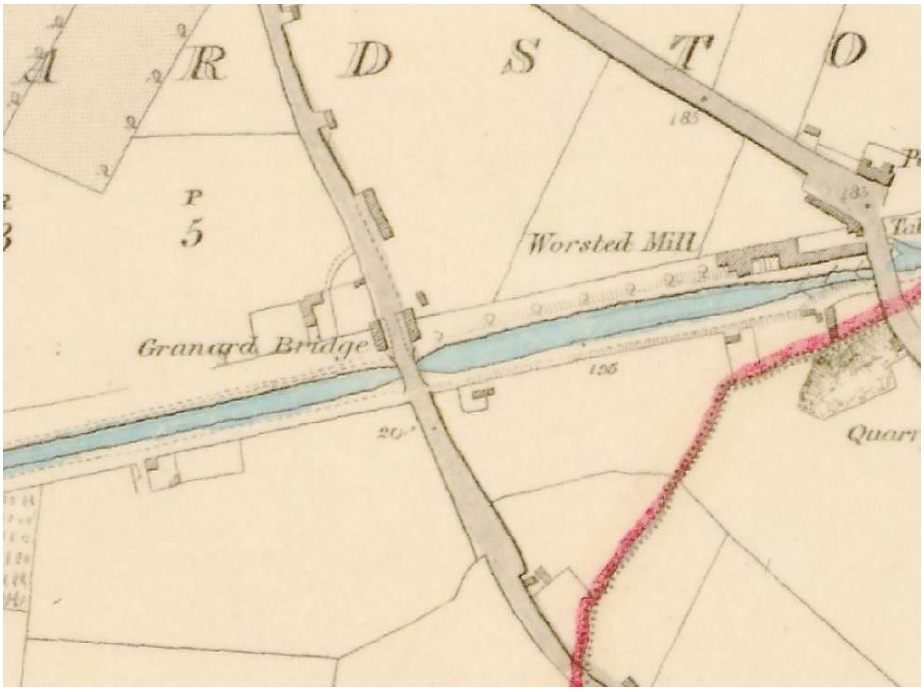

Figure 22 – Extract from 6inch OSI Map 1829 - 1841 showing Granard Bridge crossing the Royal Canal.

The 25inch OSI Map records the arrival of the railway line. A new bridge appears over the railway line, and a slight change in direction is shown due to the differing road angles either side. The towpath along the south of the canal remains and Laurel Lodge is now shown to the south west.

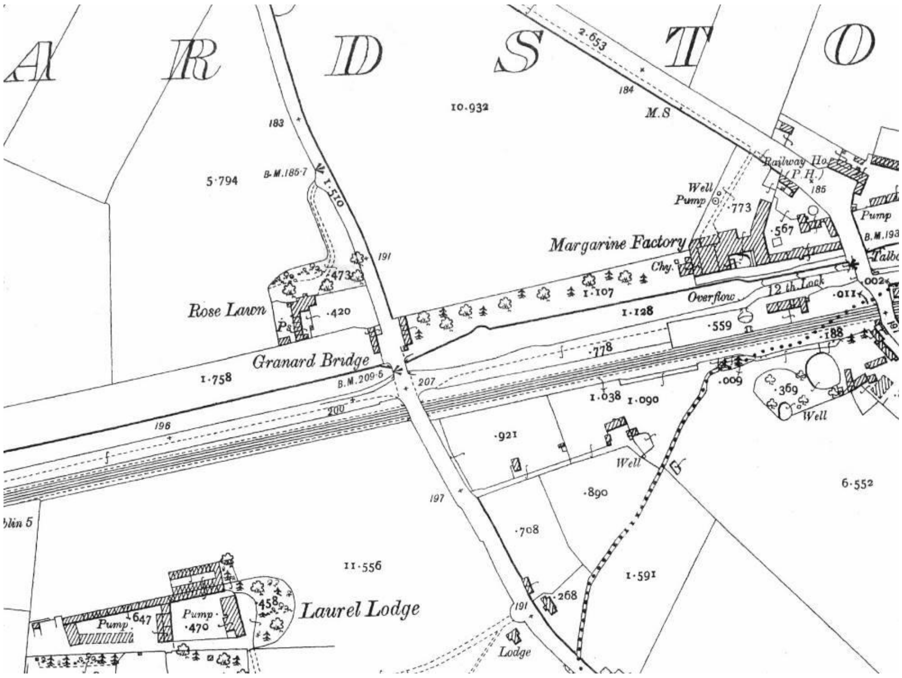

Figure 13 - 25inch OSI Map 1888-1913 showing the addition of the rail line and bridge.

5.0 ASSESMENT OF SIGNIFICANCE

Statement of Significance

The categories of special interest which define a protected structure as per the Planning and Development Act 2000 (as amended) are Architectural, Historical, Archaeological, Artistic, Cultural, Scientific, Social or Technical. These categories are not mutually exclusive, and a structure may be attributed with several of the categories. The categories identified as particular to Granard Bridge, by the NIAH, are Architectural and Technical. Castleknock Bridge has not been included in the NIAH, or Record of Protected Structures.

In many cases bridges over the Royal Canal were extended to span over the railway line when it was constructed adjacent to the canal. However, in this case an embankment of land separates Granard and Castleknock Bridge. The bridges while separate, are co-dependant and are connected over the embankment surface by Castleknock road.

Relatively few of the railway bridges remain unchanged today, highlighting the bridge's importance as part of Ireland's industrial architectural heritage.

As Castleknock Bridge is not recorded by the NIAH it has not been formally prescribed categories of special interest. However, the bridge carries significance for a number of reasons. We believe the bridge is significant under the following categories.

Architectural
Like other railway bridges of this typology, high quality stonework and simple decorative features in carved and dressed limestone contribute to the overall architectural expression of the bridge and testify to the skilled masonry craftsmanship employed in its construction.

Historical
Historically, it represents the construction of the Great Western Railway in the 1840s at a time of significant industrial development and advancement in the area of transport and trade in Ireland.
The fact that the railway was added after The Royal Canal is important as a layer of history. In this, Castleknock Bridge signifies a period in the history of transport in Ireland, when the canals were superseded by the railways, but continued to function in parallel.

Technical
The vault of the bridge is skewed which allowed the arch to be constructed at an angle over the railway due to the position of the approaching road. The arch is a technically impressive feat which required skilled engineering and craftsmanship to ensure the thrust of the arch was successfully transferred either side. The execution of it in slender stone sections which ties in with decorative quoins and voussoirs either side required particular craftsmanship and skill.

Social
The bridges of the Royal Canal and the railway line, including Castleknock Bridge, carry social significance for several reasons. Bridges act as a connection point between areas previously separated and often provide a sense of identity and place for the people and communities around them. Both the canal and the railway line formed a manmade boundary where the bridges then provided essential connection points. This is especially true for pedestrian bridges as they are more directly experienced by people. Additionally, bridges often survive development around them, as standalone independent structures further reinforcing the sense of identity provided.

Today the bridges are important architecturally as standalone features, acting as nodes of identity along the canal and railway which extends through many towns and communities into the Midlands. The canals and some railway lines around Ireland are now important places used for walking and cycling, especially in urban settings where outdoor recreational infrastructure is limited. The Royal Canal Way is one example on the Royal Canal. The canals are popularised with barge boating culture and there are several examples of disused railway infrastructure being converted into greenways around Ireland.

Taking the above into consideration we therefore recommend that Castleknock Bridge be included in the NIAH assigned with a Regional Significance and also entered into the Record of Protected Structures.

6.0 OUTLINE CONDITION ASSESSMENT

Due to the limited access available it was not possible to fully assess the condition of Castleknock Bridge. Inspections were carried out from the road over the bridge and from the train platform.

From a distance the stonework of the arches, buttresses and spandrels do not appear to have major structural issues. The stonework on the face generally appears to be in good condition and has not suffered excessive weathering. The stonework forming the arch could not be inspected but it is clear that all the stone has been painted at low level, presumably to cover earlier graffiti. There appears to be a number of phases of pointing on the bridge, some of which is likely to be an inappropriate cement mortar. The pointing has been washed out or fallen away in some areas.

Figure 14 – Painting and graffiti under the bridge.

Figure 15 – West elevation of bridge.

There are two wing walls of varying condition on the north side of the bridge. The wall to the north west is covered with extensive vegetation on the road side. The vegetation extends down over the parapet to the rail side. A large service pipe runs along the face of the bridge and penetrates the wing wall causing significant stone disturbance. A substantial amount of rebuilding has taken place, particularly below the pipe. This has been poorly carried out and does not match the original stone pattern. The string course has also been altered creating an odd junction where different string thicknesses meet. A lot of the internal face of the wall appears to be painted below the string course and ivy growth is starting to take hold near the base of the wall. The east face also has a service pipe fixed to the external face but it is not possible to see the extent of disturbance caused where the pipe penetrates the north east wing wall. The parapet of this wall has been substantially rebuilt with blockwork, particularly on the internal face. It is difficult to determine the extent of blockwork on the wing parapet due to the extent of vegetation growth. The copings on this section of wall have also been replaced with blockwork and there are a number of cracks in the joints. It was not possible to assess the pointing on the wing walls due to access limitations but it appears to be in a similar condition to the adjoining spandrels and piers.

Figure 16 – Poorly rebuilt stonework around service pipe on north west side.

Figure 17 – Vegetation and paint on north west wing wall and paint under bridge.

Figure 18 – North east parapet repaired in blockwork with cracks visible.

Figure 19 – North east wing wall parapet rebuilt in blockwork internally.

The parapet stonework appears to be in fair condition but it is not possible to properly inspect the external faces. It is clear that substantial disturbance has occurred on the external face of both parapets where steel beams have been built in to support the service pipes. The joints have been strap pointed in areas in what appears to be a hard cement mortar. Some flush pointing has also been carried out more recently where vegetation was removed. There is evidence of shrinkage cracks between the stonework and mortar on the internal faces. There is also evidence of mortar joints breaking away from the coping stone in a number of areas potentially due to movement of the coping. The coping stones have been repaired in isolated areas where original stone has been lost. These repairs have been poorly carried out in mortar and are likely to fail quite quickly. The base of the parapet is visible on the south east internal face where the road has been lowered. This important stonework appears to be stable, but it would benefit from pointing works to reduce the likelihood of unravelling in future.

Figure 20 – East parapet with steel beams built in to historic stonework.

Figure 21 – Joint below coping stones broken.

Figure 22 – Poor mortar repairs to copings.

Figure 23 – Stonework at base of wall requiring pointing.

7.0 PROPOSED WORKS

As identified in the accompanying documentation, it is proposed to demolish the section of historic bridge over the railway line to allow for the electrification of the rail system. The existing bridge does not provide the clearance required to allow the Overhead Line Equipment (OHLE) to run under the bridge.

A number of approaches to provide the additional clearance required were considered. These included re-directing the tracks around the bridge, lowering the tracks and demolishing the railway side of the bridge to build a new bridge at a higher level. The evaluation process is detailed in EIAR Volume 4 Appendix A3.3 Option Selection for OHLE Intervention. On completion of this assessment the design team lead and client concluded that the demolition and re-build of the existing bridge at a higher level was the most suitable approach.

The removal of this section of bridge over the tracks is an irreversible loss of important historic fabric and permanently alters the historic structure and surrounding setting. This section of the bridge has significant historic value, particularly as it is one of the few remaining skewed historic bridges on this part of the line. The historic wall on the west side when approaching from the south is also largely being removed. This is an important layer of history and an important element of the overall historic setting. To mitigate the loss of the historic fabric as far as possible, the construction of the new bridge arch is being carefully considered. It is essential that the replacement section of bridge is well designed, detailed and executed. The most important consideration in the process is to ensure that the new build element sits comfortably alongside the remaining historic fabric. The stonework from the dismantled railway arch will also be salvaged and used for repairs where required.

Due to the significant raising of the bridge to accommodate the OHLE and the requirement to install a precast concrete arch, it is not possible or desirable to reconstruct the span to match the existing. Instead, a contemporary solution using modern materials is being designed. The extent of demolition will be confined to the section of bridge between the stone piers to ensure that the reconstructed section will be read as an insertion rather than an entirely new bridge.

A number of finishes and construction methods were assessed during the design process. Initially the preferred option was to re-use the original facing stone but it became clear that this would not be successful due to the technical constraints of the new construction. The string course is an essential element of the existing composition but the increased height of the arch would distort its connection to the string course on the piers. The precast arch construction would reduce the existing voussoirs to cladding stones and the facing stone of the spandrels would also become cladding stones tied back to the concrete structure behind. The combination of all these factors made it very difficult to design or build stonework that would sit well alongside the original fabric and there were concerns that it would very much read as modern stone cladding.

Figure 24 – West elevation with string course highlighted.

Figure 25 – East Elevation with string course highlighted.

The use of a weathered steel facade was also explored as this material is being used on new build elements elsewhere in the project. After careful assessment it was decided to proceed with a concrete structure as this has the potential to sit most comfortably with the remaining original stonework. It is proposed to use a board marked concrete finish on all faces and to select a concrete colour that best complements the original stonework.

Figure 26 - Example of a new board marked concrete insertion in an existing stone structure.

The colour and texture of the concrete finish, along with the quality of the detailing and workmanship is critical to its success. There are many examples of fine concrete work next to historic stonework across Europe, as identified in the image above. The design team is aware that Irish conditions are generally a lot damper than elsewhere, therefore the texture and finish of the concrete will be designed to minimise algae and vegetation growth. The texture created by the board will be controlled to ensure there are no large shelves for vegetation to take root and the surface finish will be carefully specified to limit the number of bugholes present on the finished concrete. It is proposed to use hand sawn boards to provide a finish that is not too uniform. Research into materials and sample panels will be essential prior to construction to ensure the new concrete finish complements the remaining historic stonework.

The form of the new arch and its relationship to the piers and abutment walls is of critical importance. The design team have decided not to replicate the original arch exactly as the geometry of that shape would require the bridge to be raised even more than the current proposal. A slightly flatter arch provides the clearance required for both lines with less elevation.

The junctions between old and new will need to be carefully considered during detail design. The presence of the piers on either side of the arch allows the new build to be contained neatly at a natural break. These junctions will still need to be skilfully detailed and executed to ensure the concrete and stonework sit comfortably together. There will be a considerable amount of stone repair and repointing on the piers following the removal of concrete shuttering. These repairs will need to be carried out with great care by a skilled stonemason.

Figure 27 - East elevation with piers highlighted.

The new concrete parapets will extend up to the height of the original with the additional height provided by the contemporary design discussed below. The original parapet thickness will be carefully designed to ensure the new parapet sits in as neatly as possible with the original. The piers extend up through the parapet externally providing a natural break but there is no detail on the internal face. This creates a challenge that will need to be overcome with careful detailing and skilled craftspeople.

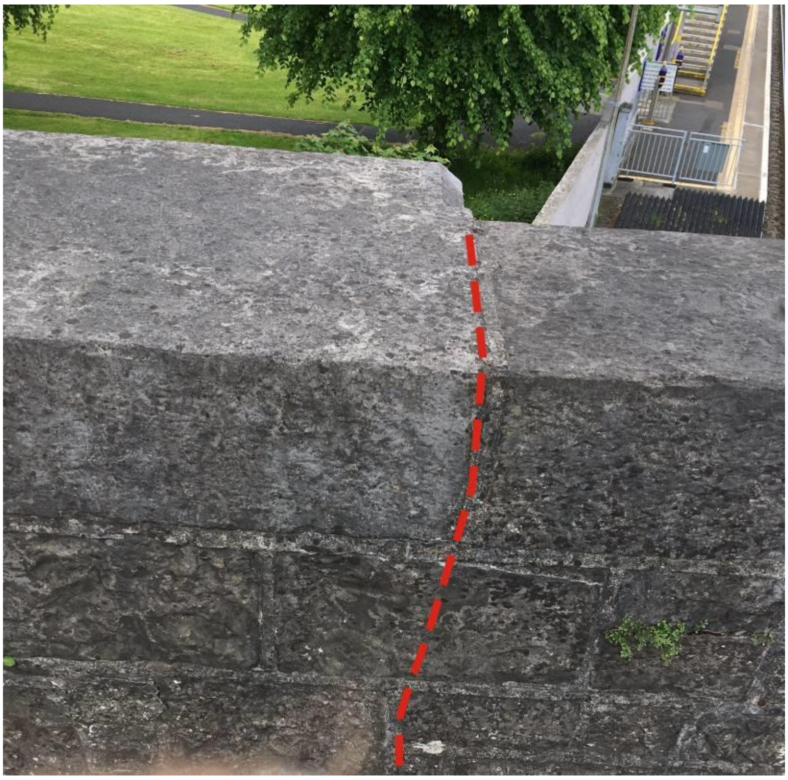

Figure 28 - Image of parapet internally with line highlighting where the junction with the new concrete parapet will be.

It is a safety requirement that the parapets are a minimum of 1800mm high, with the bottom 1200mm solid, in the area of the OHLE. This presents a significant challenge for Castleknock Bridge as the existing parapet heights are lower than 1200mm on the north side. A rigorous design process has taken place to identify a solution that will complement the historic setting and maintain a visual connection to the rail lines and surrounding landscape, when on the bridge. It is also essential that the parapet is not the dominant feature while viewing the bridge from the canal. The proposed design is a contemporary, adaptable solution that can be implemented throughout, bringing a degree of uniformity to all interventions along the railway. An alternative option with the extended parapet structure fixed on top of the coping, was also assessed. Due to wind loads and the uncertain structural integrity of the parapets, a considerable amount of damage to the original fabric would be required to anchor the new structure through the existing parapet to new concrete pads below.

For Castleknock Bridge it is proposed to provide a solid metal panel from the top of the parapet up to 1200mm with an expanded metal mesh to continue up to 1800mm. The vertical supports and mesh will be carefully designed to ensure the internal face of the parapet is not obscured and that the mesh allows a good visual connection to the surroundings.

Figure 29 – Render of design proposal to increase the parapet height to 1800mm with mesh about 1200mm.

Repair works will be required to the remaining existing parapet before the proposed heightening works can take place. This will include stabilising works to the wider section of parapet just above road level that is likely to have originally been below the road level. All joints will need to be examined and raked out where the existing mortar is lost or failing. Joints will need to be repointed in a suitable lime mortar and protected until satisfactorily carbonated. These works must be carried out by a skilled mason with extensive experience with historic stonework.

8.0 ARCHITECTURAL HERITAGE IMPACT ASSESSMENT

Proposed Alteration	Negative Impact	Neutral Impact	Positive Impact	Mitigating Measures
Demolition of the section of original bridge over the railway line.	Loss of important historic fabric. Alters the historic setting. Loss of original skewed bridge arch, one of the few remaining along this section of the line. Impacts the setting of the canal bridge.		Allows for the train system to be electrified. The unsightly supports for the service pipes along each side of the bridge will be removed and replaced with carefully designed supports to minimise the impact on the new bridge.	The demolition will be contained between the stone piers on each side to minimise the loss of historic fabric. A carefully designed replacement section of bridge will be constructed to sit comfortably with the original fabric on each side. The stonework will be carefully dismantled and used for repairs on the historic bridges where necessary.
Removal of original parapets from the section of bridge being removed.	Loss of important historic fabric. Removes the only visible connection to the historic bridge when crossing over.		Allows for the train system to be electrified.	The replacement parapets will be reinstated to the original level. The additional required height will be provided with a modern parapet detail. The parapets will be carefully designed to ensure they connect neatly to the remaining historic parapets on each side.
Construction of the new bridge section over the railway line.	The use of a precast concrete will create a construction joint under the bridge between the arch and board marked concrete face. The concrete arch will read differently to the shuttered concrete on completion. The removal of a section of boundary wall on the approach from the south is an unfortunate loss of original fabric that the new bridge infill was designed to sit in harmony with.		Concrete colour and texture will be designed to be compatible with the surrounding historic stonework. The junctions between the concrete and original stone will be carefully detailed to ensure the two phases of construction sit comfortably together.	The cast in-situ concrete will be carefully designed to ensure the precast arch is not visible while viewing the original structure in elevation. The surface finish of the concrete will be carefully considered to limit the vegetation growth as much as possible.

Proposed Alteration	Negative Impact	Neutral Impact	Positive Impact	Mitigating Measures
Increase of parapet height.	Obscures the original design intent of the remaining section of existing parapets to some degree on the internal faces. Visual connection to the top of the coping stones will be lost on internal faces. The connection to the surrounding setting is compromised by increasing the parapet height to 1800mm.		Allows for the train system to be electrified. This approach allows the original parapets to be retained on each side.	The new parapet will be carefully designed to minimise the impact on the remaining historic parapets. Fixings on the historic parapets will be minimised and will be installed in joints where required. The majority of the structural load will be transferred to the deck, decreasing the impact on the parapets. The metal mesh will be carefully selected to ensure the visual connection to the surrounding landscape is maintained as much as possible. The parapet supports will be designed to be as slender and elegant as possible to reduce the visual impact on the parapets.

9.0 CONCLUSION

The demolition and replacement of the span of Castleknock Bridge over the railway line is a very significant loss of important historic fabric. Unlike the two other historic bridges of the scheme being partially removed, this bridge stands separate, but close to Granard Bridge over the canal, a protected structure. The loss of this section of bridge along with the boundary wall to the south, will have a considerable and irreversible impact on the character of the setting, surrounding environment and the canal bridge. From a conservation perspective it would be preferable to incorporate the welcomed new infrastructure into the existing setting, while retaining this important historic structure. As identified in Appendix A3.3 Option Selection for OHLE Intervention in Volume 4 of the EIAR, the bridge can be retained, but due to significant financial and programme reasons, removal and replacement has been chosen as the preferred option.

By raising the railway arch, the connection between this and the historic abutments is fundamentally altered, so constructing a stone facade on the new bridge section is not considered appropriate. After carefully assessing the alternatives, it was concluded that a contemporary concrete structure would sit most comfortably with the remaining historic stonework. Considerable effort will be required during detail design and construction to ensure the colour and texture of the concrete complement the existing stonework. Careful detailing and execution at the junctions will also be fundamental but these are all achievable and should lead to a successful outcome. Containing the re-build between the piers on each side is positive and will allow the new section of bridge to be read as an insertion into the original rather than a new bridge.

The proposed parapet heightening design provides a flexible solution that can be adapted to each historic bridge along the length of the Dart+ West project. Raising the parapet is a fundamental safety requirement when installing OHLE, so the proposal needs to incorporate these essential requirements. The use of an expanded metal mesh above 1200mm ensures that a visual connection to the surroundings is maintained while on the bridge. The positioning of the new parapet on the internal face also ensures that it reads as a secondary element when viewing the external faces of the bridge. Unfortunately, the raised parapet will obscure the top of the existing coping stones internally, but it is an essential safety requirement to remove any ledges that could be used to climb up on the parapet.

It is clear from a conservation perspective that the demolition of the section of bridge over the railway, and boundary wall to the south, is a major loss to the overall structure and surrounding setting. However, the proposal to reconstruct the arch with a carefully designed and detailed concrete finish should sit comfortably with the remaining canal bridge and reflect a high quality contemporary design. The required conservation and repair works to the existing fabric should also be incorporated into any future works on the bridge.

APPENDIX C. Technical Note for OBG14 Cope Bridge: MAY-MDC-STR-OTHE-RP-Z-0001

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Technical note on OBG14 Cope Bridge reconstruction

MAY-MDC-STR-OTHE-RP-Z-0001

27th May 2022

Table of contents

EXECUTIVE SUMMARY

The report aims to justify the option selected for constructing the Overhead Line Equipment (OHLE) below the Cope Bridge (OBG14) to achieve the project's objective.

The three potential solutions analysed in this report are as follows:

1. Reduced height OHLE.
2. Track Lowering.
3. Bridge reconstruction.

The conclusion of the report is that bridge reconstruction is the preferred option. This option limits the disruption to station and railway users/operators and does not require the closure of the canal. It has a shorter construction programme, reducing the impacts on residents during construction and does not increase the track flooding risk in this location. It is also an economically advantageous option . It is acknowledged that this option impacts significantly on the historic railway bridge, however engagement with a Grade 1 Conservation Architect will ensure that the reconstruction is done sympathetically and in keeping with the historic canal structure. Significant road diversions are also required, but traffic assessments will be completed to ensure disruption is kept to a minimum.

No reduced height OHLE solution was identified that proved acceptable to the IÉ SET and CCE departments due to the additional safety measures that would need to be implemented during the inspection and maintenance activities and the higher lifecycle costs.

Regarding track lowering, while this option minimises the impact on the historic railway bridge and does not require significant road diversions, the disruption to railway users and operations is significant along the length of the Maynooth line. The Royal Canal is also impacted during construction. In addition the cost and programme impact of the construction work at the station was greater for this option. A gravity drainage solution could be installed to mitigate the risk of the track flooding due to the new low point in the tracks, but the risk of the tracks flooding remains a concern which could have long term operational impacts for the DART+ West project. Impacts were also identified on local residents during construction due to the proximity of the works to residential properties.

1. INTRODUCTION

1.1 Background

The DART+ West Project will introduce electrified high-capacity trains at the increased frequency for all stations between Maynooth/M3 Parkway and Dublin city centre at Connolly Station and the new Spencer Dock Station (approximately 40 km in length). A new Electric Multiple Unit (EMU) depot will be constructed west of Maynooth station that will serve the entire DART+ network.

OverHead Line Equipment (OHLE) will be required to be constructed to provide electrical power to the trains (EMUs). All the bridges on the Maynooth Line have been assessed to determine the most appropriate mechanism for OHLE installation.

The technical note titled ‘Option selection for Overhead Line Equipment (OHLE) intervention at OBG5, OBG11 and OBG14’ (document number MAY-MDC-STR-OTHE-RP-Z-0004) gives an overview of the option selection process followed for the installation of OHLE at three specific historic bridges along the route (OBG5 Broombridge, OBG11 Castleknock and OBG14 Cope Bridge).

1.2 Purpose of the document

This report aims to justify the option selected to achieve the project objective of electrifying the line and providing OHLE through the OBG14 Cope Bridge, whilst considering impacts such as heritage, environment, disruption, cost and programme.

This report explains the solutions analysed and the decision-making process to determine the preferred option.

2. OBG14 COPE BRIDGE

OBG14 Cope Bridge is located on the Maynooth line at 10 miles 264 yards mileage, at Leixlip Confey Station.

Figure 2-1 OBG14 Location Plan

Figure 2-2 OBG14 – Cope Bridge

Cope Bridge above the Royal Canal was constructed in 1794 to carry the local road between Leixlip and Confey. A railway bridge was required alongside Cope Bridge and OBG14 was built around 1846. In 1990 Leixlip Confey Station was opened on the western side of the railway bridge.

OBG14 Cope Bridge is a proposed protected structure in the Draft Kildare County Council Development Plan 2023-2029. Therefore any modifications to either of these structures needs to be considered carefully and in line with guidance received from a Grade 1 Conservation Architect.

OBG14 Cope Bridge is a 7.6 m wide, two-span masonry arched bridge, incorporating a span over the railway and one over the Royal Canal. The railway span is approximately 8.5 m long (measured square to the railway) and generally lies perpendicular to the railway.

A one-way shuttle system controlled by traffic lights is in place for road traffic over the bridge. There is footpath access to the Royal Canal immediately north of the bridge.

3. ASSESSMENT OF OPTIONS

3.1 Introduction

The options assessed to construct the OHLE beneath OBG14 at Cope Bridge are listed below. The three options reviewed are as follows:

1. Reduced height OHLE solution.
2. Track lowering.
3. Bridge reconstruction.

Track realignment was not considered in this location due to its extremely high cost and impact on adjacent land and residents.

3.2 Reduced height OHLE solution

In order for the reduced height OHLE solution to be implemented at OBG14, a special reduced Contact Wire Height of 4200 mm would need to be implemented. According to I-ETR-4004 Clearance Requirements for DC 1500V Electrified Lines, the minimum Contact Wire Height shall be 4400 mm. The special reduced height of 4200 mm is only possible by requesting a Signalling, Electricity and Telecommunications (SET) standard derogation as per SET-AMS-12.

A number of technical issues would need to be resolved in order for this solution to be acceptable to IE SET and Chief Civil Engineer (CCE) departments, and hence the SET standard derogation approved, including:

- A minimum dynamic passing electrical clearance of 50 mm (as per EN 50119) would be required – this is not compliant with the minimum required by IE and SET standards for electrical clearances for 1.5 kV DC, which are as follows:
    - Passing Clearances (Normal): 100mm
    - Passing Clearances (Special Reduced): 80 mm
- The reduced height OHLE solution provides a 50 mm mechanical clearance, directly related to the dynamic passing electrical clearance, which does not comply with the minimum requirement of 75mm from CCE.
- The OHLE Maintenance Tolerance generally applied in the DART for open route is 30mm (as per I-ETR-4101 Maintenance Parameters for 1500 Vdc OHLE), and the proposal would require this to be reduced to 10 mm, below the minimum accepted by IE SET.
- The reduced height OHLE solution provides a Track Maintenance Tamping Allowance of 0mm - the minimum accepted by CCE is 50 mm.
- The reduced height OHLE solution requires a reduction of the Track Maintenance Tolerance to 5 mm - the minimum accepted on ballast track by CCE is 25 mm.

The above technical points, should this solution be implemented, would result in:

- Increased occupational safety risk to operatives due to increased frequency of inspections.
- Increased life cycle costing – wires require to be replaced more frequently (due to increased wear because of low contact wire height) and increased frequency of inspections would increase costs.
- Permanent speed restrictions (both directions) in this area which would constrain the network.

No reduced height OHLE solution was identified that was acceptable to IÉ SET and CCE departments due to the above points. The standard derogation from SET-AMS-12 was rejected. Hence this option was deemed rejected.

3.3 Track lowering

To install the OHLE equipment beneath OBG14 and achieve the required 4700 mm contact wire height, a track lowering was considered. This potential solution would require the vertical lowering of the tracks by approximately 580 mm directly below OBG14, which would result in lowering works for a length of approximately 600 m along the tracks. Whilst this is a technically feasible solution, some substantial issues were identified, as identified below.

3.3.1 Leixlip Confey Station

The option to lower the tracks requires extensive modifications to existing station infrastructure at Leixlip Confey station (platforms, accesses, footbridge, utilities, fences, etc.) due to the close proximity of the OBG14 bridge to the station. This impact is the most problematic issue related to track lowering at OBG14. It would require, in effect, a station reconstruction. These works would have a significant cost implication and would severely impact station functionality during the extensive construction period required.

The impacts on the station infrastructure are described in the sections below.

3.3.1.1 Structural assessment

3.3.1.1.1 Introduction

Near the OBG14 Cope bridge, there are many existing structures, including the OBG14A footbridge, the retaining wall between the railway and the Canal, and the platform structures.

For the proposed track lowering solution a maximum track lowering of 0.92 m is required at the west end of the access ramp, hence the platform structures must be modified to adapt to this new longitudinal alignment. This in turn impacts the footbridge and the retaining wall structures.

The proposed track lowering directly below OBG14 is approximately 0.58 m. However, the proposed drainage and track design (i.e., ballast and sub-ballast layers) require deeper excavation. Therefore, soil improvement is necessary around the existing bridge foundations before any excavation work on the track can commence.

The interventions on existing structures in this location have been summarised in the following list:

a) The existing OBG14A footbridge must be demolished and rebuilt.
b) The platform structures on both sides of the track need to be either partially (down platform) or completely (up platform) demolished and rebuilt.
c) The existing retaining wall between the Canal and the track needs to be modified.

Figure 3-1 Track lowering structural intervention – Plan view

3.3.1.2 Existing structures

The following list is the existing structural drawings received from IE, which have been used to carry out the initial structural assessment described in this report:

- 99-31.3.354-02 1 Rev D GA.
- 99-31.3.354-02 2 Rev D GA.
- 99-31.3.354-01 GA.
- 99-31.3.354-09 Pile & GB.
- 99-31.3.354-10 GB.
- 2008-45-01 Rev A Underpinning.
- LCS-SK-001.
- LCS-SK002A.
- LCS-SK-003.

The existing platform structures were designed with the following typology:

- Southside: RC cantilever retaining walls with the footbridge's foundation expected to be under the existing RC platform structure (no information of the footbridge's foundation has been provided in the existing drawings).

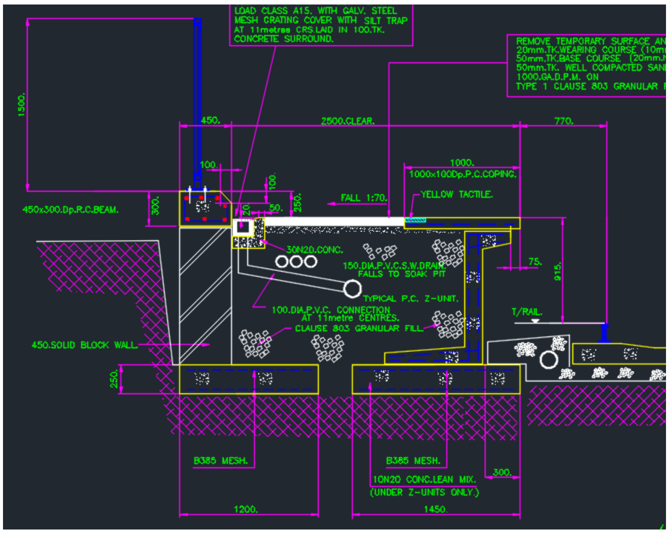


Figure 3-2 Existing drawing –Southside

- Northside: RC cantilever retaining walls with a pair of micropiled foundation, and the footbridge supports anchored to the lateral side of the RC vertical wall. This complex design of the RC cantilever wall and micropiled foundation structurally balances the bending moment generated from the footbridge.

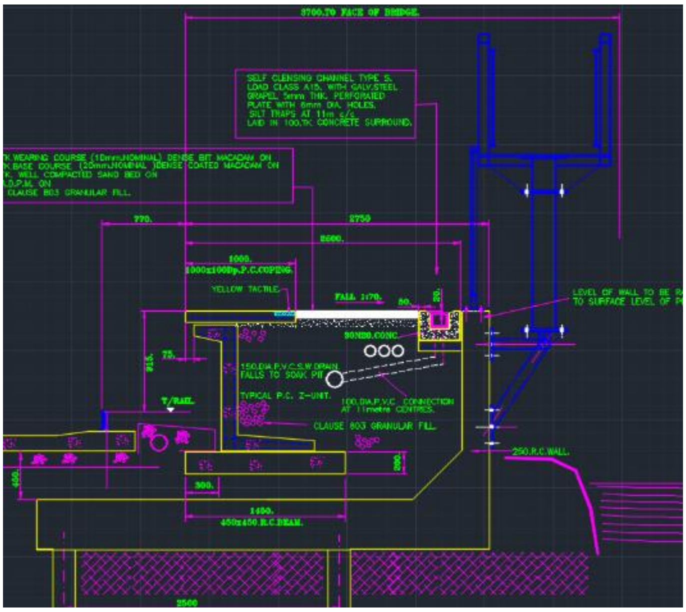


Figure 3-3 Existing drawing – Northside

The following figures show the existing platform structures with three different cross sections:

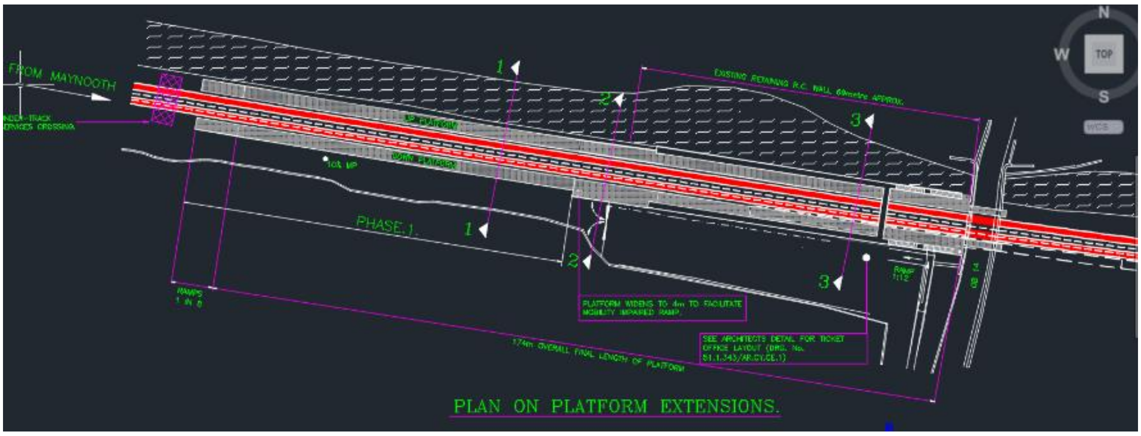


Figure 3-4 Existing drawing – platform structure, plan view

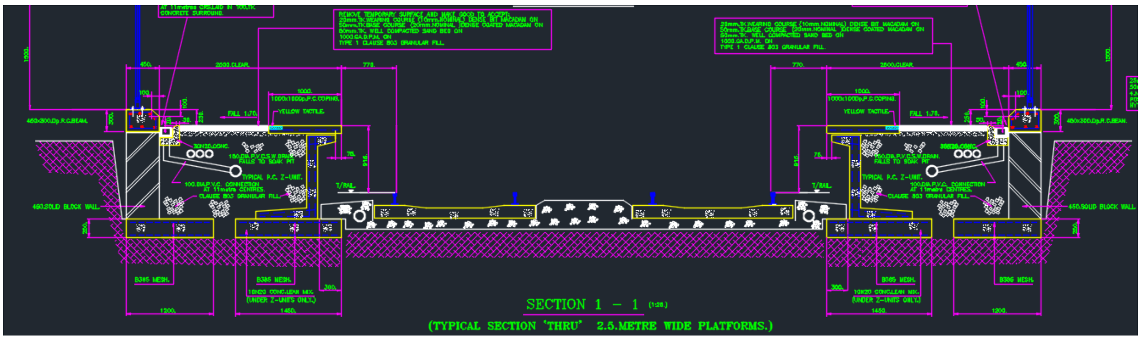


Figure 3-5 Existing drawing – platform structure, Section 1-1

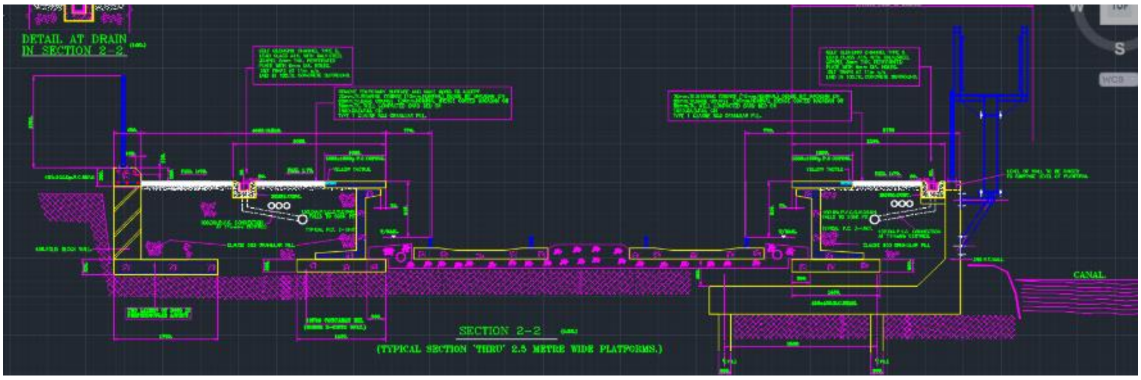


Figure 3-6 Existing drawing – platform structure, Section 2-2

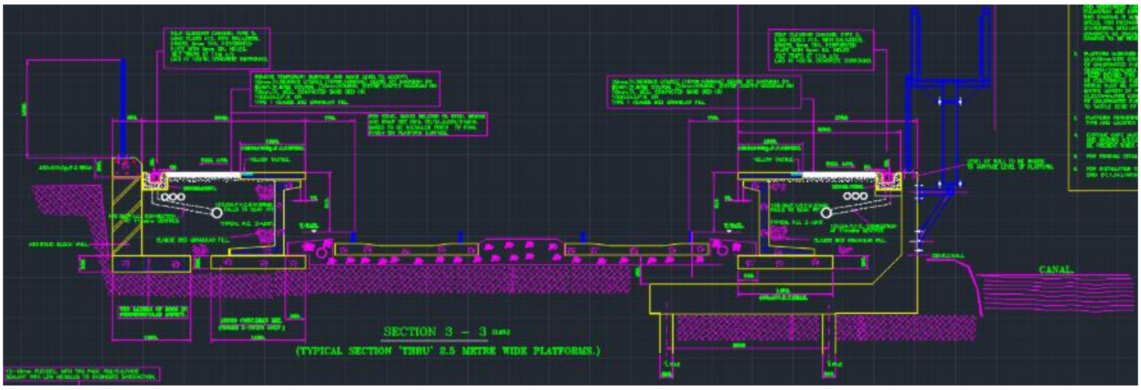


Figure 3-7 Existing drawing – platform structure, Section 3-3

3.3.1.3 Longitudinal alignment of the proposed track lowering

The figure below shows the proposed track lowering solution at this location. The maximum proposed track lowering is approximately 0.92 m at the western end of the access ramps (chainage 74+800). At OBG14 (chainage 74+620), the proposed track lowering is approximately 0.58 m, and it goes deeper toward OBG14A.

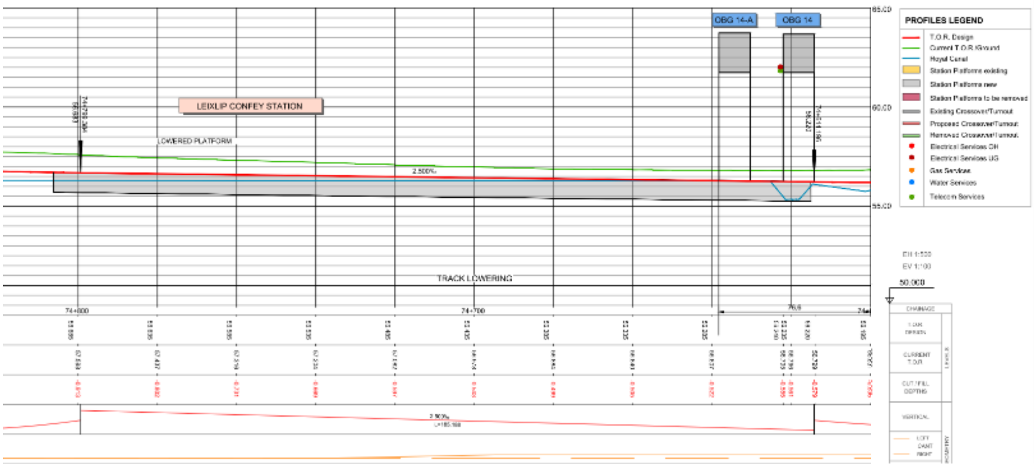


Figure 3-8 Longitudinal alignment of the proposed track lowering

3.3.1.4 Impact on the existing structures

3.3.1.4.1 Chainage 74+635 - northside (with the existing footbridge and ramp structures)

The most critical area with the proposed track lowering is the section near the OBG14, where there is the footbridge anchored to the platform RC retaining wall structures. The proposed track lowering in this area is around 0.58 m. Based on the existing drawing, the following structural interventions are expected:

- In the current situation, the distance from the soffit of the sleeper to the top level of the bottom slab of the RC cantilever wall is around 0.45 m, which generates a higher stiffness under the track elements than the rest of the section without any RC structure under it. The proposed track lowering solution will increase the stiffness as the track elements will be closer to the RC structures.
- **The existing platform RC retaining structures must be demolished and rebuilt at a lower level aligned with the proposed track level.**
- **The existing footbridge must be demolished and rebuilt compliant to relevant standards.**
- The proposed track lowering design **may significantly impact the existing RC cantilever retaining wall** with micropiled foundation and the footbridge supports anchored to the lateral side of the RC vertical wall. This complex design of RC cantilever wall and micropiled foundation structurally balances the bending moment generated from the footbridge. During the track lowering work, the footbridge must be demolished before carrying out any modification work on the RC retaining walls. After the removal of the footbridge, **all the elements on top of the bottom slab of the RC wall must be removed**, which could cause an unbalanced situation of this retaining structure. Therefore, a structural verification considering the most unfavourable case during the construction stage is required before removing the elements on the RC slab to ensure the stability of the structure.
- **Part of the existing RC bottom slab and micropiles located below the track will be demolished** to align with the proposed track lowering solution. This demolition of the bottom slab will affect the stability of the retaining structures mentioned in the previous point. **A new pair of micropiled foundation may need to be installed** to maintain the stability of the structure. A structural verification is required before any demolition of structures.
- All the expected structural work at this location will be carried out with the Royal Canal on the north side of the RC wall. The construction strategy must include mitigation measures of the effect on the Canal and **a temporary dewatering system at the platform section** during the construction work has been considered. This will include **temporary works and an overpumping system, impacting the canal use in this area.**
- The total length of the affected structures is around 75 m.

The following figures show the current state of the existing structures and the expected structural interventions at this location:

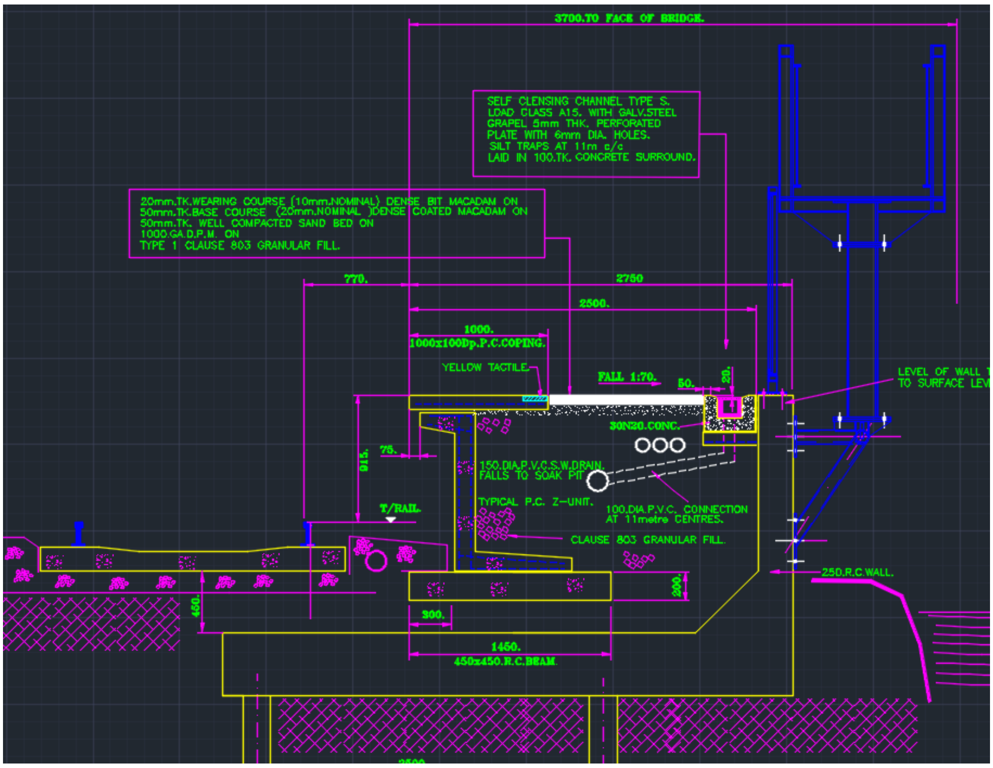


Figure 3-9 Existing drawing - Current state of the northside platform retaining walls

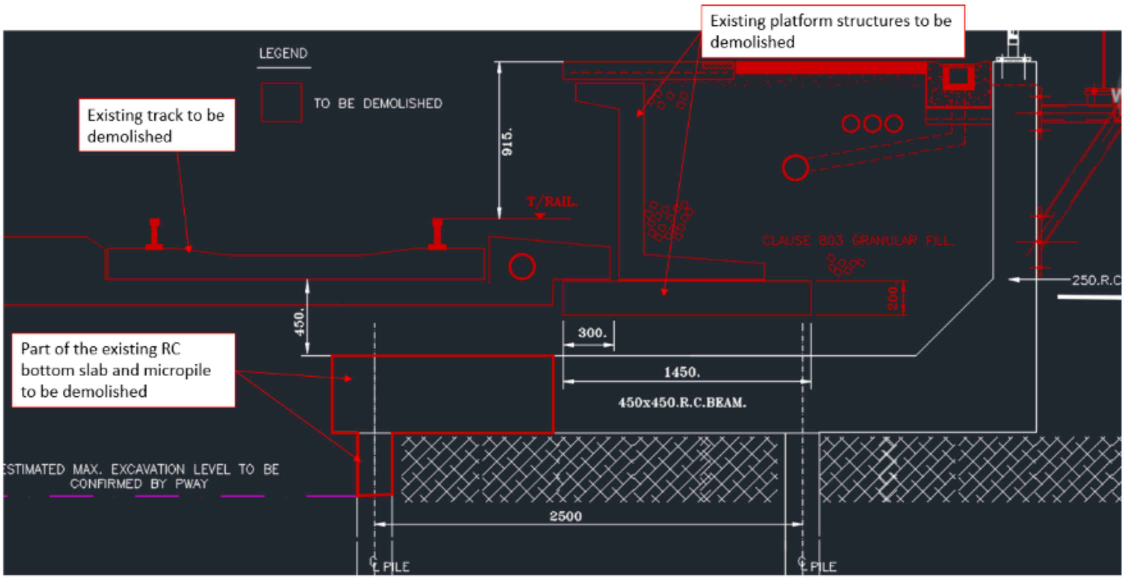


Figure 3-10 Structural intervention – Existing structures and track to be demolished

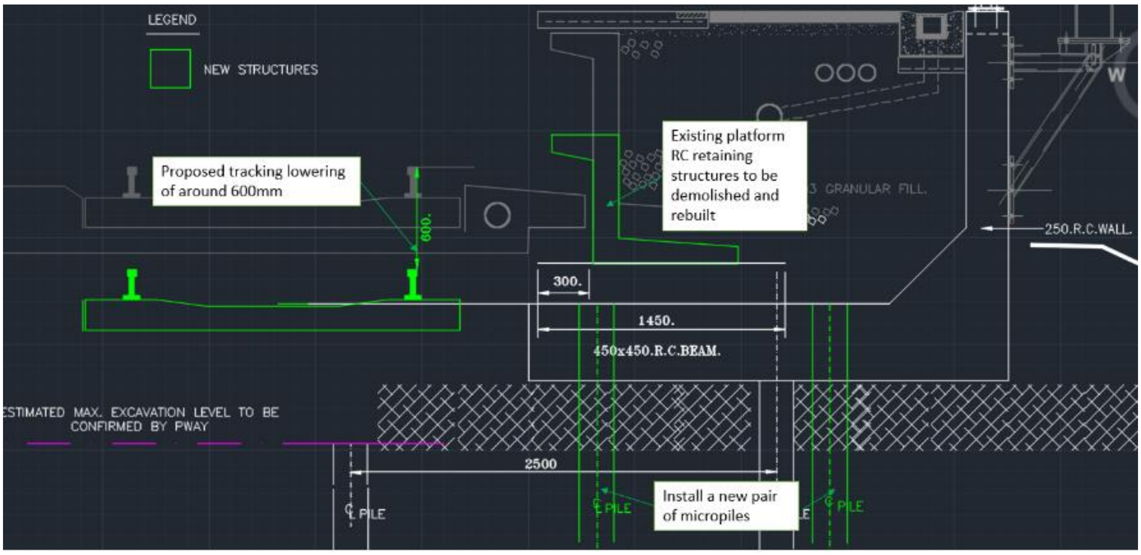


Figure 3-11 Structural intervention – Structural proposal of the track lowering

3.3.1.4.2 Chainage 74+635 – southside (with the existing footbridge and ramp structures)

The structural intervention on this side of the platform structures is listed below:

- The existing platform RC retaining structures must be demolished and rebuilt at a lower level aligned with the proposed track level.

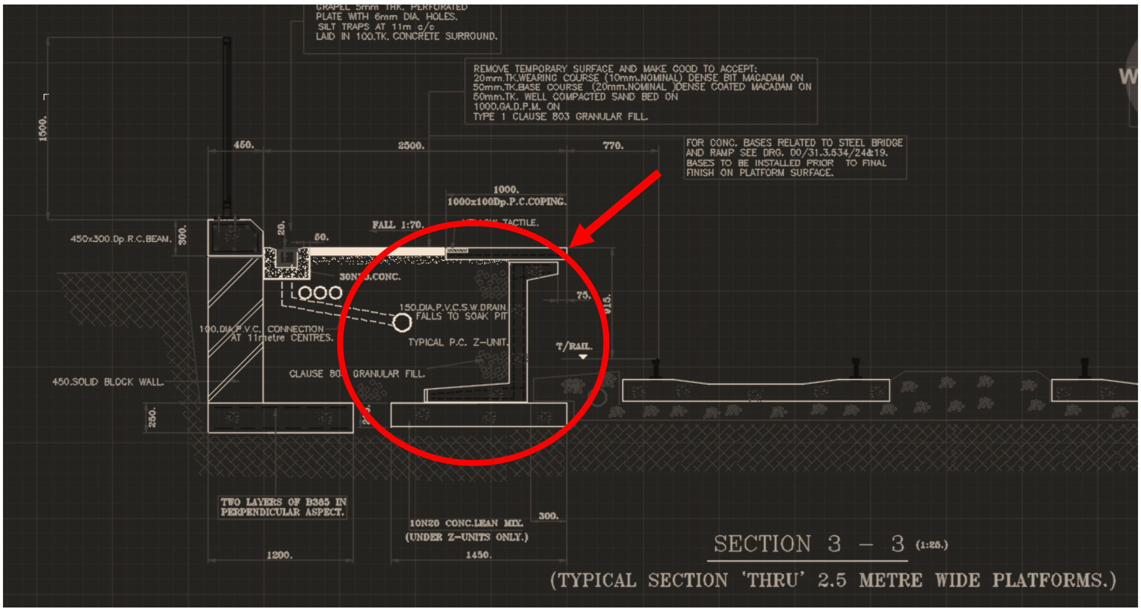


Figure 3-12 Existing drawing - Current situation of the southside platform retaining walls - Platform RC retaining structures to be rebuilt

- The existing footbridge must be demolished and rebuilt to relevant standards.
- The total length of the affected structures is around 75m.

3.3.1.4.3 Chainage 74+695 – north and south sides (without the footbridge and ramp structures)

The proposed track lowering in this area is from 0.50 m to 0.92 m. The structural intervention on the platform structures at this location is listed below:

- The existing platform RC retaining structures must be demolished and rebuilt at a lower level aligned with the proposed track level. The total length of the affected structures is around 105m on each side (210 m in total).

Figure 3-13 Existing drawing - Current situation of the platform retaining walls - Platform RC retaining structures to be rebuilt

As can be seen from the analysis carried out above there is significant structural works required at this station to allow the track lowering solution to be implemented. These works will cause significant disruption to station users during construction and result in high construction costs. These impacts have been covered in section 4.1.

However, it should be noted that track lowering works in this location would provide a compliant track gradient of 2.5 mm/m. The current track gradient at this station is non-compliant with current standards.

3.3.2 Flood risk

If the track lowering was to be implemented at OBG14, the tracks need to be lowered by 0.58 m below OBG14. The level of the Royal Canal at this point is 56.25 m. After the lowering, the track levels (Top of Rail) would be 56.22 m at their lowest point, which (considering the depths of the rail and the sleepers, 160 mm and 200 mm, respectively) would locate the top of the ballast layout at level 56.19 m, which is below the canal water level.

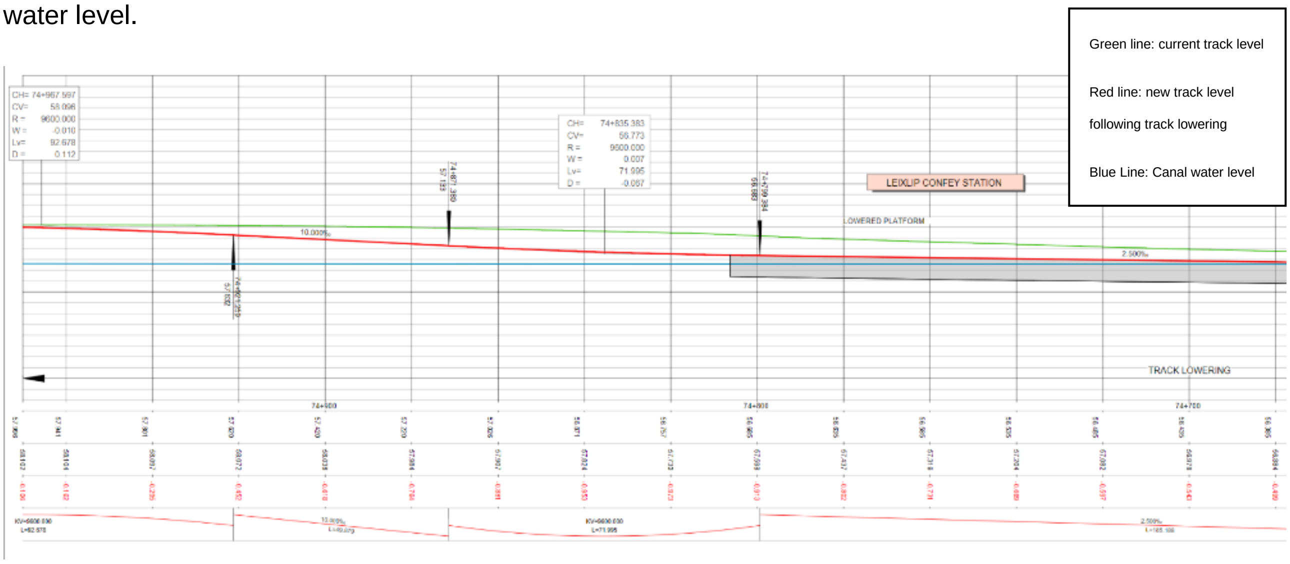


Figure 3-14 Track Lowering Longitudinal Profile - West Section

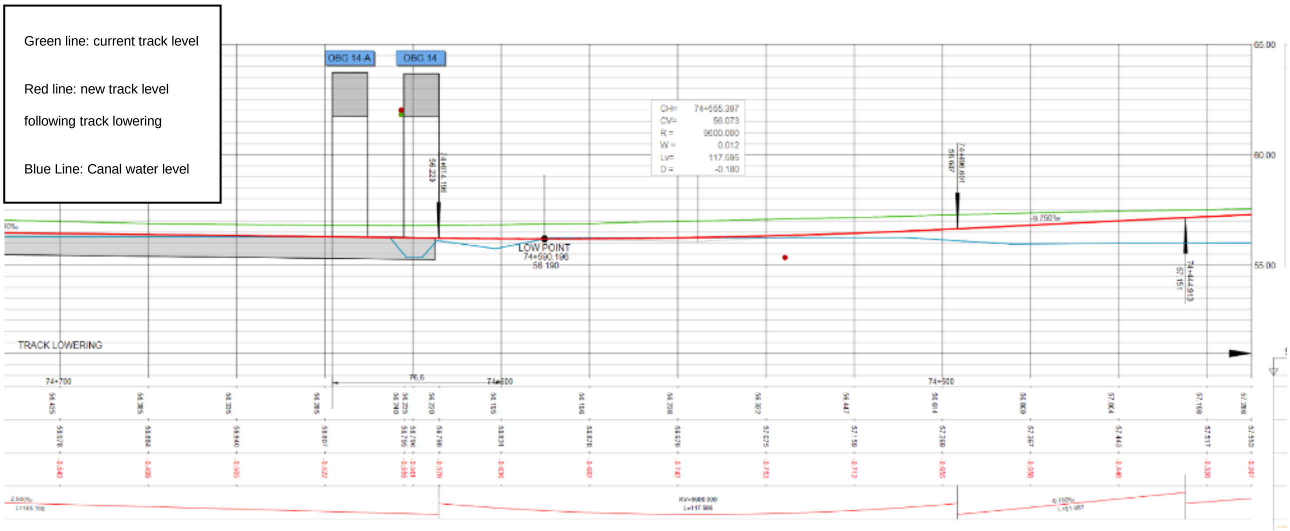


Figure 3-15 Track Lowering Longitudinal Profile - East Section

In the early stages of the project, the flood risk assessment determined that Leixlip Confey station had some flooding risk. After the initial analysis, it was found that flooding emanated from minor tributaries of the Ryewater River as they crossed under the canal/railway. Flooding was indicated along the northern edge of the canal and might potentially affect the rail line to the south. On the conclusions of Stage 1 and 2 Flood Risk Assessment, the Leixlip Confey area was considered to require a Stage 3 detailed flood risk assessment to quantify and confirm the risk of fluvial flooding.

During Stage 3, CFRAMS flood mapping for the design flood event at this location was studied. Floodwaters were shown within Leixlip Confey station and the Rail line to the east and west. However, it was found that it is unlikely that floodwaters would cross the canal and inundate the station/track given the embankment/wall between the canal and track and the gradual fall of the canal to the east, which would also convey floodwaters away. Having reviewed the CFRAMS hydraulic model, the flood extents may be explained by the relatively course 2D grid size that would provide an insufficient resolution to represent the walls/canal embankments appropriately, hence a risk still exists.

Given this conclusion from the flood modelling, similar flood management measures to other line locations, such as Broombridge station, could be implemented. These include implementing flood resilient design and materials, demountable barriers, and a flood emergency response plan.

At OBG14 the current track alignment already presents a low point just below the overbridge - by lowering this section further, a potential flooding issue becomes more likely, particularly due to the barrier effect of the canal. This goes against the recommended conclusions from the flood modelling.

In addition, the change from diesel (DMU's) to electrically powered trains (EMU's) will reduce the vertical allowance from the distance between the rolling stock and the water surface by approximately 200 mm; meaning accepted flood levels would be an additional 200 mm lower than they currently are.

Considering all of the above points, track lowering would increase the risk of flooding at this location and the tracks would require the implementation of a pumped drainage system or a gravity drainage system in order to mitigate against this increased risk. In case of failure of the pumping system, or blockages of the gravity drainage system, flooding may occur, which in turn would cause an operation closure. All of these factors would put the operational railway at increased risk.

Figure 3-16 OBG 14 Cope Bridge view from the Royal Canal

3.3.3 Drainage

3.3.3.1 Introduction

Two options have been reviewed with regards to drainage required to be constructed for the track lowering option in order to discharge water from the low points of the track:

1. Gravity drainage.
2. Pumped drainage.

3.3.3.2 Gravity drainage

A gravity drainage solution has been reviewed. The connection point from OBG14 is proposed at UBG13A as this is the closest culvert to OBG14. This UBG is located approximately 300 m to the east of the OBG14 as it is shown in the image below.

Figure 3-17 UBG 13A Location

Existing drainage information for the area has been reviewed and current information indicates there is no existing stormwater network that can be connected into, hence the proposal to connect into UBG13A culvert.

After the track lowering, the track level at OBG14 is 56.19 mOD. The invert level of the UBG13A is 51.89 mOD. For this reason, a drainage gravity system from OBG14 towards UBG13A is feasible.

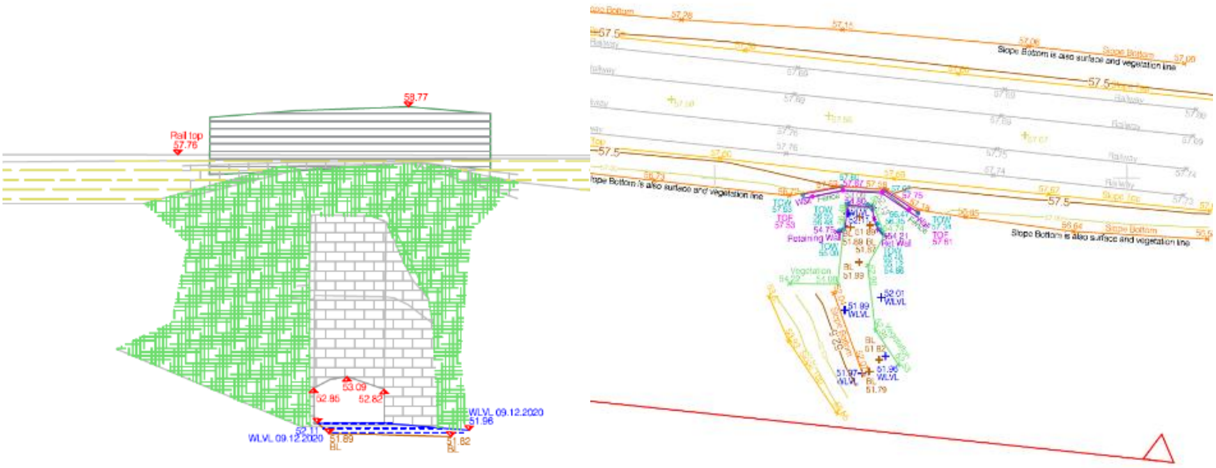


Figure 3-18 Invert Level of UBG 13A

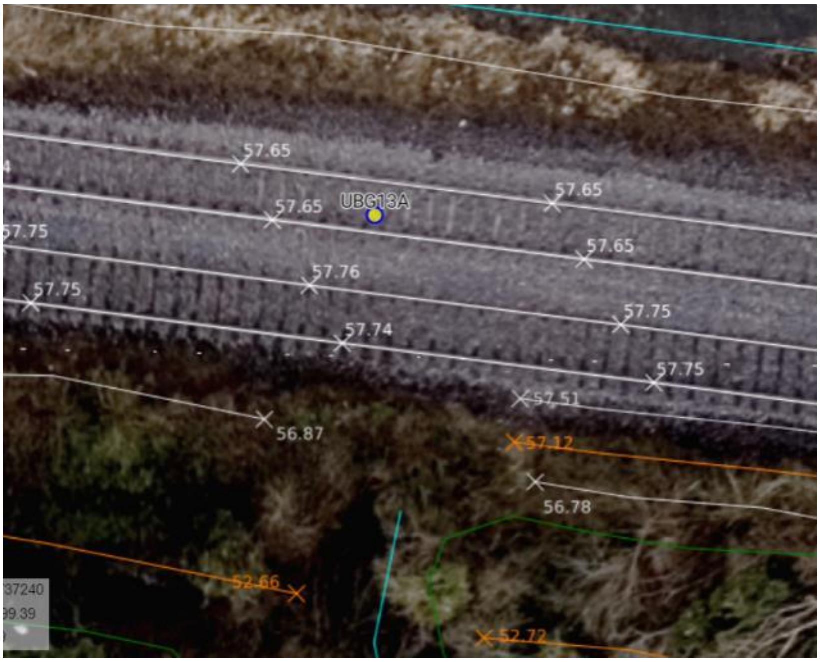


Figure 3-19 Comparison between OBG14A and UBG13A Track Levels

At UBG13A the track level is 57.74 m so to construct the drainage at track level does not provide for a sufficient slope. The drainage would need to be constructed by a counter slope for the 300 m between OBG14 and UBG13A, requiring excavations higher than 3 m before out falling to the culvert running adjacent to the live running lines. The alternative to this would be a pumped drainage solution, which has been described in Section 3.3.3.3.

Construction of a 3 m deep excavation directly adjacent to the railway line introduces increased risks during construction and requires extensive temporary works and monitoring of the existing tracks to ensure the live railway is not affected. It is proposed that this work would be done at the same time as the closure of the down track to improve safety of the workforce. If this is not possible, these works would need to be completed during night-time and weekend possessions.

In addition, there are a number of properties which have gardens backing onto this drainage route as shown below in red. Doing these works right outside of these houses would be very disruptive and has been considered during evaluation of this option.

Figure 3-20 Houses affected by drainage works

Given the depth of this gravity drainage and the proposed outfall point it will be difficult to maintain and hence may be more prone to blockages. If the gravity drainage was to block and a flood event occurred, the railway would be forced to shut until this was resolved.

3.3.3.3 Pumped drainage

Pumped drainage was the first option considered in order to minimise the risk of the tracks flooding as described in Section 3.3.2. This would require the installation of a pump and drainage system in the vicinity of the tracks. This option would introduce increased operational costs and operational safety risks to the operator as a result of the regular maintenance required. Pumped drainage also has the possibility of failure and so if this failure coincided with a flood event, this would cause the railway to close. For this reason, gravity drainage has been considered in terms of evaluating the track lowering option.

3.3.4 Utilities diversions

At present it is unknown what utilities run under the tracks at this location.

Further surveys would be required to confirm depth of utilities to determine if diversions/protection of utilities is required.

It is not possible to estimate the impact any potential utility diversions would have on operations, cost and programme.

3.4 Bridge structural intervention

Raising the historic bridge deck at OBG14 to provide the required vertical clearance for the OHLE was also studied. Raising the deck by means of jacking was identified as unfeasible due to the nature of the structure, so demolition and reconstruction of the deck was identified as the most suitable solution to obtain the required vertical clearance.

The structural solutions 4A (precast arch) & 4B (precast frame) were the two options reviewed to increase the vertical clearance (the current TOR to soffit clearance is 4650 mm).

The precast arch deck solution was chosen as it maintains the geometry of the current stone arch with a minimised negative aesthetic impact, and it achieves sufficient vertical clearance for the overhead electrical lines under the bridge.

The chosen dimensions are as follows:

- 4400 mm contact wire height bringing the messenger wire to the contact wire level.
- TOR to Soffit: 4700 mm.
- Bridge lifting: 330 mm.
- Road level lifting: 350 mm.

This structural solution has the potential to impact the adjacent arched span; therefore, it is proposed to use lightweight fill for the road backfill to the new elevation to reduce the additional dead load on the arch and the abutments.

The proposal also includes the partial deconstruction of the parapet and spandrel and reinstatement to a greater height to ensure safety regarding the electrified overhead lines.

Figure 3-21 OBG14 Plan drawing

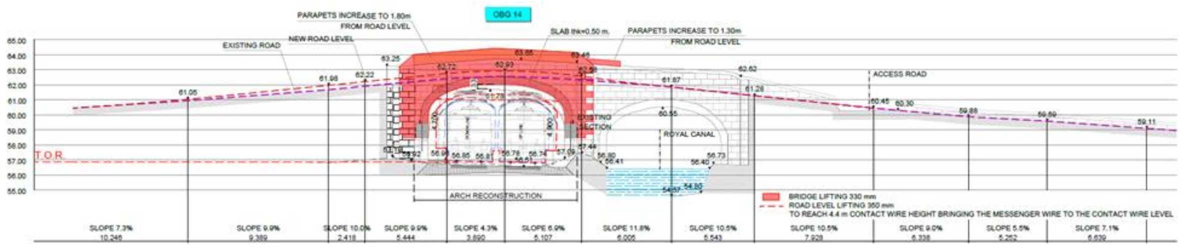


Figure 3-22 OBG14 Proposed arch deck reconstruction. East elevation

To ensure the new section of the bridge is constructed in line with heritage considerations, all of the design elements will need to be carefully considered in relation to the historic setting and, in particular, the remaining canal bridge. All junctions and interventions will need to be rigorously detailed to ensure the two bridges sit comfortably together in the landscape.

One advantage to reconstructing the bridge is that the railway bridge arch would be rebuilt to current structural design standards. The existing arch is thought to have been constructed around 1846 and so rebuilding the arch to current design standards would provide a compliant structure.

The bridge arch deck reconstruction would result in the following impacts:

- Considerable impact on the rail and canal bridges in terms of heritage.
- Closure of the road during construction would require traffic to divert to other crossing locations.
- Utilities: through Cope Bridge, there is one Eircom duct that would need to be diverted temporarily if the bridge deck is modified.

The above points have been considered in more detail in the following sections.

3.4.1 Heritage impact and considerations

The removal and replacement of the span of OBG14 Cope Bridge over the railway line is a very significant loss of important historic fabric. This will have a considerable impact on the character of the setting, surrounding environment and the remaining canal bridge, dating from 1794. As this technical note identifies, the bridge could be retained but at a significant financial and programme cost. From a conservation perspective it would have been preferable to incorporate the welcomed new infrastructure into the existing setting while retaining this important historic structure.

To mitigate the loss of this historic structure as much as possible, it is essential that the replacement section of the bridge is well designed, detailed and executed. The most important consideration in the process will be to ensure that the new build element sits comfortably alongside the remaining canal bridge.

Due to the significant raising of the bridge to accommodate the OHLE and the requirement to install a precast concrete arch, it will not be possible or desirable to reconstruct the span to match the existing. Instead, a contemporary solution using modern materials will be designed to complement the proportions and style of the remaining canal bridge. The extent of demolition will be confined to the section of bridge between the stone piers to ensure that the reconstructed section will be read as an insertion rather than an entirely new bridge. The colour and texture of the concrete finish, along with the quality of the detailing and workmanship will be critical to its success. Research into materials and sample panels will be essential prior to construction to ensure the new concrete finish complements the remaining historic stonework. The junctions between old and new will need to be carefully considered, particularly the change in levels between the two spans, the parapets, and the interface between the original stonework and new concrete facing at the piers.

A number of finishes and construction methods were assessed during the design process. Initially the preferred option was to re-use the original facing stone, but it became clear that this would not be successful due to the technical constraints of the new construction. The string course is an essential element of the existing composition, but the increased height of the arch would distort its connection to the string course over the canal. The precast arch construction would reduce the existing voussoirs to cladding stones and the facing stone of the spandrels would also become cladding stones tied back to the concrete structure behind. The combination of all these factors made it very difficult to design or build stonework that would sit well with the original fabric on each side.

The use of a weathered steel facade was also explored as this material would tie together the rebuilt bridge and new pedestrian bridges on each side. After careful assessment it was decided to proceed with a concrete finish as this will sit most comfortably with the remaining original stonework. Provided a suitable colour and finish are achieved on the concrete, it should complement, not dominate the original structure. The proposed finish is shown in Figure 3-23 below for OBG5 Broome Bridge as an example.

Figure 3-23 OBG5 Broome Bridge Photomontage - Canal View West

It is a safety requirement that the parapets are a minimum of 1800 mm high and the bottom 1200 mm must be solid, in the area of the OHLE. This presents a significant challenge to all of the historic bridges along the scheme, as the existing original parapet heights are lower than 1200 mm. A rigorous design process has taken place to identify a solution that will complement the historic setting and maintain a visual connection to the rail lines and surrounding landscape, when on the bridge. It was also considered essential that the parapet would not be a dominant feature while viewing the bridge from the canal. The proposed design is a contemporary, adaptable solution that can be implemented throughout, bringing a degree of uniformity to all interventions along the railway. For Cope Bridge it is proposed to provide a solid metal panel from the top of the parapet up to 1200 mm with an expanded metal mesh to continue up to 1800 mm. The fixing stays and mesh will be carefully designed to ensure the internal face of the parapet is not obscured and that the mesh allows a good visual connection to the surroundings.

To ensure the new span over the railway is successful, all elements of the design will need to be carefully considered in relation to the setting, and in particular, the remaining canal bridge. All junctions and interventions will need to be well designed and detailed to ensure the two phases of construction sit comfortably together and in the landscape.

3.4.2 Road closure and impact on the community

In order to reconstruct the bridge road closure will be required. This includes:

- 15 weeks of total road closure
- 19 weeks of partial road closure (one lane open)

For the road closure of 15 weeks, a diversion route has been proposed. The impact of this road closure has been assessed in the Traffic and Transport chapter of the EIAR, and the impact is deemed to be a minimal short term impact.

Pedestrian and cycle closure will not be required at this location due to the construction of the new pedestrian and cycle bridges alongside the historic bridge being scheduled to be constructed before the reconstruction of the bridge arch. Pedestrians and cyclists can therefore use these alternative bridges to cross the railway and canal during construction.

3.4.3 Utilities Diversions

Due to the demolition and reconstruction of the railway arch and deck, one Eircom utility duct will need to be diverted temporarily, and then reinstated.

These utilities are proposed to be diverted via a provisional beam adjacent to the existing bridge during construction.

Figure 3-24 Utility diversion at OBG14 Cope Bridge

In general, the disruption time of the service is mainly due to the connection of the temporary diversion. This is expected to be hours. To minimize the disruption time, the temporary diversion, ducting and the connections will be planned properly.

4. COST AND PROGRAMME IMPACTS

4.1 Track Lowering

4.1.1 Construction duration

The table below indicates the estimated duration for the track lowering option.

Table 4-1 Estimated duration of the works

Track lowering solution
15 months

*As reference in report 'Option selection for Overhead Line Equipment (OHLE) intervention at OBG5, OBG11 and OBG14' (document number MAY-MDC-STR-OTHE-RP-Z-0004) the existing footbridge requires to be widened regardless as a result of the increase in passenger numbers. Hence if we remove the time for the footbridge construction this duration reduces to 12 months.

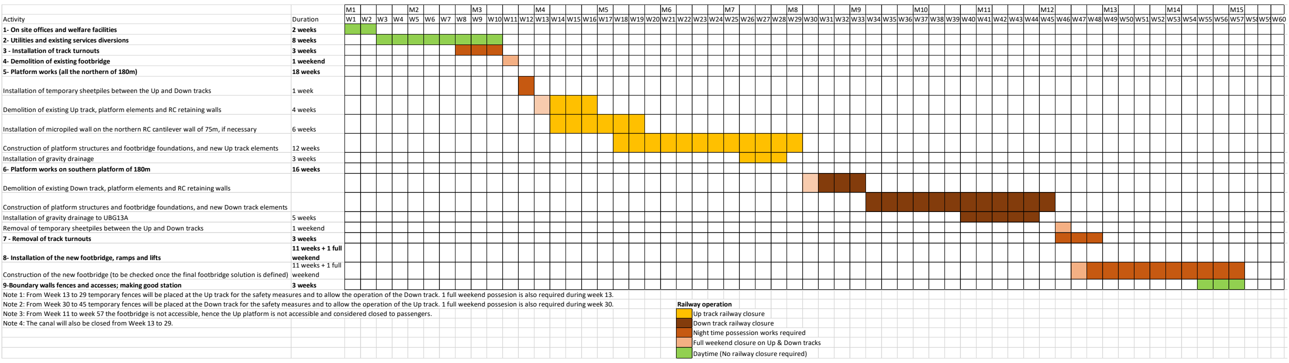
Note that durations have been estimated high level at this stage of design. Note this assumes implementation of a gravity drainage system.

The construction strategy for the track lowering and station works is proposed as follows:

1. Utility diversions within the station and track lowering area.
2. Installation of track crossovers (night-time possessions) to allow for track cross overs during track lowering and platform works.
3. Demolition of existing footbridge (full weekend closure required on both tracks).
4. Foundation strengthening around OBG14 bridge if required.
5. Platform works on the northern platform of 180 m.
   - 5.1. Installation of temporary sheet piles between the Up and Down tracks (both tracks closed, to be done either in weeknight or weekend possessions).
   - 5.2. Demolition of existing Up track, platform elements and RC retaining walls (Up track closed for duration; royal canal will be affected for this duration and propose to use temporary works and an overpumping system to dewater this section of the canal to allow construction to be completed).
   - 5.3. Installation of micropiled wall on the northern RC cantilever wall of 75 m, if necessary (Up track closed for duration)
   - 5.4. Construction of platform structures and footbridge foundations, and new Up track elements (Up track closed for duration).
   - 5.5. Installation of gravity drainage (Up track closed for duration OR weeknight or weekend possessions).
6. Platform works on the southern platform of 180 m.
   - 6.1. Demolition of existing Down track, platform elements and RC retaining walls (Down track closure for duration).
   - 6.2. Construction of platform structures and footbridge foundations, and new Down track elements (Down track closure for duration).
   - 6.3. Installation of gravity drainage (Down track closed for duration OR weeknight or weekend possessions).
   - 6.4. Removal of temporary sheetpiles between the Up and Down tracks (weeknight or weekend possessions).
7. Installation of the new footbridge to current standards (full weekend closure required on both tracks, plus night-time possessions).
8. Boundary walls fences and accesses (daytime or weeknight/weekend possessions depending on activity).

The following table shows an indicative sequence of activities:

Table 4-2 Indicative programme for track lowering and footbridge reconstruction



Note 1: From Week 13 to 29 temporary fences will be placed at the Up track for the safety measures and to allow the operation of the Down track.

Note 2: From Week 30 to Week 45 temporary fences will be placed at the Down track for the safety measures and to allow the operation of the Up track.

Note 3: From Week 11 to Week 57 the footbridge is not accessible, hence the Up platform is not accessible and considered closed to passengers.

Note 4: The canal will also be closed to users from Week 13 to 29.

4.1.2 Disruption of services

Road closure

For the track lowering option, the road access would not be impacted.

Station closure

For the track lowering option, it will require around 18 weeks of the Up-track closure to carry out the platform and foundations works. During this period (from Week 13th to 29th) temporary fences will be placed at the Up track for the safety measures and to allow the railway operation of the Down track. Once the Up-track work is finalized, the works will continue on the Down track. It will require around 16 weeks of the Down-track closure to carry out the platform and foundations works. During this period (from 30th to 45th) temporary fences will also be placed at the Down track for the safety measures and to allow the railway operation of the Up track. Considering the current constraints (i.e., site clearance and spatial limitation between the existing Up and Down tracks), it will be challenging to carry out the construction work while maintaining the operation of both the Up and Down track. During the platform demolition and foundation construction work, several weeks of night closure and weekends closure on both Up and Down track will be required. Detailed safety measures will be required in the following design stages to mitigate any possible risk on people during the construction work.

The figures below show an example of the set up required to close one track in order to complete platform reconstruction works.

Figure 4-1 Example of track closure required to complete platform works

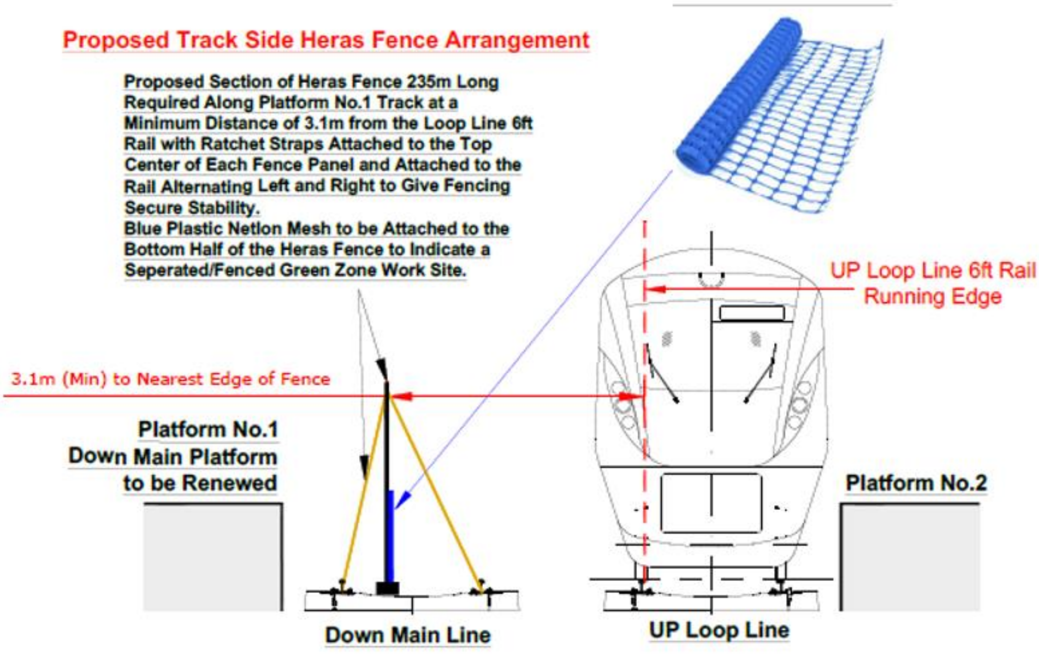


Figure 4-2 Required working space when working next to a live rail line

The closure of a track for demolition work and reconstruction of the adjacent platform means that the line needs to be operated on a single bi-directional track section.

The nearest crossovers to Leixlip Confey Station that allows for track switching are located on Maynooth line to the west (about 7 km away) and Clonsilla to the east (about 5 km away). This would result in the line operating on a single bi-directional track between Maynooth and Clonsilla (about 12 km affecting four stations along the line) resulting in operational constraints for the operator.

To avoid this situation, temporary turnouts could be provided at each end of the station (beyond the track lowering area) to allow trains to pass through the station on a single track section for approximately 600 m in length.

In the first phase, while work is being done on Platform 1 and the Up track is closed, the Down is a single track. Two provisional turnouts allow the change from the Up to the Down track and vice-versa.

Figure 4-3 Works at Platform 1. Up track closed. Trains running through Down track

In the second phase, works are done at Platform 2 and the Down track is closed; meanwhile, the Up track is the single running line. For this situation, the provisional turnouts have to change sides.

Figure 4-4 Works at Platform 2. Down track closed. Trains running through Up track

Temporary signalling works will also be required in order to implement these temporary turnouts, which adds additional cost, programme, risk and environmental impacts to these works.

The time estimation for the works has been calculated based on some staging in the down platform, which would keep the station open with only half of the train boarding and alighting to the station.

In summary, the Down platform would require disruptive interventions for 16 weeks. The Up platform would be closed for 18 weeks. The Up platform is also not accessible to passengers from the point when the footbridge is demolished until it is re-commissioned as there is no other way to access the Up platform (total of 47 weeks). A temporary bridge could be constructed over the canal to provide access to the Up platform, which would add additional cost, programme, risk and environmental impacts to this option. For the purposes of this comparison exercise this has not been included and closure of the platform has been assumed.

The disruption of service to the station may need to be mitigated by provision of a shuttle bus service to bring the passengers to and from Leixlip Louisa Bridge Station. This would need to be agreed with IE operations should this option be considered.

Canal Closure

As mentioned above, in order to complete the works affecting the retaining wall, the canal is proposed to be dewatered in this section for the duration of the Up platform works (18 weeks). This is a requirement in order to reduce the risk of flooding from the canal as a result of the alterations to the retaining wall structure during construction. This will cause a significant disruption to users of the canal between Maynooth and Spencer Dock and also to Waterways Ireland maintence activities.

The table below indicates the summary of the estimated time of disruption.

Table 4-3 Estimated time of disruption

Track lowering and station reconstruction	
Road closure	-
Railway closure	18 weeks on the up track and 16 weeks on the down track; up platform closed for 47 weeks
Canal closure	18 weeks

4.1.3 Cost Estimation

Th table below indicates the estimated cost of the track lowering works.

Table 4-4 Estimated cost

Track lowering (*) (€ '000)
10,678

(*) Cost includes reconstruction of the station infrastructure, track lowering and drainage system. Does not include the cost of the new footbridge bridge, as noted in report 'Option selection for Overhead Line Equipment (OHLE) intervention at OBG5, OBG11 and OBG14' (document number MAY-MDC-STR-OTHE-RP-Z-0004), and this would have required to be replaced as a result of the DART+ West project regardless. Excludes transporting passengers by bus based on the construction strategy below.

4.2 Bridge Reconstruction

4.2.1.1 Construction duration

The table below indicates the estimated duration for the bridge reconstruction works.

Table 4-5 Estimated duration of the works

Bridge modification
10 months

Note that durations have been estimated high level and can be refined during detailed design.

The construction strategy for the bridge modification is proposed as follows:

1. Traffic and utility diversions shall be carried out before the arch deck reconstruction, including site setup, accommodation works, utility diversions, earthworks, and pavement works
2. Soil improvement behind the existing wall using jet grouting
3. Excavation, deconstruction of the surface of the existing arch (existing masonry to be reused for surfacing and finishing work of the reconstructed arch) and demolish the inner upper part of the existing arch structure. The pavement and backfill on the Royal Canal arch to be removed temporarily and symmetrically to avoid uneven loads on the Royal Canal arch, if necessary. A protective element should be placed to protect the parapets and the stone face of the Royal Canal arch.
    a. Underpinning of existing foundations using lateral micropiles to strengthen existing foundations, if necessary
4. Placing of the precast concrete wall blocks for arch support and anchoring to the existing walls with dowel bars
5. Placing of the precast concrete arch deck
6. Waterproofing membrane on the precast concrete arch deck and precast concrete wall blocks
7. Backfill to bedstone behind the vertical walls to consist of semi-dry mortar not less than 750 mm in width
8. Reconstruction of the road
9. Make good restoration work along the deck to integrate aesthetically with the arch bridge

10. Load test to be carried out on the adjacent canal bridge before allowing the road traffic to pass over.
11. Place temporary jersey barrier (or similar) in the carriageway to allow vehicles and pedestrians to cross, reinstallation of diverted utilities
12. Repair the pavements and parapets in accordance with conservation architects' requirements.

The following table shows an indicative sequence of these activities:

Table 4-6 Indicative programme for bridge modification

		Month	1				2				3				4				5				6				7				8				9				10			
		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1. Site preparation	Traffic and utility diversions, etc.																																									
2. Soil improvement																																										
	Soil improvement behind existing wall								x	x																																
3. Excavation and deconstruction & demolition of existing structure																																										
	Excavation to the wall below springer level										x																															
	Deconstruct the surface of arch structure and arch support										x																															
	Demolish the inner part of arch structure and arch support											x																														
3a.	Foundation strengthening, if necessary																																									
4. Deck support reconstruction																																										
	Concrete wall blocks												x	x	x																											
5. Deck reconstruction																																										
	Precast arch deck												x	x	x																											
6. Deck waterproofing																																										
	Waterproofing membrane															x	x																									
7. Backfill																																										
	Backfill to bedstone behind walls																	x	x	x	x																					
8. Road modification to a new level																																										
	Road modification																			x	x	x	x	1	1	1	1															
	Finishing																											1	1	1												
9. Restoration																																										
	Restoration work																			x	x	x	x																			
10. Reinstallation of diverted utilities																																										
	Place temporary jersey barrier (or similar), utilities diversions																							1	1	1	1	1	1	1	1	1	1	1	1							
11. Deck																																										
	Parapets																																		1	1	1	1	1	1		
	Finishing, load test to be carried out on the adjacent canal bridge before allowing the road traffic to pass over																																								1	1

Total construction duration: 40 weeks
Railway closure: 4 full weekends of possession +11 weeks of night closure working on the railway + 1 weeks of total railway closure
Total road closure: 15 weeks
At least one-lane road closure: 15 weeks (total closure) +19 weeks (one-lane closure) = 34 weeks

Road closure
x Total road closure
1 One lane road closure

Railway operation
Close to railway
Service total closure
Full weekend closure
Week of night closure
No railway closure required

Note: From 20th week the temporary jersey barrier (or similar) will be placed in the carriageway and in 20th and 21st weeks temporary pedestrian ramps will also be placed to allow pedestrian to cross.

Note: From 20th week the temporary jersey barrier (or similar) will be placed in the carriageway and in 20th and 21st weeks temporary pedestrian ramps will also be placed to allow pedestrian to cross.

4.2.1.2 Disruption of services

Road closure

Within the estimated time for the bridge modification:

- The road would be closed to vehicles completely for 15 weeks, with a one lane closure for a further 19 weeks. Note Chapter 6 Traffic and Transport of the EIAR states that the construction impact of this diversion is 'slight' and 'temporary'.
- Pedestrian and cycle closure will not be required at this location due to the new pedestrian and cycle bridges being constructed alongside the historic bridge being scheduled to be constructed before the reconstruction of the bridge arch.

Station closure

For the bridge modification, the station would be closed during four-weekend track possessions and 1 full week for stages 2 to 3 (refer to **Table 4-5** above).

The table below indicates the summary of the estimated time of disruption.

Table 4-7 Estimated time of disruption

Bridge modification	
Road closure	15 weeks total closure; further 19 weeks one lane closure
Station closure	4 full weekends and 1 full week

4.2.1.3 Cost estimate

The table below indicates the estimated cost of the bridge reconstruction option.

Table 4-8 Estimated cost

Bridge modifications (*) (€ '000)
1,423

(*) Cost includes the diversion of the existing utilities (being 1 EIRCOM duct running across the bridge deck the main one) and allowance for road closures and diversions.

5. SELECTION OF PREFERRED OPTION

5.1 Multicriteria Analysis (MCA)

In order to compare the two viable options of track lowering Vs bridge reconstruction, a dedicated multi-criteria analysis (MCA) has been undertaken to consolidate the quantifiable and non-quantifiable impacts of each option.

The feasible options considered as part of the MCA process are listed in the table below:

Table 5-1 Options Assessed

Options	Description
Option 1	Track lowering to allow a 4700 mm contact wire system
Option 2	Bridge deck reconstruction

5.1.1 Option 1. Track lowering to allow a 4700 mm contact wire system

5.1.1.1 Description

The Option 1 to achieve 4700 mm contact wire height requires the lowering of the tracks approximately 580 mm directly below OBG14, as described in the previous sections.

The main advantages of this option are:

- Historic bridge is not affected by the works.
- Renewal of existing platforms allows for a compliant track gradient of 2.5 mm/m.
- No disruption to road users using OBG14 to cross the canal and railway at this location.

The disadvantages of this option are:

- It requires extensive work in and around the station platforms, accesses, footbridges, utilities, fences, etc. requiring extensive track closures and disruption to passengers.
- Royal Canal requires to be closed for 18 weeks during the works on the Up platform.
- The Royal Canal is very close to the tracks and the creation of a longitudinal profile low point in the tracks increases the risk of flooding during heavy rainfall. This requires a new gravity drainage system to be installed adjacent to the live rail line and close to residential properties. The depth and location of this drainage makes construction and maintenance more difficult and impacts negatively on residents during construction. If a blockage occurs during a flood event, the railway could be forced to close.
- This option has increased costs and programme duration.

5.1.2 Option 2. Bridge deck reconstruction

5.1.2.1 Description

Option 2 to reconstruct the existing railway arch requires the modification of this structure to provide an additional clearance of 330mm higher than the original bridge, as described in previous sections.

The main advantages of this option are:

- Limited disruption to station and railway users/operators.
- No closure required of the Royal Canal.
- Shorter programme reducing impacts on residents in this area during construction.
- Reduced construction costs.
- No increase in flooding risk to the railway from existing situation.

- Railway bridge arch is rebuilt to current structural design standards.

The disadvantages of this option are:

- Significant heritage impact to the historic bridge.
- Disruption to road users in this area during the closure of the bridge.

5.1.3 MCA Assessment

The options assessment summary is shown in Table 5-2 and the MCA full MCA Assessment is shown inTable 5-3.

The results of the MCA led to recommend **Option 2, deck bridge reconstruction** (precast arch deck) as the preferred option.

Table 5-2 MCA Summary Assessment

	Criteria	Sub-Criteria (Quantitative Qualitative)	Option 1. Track Lowering	Option 2. Deck bridge reconstruction
1	Economy		Significant comparative disadvantage over other options	Significant comparative advantage over other options
2	Integration		Comparable to other options	Comparable to other options
3	Environment		Some comparative disadvantage over other options	Some comparative advantage over other options
4	Accessibility and social inclusion		Some comparative disadvantage over other options	Some comparative advantage over other options
5	Safety		Comparable to other options	Comparable to other options
6	Physical Activity		Some comparative advantage over other options	Some comparative disadvantage over other options
	Chosen Option		No	Yes
	Comment		Option 1 does not impact the historic structure. Option 1 has a negative impact on Leixlip Confey Station in terms of diruption to rail users and the operator. Option 1 negatively impact on the Royal Canal during construction and maintenance. Option 1 increases the low point of the tracks with risk of drainage/flooding issues and installation of gravity drainage system will impact negatively on residents in the area. Option 1 is the option that requires the highest construction cost.	Option 2 negatively impacts on the historic structure and the challenge of this option is to find a sympathetic solution that minimizes the impact on the historic bridge. Option 2 impacts on road users more than Option 1. Option 2 is cheaper and requires less time to construct, minimising disruption in this area. Option 2 does not increase the risk of flooding at this location.

Table 5-3 OBG14 Cope Bridge MCA Assessment

DART Maynooth & City Centre Enhancements. Draft Permanent Way Preliminary Assessment Criteria and parameters

IDO 12 OBG14 MCA1 Assessment

	Parameter		Criteria	Option 1 Track Lowering	Option 2 Deck bridge reconstruction
1	Economy	1.1	Construction and Land Cost	**Significant comparative disadvantage over other options**	**Significant comparative advantage over other options**
				This solutions requires lowering 550 mm both tracks below OBG14, which has increased costs when compared to Option 2. This solutions requires significant alterations to Leixlip Confey Station (platforms, accesses, footbridges, utilities, fences, etc). Royal Canal is very close to the tracks and lowering will put the tracks at a higher risk of flooding. Requires lengthy closure of tracks and the canal waterway.	This solution requires a reconstruction of the arch bridge. This construction solution is cheaper than the track lowering and requires minimal impact on the operational railway and no impact on the canal.
		1.2	Long Term Maintenance costs	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				Lowering the track puts the track below Royal Canal water level and creates a low point in the track which will increase risk of flooding. Flooding and platform issues will require maintenance and reinvestment in the drainage system.	This solutions requires less drainage maintenance. Construction of the new structure will improve bridge maintenance regime and reduce future maintenance costs as this is now a new compliant structure over the railway.
		1.3	Train Operation Functionality /economic benefit	**Significant comparative disadvantage over other options**	**Significant comparative advantage over other options**
				Longitudinal profile low point. Risk of drainage/flooding issues and service interruption.	Option 1 introduce a risk of services interruption that Option 2 do not.
2	Integration	2.1	Transport Integration	**Some comparative disadvantage over other options**	**Some comparative advantage over other options**
				This solution impacts on the operation during the construction works because the track lowering. This solutions impacts on Leixlip Convey Station operation during the construction works.	This solutions impacts on Cope Bridge road during the works.

	Parameter		Criteria	Option 1 Track Lowering	Option 2 Deck bridge reconstruction
		2.2	**Land Use Integration**	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the land use integration.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the land use integration.
		2.3	**Geographical Integration**	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the geographical integration.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the geographical integration.
		2.4	**Other Government Policy**	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to other Government Policy.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to other Government Policy.
3	**Environment**	3.1	**Noise and Vibration**	**Some comparative disadvantage over other options** Impact on local houses during construction works for the drainage higher for this option. Construction duration is also longer, impacting the public for longer. There is likely to be temporary construction impacts on sensitive receptors in this location which will be the subject of further assessment.	**Some comparative advantage over other options** There is likely to be temporary construction impacts on sensitive receptors in this location which will be the subject of further assessment.
		3.2	**Air Quality and Climate**	**Some comparative disadvantage over other options** Higher volume of infrastructure affected by this option, so higher volume of materials required and higher waste generated likely.	**Some comparative advantage over other options** Existing materials (e.g. stone parapets) planned to be reused
		3.3	**Landscape and Visual (including light)**	**Significant comparative advantage over other options** Track lowering. No direct impacts to the key views to and from Cope bridge. Potential slight/moderate indirect negative impacts due to presence of overhead wires.	**Significant comparative disadvantage over other options** Historic railway bridge structure requires to be altered. Views to and from OBG14 Cope bridge are protected (Key view RC2) and will be directly affected by structural alterations.
		3.4	**Biodiversity (flora and fauna)**	**Significant comparative disadvantage over other options** 18 week closure of the canal and requirement to dewater in this area may affect negatively on the flora and fauna in and around the canal. Works proposed in proximity to the Royal Canal pNHA. There is potential for water quality, noise and lighting impacts within the pNHA. Future maintenance work may also require closure of the canal.	**Significant comparative advantage over other options** Works proposed in proximity to the Royal Canal pNHA. There is potential for water quality, noise and lighting impacts within the pNHA.

	Parameter		Criteria	Option 1 Track Lowering	Option 2 Deck bridge reconstruction
3	Environment	3.5	**Cultural, Archaeological and Architectural Heritage**	**Significant comparative advantage over other options** Track lowering. No direct impacts to the Cope bridge. Potential slight/moderate indirect negative impacts due to presence of overhead wires.	**Significant comparative disadvantage over other options** Cope Bridge directly and negatively impacted to a significant degree as structural alterations are required. Whilst not protected, alterations to the structure should be in consultation with Kildare County Council and design input from a conservation architect/engineer has been saught.
		3.6	**Water Resources**	**Significant comparative disadvantage over other options** 18 week closure of the canal and requirement to deater in this area may affect negatively on the water resource attributes.Potential for existing flooding on tracks at Leixlip Confey. Option may increase flood risk by increasing effective depth of tracks and creation of low point. Need to confirm by hydraulic assessment as part of SSFRA. Potential water quality impacts during construction.	**Significant comparative advantage over other options** Option would have minimal impact on existing flooding regime. Potential water quality impacts during construction.
		3.7	**Agriculture and Non-Agricultural**	**Comparable to other options** No impact on agricultural or non-agricultural property.	**Comparable to other options** No impact on agricultural or non-agricultural property.
		3.8	**Geology and Soils (including Waste)**	**Some comparative disadvantage over other options** No geological heritage sites. Till overlain by poorly drained grey soil. May remove passive resistance from retaining walls and abutments which are structurally significant and will require structural modifications. Likely contaminants disturbance of trackbed ballast due to operations of diesel.	**Some comparative advantage over other options** No contaminants disturbance due to work being undertaken off track. However, jet grouting may be required to support existing foundations during construction.
		3.9	**Radiation and Stray Current**	**Comparable to other options** All options are comparable from an EMI perspective.	**Comparable to other options** All options are comparable from an EMI perspective.
4	Accessibility & Social inclusion	4.1	**Impact on Vulnerable Groups**	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the Impact on Vulnerable Groups.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the Impact on Vulnerable Groups.
		4.2	**Stations Accessibility**	**Some comparative disadvantage over other options** The lowering of the tracks and as a consequence of the station platforms can negatively affect the current accessibility of the station during construction.	**Some comparative advantage over other options** This solution does not modify the current accessibility to the station.

	Parameter		Criteria	Option 1 Track Lowering	Option 2 Deck bridge reconstruction
		4.3	**Social Inclusion**	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the Social Inclusion.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the Social Inclusion.
5	**Safety**	5.1	**Rail Safety**	**Some comparative disadvantage over other options** Renewal of existing platforms allows for a compliant track gradient of 2.5 mm/m. However, creation of low point introduces flooding risk. Some risks present working adjacent to the railway during construction.	**Some comparative advantage over other options** The tracks remain at the existing gradient. No additional flooding risk with this option. Some risks present working over the railway during construction.
		5.2	**Vehicular Traffic Safety**	**Some comparative advantage over other options** No impact on road users.	**Some comparative disadvantage over other options** Diversions required during construction
		5.3	**Pedestrian, Cyclist and Vulnerable Road user Safety**	**Comparable to other options** No impact on pedetrian, cyclist and vulnerable road user safety.	**Comparable to other options** No impact on pedetrian, cyclist and vulnerable road user safety as new pedestrian and cycle bridge constructed prior to bridge reconstruction.
		5.4	**Structures safety**	**Significant comparative disadvantage over other options** This solutions requires track lowering of 550 mm involving deep excavations and complex structural works next to a live railway. Impact on the historic railway and canal bridge also requires further investigation.	**Significant comparative advantage over other options** This solution may require jet grouting to stabilise the foundations during construction, but this solution provides a new compliant structure in line with current design standards, improving safety of the structure in the long term.
6	**Physical Activity**	6.1	**Connectivity to adjoining cycling facilities**	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the connectivity to adjoining cycling facilities.	**Comparable to other options** There is no foreseen advantage or disadvantage of this option in regards to the connectivity to adjoining cycling facilities.
		6.2	**Permeability and local connectivity opportunity**	**Some comparative advantage over other options** No diversions required and hence limited impact on permeability and local connectivity.	**Some comparative disadvantage over other options** Road diversions may affect permeability and local connectivity negatively during construction.

6. CONCLUSIONS

As stated in Section 3.2, no reduced height OHLE solution was identified that proved acceptable to the IÉ SET and CCE departments due to the higher lifecycle costs and the additional safety measures that would need to be implemented during the inspection and maintenance activities. For all these reasons, this option was ruled out.

Regarding track lowering, while this option minimises the impact on the historic railway bridge and does not require road diversions during construction, the disruption to railway users and operations during construction is significant. The Royal Canal is also significantly impacted during construction. In addition the cost and programme impact of the construction work at the station is greater for this option. A gravity drainage solution could be installed to mitigate the risk of the track flooding due to the new low point in the tracks, however this option introduces risks during construction and has the potential to impact negatively on residents during construction. The risk of the tracks flooding remains a concern.

The option proposed given the points outlined in this report, specifically in the MCA, is a **Bridge deck reconstruction (precast arch deck)**. This option limits the construction period disruption to station and railway users/operators and does not require the closure of the canal. It has a shorter construction programme, reducing the impacts on residents during construction and does not increase the track flooding risk in this location. It is also a lower cost option. It is acknowledged that this option impacts on the historic railway bridge, however engagement with a Grade 1 Conservation Architect will ensure that the reconstruction is completed sympathetically and in keeping with the historic canal structure (Refer to Appendix A of this report for the Architectural Heritage Impact Assessment). Road diversions are also required for this option, but traffic assessments have deemed the impact minimal and temporary.

APPENDIX A. Cope Bridge – Architectural Heritage Impact Assessment

BLACKWOOD ASSOCIATES

ARCHITECTS

AND

BUILDING CONSERVATION CONSULTANTS

20, STEPHEN STREET LOWER, DUBLIN 2.

PH: (01) 478 4590 FAX: (01) 478 4561

email:studio@blackwood.ie

DART+ West

Proposed Works at Cope Bridge, Leixlip, Co. Kildare

Architectural Heritage Impact Assessment

June 2022

CONTENTS

1.0 INTRODUCTION

This report has been prepared by Blackwood Associates Architects to accompany the Railway Order application for the DART+ West project. The report will assess the impact of the proposed works on the existing structure and setting at Cope Bridge. The proposed works referred to in this document have been designed by IDOM, the design team lead, for the client, Iarnród Éireann.

2.0 DESCRIPTION OF STRUCTURE

Note: Much of the information below is based on the report provided by Rob Goodbody in the appendices to Chapter 21 – Architectural Heritage (Appendix A21.4 in Volume 4 of this EIAR)

Cope Bridge is a masonry road bridge dating from 1790 and spanning over the Royal Canal in Leixlip, Co. Kildare. The bridge is approximately 1.4km from the centre of Leixlip, accessed from the R149 (Captain's Hill). Immediately to the west of the bridge is Leixlip Confey Train station, built in 1990.

The bridge was extended in c.1846 to provide passage over the railway line, which was introduced alongside the canal at that time as part of the Great Western Railway. The railway line passes directly to the south of the canal. The roads on either side of the bridge are at slightly different angles to each other. The change in angle is corrected in the centre of the bridge, between both arches.

The older portion of the bridge spanning over the canal is identified by a lower elliptical or three-circle arch. The later extension of the bridge over the railway line is characterized by a similarly shaped arch but with its crown raised to accommodate trains passing below.

Figure 1 – East elevation of Cope Bridge showing both arches with the railway on the left hand side and canal on the right hand side.

The bridge is built of a mixture of rubble and squared limestone of varying sizes brought to courses in parts and laid randomly in others. It comprises two arches, one spanning over the canal and one over the railway line. When the bridge was extended over the railway the second arch was constructed with two engaged piers, one of which now sits centrally in the middle of the bridge. A continuous string course and parapet run across the bridge's hump-back shape. Decorative features include arch rings comprising voussoirs, chamfered on their outermost edges and a raised keystone, all in hammer dressed limestone.

Figure 2 – East elevation showing arch ring.

Figure 3 – Chamfer detail on arch voussoirs.

The bridge terminates at land to the north and south with wing walls that curve away from the bridge and slope down towards the canal. The north east wing is topped with rounded concrete flaunching. The north west wing wall does not have coping stones or concrete flaunchings, leaving the wall top open. It appears to have a recently constructed pier at its end. Wing walls to the south are capped with limestone copings, sloping steeply down on both sides. The south east wing is densely overgrown with vegetation.

Figure 4 – North east wing wall with concrete flaunching.

Figure 5 – North west wing wall with pier recently rebuilt. Note the wall is missing coping stones...

Figure 6 – Oblique view of east elevation.

Beneath the arch on the canal side, the abutments are constructed in limestone ashlar in even courses but of varying heights. The underside of the arch is constructed of slender courses of squared limestone, tying into quoins either side.

Figure 7 – Canal arch vault and south facing abutment of limestone ashlar.

Figure 8 – Railway arch and south facing abutment obscured by platform.

Beneath the arch on the railway side, the abutments are mostly concealed by the tail end of the station platform but visible masonry is of coursed squared limestone, to suit corresponding quoins. The underside of the arch is of smaller courses of the same, also tying in with quoins.

The spandrels of the canal arch are faced with squared limestone in slender courses. The spandrels of the railway arch and the engaged piers constructed with it, are in the same style being of random squared limestone.

Figure 9 – East facing spandrel of the canal arch showing squared limestone laid in slender courses.

Figure 10 – West facing spandrel of the railway arch showing random squared limestone.

The parapet stonework is a similar style of random squared limestone across the full length of the bridge, demarcated with the continuous string course below. The parapet slopes continuously to the crown of the bridge, which is centred over the railway arch. The parapets are topped with dressed limestone copings on either side with overhanging outer edges. Parapets curve away from the bridge and end with a small pier, resting on the curved wing walls below.

Figure 11 – Random squared limestone parapet and stringcourse across full length of bridge.

On the bridge the deck rises towards the crown over the railway line. The roads leading to the bridge from the south are flanked by random rubble limestone walls topped with large limestone blocks on both sides. To the north of the bridge, once the parapets curve away in the direction of the wing walls below, there is a small clearing between the parapet and a separate free-standing length of wall topped with rounded concrete cappings, on the west side. On the east side, the wall directly abuts the parapet.

Figure 12 – Road leading to the bridge from the south. The wall flanking the road is visible on the left. The crown over the railway arch and the bridge parapet are visible on the right.

Figure 13 – View taken standing on crown of the bridge over the railway arch, looking north. Parapet over canal arch visible with gap between parapet and separate wall, in background.

The parapet wall also widens in depth on the north east side of the bridge. It is clearly visible in the coping stone from above, see Figure 14 below.

Figure 14 – View taken looking down on coping stones on Cope Bridge's north east parapet, showing the depth of the wall top extending into the bridge.

3.0 STATUTORY CONTEXT

Cope Bridge is not currently included in the National Inventory of Architectural Heritage (NIAH).

It is a proposed Protected Structure (Reference No. PPS 20) in the Draft Kildare County Development Plan 2023-2029. As such, it is afforded the same protections as a Protected Structure. A section of the Royal Canal is protected in the neighbouring Fingal County and is recorded in the current Development Plan.

A portion of Leixlip is designated an Architectural Conservation Area, but Cope Bridge is outside its boundary. This is also recorded in the Draft Kildare Development Plan 2023-2029.

Recorded Monuments nearby include Confey Church and graveyard approximately 0.5km north east.

4.0 HISTORY & DEVELOPMENT

Below is an extract taken from the conservation report provided by Rob Goodbody in the Appendix A21.4 to Chapter 21 – Architectural Heritage.

''Cope Bridge was constructed in 1794 to carry the local road between Leixlip and Confey. The bridge was named in honour of William Cope, who was a director of the Grand Canal Company in 1784-85 and of the Royal Canal Company from 1789 to 1802. He is thought to have been the instigator of the project to build the Royal Canal.

To the west of the bridge the canal bank curves to allow for a short length of broader canal to allow boats to pull in away from the main navigation channel. It is likely that this was provided as part of a project for cutting turf for transportation to markets along the canal. Cope Bridge was one of the locations where turf was saved for this purpose, part of an industry that grew up in various locations along the canal route.

With the coming of the Midland Great Western Railway a new bridge was required alongside Cope Bridge and was built in about 1846. In 1990 Leixlip Confey Station was opened on the western side of the railway bridge.''

Map Comparison
Cope Bridge as portrayed in available historic maps generally aligns with its construction date of c.1790 and its latter extension in c.1846 over the railway line. As noted in the extract above, the historic 6inch OS map (Figure 15) shows a wider bay in the canal just west of the bridge, presumably a set down area for canal traffic.

In this OS Map, the railway line has not yet been constructed. Two small structures are recorded where the current day Leixlip Confey Station sits.

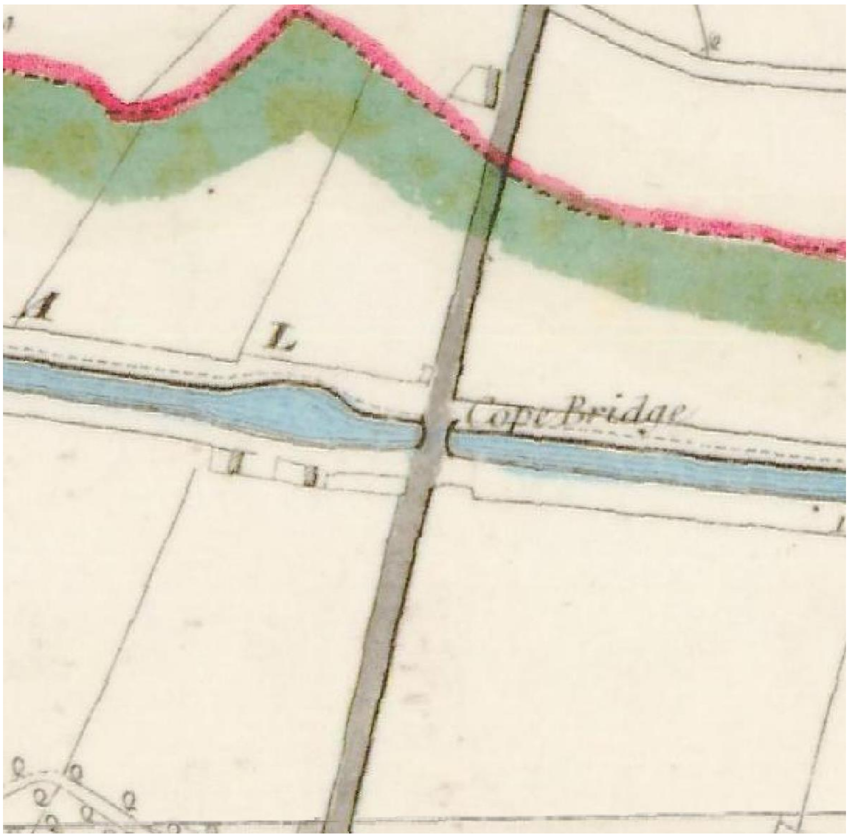


Figure 15 – Extract from 6inch OSI Map 1829 - 1841 showing the original Cope Bridge crossing the Royal Canal.

The 25inch OS Map (Figure 16) records the arrival of the railway line in Leixlip and also documents Cope Bridge in context in greater detail. The wider bay in the canal remains west of the bridge. The bridge is clearly extended over the railway line, and a slight change in direction is shown on the extended portion to navigate the differing road angels either side of the bridge. Dotted lines to the north west of the bridge indicate an informal route from the road down to the level of the canal. The towpath along the south of the canal is also visible. Pedestrian access to the canal was maintained from the northern banks after the railway line was added.

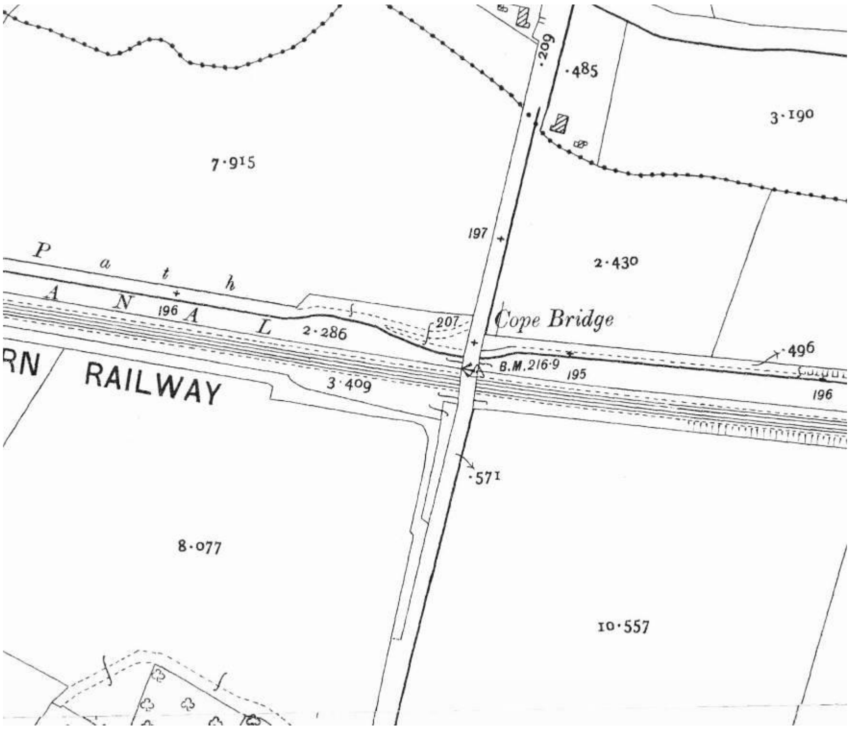


Figure 16 – Extract from 25inch OSI Map 1888-1913 showing the addition of the rail line and the extension to Cope Bridge.

Google satellite imagery from 2022 shows Cope Bridge as it is today with the train station to the west. The pedestrian access to the canal from the north is clearly visible.

Figure 17 – Screengrab taken from Google Satellite Imagery, 2022.

5.0 ASSESMENT OF SIGNIFICANCE

Statement of Significance

The categories of special interest which define a Protected Structure as per the Planning and Development Act 2000 (as amended) are Architectural, Historical, Archaeological, Artistic, Cultural, Scientific, Social or Technical. These categories are not mutually exclusive, and a structure may be attributed with several of the categories.

It is important to note that while the canal and railway bridges are individually a typology of their own, in this instance their compositions and significance must be read together due to their co-dependency and the fact that both are experienced as essentially one symbiotic bridge. This is due to the fact that the canal bridges in many cases were extended to span over the railway line which were constructed adjacent to the canal.

Cope Bridge is a proposed Protected Structure, but it is not recorded by the NIAH. Therefore, it has not been formally prescribed categories of special interest. However, the bridge carries significance for various reasons and we would categorise it as a structure of regional importance. We believe the following categories of special interest are applicable:

Historical
The bridge represents two significant periods in Ireland's transport and industrial heritage in the form of two distinct developments with the construction of The Royal Canal in the 1790s and The Great Western Railway in the 1840s. The fact that the railway line was added after the canal is also important as a layer of history of the overall composition of the bridge. In this, the twin form of Cope Bridge can be read as the embodiment of the period in the history of transport in Ireland, when the canals were superseded by the railways, but continued to function in parallel.

Architectural
Like other canal bridges of this typology, high quality stonework and simple decorative features in carved and dressed limestone contribute to the overall architectural expression of the bridge and testify to the skilled masonry craftsmanship employed in its construction. The bridge and the associated waterway infrastructure of the canal together are also a tribute to the level of technical expertise and engineering advancements, developed at that time.

Social
The bridges along the Royal Canal, including Cope Bridge, each carry social significance for a number of reasons. Bridges act as a connection point between areas previously separated and often provide a sense of identity and place for the people and communities around them. Both the canal and the railway line formed a manmade boundary where the bridges then provided essential connection points. This is especially true for pedestrian bridges as they are more directly experienced by people. Additionally, bridges often survive development around them over a long period of time, as standalone independent structures further reinforcing the sense of identity provided.

Today the bridges are important architecturally as standalone features, acting as nodes of identity along the canal which extends through many towns and communities into the midlands.
The canals and some railway lines around Ireland are now important places used for walking and cycling, especially in urban settings where outdoor recreational infrastructure is limited. The Royal Canal Way is one example on the Royal Canal. The canals are also popularised with barge boating culture and disused railway infrastructure has also been converted into greenways around Ireland.

Relatively few of the railway bridges remain unchanged today, further highlighting the bridge's importance as part of Ireland's industrial architectural heritage.

Taking the above into consideration and noting its status as a proposed Protected Structure, we recommend that Cope Bridge is entered into the NIAH.

6.0 OUTLINE CONDITION ASSESSMENT

Cope Bridge is generally in fair condition considering its proximity to the canal and road, but there are areas where repair works are required.

The stonework of the arches, buttresses and spandrels do not appear to have major structural issues. One of the voussoirs over the canal on the west side appears to have slipped slightly from its original position. No structural cracks were identified. The stonework on the face and the rising wall under the arches generally appears to be in good condition and has not suffered excessive weathering. There are small areas where sections of stone have broken away along weak seams but this is not widespread. The smaller stonework forming the arches is more weathered and there is evidence of consistent moisture penetration from the road deck above. There appears to be a number of phases of pointing on the bridge, some of which is likely to be an inappropriate cement mortar. This pointing has been washed out or fallen away in many areas, particularly beneath the arches and on the spandrels of the canal span.

Figure 18 – Condition of arch stonework.

Figure 19 – Pointing loss on spandrel.

There are three wing walls on the bridge and their condition varies. The wall to the north west is currently being repaired and the pier has been rebuilt at the end of the wall. There are no coping stones on this section of the wall and the core is exposed. The majority of the wall is covered in graffiti and there are small areas of vegetation growing from the joints. The stonework on the southwest wall appears to be sound and historic coping stones remain in place. These copings do not appear to be bedded properly and vegetation is growing over from the rear of the wall. The condition of the stonework on the north east is similar to the north west. There is significant graffiti and extensive vegetation growth at high level. The original copings have been lost and replaced with a concrete capping. The pier at the end of the wing wall appears to have lost some of its height, leaving loose stonework on top and the end of the concrete coping exposed. The walls have been repointed a number of times, some more successfully than others. This pointing is failing in localised areas.

Figure 20 – North West canal wing wall.

Figure 21 – North East wing wall.

Figure 22 – South East wing wall.

Figure 23 – Top of pier lost, exposing end of modern concrete copings on north west wing.

The parapet stonework appears to be sound but closer inspection reveals there may be some structural issues. The joints have been repointed in what appears to be a hard cement mortar. In a number of areas the mortar has broken away from one face which may suggest that there has been some movement in the stone. The north east corner of the parapet has recently been rebuilt but the quality of stonework and pointing is poor. It is difficult to get close to the external face of the parapets but from a distance they appear to be in fair condition. The coping stones appear to have been repositioned at some point. The copings on the west side do not extend as far as the internal face and the gap is filled with a mortar fillet. There are a number of areas of damage on the copings including hairline cracks and a large section of coping over the canal has been lost. Like the rest of the bridge the condition of the pointing varies but in some areas it is in a poor state.

Figure 24 – Mortar broken away from coping stone.

Figure 25 – Coping does not extend to internal face of wall.

Figure 26 – Recent repairs to north east corner.

Figure 27 – Lost section of coping stone over canal.

7.0 PROPOSED WORKS

As identified in the accompanying documentation, it is proposed to demolish the section of existing historic bridge over the railway line to allow for the electrification of the rail system. The existing bridge does not provide the clearance required to allow the Overhead Line Equipment (OHLE) to run under the bridge.

A number of approaches to provide the additional clearance required were considered. These included re-directing the tracks around the bridge, lowering the tracks and demolishing the railway side of the bridge to build a new bridge at a higher level. The evaluation process is detailed in EIAR Volume 4 Appendix A3.3 Option Selection for OHLE Intervention. On completion of this assessment the design team lead and client concluded that the demolition of the existing bridge and re-building at a higher level was the most suitable approach for the overall scheme.

The removal of this section of bridge over the tracks is an irreversible loss of important historic fabric and permanently alters the historic structure and surrounding setting. This section of the bridge has significant historic value, particularly as it was a carefully designed and built extension to the 1790's bridge over the canal. As such, it is very much an important layer of history. To mitigate the loss of the historic fabric as far as possible, the construction of the new bridge arch is being carefully considered. It is essential that the replacement section of bridge is well designed, detailed and executed. The most important consideration in the process is to ensure that the new build element sits comfortably alongside the remaining canal bridge. The stonework from the dismantled railway arch will also be salvaged and used for repairs where required.

Due to the significant raising of the bridge to accommodate the OHLE and the requirement to install a precast concrete arch, it is not possible or desirable to reconstruct the span to match the existing. Instead, a contemporary solution using modern materials is being designed to complement the proportions and style of the remaining canal bridge. The extent of demolition will be confined to the section of bridge between the stone piers to ensure that the reconstructed section will be read as an insertion rather than an entirely new bridge.

A number of finishes and construction methods were assessed during the design process. Initially the preferred option was to re-use the original facing stone but it became clear that this would not be successful due to the technical constraints of the new construction. The string course is an essential element of the existing composition but the increased height of the arch would distort its connection to the string over the canal. The precast arch construction would reduce the existing voussoirs to cladding stones and the facing stone of the spandrels would also become cladding stones tied back to the concrete structure behind. The combination of all these factors made it very difficult to design or build stonework that would sit well alongside the original fabric and there were concerns that it would very much read as modern stone cladding.

Figure 28 – Existing bridge with continuous string course over both arches highlighted.

The use of a weathered steel facade was also explored as this material would tie together the rebuilt bridge and new pedestrian bridges on each side. After careful assessment it was decided to proceed with a concrete structure as this has the potential to sit most comfortably with the remaining original stonework. It is proposed to use a board marked concrete finish on all faces and to select a concrete colour that best complements the original stonework.

Figure 29 - Example of a new board marked concrete insertion in an existing stone structure.

The colour and texture of the concrete finish, along with the quality of the detailing and workmanship is critical to its success. There are many examples of fine concrete work next to historic stonework across Europe, as identified in the image above. The design team is aware that Irish conditions are generally a lot damper than elsewhere, therefore the texture and finish of the concrete will be designed to minimise algae and vegetation growth. The texture created by the board will be controlled to ensure there are no large shelves for vegetation to take root and the surface finish will be carefully specified to limit the number of bugholes present on the finished concrete. It is proposed to use hand sawn boards to provide a finish that is not too uniform. Research into materials and sample panels will be essential prior to construction to ensure the new concrete finish complements the remaining historic stonework.

The form of the new arch and its relationship to the remaining canal arch is of critical importance. The design team have decided not to replicate the original arch exactly as the geometry of that shape would require the bridge to be raised even more than the current proposal. A slightly flatter arch provides the clearance required for both lines with less elevation.

The junctions between old and new will need to be carefully considered during detail design. The presence of the piers on either side of the arch allows the new build to be contained neatly at a natural break. These junctions will still need to be skilfully detailed and executed to ensure the concrete and stonework sit comfortably together. There will be a considerable amount of stone repair and repointing on the piers following the removal of concrete shuttering. These repairs will need to be carried out with great care by a skilled stonemason.

Figure 30 - Existing bridge with piers highlighted. Existing bridge to be removed between piers.

The new concrete parapets will extend up to the height of the original with the additional height provided by the contemporary design discussed below. The original parapet thickness will be carefully designed to ensure the new parapet sits in as neatly as possible with the original. The piers extend up through the parapet externally providing a natural break but there is no detail on the internal face. This creates a challenge that will need to be overcome with careful detailing and skilled craftspeople.

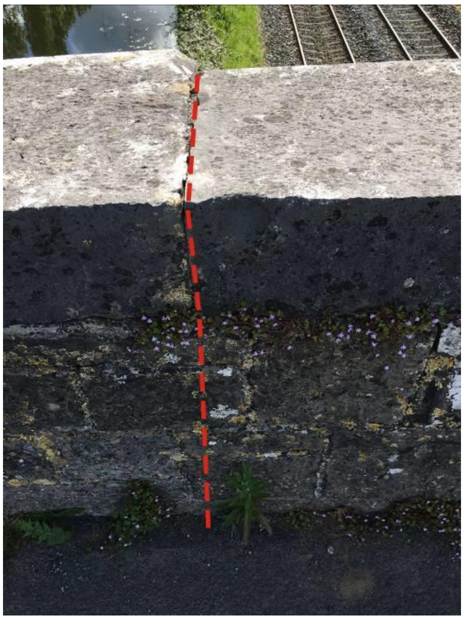


Figure 31 - Image of parapet internally with line highlighting where the junction with the new concrete parapet will be.

It is a safety requirement that the parapets are a minimum of 1800mm high, with the bottom 1200mm solid, in the area of the OHLE. This presents a significant challenge for Cope Bridge and all of the historic bridges along the line, as the existing original parapet heights are lower than 1200mm. A rigorous design process has taken place to identify a solution that will complement the historic setting and maintain a visual connection to the rail lines and surrounding landscape, when on the bridge. It is also essential that the parapet is not the dominant feature while viewing the bridge from the canal. The proposed design is a contemporary, adaptable solution that can be implemented throughout, bringing a degree of uniformity to all interventions along the railway. An alternative option with the extended parapet structure fixed on top of the coping was also assessed. Due to wind loads and the uncertain structural integrity of the parapets a considerable amount of damage to the original fabric would be required to anchor the new structure through the existing parapet to new concrete pads below.

For Cope Bridge it is proposed to provide a solid metal panel from the top of the parapet up to 1200mm with an expanded metal mesh to continue up to 1800mm. The vertical supports and mesh will be carefully designed to ensure the internal face of the parapet is not obscured and that the mesh allows a good visual connection to the surroundings.

Figure 32 – Render of design proposal to increase the parapet height to 1800mm with mesh about 1200mm.

Repair works will be required to the existing parapet before the proposed heightening works can take place. It is anticipated that some re-bedding of stonework will be required when the existing footpath is removed. There may also be considerable work required to the top of the parapets to ensure the stability of the facing stone and copings. This stone must be carefully dismantled, cleaned down and re-bedded in a suitable lime mortar. All joints will need to be examined and raked out where the existing mortar is lost or failing. Joints will need to be repointed in a suitable lime mortar and protected until satisfactorily carbonated. These works must be carried out by a skilled mason with extensive experience with historic stonework.

Figure 33 – Stonework and pointing on parapet to be repaired.

Cope Bridge is currently a single lane bridge with a footpath on the east side. During discussions with Kildare County Council it was agreed to provide extra carriage width to allow two lanes of traffic, along with a footpath and cycleway. A number of options were examined including demolition of the parapets to allow for the widening of the existing bridge deck, a new parallel road bridge with the existing bridge used for pedestrians and cyclists, and a new pedestrian bridge with the existing bridge retained for road traffic. It was established that there was just enough room to have two lanes of traffic on the existing bridge so it was agreed to retain this bridge for road traffic and provide a new route for the pedestrians and cyclists. It is a requirement of Kildare County Council that pedestrian and cycle routes are provided on both sides of the road. This means that a new bridge is required on both sides.

The proposed bridges are separated from the historic bridge on both sides by 2 metres. This separation is limited by the proximity of the pedestrian bridge in the station that Irish Rail do not want to relocate. Alternative routes for the bridges were assessed but it was determined that it is most beneficial to the community to keep the bridges parallel to the road bridge and remove the temptation to walk or cycle on the narrow roadway.

Figure 34 – Proposed east elevation showing new pedestrian bridge and new concrete face over railway behind.

The new bridges have been designed in a contemporary style using modern materials. This contrasts with the original stone bridge but the aim is for the new bridges to sit comfortably in the historic setting. It is essential that the footbridges are as elegant and light as possible, so the bridge deck is designed to be as shallow as possible to facilitate this. The height requirement for parapets remains at 1800mm over the OHLE but it is proposed to reduce this height along the rest of the bridge to lessen the overall impact of the parapets. The parapet style will be in keeping with the new parapets on the historic bridge with regular vertical elements supporting the parapet screen. These vertical elements will be closer together on the new bridges to reduce the requirement for mesh parapets away from the OHLE.

It is proposed to use a weathered steel for the two new bridges. This will contrast with the concrete and stone of the road bridge but it should be a complementary material if it is detailed and constructed skilfully. The final design of the abutments will be critical to the overall success of the project. The abutments need to be as unobtrusive as possible and screened to reduce their impact on the canal and historic bridge.

The connections to the canal will be altered by the installation of the new pedestrian bridges and provision of a cycleway under the road. The route down to the canal will be extended on both sides of the bridge but the gradients will be much more accessible than the existing.

Figure 35 – Overview render of Cope Bridge with new pedestrian and cycle bridges on each side.

8.0 ARCHITECTURAL HERITAGE IMPACT ASSESSMENT

Proposed Alteration	Negative Impact	Neutral Impact	Positive Impact	Mitigating Measures
Demolition of the section of original bridge over the railway line.	Loss of important historic fabric. Partial loss of one of the few remaining original canal and railway bridges in the area. Alters the historic setting.		Allows for the train system to be electrified.	The demolition will be contained between the stone piers on each side to minimise the loss of historic fabric. A carefully designed replacement section of bridge will be constructed to sit in harmony with the original fabric on each side. The stonework will be carefully dismantled and used for repairs on the historic bridges where necessary.
Removal of original parapets from the section of bridge being removed.	Loss of important historic fabric. Removes the only visible connection to the historic bridge when crossing over.		Allows for the train system to be electrified.	The replacement parapets will be reinstated to the original level. The additional required height will be provided with a modern parapet detail. The parapets will be carefully designed to ensure they connect neatly to the remaining historic parapets on each side.
Construction of the new bridge section over the railway line.	The use of a precast concrete will create a construction joint under the bridge between the arch and board marked concrete face. The concrete arch will read differently to the shuttered concrete on completion.		Concrete colour and texture will be designed to be compatible with the surrounding historic stonework. The junctions between the concrete and original stone will be carefully detailed to ensure the two phases of construction sit comfortably together.	The cast in-situ concrete will be carefully designed to ensure the precast arch is not visible while viewing the original structure in elevation. The surface finish of the concrete will be carefully considered to limit the vegetation growth as much as possible.

Proposed Alteration	Negative Impact	Neutral Impact	Positive Impact	Mitigating Measures
Increase of parapet height.	Obscures the original design intent of the existing parapets to some degree on the internal faces. Visual connection to the top of the coping stones will be lost on internal faces. The connection to the surrounding setting is compromised by increasing the parapet height to 1800mm.		Allows for the train system to be electrified. This approach allows the original parapets to be retained on each side of the rebuilt section.	The new parapet will be carefully designed to minimise the impact on the remaining historic parapets. Fixings into the historic parapets will be minimised and will be installed in joints where required. The majority of the structural load will be transferred to the deck, decreasing the impact on the parapets. The metal mesh will be carefully selected to ensure the visual connection to the surrounding landscape is maintained as much as possible. The parapet supports will be designed to be as slender and elegant as possible to reduce the visual impact on the parapets.
Construction of new pedestrian and cycleway bridges on each side of the original bridge.	Alters the original setting of the historic bridges. The two metre gap between the new and existing bridges is not optimal and it would have benefited from a wider separation. Providing a bridge on both sides prevents the original bridge from being properly viewed from either side. The buttresses may become a dominant feature depending on their final design.		The construction of the pedestrian and cycleway routes allows the original canal bridge to continue to be used as a road bridge. The approach chosen to provide the additional carriage width ensures the original canal bridge remains relatively unaltered.	The new bridges will be designed to appear as light as possible to reduce the visual impact on the original bridge. The proposed design of the new bridges allows the depth of the deck to be kept to a minimum. The detailing of the weathered steel parapets will be carefully considered to ensure an elegant finish on completion. The buttresses will be screened with planting where possible to reduce their impact on the setting.

Proposed Alteration	Negative Impact	Neutral Impact	Positive Impact	Mitigating Measures
Connections to canal walkways and proposed cycle path.	The length of the route from the road down to the canal has been extended.		The gradients on the route to the canal will be improved, making it more accessible for people with impaired mobility, buggies etc.	

9.0 CONCLUSION

The demolition and replacement of the span of Cope Bridge over the railway line is a very significant loss of important historic fabric. This will have a considerable and irreversible impact on the character of the setting, the surrounding environment and the remaining canal bridge, dating from 1794. From a conservation perspective it would be preferable to incorporate the welcomed new infrastructure into the existing setting, while retaining this important historic structure. As identified in Appendix A3.3 Option Selection for OHLE Intervention in Volume 4 of the EIAR, the bridge can be retained, but due to significant financial and programme reasons, removal and replacement has been chosen as the preferred option.

By raising the railway arch, the connection between this and the canal arch is fundamentally altered, so constructing a stone facade on the new bridge section is not considered appropriate. After carefully assessing the alternatives, it was concluded that a contemporary concrete structure would sit most comfortably with the remaining historic stonework. Considerable effort will be required during detail design and construction to ensure the colour and texture of the concrete complement the existing stonework. Careful detailing and execution at the junctions will also be fundamental but these are all achievable and should lead to a successful outcome. Containing the re-build between the piers on each side is positive and will allow the new section of bridge to be read as an insertion into the original rather than a new bridge.

The proposed parapet heightening design provides a flexible solution that can be adapted to each historic bridge along the length of the Dart+ West project. Raising the parapet is a fundamental safety requirement when installing OHLE, so the proposal needs to incorporate these essential requirements. The use of an expanded metal mesh above 1200mm ensures that a visual connection to the surroundings is maintained while on the bridge. The positioning of the new parapet on the internal face also ensures that it reads as a secondary element when viewing the external faces of the bridge. Unfortunately, the raised parapet will obscure the top of the existing coping stones internally, but it is an essential safety requirement to remove any ledges that could be used to climb up on the parapet.

It is unfortunate that site constraints dictate that there is only a two metre separation between the new bridges and the existing, as a greater separation would have lessened the impact on the original structure. From a conservation perspective it would also have been preferable to have a single new cycle and pedestrian bridge so that the original form of the historic bridge could have been read from one side in its entirety.

The new parallel bridges do provide considerable benefits to the original bridge, primarily allowing it to be retained as a road bridge and reverting back to a two lane carriageway without the loss of original features. A heavy road bridge next to this historic structure would have had a detrimental effect on the setting. The materiality, proportions and form complement the original bridge while maintaining as much visual connection as possible considering the existing constraints. The ultimate success of these structures will be determined by the quality of design, detailing and materials specified along with precise fabrication and installation. The well-considered proposal and existing design team should ensure that the bridges are well designed and executed.

It is clear from a conservation perspective that the demolition of the section of bridge over the railway is a major loss to the overall structure and surrounding setting. However, the proposal to reconstruct the arch with a carefully designed and detailed concrete finish should sit comfortably with the remaining canal bridge and reflect a high quality contemporary design. The required conservation and repair works to the existing fabric should also be incorporated into any future works on the bridge. The electrification of the rail network is to be welcomed and the additional carriage width provided by the new bridges and provision for a cycle route along the canal ensures that this upgraded infrastructure will benefit the local community.