Appendix J.1
Preliminary Design Report
ST01 - Greenhills Road Pedestrian and Cycle Bridges

CBC009-ST01 Greenhills Road Pedestrian and Cycle Bridges
Preliminary Design Report

Tallaght to City Centre Core Bus Corridor
BCIDA-ACM-STR_ZZ-0009_XX_00-RP-CB-0008

Client – National Transport Authority
Stage – Stage 2

Project Reference: BusConnects Package A
Project Number: 60599123
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Structures Options Report

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Table of Contents

Figures

Tables

1. Introduction

1.1 Brief

The BusConnects Dublin – Core Bus Corridor (CBC) Infrastructure Works (herein after called the CBC Infrastructure Works) involves the development of continuous bus priority infrastructure and improved pedestrian and cycling facilities on sixteen radial core corridors in the Greater Dublin Area.

The National Transport Authority (NTA) have appointed AECOM in association with Mott MacDonald to undertake the design of the infrastructure works for Package A of the BusConnects Programme. Package A includes the following four bus routes:

- Clongriffin to City Centre CBC
- Lucan to City Centre CBC
- Clondalkin to Drimnagh CBC
- Tallaght to City Centre CBC

Each route contains several bridge structures with various structural forms. As part of the scope AECOM have agreed to take all structures which affect the Transport Infrastructure Ireland (TII) Road Network through the *Technical Acceptance of Road Structures on Motorways and Other National Roads* procedure as outlined in DN-STR-03001.

This Preliminary Design Report (PDR) will focus on the Greenhills Road Pedestrian and Cycle Bridges (previously known as Greenhills Road Bridge No.2) crossing the M50, located within the TII road network and the Tallaght to City Centre CBC. The bridges will be located parallel to the existing Greenhills Road Bridge providing additional capacity along the R819 Greenhills Road. The PDR is a deliverable at Phase 4 of the Technical Acceptance process.

1.2 Background information covering origins for the need for the structure

BusConnects plans to transform Dublin's bus and cycle network, with an aim of increasing the attractiveness of public transport and cycling encouraging a modal shift from private car. The scheme consists of 16 radial Core Bus Corridor's (CBC), which will be supplemented at a later stage with a network of orbital corridors. Overall the scheme will provide 230kms of continuous bus priority lanes and 200kms of cycle tracks/lanes throughout Dublin. The Tallaght to City Centre CBC has been identified as one of the 16 routes proposed along the Core Bus Network.

The route commences in Tallaght at the Square Shopping Centre, proceeds through Tallaght Village and along the R819 Greenhills Road. The route proceeds through Greenhills, Walkinstown, Crumlin, Drimnagh and the Liberties to its terminus point in the city centre near Christchurch Cathedral.

The CBC crosses the M50 on the existing Greenhills Road Bridge (TII ref. SD-M50-013.00). The existing bridge is 14m wide and provides a designated traffic lane, cycle lane and footpath in each direction. However, this cross section fails to provide the project requirements for a 2m wide pedestrian footpath, 2m wide cycle lane, 3m wide bus lane and 3m wide traffic lane in each direction. As a result, additional cross-sectional width is required.

Two new single span pedestrian/cycle bridges have been proposed to be located adjacent to the existing Greenhills Bridge.

1.3 Previous studies and their recommendations

The following table is a list of documents as part of previous studies for the development of the proposed bridge:

Table 1.1 Previous Studies

Date	Document Reference	Report Title	Author
February 2021	BCIDA-ACM-STR_ZZ-0009_BR_00-TN-CB-0002	Greenhills Road Bridge No.2 Technical Note	AECOM
March 2021	BCIDA-ACM-STR_ZZ-0009_XX_00-RP-CB-0006	Greenhills Bridge Stage 1 Structural Assessment	AECOM
November 2020	BCIDA-ACM-STR_ZZ-0009_XX_00-RP-CB-0007	CBC009-ST01 Greenhills Road Bridge-Structures Options Report	AECOM
2020-2021	BCIDA-ACM-PMG_ZZ-0809_XX-RP-ZZ-0001	Clondalkin to Drimnagh and Tallaght (Greenhills) to City Centre Preliminary Design Report	AECOM

2. Site & Function

2.1 Site Location

The proposed bridges are situated along Greenhills Road parallel to the existing Greenhills Road Bridge (TII ref. SD-M50-013.00). The existing Greenhills Road Bridge spans the M50 carriageway between Junction 10 and 11. The co-ordinates of the bridge are 709981.615 Easting, 729536.932 Northing (ITM).

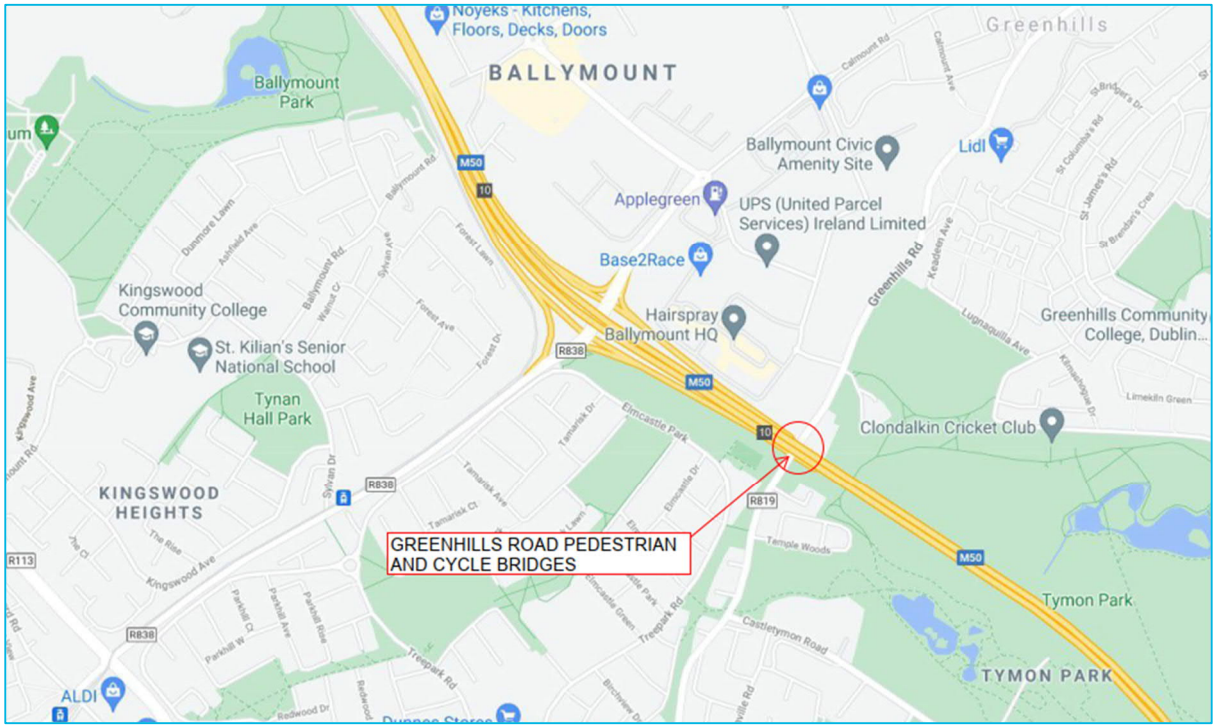

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Figure 2-1 Location Map of Bridges

2.2 Function of the structure and obstacles crossed

The bridges will carry all pedestrian and cycling facilities of the R819 Greenhills Road over the M50. At this location the bridges will span nine traffic lanes consisting of five northbound lanes (three traffic lanes and two diverge lanes) and four southbound lanes (three traffic lanes and one merge lane). The M50 is designated with a 100Km/h speed limit with an ADDT of 122570 for 2019 between Junction 10 and 11.

2.3 Choice of location

The bridges will be located to the northern and southern side of the existing Greenhills Road Bridge. The location has been determined based on the proposed alignment of the R819 Greenhills Road and positioning of the existing bridge.

2.4 Site description and topography

The area surrounding the bridge is a busy urban area which includes existing structures, motorway infrastructure, commercial & industrial buildings, a community centre and private properties. Amenities such as Tymon Park and the Kilnamanagh Recreational Centre are located to the south east and north west of the bridge location respectively. Additionally, the proposed bridges will span nine lanes of the M50 carriageway.

2.5 Vertical and horizontal alignment

A minimum vertical clearance of 5.7m shall be provided to the M50 carriageways based on the requirements of DN-GEO-03036 Cross Sections and Headroom. The vertical alignment over the bridges are a crest curve with a

radius of 2243.105m over a length of 92.136m. This results in the road rising gradually on approach to the bridge and falling on departure. The horizontal alignments are straight across the bridges with slight curvature on approach and departure. The horizontal alignment has been designed to ensure a bridge skew of 0º to the perpendicular.

2.6 Cross sectional dimensions on the alignment

The proposed cross-section of the bridge is provided below:

Table 2.1 Greenhills Proposed Bridges Cross-Section

Section	Width (m)
Truss Structure	0.35
Cycle lane	2.65
Footpath	2.00
Truss Structure	0.35
Total	**5.35**

The M50 cross section at the bridge location is as follows:

Table 2.2 M50 Cross-Section

Section	Width (m)
Verge	2.207
Hard shoulder	1.00
Northbound Carriageways	17.85
Hard shoulder	1.00
Central Reserve	2.50
Hard shoulder	1.00
Southbound Carriageways	13.9
Hard shoulder	3.33
Verge	3.735
Total	**46.522**

2.7 Existing underground and overground services

There are a number of existing underground services along the verges of the M50 carriageways and along Greenhills Road at the bridge tie-in points. The following table summarises the service providers, utilities and locations.

Table 2.3 Existing Services

Service Provider	No. Services	Location
EIR	1 No. Eircom Duct	East verge over Greenhills Road Bridge
	2 No. Eircom Duct	M50 Northbound Carriageway
	1 No. Eircom Duct	M50 Southbound Carriageway
Virgin Media	2 No. Virgin Media Duct	East verge over Greenhills Road Bridge
	1 No. Virgin Media Duct	M50 Northbound Carriageway
SSE Ireland (Street lighting)	1 No. Duct	West verge over Greenhills Road
SDCC	Carriageway Drainage 150mm Ø Clay Pipe	North approach embankment
		South approach embankment
Fibre Optics	1 No. Duct	East verge over Greenhills Road
	1 No. Duct	M50 Northbound Carriageway

Overground services in the area consist of lighting columns lining the verges of the M50 carriageways and the existing Greenhills Road Bridge.

2.8 Geotechnical summary

2.1.1 Ground Investigation

Four boreholes (R9-CPGS01-R9-CPGS04) were carried out as part of the ground investigation to inform the planning design. The locations are shown in the figure below.

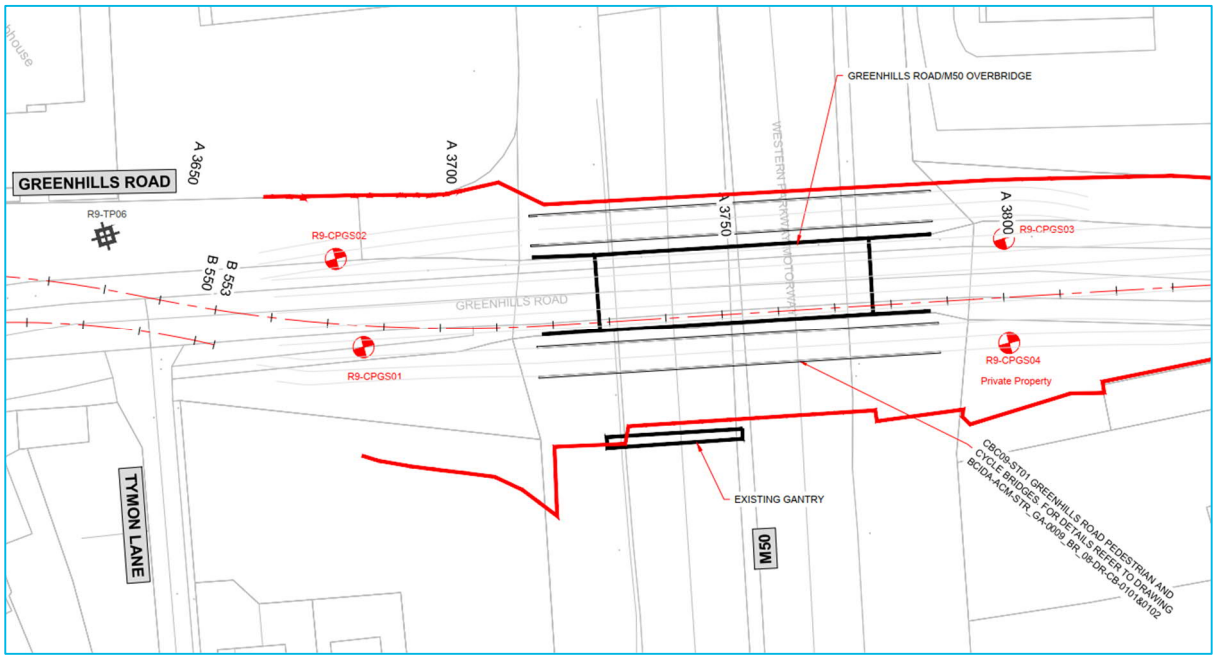

Figure 2.2 Borehole Locations

Site operations, which were conducted between 13th and 22nd October 2020, comprised:

- Four boreholes (R9-CPGS01-R9-CPGS04) put down by a combination of light cable percussion boring, using a Dando 2000 rig, and rotary follow-on drilling techniques with core recovery in bedrock using a truck mounted Berretta T44 rotary drilling rig.
- A groundwater monitoring standpipe was installed in R9-CPGS01 and R9-CPGS04.

2.1.2 Ground Summary

The ground conditions at the bridges are complex as shown in the excerpt of the drift geological map presented in the figure below.

Figure 2.3 Ground Conditions

Typically, based on the results of the overall investigation, fine-grained glacial till (boulder Clay) is prevalent to the south of the M50 with gravels derived from Limestone to the north.

A review of historical drawings indicated ten boreholes were carried out as part of the investigation for the existing Greenhills Road Bridge. The ground conditions generally comprise predominantly granular material described as medium dense silty sand to silty sandy gravel with cobbles; overlying stiff silty stoney clay; overlying limestone. The limestone was typically described as “broken”.

The following lists the sequence of ground conditions expected to be present at the site in approximate stratigraphic order.

- General Embankment Fill comprising of reworked Glacial Till
- Glacial Till consisting of sandy gravelly silt/clay with low to medium cobble content interlayered with silty Sand and Gravel deposits; overlying
- Limestone Bedrock (2 m thick zone of Mudstone encountered in R9-CPGS04)

An interpreted geotechnical longitudinal section is shown, and a summary of the available ground investigation data is recorded, in the figure and table below, respectively.

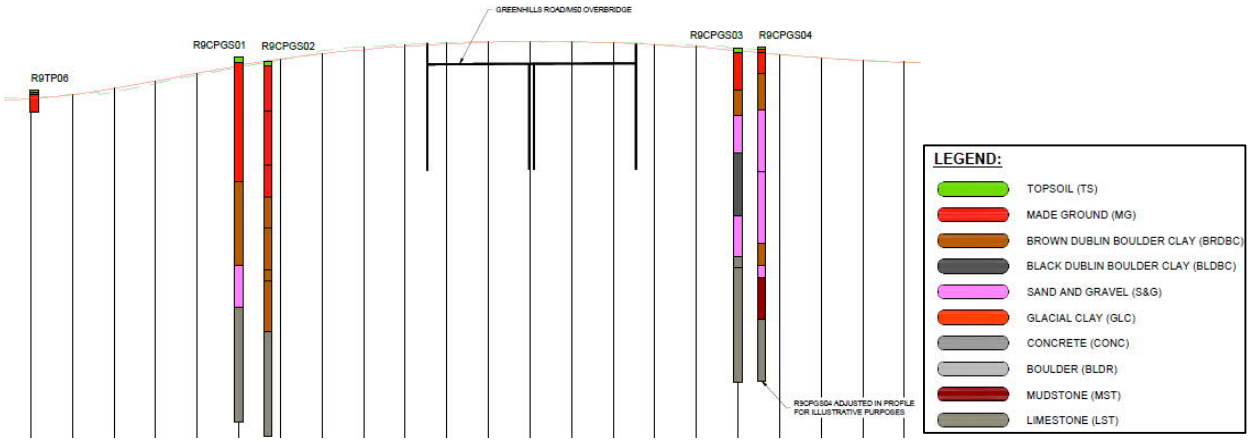

Figure 2.4 Geotechnical Longitudinal section

Table 2.4 Ground Summary

Stratum	Typical Stratum Description	Depth at Top of Stratum (mbgl)	Level at Top of Stratum (m AOD)	Thickness Range (m)	Occurrence
Topsoil		0	72.38 to 73.07	0.1 to 0.3	All boreholes
General Embankment fill	Typically, firm, firm becoming stiff sandy gravelly CLAY	0.1 to 0.3	72.18 to 72.97	5.7 to 6.3 (southside) 1.3 to 1.8 (northside	All boreholes
Sand and Gravel deposits	Typically, sand and gravel deposits with variable fines component. Interlayered with Fine grained glacial till deposits	3 to 10*	62.60 to 70.07*	1.8 to 6.4	R9-CPGS01, R9-CPGS03 and R9-CPGS04
Glacial Till -	Sandy gravelly CLAY of varying stiffness from firm to stiff to very stiff. Interlayered with granular deposits	2 to 6.5*	65.88 to 71.77*	1.2 to 6.5	All boreholes
Mudstone	Medium strong thinly laminated black MUDSTONE	11.05	62.02	2	R9-CPGS04
Limestone	Typically, medium strong thinly laminated black argillaceous LIMESTONE	10.5 to 13.05	59.43 to 62.49	2.95 to 5.5**	All boreholes

*first instance encountered
**base not proven
mbgl = metres below ground level

2.1.3 Groundwater Summary

The results of groundwater monitoring are as follows:

Table 2.5 Results of Groundwater Monitoring

Testhole	Standpipe Depth	Slotted Screen Range (mbgl)	Response Zone	Water Level (mbgl) 19-11-2020	Water Level (mbgl) 19-01-2021	Water Level (mbgl) 12-12-2021	Water Level (mbgl) 12-03-2021
R9-CPGS01	12	6 - 12	6 – 10 m bgl: Glacial Till deposits 10- 12 m bgl: Granular deposits	8	7.79	7.61	7.84
R9-CPGS04	11.04	6 - 11.05	6- 9.4 and 10.5 - 11 m bgl: Granular deposits 9.4 – 10.5 m bgl : Glacial Till deposits	8.92	8.77	8.7	8.64

mbgl = metres below ground level

2.9 Hydrology and hydraulic summary

A review of the OPW flood mapping (www.floodinfo.ie) shows that there are no historical flood events in the vicinity surrounding the bridges locations. The nearest recorded flood event was recorded within Templeogue approximately 1km to the east in November 1982 when 55.1mm of precipitation was recorded at Dublin Airport.

A second flood event was reported along the river Poddle in October 2011 approximately 1.5km to the east. The flood report stated the river Poddle overtopping its banks with water coming up through private drains along the front of eight properties.

Flood mapping in the area should be revisited at the detailed design stage to identify any updates to the flood record.

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Figure 2-5 Exert from OPW flood maps

2.10 Archaeological summary

No sites of major archaeological importance were identified at the proposed bridges locations during the EIA stage of the project.

2.11 Environmental summary

The EIAR prepared as part of the preliminary design did not identify any particular major environmental impacts associated with the construction of the bridges. The main findings of the EIAR relating to the bridge are as follows:

- Removal of existing plantings on approaches to bridge, including section of boundary with trees at Tymon Park and part of dense planting at boundary with Fashion City (Ch. A3650 to Ch. A3950);
- Loss of areas of immature woodland and mixed broadleaved woodland located along Greenhills Road, either side of the M50 motorway.
- Potential for construction activities to result in adverse noise impacts at properties in the surrounding area (awaiting further detail as noise impact assessment is still to be completed).
- No protected structures in the area of the proposed bridge construction – the closest are in the Parkview / Elmcastle Walk area – the proposed bridge is outside of the zone of inclusion for these protected structures.

3. Structure and Aesthetics

3.1 General description of recommended structure or family of structures and design working life

Greenhills road bridge will be formed of two new pedestrian/cycle bridges located adjacent to the existing Greenhills Bridge spanning the M50. The new bridges will provide dedicated facilities for pedestrians and cyclists travelling in both directions along Greenhills Road. Traffic and bus lanes will be accommodated on the existing Greenhills Road Bridge. The new bridges will span 48.55m over the M50 carriageway. The width of the new pedestrian/cycle bridges will be 4.65m wide providing a 2.65m segregated cycle track and 2m pedestrian footpath. A minimum internal vertical clearance of 2.7m will be provided along the length of the bridges.

The structures will span the M50 with no skew and have a constant longitudinal gradient falling from the western to the eastern support. The warren truss will be designed with a full through construction where the structure is built up around the deck. This is a light and economical form of construction and works well with longer spans. The warren truss also reduces the structural depth of the bridge, allowing the 5.7m clearance envelope to the carriageway to be achieved. The bridges will be designed with circular steel structural hollow sections as the main top and bottom chords and as the secondary members. The top chord will act in compression and the bottom chord is in tension under downward loading and the two chords are braced by the diagonal members. The diagonal members create a series of triangles which are inherently rigid shapes thus reducing the sag that occurs in comparison to a simply supported beam. In theory a truss design uses pinned joints between members to eliminate any restraint to free rotation and thus preventing the creation of any internal bending moments. Resulting in the components of the truss are only imparted with axial forces, compression and tension. In axial loading the force is carried equally by each part of the member, enabling the designer to maximise the efficiency of the truss members and create a lightweight structure. A steel plate deck will be provided along the length of the bottom cord. The steel deck will be finished with an anti-skid surfacing. Both new bridges will be supported on two reinforced concrete full height abutments constructed in-situ within the embankments on either side of the M50 carriageway. The south abutment will be set back 2.60m from the edge of the M50 northbound carriageway with the face of the north abutment set back 4.20m from the edge of the south bound carriageway. A safety barrier will be incorporated between the face of abutments and the edge of both the north and south bound carriageway. This is to remove the potential of impact loading on abutments. No central supports will be required within the M50 central median for either bridge. It is envisaged that due to the structural form and material, the use of bridge bearings and expansion joints will be required for both new pedestrian/cycle bridges. The choice of a through truss offers the advantage of providing a built-in, fully contained pedestrian parapet railing supported via the vertical bracing members.

In addition to construction of the new pedestrian/cycle bridge the carriageway layout on the existing Greenhills Road bridge will also be altered with all pedestrians and cyclists diverted away from the existing bridge to the new bridges. The current arrangement across the existing bridge is as follows: 2m footpath, 4.5m carriageway with shared cycle facilities in each direction and 2m footpath. The altered carriageway layout will see the removal of existing footpaths and shared areas. The revised bridge cross section will be as follows: 0.6m raised verge, 3m bus lane, 2.9m traffic lane, 2.9m traffic lane, 3m bus lane and 0.6m raised verge. A Stage 1 Structural Assessment has been carried out in accordance with AM-STR-06056. The assessment has confirmed that the new proposed carriageway layout passes for 30 units of HA and HB loading and provides a similar load rating to that of the existing carriageway layout.

The design working life of the bridges will be a minimum of 120 years as defined in the TII publication, DN-STR-03012 - Design for Durability. Maintainable elements and components listed below are subject to greater wear and will require replacement within the design life. Careful design and detailing combined with thorough routine inspections, quality control and supervision on site will help achieve the minimum expected design life listed in the below table:

Table 3.1 Minimum Design Life for Structural Elements

Component	Years
Parapets	50
Drainage Systems	50
Deck Waterproofing	50
Bearing and Expansion Joints	50

3.2 Aesthetic Considerations

The bridge design has been developed to take account of the basic principles of aesthetics which respects the surrounding landscape, minimises the environmental intrusion and protects existing vegetation where possible. Pattern profile finishes will not be specified with plain concrete surfaces used to match the existing bridge. The concrete finishes shall be specified in accordance with TII Publication CC-SPW-01700 and selected to ensure they complement that of the existing abutments will be provided. The bridge aesthetics will be considered in depth during detailed design with the CIRIA C543 Bridge Detailing Guide used to determine a number of aesthetic requirements thus ensuring consistency across the bridge.

3.3 Proposals for the recommended

3.1.1 Proposed Category

The bridges will be a Category 2 structure as the main span is greater than 10m and less than 50m in accordance with TII publication DN-STR-03001 Technical Acceptance of Road Structures on Motorways and Other National Roads.

3.1.2 Span Arrangements

The new bridges will span 48.55m over the entire M50 carriageway.

3.1.3 Minimum Headroom Provided

A minimum vertical clearance of 5.7m will be provided to the M50 carriageways below the bridges in accordance with TII publication DN-GEO-03036, Cross-Sections and Headroom.

3.1.4 Approaches including run-on arrangements

The approaches to the bridge abutments will be formed of compacted acceptable 6N/6P backfill material. The backfill layer will be designed, detailed, specified and constructed with plant and compaction methods appropriate to the requirements in accordance with CC-SPW-00600 for fill to structures.

Run-on slabs will not be included within the design.

3.1.1 Foundation Types

Reinforced concrete end-bearing piled foundations will be provided to the bridge abutments. The length of the piles will be confirmed during the detailed design stage and are dependent on the depth to bedrock at the north and south support locations.

3.1.2 Substructure

The end supports will be formed using two full height reinforced concrete abutments located within the north and south embankments of the M50 respectively. The south abutments will be set back a distance of 2.60m from the edge of the M50 northbound carriageway with the face of the north abutments set back a distance of 4.20m from the edge of the south bound carriageway.

3.1.3 Superstructure

The full-through truss arrangement has the advantage of reducing the construction depth and ease at which the clearance envelope over the M50. Circular steel hollow sections will be used for all elements including the main top and bottom longitudinal chord members. Diagonal bracing will be provided between the top and bottom chords to stiffen the superstructure against deflection. Horizontal bracing will be provided between the two top chords and bottom chords adding lateral stability to the structure. A steel mesh will be attached to the vertical and horizontal bracing creating a fully enclosed structure.

The main span warren truss will be fully enclosed with a minimum internal headroom of 2.7m above the finished surface level in accordance with TII publication DN-GEO-03036, Cross Sections and Headroom. This will be provided along the entire length of the new bridges. The overall structural depth of the new bridges will be 3.3m from upper face of top longitudinal cord to bottom of the bottom cord.

3.1.4 Articulation Arrangements, joints and bearings

It is envisaged that due to the structural form and material, the use of bridge bearings and expansion joints will be required in the bridge design. Bearings will be provided at each of the support locations to accommodate the required movements within the bridges with expansion joints provided at the top of deck level. The type of bearing and joints to be utilised will be determined at detailed design stage.

3.1.5 Vehicle Restraint System

The choice of a through truss offers the advantage of providing a built-in, fully contained pedestrian parapet railing supported via the vertical bracing members. The fully contained parapet system also reduces the potential for anti-social behaviour on the bridge.

The bridge abutments will be located within the clear zone for the M50 Northbound and Southbound carriageways. A N2/W2 safety barrier will be provided at the bridge supports to prevent accidental impact. The safety barrier will extend a minimum of 30m on approach and departure from the supports in accordance with TII publication DN-REQ-03034, The Design of Road Restraint Systems (Vehicle and Pedestrian) for Roads and Bridges.

3.1.6 Drainage

The bridges have been designed to ensure surface water drains directly to the main road drainage on approach to the bridges, avoiding the need for longitudinal drainage systems along the bridge decks. The alignment incorporates a longitudinal fall of approximately 1.64% over the bridge decks and a standard cross-fall of 2.5% either side of the centre line of the bridge decks. In addition, this limits the risk of standing water and ice on the bridge deck.

A permeable drainage layer will be provided to the back of the abutments, in accordance with the requirements of CC-SPW-00500 – Drainage and Service Ducts. At detailed design stage consideration shall be given to build up of hydrostatic water pressure in the event of failure of the back of wall drainage. Suitable rodding points shall be provided to allow maintenance of the drainage system

3.1.7 Durability

The bridges will be designed in accordance with the TII publication DN-STR-03012 - Design for Durability with a minimum design life of 120 years. The design life for replaceable parts such as waterproofing systems and surfacing will be 50 years in accordance with DN-STR-03012. The design working life of the bridges will be working life category 5 while replaceable parts will be working life category 2 in accordance with GE-POL-01008.

All exposed structural steelwork will have a protective paint system applied such that no maintenance shall be required up to 12 years and no major maintenance before 20 years. The steelwork will be designed and detailed to discourage the accumulation of water, dirt and debris and minimise the risk of rusting or deterioration. Intermittent welds will be avoided, with simple connections utilised as the preferred.

All buried concrete surfaces will be treated with two coats of epoxy resin waterproofing in accordance with DN-STR-03012 – Design for Durability and CC-SPW-02000 Specification for Road Works Series 2000 – Waterproofing for Concrete Structures.

All exposed concrete surfaces will receive a hydrophobic pore lining impregnation in accordance with DN-STR-03012 – Design for Durability and CC-SPW-02000 Specification for Road Works Series 2000 – Waterproofing for Concrete Structures.

3.1.8 Sustainability

Structural steel members will be prefabricated in a factory with high precision and efficiency. This reduces the material waste and waste disposal requirements thus reducing the environmental impacts and harmful emissions created in production.

The use of cement replacement products, such as Ground Granulated Blast Slag (GGBS) will be maximised in the design, reducing the environmental impacts of concrete production. The replacement levels will be in accordance with the levels specified within IS EN 206:2013.

3.1.9 Inspection and Maintenance

Inspection of the bridges will be required regularly throughout its life. The inspections will be carried out in line with the TII EIRSPAN Bridge Management System. The EIRSPAN system was introduced in 2001 to provide an integrated management system for the bridges in Ireland. The system coordinates activities such as inspection, repairs, and maintenance work to ensure optimal management of the bridge stock.

The EIRSPAN system recommends the following intervals for inspections:

- Routine Inspection to be undertaken every year; and
- Principal Inspection to be undertaken at least every 6 years.

The above recommendations are the maximum recommended intervals and are dependent on the condition of the bridges and levels of deterioration since the previous inspection. If high levels of deterioration are identified the inspection interval should be decreased.

The full-through structural form enables inspection and minor maintenance of the top of deck, top chord, vertical and horizontal bracing and mesh to be carried out from the deck level. Inspection and maintenance of the bridge soffit will require access from the M50 carriageway and temporary lane closures. The soffit of the bridge can be designed to incorporate details allowing rope inspections which eliminates the need for MEWP access to the M50. The inspection of the end supports such as abutments and wing walls shall be carried out from the bridge deck and the edge of the M50 carriageways.

4. Safety

4.1 Traffic management during construction including land for temporary diversions

Construction within and over the live carriageways of the M50 have been considered in detail as part of the preliminary design. The bridges have been detailed with a main clear span over the M50 to avoid works within the central reserve and associated traffic management.

The construction area will be predominantly located on the embankments with all north and southbound carriageways utilising the existing carriageway layout. The existing hard shoulders and Junction 10 Diverge Lane 1 will be occupied for the construction area of the abutments, and safety barriers within the embankments. It is envisaged that traffic management restrictions within the M50 hard shoulders will be required for approximately four months to allow construction of the end supports.

The bridges will be fabricated in an offsite location and assembled within the temporary land take boundary. Erection of the superstructure will be carried out by a crane positioned on the M50 carriageway/hard shoulders. During the bridges erection all carriageways will be closed to southbound and northbound directions with significant traffic management required to divert traffic. It is expected that closure of the M50 carriageways will be limited to a single closure during night-time or weekend works, limiting the effects on traffic flow.

During construction stage, a vertical clearance of 5.7m to the M50 carriageways will be maintained at all times.

4.2 Safety during construction

As part of the design development, a Designer's Risk Assessment (DRA) has been prepared in accordance with the Safety, Health and Welfare at Work (Construction) Regulations 2013 and the amendments of 2019 and 2020. The DRA shall be viewed as a working document to be developed further as the design develops. The DRA has been included within the appendices and includes all risks identified and the resulting mitigation measures or alterations incorporated within the design, where no mitigation is possible the DRA will be used to communicate the risks to the Contractor and site personnel.

Where possible, the hierarchy of risk control will be implemented within the design and construction, with the Designer and Contractor aiming to control all risks through elimination. Where this is not possible, reduction, isolation or mitigation controls will be incorporated to ensure safety during construction.

A particular risk identified is construction over a live carriageway and must be considered during the development of the risk register. The M50 is a highly trafficked carriageway. A specific construction sequence and measures should be introduced to minimise the disruption to traffic and mitigate against the risk of falling materials or debris on to the carriageway.

Temporary works will be required at numerous stages of the construction progress to enable safe site works to continue. The following items have been identified as potential temporary works required during the construction of the bridge:

- Construction of piling platforms which are designed to sustain the loading of the piling rig.
- The design of crane platforms to enable the lifting of prefabricated steel.
- Temporary works will be required for the shim arrangements to the soffit of the Warren Truss prior to placing on bridge supports.

4.3 Safety in use

Safety of the end user has been considered as part of the designer's risk assessment. The location of the bridges over a live motorway limits the risk to vandalism with access to elevations, deck soffit and abutments limited to inspection and maintenance personnel.

Pedestrian bridges in the past have been susceptible to dynamic excitation, due to the frequency of pedestrian movements and wind loading. Depending on the conditions, if the frequency of the loading approaches the natural frequency of the bridge it can result in excessive vibrations causing discomfort to the user. A dynamic analysis will

be carried out as part of detailed design to determine the natural frequency and response of the bridges to movement. This analysis will allow the designers to make adjustments to the bridge designs such as increasing the dead load moving the natural frequency of the bridge away from the expected range of frequencies from the live loading and improving the comfort of the user. The bridges will also be designed for potential crowd loading in accordance with IS EN 1991-2.

The main bridge spans will be fully enclosed structures reducing the risk of anti-social behaviour, objects being dropped onto vehicles passing beneath the bridges and users falling or jumping from the bridge decks.

Inspection of the top of decks will be carried out from top of deck level, with inspection of the deck soffit and warren truss members to be carried out from a mobile elevated platform positioned on the motorway below during lane closures. Access arrangements for maintenance will be similar to those required for inspection.

4.4 Lighting

Where required public lighting will be installed along the length of the bridges to improve visibility and reduce the risk of anti-social behaviour. The detailed lighting design will ensure that the lighting is vandal proof and easily maintained.

5. Cost

5.1 Budget estimate in current year

The construction costs provided below have been based on quantities calculated from the preliminary bridge design and include for both bridges. Major elements associated with bridges such as earthworks, piling, structural concrete, reinforcement, structural steel and waterproofing have been included. Rates have been based on AECOM's internal cost database or based on Spon's Civil Engineering and Highway Works Price Book 2021 as required. It should be noted that costs are indicative only and may vary depending on the detailed design and the Contractor's methodology.

During the preliminary design stage, Thompsons of Carlow Ltd. have been engaged to provide current Structural Steelwork rates (2021). The steel tonnage quantities were based off the preliminary design drawings provided in Appendix B. The rates provided include supply, fabrication, painting, installation and all associated quality assurance for all structural steel elements including bridge parapets.

Allowances have been made for preliminaries, consultancy fees and contingency. A budget of 20% of the construction cost has been provided for preliminaries (excluding traffic management) to cover site compound, PSCS, temporary accommodation etc.. The contingency is 25% of the construction cost and will cover minor elements such as drainage, fencing, landscaping works and any unforeseen unknowns. Finally, an allowance of 10% of the construction cost has been provided for professional fees to deliver the bridge from detailed design to handover. These fees will include detailed design, CAT II checks, construction supervision and handover.

The rates used to calculate the amounts presented below are all exclusive of VAT. No allowance has been made for land acquisition within the costs provided below. The cost of land acquisition will be covered under the construction costs for the entire BusConnects CBC09 Tallaght to City Centre route.

Table 5.1 Budget Estimate in the current year

Series	Amount (€)
CC-SPW-00600 - Earthworks	63,503.40
CC-SPW-01600 - Piling and Embedded Retaining Walls	260,990.53
CC-SPW-01700 - Structural Concrete	378,738.00
CC-SPW-01800 - Structural Steel	676,319.88
CC-SPW-02000 - Waterproofing of Structures	45,151.50
Construction Cost	**1,424,703.31**
Preliminaries (20% of Construction Cost)	284,940.66
Contingency (25% of Construction Cost)	356,175.83
Professional Fees (10% of Construction Cost)	142,470.33
Final Cost	**2,208,290.12**

6. Design Assessment Criteria

6.1 Actions

6.1.1 Permanent actions

Permanent actions and material densities will be applied in accordance with IS EN 1991-1-1 and the Irish National Annex. Material/partial factors will be as detailed in IS EN 1990 and the Irish National Annex. The accepted densities for principal construction materials are as follows:

Table 6.1 Material Densities for Design

Material	Density
Reinforced Concrete	25 kN/m^3
Structural Steelwork	78.5 kN/m^3
6N/6P backfill to structures	21 kN/m^3

6.1.2 Snow, Wind and Thermal Actions

Snow loads are not deemed a critical load case and will not be considered in accordance with the National Annex to IS EN 1991-1-3.

Wind loading will be considered in accordance with IS EN 1991-1-4 and the Irish National Annex. Wind loads will be taken to act simultaneously with other loads in accordance with the NA to IS EN 1990. Wind loads will not be considered in combination with thermal loading in accordance with clause A2.2.2 (6) of the NA to IS EN 1990.

Thermal loading will be considered in accordance with IS EN 1991-1-5 and the Irish National Annex. The combination of thermal and wind loading will not be considered for the bridge in accordance with the National Annex to IS EN 1990.

6.1.3 Actions relating to normal traffic

Not Applicable.

6.1.4 Actions relating to abnormal traffic

Not Applicable.

6.1.5 Footway or footbridge live loading

Actions on the bridge will be considered in accordance with IS EN 1991-2 and the Irish National Annex. The bridge will be designed for a uniformly distributed load pedestrian loading of 5kN/m^2. In addition, the bridge will also be designed for a concentrated load of 20kN acting on a square surface area 0.2m by 0.2m.

No service vehicle loading will be considered as part of the design as service vehicles will be excluded from crossing the bridge through the introduction of suitable bollards on approach to the bridge.

6.1.6 Provision for exceptional abnormal loads

Not Applicable.

6.1.7 Accidental Actions

Not applicable. The bridge will be designed to provide a minimum of 5.7m clearance above the M50 carriageways avoiding the risk of accidental impact with the superstructure. The bridge substructures will be set-back sufficiently outside of the clear zone of the carriageways or else protected by a suitable vehicle restraint system to avoid the risk of accidental impact on the bridge supports.

6.1.8 Actions during construction

Actions arising during construction will be considered in accordance with IS EN 1991-1-6 and the Irish National Annex.

6.1.9 Any special loading not covered

Not applicable.

6.2 Authorities consulted and any special conditions

The following authorities have been consulted as part of the development of the scheme:

- Transport Infrastructure Ireland
- National Transport Authority
- South Dublin County Council
- Landowners

6.3 Proposed departures from standards

No departures from standards are proposed for the project.

6.4 Proposed methods of dealing with aspects not covered by standards

Not applicable.

7. Ground Conditions

7.1 Geotechnical Classification

Applying the guidance in IS EN 1997-1, it is considered that Geotechnical Category 2 is currently the most appropriate for the proposed bridges.

Geotechnical Category 2 applies to conventional types of structures and foundations with no exceptional risk or difficult loading conditions. This includes spread footing, raft foundations, piled foundations, walls or other structures retaining or supporting water, excavations, bridge piers and abutments, embankments and earthworks, ground anchors and other systems and tunnels in hard, non-fractured rock and not subjected to special water tightness or other requirements.

7.2 Description of the ground conditions and compatibility with proposed foundation design

A review of the historical drawings for the existing bridge indicates the following:

- The abutment drawings show 400 mm square precast concrete piles. The piles consist of a combination of vertical and raking piles. The piles are arranged in a 7 x 4 plan configuration.
- The central pier drawings show 400 mm square precast concrete piles. The piles consist of a combination of vertical and raking piles. The piles are arranged in a 10 x 3 plan configuration. The safe working load for pile is noted at 700 kN.

Although not stated on the drawings, it is likely that the piles were driven piles, deriving their geotechnical capacity via a combination of skin friction and end bearing.

The existing approach embankments will not provide suitable bearing for shallow foundations due to stiffness of the cohesive embankment fill and the difficulty of controlling differential settlements. Consequently, it is recommended that the abutments are piled.

To avoid disturbing the existing bridge, it is likely that rotary piles will be the preferred solution generating the majority of their capacity via end bearing and shaft friction of a rock socket in the underlying bedrock.

8. Drawings and Documents

8.1 List of all documents accompanying the submissions

The following table lists the drawings accompanying this submission. The drawings are contained within Appendix B:

Table 8.1 Greenhills Road Bridge Drawing List

Drawing Number	Revision	Drawing Title
BCIDA-ACM-STR_GA-0009_BR_08-DR-CB-0101	L02	Greenhills Road Bridge Plan
BCIDA-ACM-STR_GA-0009_BR_08-DR-CB-0102	L02	Greenhills Road Bridge Details

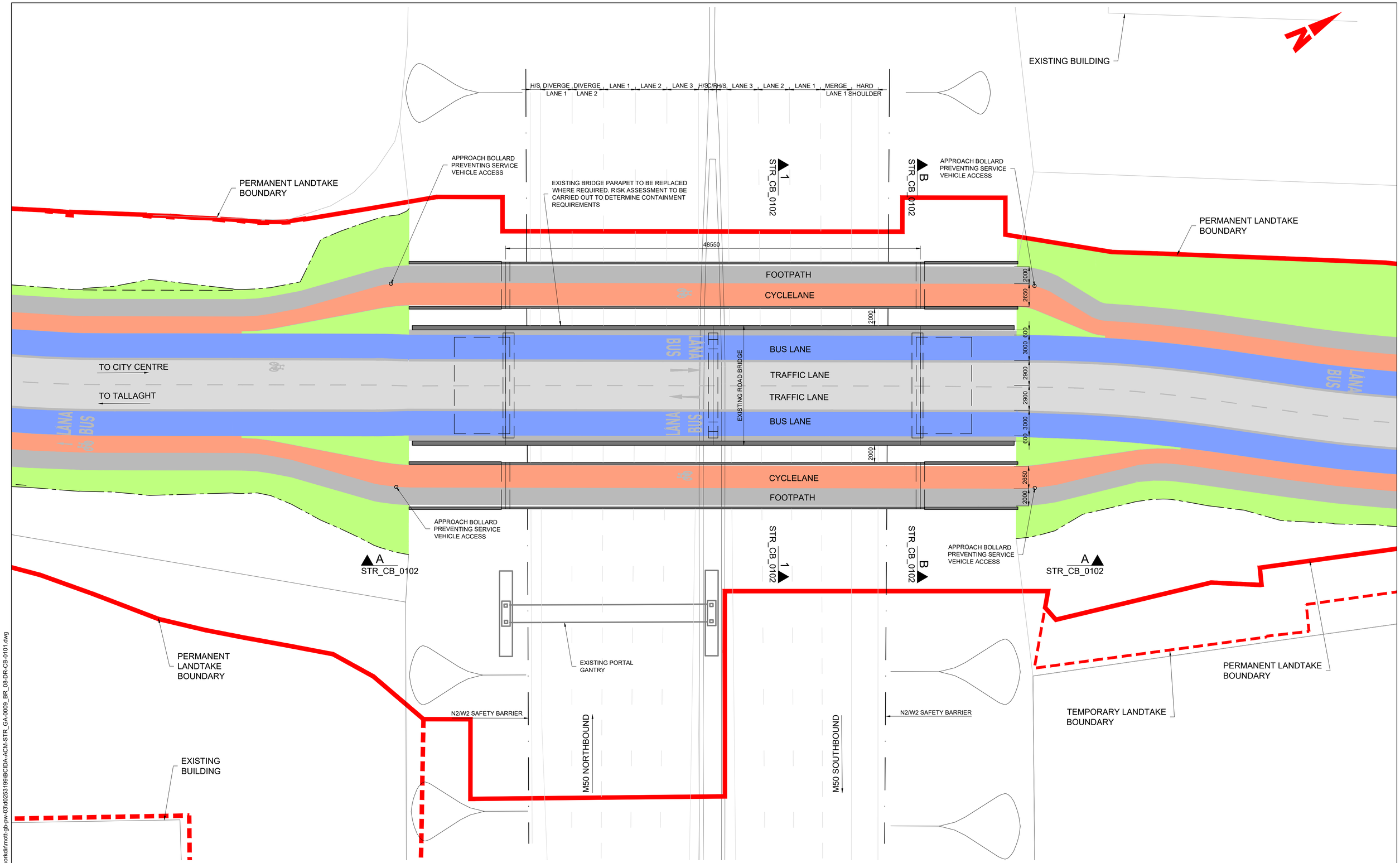
Appendix A Photographs and Photomontages

Photo 1 – Proposed bridge location spanning the M50

Photo 2 – Existing Greenhills Road Bridge looking west

Photo 3 – Existing Greenhills Road Bridge looking east

Appendix B Drawings



PLAN
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Disclaimer

a. © National Transport Authority (NTA) 2021. This drawing is confidential and the copyright in it is owned by NTA. This drawing must not be either loaned, copied or otherwise reproduced in whole or in part or used for any purpose without the prior permission of NTA.
b. This drawing is to be used for the design element identified in the titlebox. Other information shown is to be considered indicative only. The drawing is to be read in conjunction with all other relevant design drawings.
c. O.S. data used for plans are printed under © Ordnance Survey Ireland Government of Ireland. All rights reserved. Licence Number 2021/OSi_NMA_180 National Transport Authority. All elevations are in metres and relate to OSi Geoid Model (OSGM15) Malin Head. All Co-ordinates are in Irish Transverse Mercator Grid (ITM) as defined by OSi active local GPS station.
d. Information concerning the position of apparatus shown on this drawing is based on drawings supplied by the utility owners and/or the utility works contractor, whilst every care has been taken in the preparation of this drawing, positions should be taken as approximate and are intended for general guidance only and no representation is made by the NTA as to the accuracy, completeness, sufficiency or otherwise of this drawing and the position of the apparatus.The information contained herein does not purport to be comprehensive or final as the apparatus is subject to being altered and/or superceded. Recipients should not rely on this information. Any liabilities are hereby expressly disclaimed.
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Project Ireland 2040 Building Ireland's Future

Rev	Date	Drn	Chk'd	App'd	Description
L04.1	13/07/21	DH	AD	JS	ISSUE FOR PEER REVIEW
L03	30/06/21	DH	AD	JS	ISSUED FOR APPROVAL
L02	28/04/21	DH	AD	JS	ISSUE FOR PEER REVIEW
L01	09/12/20	DH	AD	JS	STAGE B1 - PEER REVIEW

Client: NTA Údarás Náisiúnta Iompair / National Transport Authority
Engineering Designer: AECOM / MOTT MACDONALD

Date	Scale	Drawn	Checked	Approved
13/07/21	1:200 @ A1, 1:400 @ A3	---	---	---

Project Code	Originator Code	QMS Code
BCIDA	ACM	

Programme Title: **BUSCONNECTS DUBLIN**
CORE BUS CORRIDORS INFRASTRUCTURE WORKS

Drawing Title: TALLAGHT/CLONDALKIN TO CITY CENTRE SCHEME
ST01.09 - GREENHILLS ROAD PEDESTRIAN & CYCLE BRIDGES
PLAN

Drawing File Name	Sheet Number	Status	Rev
BCIDA-ACM-STR_GA-0009_BR_08-DR-CB-0101	1 of 1		L04.1

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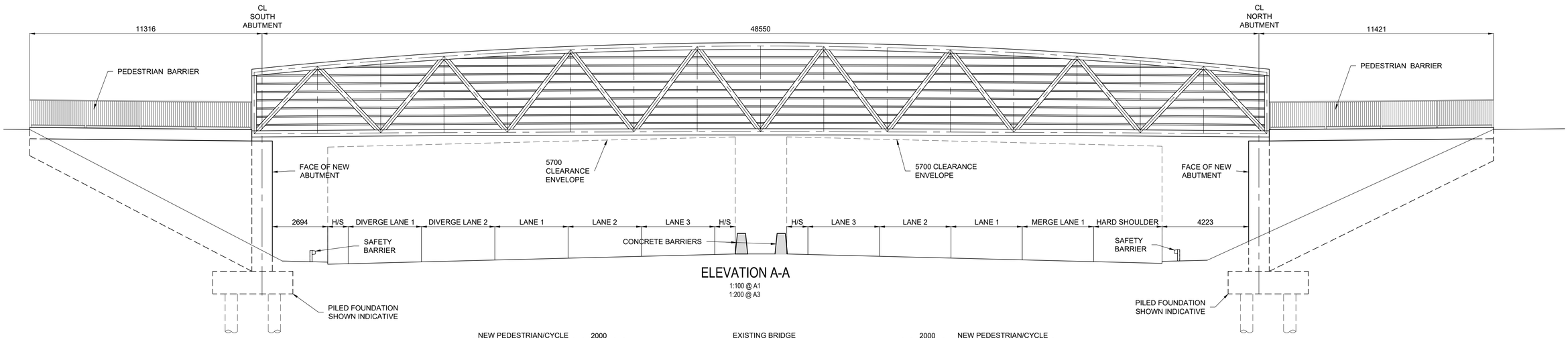

ELEVATION A-A

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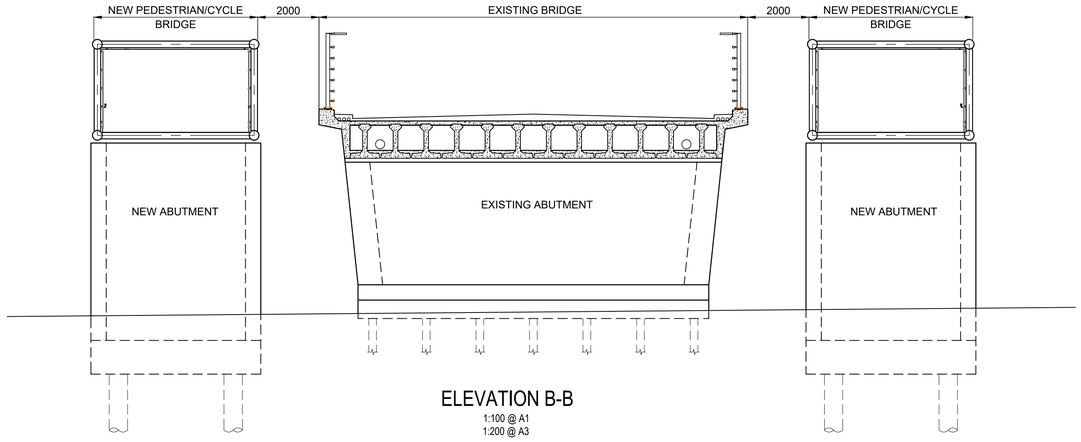
1:200 @ A3



ELEVATION B-B

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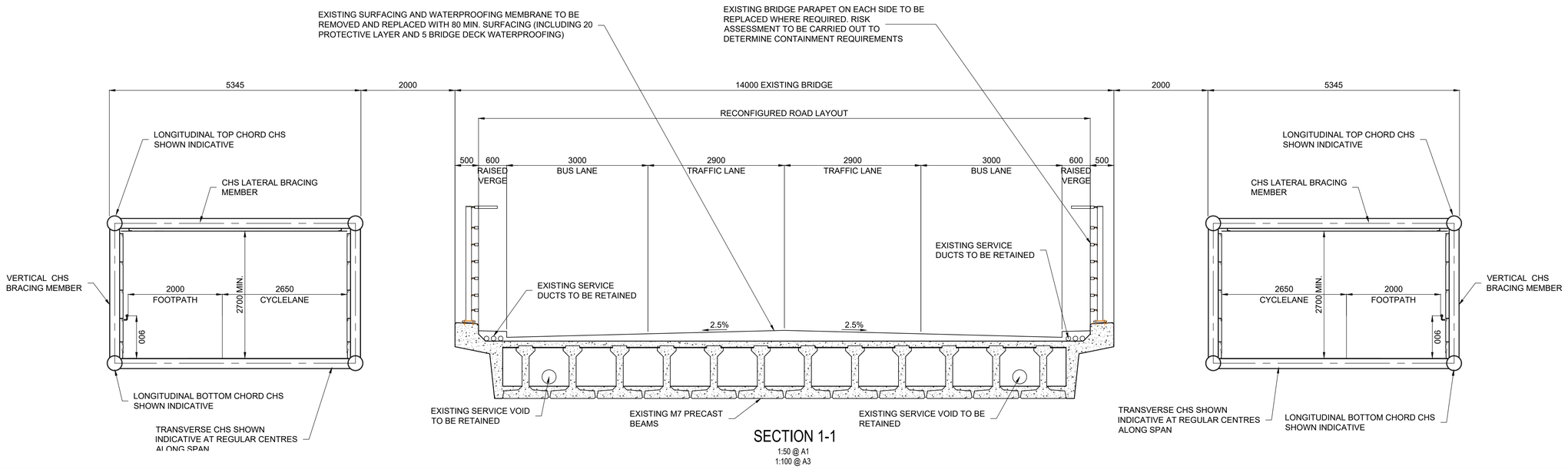
1:200 @ A3



SECTION 1-1

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Project Ireland 2040 Building Ireland's Future

Rev	Date	Drn	Chk'd	App'd	Description
L04.1	13/07/21	DH	AD	JS	ISSUE FOR PEER REVIEW
L03	30/06/21	DH	AD	JS	ISSUED FOR APPROVAL
L02	28/04/21	DH	AD	JS	ISSUE FOR PEER REVIEW
L01	09/12/20	DH	AD	JS	STAGE B1 - PEER REVIEW

Client: NTA Údarás Náisiúnta Iompair / National Transport Authority

Engineering Designer: AECOM / MOTT MACDONALD

Programme Title: **BUSCONNECTS DUBLIN**
CORE BUS CORRIDORS INFRASTRUCTURE WORKS

Drawing Title: TALLAGHT/CLONDALKIN TO CITY CENTRE SCHEME
ST01.09 - GREENHILLS ROAD PEDESTRIAN & CYCLE BRIDGES
DETAILS

Date	Scale	Drawn	Checked	Approved
13/07/21	AS SHOWN @ A1 / AS SHOWN @ A3	---	---	---

Project Code	Originator Code	QMS Code	Drawing File Name	Sheet Number	Status	Rev
BCIDA	ACM		BCIDA-ACM-STR_GA-0009_BR_08-DR-CB-0102	1 of 1		L04.1

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Appendix C Utility Drawings

0 5.0 10.0 20.0 30.0 40.0 50.0m

SCALE 1:500 @ A1; 1:1000 @ A3

WESTERN PARKWAY MOTORWAY

M50

Fashion City

BALLYMOUNT ROAD UPPER

Car Park

GREENHILLS ROAD

TYMON PARK

A 3700

A 3750

A 3800

A 3850

A 3900

A 3950

A 4000

A 4050

A 4100

SHEET 12

SHEET 13

LEGEND:

- EXISTING HV ELECTRICITY (UNDERGROUND)
- EXISTING HV ELECTRICITY (OVERHEAD)
- EXISTING MV ELECTRICITY (UNDERGROUND)
- EXISTING MV ELECTRICITY (OVERHEAD)
- EXISTING LV ELECTRICITY (UNDERGROUND)
- EXISTING LV ELECTRICITY (OVERHEAD)
- EXISTING LP GAS NETWORK
- EXISTING MP GAS NETWORK
- EXISTING HP GAS NETWORK
- EXISTING STORM WATER DRAINAGE
- EXISTING FOUL WATER DRAINAGE
- EXISTING COMBINED NETWORK
- EXISTING WATER NETWORK
- EXISTING VIRGIN MEDIA NETWORK
- EXISTING ESB DUBLIN DARK FIBRE
- EXISTING TELCO DUCT
- EXISTING ENET NETWORK
- EXISTING EIR NETWORK
- EXSTING FIBRE DUBLIN CITY COUNCIL NETWORK
- PROPOSED KERB LINE
- SITE BOUNDARY LINE
- TEMPORARY LAND ACQUISITION

NOTE: UTILITY LOCATIONS ARE INDICATIVE ONLY AND BASED ON UTILITY PROVIDER RECORDS

Project Ireland 2040 Building Ireland's Future

Rev	Date	Drn	Chk'd	App'd	Description
L02	30/04/21	PZ	AD	JS	ISSUED FOR PEER REVIEW
L01	23/10/20	PZ	AD	JS	STAGE A - PEER REVIEW

Client: NTA Údarás Náisiúnta Iompair National Transport Authority

Engineering Designer: AECOM MOTT MACDONALD

Date	Scale	Drawn	Checked	Approved
30/04/21	1:500 @ A1, 1:1000 @ A3	P.ZAJAC	A.DUGGAN	J.SEYMOUR

Project Code	Originator Code	QMS Code
BCIDA	ACM	

Programme Title: **BUSCONNECTS DUBLIN**
CORE BUS CORRIDORS INFRASTRUCTURE WORKS

Drawing Title: CBC09
TALLAGHT/CLONDALKIN TO CITY CENTRE
COMBINED EXISTING UTILITIES RECORDS
SHEET 12

Drawing File Name	Sheet Number	Status	Rev
BCIDA-ACM-UTL_UC-0009_XX_00-DR-CU-0012	12 of 44	S3	L02

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Appendix D Designers Risk Assessment

BUSCONNECTS – CBC009 Greenhills to City Centre
CBC009-ST01 Greenhills Road Pedestrian and Cycle Bridges
Designers Risk Assessment

Project Number:	60599126	**Revision**						
Client:	National Transport Authority	**Rev**	01	02	03	04	05	06	07
Designer:	AECOM	**Date**	16/07/21						
Contractor:	Not applicable	**Client**	✓						
Prepared by:	Rionach Murphy	**Designer**	✓						
Checked by:	Arthur Costello	**Main Contractor**	-						
Approved by:	Niamh Rodgers	**Sub-Contractors**	-						
		Other	-						

Ref.	Feature, element, process or work activity	Constraints and significant hazards identified	Risk Rating before Intervention	Designers interventions to eliminate or reduce hazards	Significant residual hazards remaining	Residual Risk Rating	Information to be provided to enable project partners to manage hazards
1	Live Carriageways	Site is on the Greenhills Road and crosses over the M50 motorway. The road will be live during majority of construction.	High	Bridges have been designed with a main span over all lanes of the M50 avoiding works within the central reserves. All traffic lanes to be closed during lifting of bridges superstructures Traffic management to be implemented to ensure that safe working zones are provided to any works near live carriageways.	Live traffic with traffic management zones	Medium	Traffic Management will be required for bridges lifts and any construction works on or near live carriageways. All traffic management plans to be developed in accordance with Chapter 8 of the Traffic Signs Manual. Contractor is to ensure that all staff are aware of the risks of working near a live road.
2	Access and egress to the site and compound	Access and egress to site.	High	Design of the overall CBC0809 Clondalkin to Drimnagh & Greenhills to City Centre has ensured that sufficient lands are made available within the temporary CPO area.	N/A	Low	Contractor to be made aware of temporary CPO area and to ensure that construction works are carried out within this area.
3	Site security	Unauthorised access by members of the public to the works areas	High	Sufficient space has been provided within the Temporary CPO area to allow suitable hoarding/fencing to be erected to prevent unauthorised access to the works areas		Low	Contractor to ensure that fencing is erected and maintained throughout the construction works.

Ref.	Feature, element, process or work activity	Constraints and significant hazards identified	Risk Rating before Intervention	Designers interventions to eliminate or reduce hazards	Significant residual hazards remaining	Residual Risk Rating	Information to be provided to enable project partners to manage hazards
4	Plant movements	Insufficient ground bearing pressure for site works.	Medium	Preliminary Ground investigations have been carried out to determine if there are potential risks of low ground bearing pressures.		Low	Further Ground Investigations to be carried out as part of Detailed Design to determine any further areas of low ground bearing pressures. Appropriate hoarding to be provided at construction stage to separate works from areas of adverse ground conditions.
5	Multiple Site Activities	Numerous concurrent construction projects are expected to take place at different locations along the Clondalkin to Drimnagh & Greenhills to City Centre CBC0809 Routes and the bus interchange	Medium	Phasing of the construction works has been considered to avoid works being carried out in parallel on CBC0809		Low	Contractor to discuss sequencing and construction programme with the client and CBC0809 construction team. On-site personnel to be aware of ongoing site activities and follow any appropriate safety requirements. Barriers and hoarding to be put in place as appropriate to protect on-site personnel and segregate different site activities.
6	Underground services	Potential for unknown and/or undocumented services in the vicinity of the proposed structures.	Medium	Desk top study of available utility information carried out and all known services in the vicinity of the proposed structures have been shown on preliminary design drawings.		Low	Further desk top study to be carried out at Detailed Design stage to identify any additional services which have been constructed in the interim. At construction stage full CAT scan site survey to be carried out prior to commencement. Any services identified should be located by hand excavation, marked and protected or re-routed before commencement of works.
7	Excavation adjacent to an existing Structure and live carriageway	Excavations required to construct the bridges run the risk of undermining the live carriageways and the existing Greenhills Road Bridge	High	The bridges locations and geometries has been determined to avoid excavation works near the existing structure. The bridges supports have been set back from the edge of carriageways to ensure safe working zones can be achieved with minimal traffic management required.		Low	The contractor is to be aware of the risk of undermining existing road. As part of the detailed design the construction methodology should consider if sheet piling is required to avoid undermining. The contractor is to ensure that vibration levels from excavation are limited and that safe working limits are developed prior to works.

Ref.	Feature, element, process or work activity	Constraints and significant hazards identified	Risk Rating before Intervention	Designers interventions to eliminate or reduce hazards	Significant residual hazards remaining	Residual Risk Rating	Information to be provided to enable project partners to manage hazards
8	Structural Instability	Instability of structural elements during construction	High	The preliminary designs have been developed for a fully through truss construction with a braced pair of truss chords to ensure stability during construction for both bridges.		Medium	Where required the Contractor shall ensure that temporary works are provided on site to ensure structural stability during construction. All temporary works required are to be designed by a temporary works designer.
9	Working at Height	Risk of fall of plant, materials and people.	High	The bridges design has been developed to ensure the main bridge spans can be lifted into position fully assembled avoiding the need for works from height over live carriageways of the M50. The bridges have been designed to require minimum construction on site with most elements being prefabricated.		Medium	The Contractor shall ensure appropriate guard rails and netting provided to the structures to prevent falling objects. Contractor to ensure suitable fall restraint systems/harnesses to be used when working at height.
10	Night-time Working	Reduced visibility and fatigue caused by night-time working poses the risk of slips, trips, falls and unsafe working practices being incorporated.	High	The preliminary designs have assumed that main spans of the bridges will be lifted during night-time works and closure of the M50. The design has been developed to ensure the lifting can be carried in a single night limiting the requirements for night-time working.		Low	The Detailed Designer and Contractor will need to consider the construction methodology and sequencing to limit night-time working. Where night works are required the Contractor must ensure that all staff are briefed on the dangers of night-time work and that site personnel are not overworked and remain vigilant.