Appendix J5 Preliminary Design Report – Structure 05

Preliminary Design Report – Consultation STA-1b

Categories 1, 2 & 3

Scheme

Name and Location: Busconnects Infrastructure Delivery – Project D

Structure(s)

Name and nature of the Structure(s): Ballymun 05 Retaining Wall

Preliminary Design Report

Reference BCIDD-ROT-STR-ZZ-0003-XX-00-RP-CB-0019

Revision L02

Date May 2022

Submitted by

Signed: 

Name: Fernando Fernandez

Position: (Structures Team Leader)

Organisation: Roughan & O'Donovan – TYPSA Consulting Engineers

Date: 23/05/2022

Structures Section confirmation of consultation:

Signed: _____

Name: _____

Position: _____

Date: _____

BUSCONNECTS INFRASTRUCTURE DELIVERY – PROJECT D

PRELIMINARY DESIGN REPORT – BALLLYMUN 05

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Brief

Roughan & O'Donovan-TYPSA have prepared this report for the National Transportation Authority (NTA) for the design of the Ballymun 05 retaining wall as part of the Busconnects Infrastructure Delivery – Project D.

1.2 Background Information

The proposed scheme for Ballymun/Finglas to City Centre aims to provide enhanced walking, cycling and bus infrastructure, which will enable and deliver efficient, safe and integrated sustainable transport movement to this corridor.

Priority for buses is provided along the entire route consisting primarily of dedicated bus lanes in both directions, with alternative measures proposed at particularly constrained locations along the scheme. Cycle tracks and footpaths will also be provided separated from the bus lanes. At constrained points, it is necessary to build new structures or widen the existing ones to provide adequate space for the new road layout.

This document relates to the Preliminary Design Report in respect of the Ballymun 05 structure in accordance with DN-STR-03001 (April 2019). A location drawing of this structure within the scheme is provided in the Appendices, as well as a general arrangement drawing of the proposed structure.

Photographs of the structure's location are included in Appendix 1.

1.3 Previous Studies

Reports prepared and published for this structure to date include:

- BCID-ROT-ERW-GI_0304-RP-CR-0001 – Geotechnical Interpretive Report: Ballymun/Finglas Corridors

2. SITE & FUNCTION

2.1 Site Location

The Ballymun 05 retaining wall is situated along St. Mobhi Road, parallel to the road on the eastern side. The site location plan is included in Appendix 2.

2.2 Function of the Structure

The objective of the new retaining wall is to provide sufficient space for the proposed scheme road layout with a bus lane, cycle lane and pedestrian footpath on the eastern side of St. Mobhi Road.

2.3 Choice of Location

The location of the structure was chosen to facilitate the proposed Ballymun to city centre corridor taking into account the layout and roadway requirements in terms of space for proposed lanes, footpaths, maximum slopes, etc.

2.4 Site Description and Topography

The site of the proposed structure is located in an urban area, close to Dublin's city centre. Consequently, there are existing buildings and infrastructure in the direct vicinity of the new structure.

2.5 Vertical and Horizontal Alignments

Horizontal and vertical road alignments at the wall location are described below. The proposed general arrangement drawings are shown in Appendix 2.

Horizontal Alignment

The structure follows St. Mobhi Road alignment.

Vertical Alignment

The retaining wall has an overall length of approximately 148m and its height varies between 1.20m and 4.00m.

2.6 Cross-Sectional Dimensions on the Alignments

Not applicable.

2.7 Existing Underground and Overground Services

A list of the existing services located in close proximity to the proposed Ballymun 05 retaining wall, at St Mobhi Rd, is outlined below.

Low and Medium Voltage Electricity Lines

ESB low voltage underground lines are in the vicinity of the structure. It is not envisaged any diversion. These may need to be further discussed with ESB.

High Voltage Electricity Lines

No conflicts were found in the vicinity of the structure.

Telecommunications

No conflicts were found in the vicinity of the structure.

Water Supply

Water mains are present at the structure's location. These may need to be diverted following discussion with Irish Water. Exact locations will need to be verified by the Contractor on site.

Gas Networks

No conflicts were found in the vicinity of the structure.

2.8 Geotechnical Summary

The existing site investigation information for the area has been taken from the Geological Survey of Ireland (GSi) website and the British Geological Survey (BGS) website, including the Quaternary and Bedrock Geology of Dublin and Depth of Bedrock digital maps.

At the date of this report there is a GI contract available that aims to assess the geology of the site and determine the ground properties and conditions to enable the design of Bus Connects Core Bus Corridors.

2.9 Hydrology and Hydraulic Summary

The wall will have no effect on the hydrology in the area.

2.10 Archaeological Summary

An Environmental Impact Assessment Report (EIAR) is currently being prepared that considers archaeological impacts along the mainline alignment.

2.11 Environmental Summary

An Environmental Impact Assessment Report (EIAR) is currently being prepared and it considered the mainline alignment at the structure location and its impact on the environment and local communities. All likely significant environmental effects are assessed, and mitigation is proposed as necessary in the Environmental Impact Assessment Report.

3. STRUCTURE & AESTHETICS

3.1 General Description of Recommended Structure

The Ballymun 05 structure is a reinforced concrete cantilever retaining wall with a new fencing atop. The overall length of the wall is approximately 148.0m and its height varies between 1.20m and 4.00m.

3.2 Aesthetic Considerations

The reinforced concrete cantilever retaining wall is a typical solution for retaining walls of this range of heights. The visual appearance of the exposed face is plain concrete.

The new fencing atop the wall shall be defined in such a way as to promote a positive aesthetic impact on the area. It will require aesthetic approval from the Employer's representative to ensure an appropriate solution is employed in construction.

3.3 Proposals for the Recommended Structure

3.3.1 Proposed Category

The proposed retaining wall is a Category 1 structure.

3.3.2 Span Arrangements

The overall length of the wall is approximately 148.0m and its height varies between 1.20m and 4.00m.

3.3.3 Minimum Headroom Provided

Not applicable.

3.3.4 Approaches (incl. Run-on Arrangements)

Not applicable.

3.3.5 Foundation Type

The foundation of the wall consists of a shallow spread footing.

3.3.6 Superstructure

Not applicable.

3.3.7 Articulation Arrangements (Joints and Bearings)

The reinforced concrete retaining wall will incorporate expansion joints at intervals no longer than 30m to accommodate thermal actions.

3.3.8 Vehicle Restraint System

All parapets will comply with TII DN-STR-03034 (historical ref. NRA TD19) and EN 1317. The parapet proposed for this structure is a pedestrian parapet, where a cycleway is adjacent to the parapet. The parapets shall be provided with infilling such that the parapet will not have footholds.

3.3.9 Drainage

The retaining wall incorporates a drainage layer, in accordance with series 513 of the specification, at the rear face of the wall with longitudinal perforated drainage channel (pipe).

3.3.10 Durability

The proposed structure will be designed to achieve the required 120 years design life.

In addition, the specification of suitable materials will enhance durability and reduce the maintenance liability. The following measures are proposed:

- Durable concrete to be provided in accordance with TII DN-STR-03012 (formerly BD57);
- Exposed concrete to be surface impregnated and buried concrete surfaces to be waterproofed in accordance with the TII Specification for Road Works;
- Exposed formed concrete surfaces to be F4 / F3;
- Provision of a fully maintainable drainage system.

3.3.11 Sustainability

Life cycle sustainability assessment (LCSA) has been considered for the detailed design of the proposed retaining wall to enable a cost-effective and sustainable solution since the construction until the end of service life, with a minimal impact on the surrounding environment.

The proposed structure is considered a sustainable solution for the following reasons:

- Concrete is manufactured in Ireland.
- Local cement and aggregates are used in the production of concrete.
- Concrete typically requires less ongoing maintenance work.
- It is proposed to adopt 50% ground granulated blast furnace slag (GGBS) as cement replacement in the mix design for all in-situ concrete which reduces CO2 emissions.

3.3.12 Inspection and Maintenance

The inspection of retaining wall shall be carried out in accordance with TII procedures by suitably qualified personnel who shall be responsible for providing the relevant equipment and establishing traffic management appropriate to the type of inspection being carried out.

Inspection of the wall can be done from finish road level, and it is not necessary traffic management.

Substructures

The substructures consist of in situ reinforced concrete, which should not incur any substantial maintenance costs.

Parapets

The parapet design is yet to be agreed with the Client. Nevertheless, it shall employ materials with low to none maintenance requirements (i.e. galvanised steel parapets).

4. SAFETY

4.1 Traffic Management during Construction

Traffic management will be required during construction. Local pedestrian diversion and partial traffic closures are expected during the construction of the new retaining wall.

4.2 Safety during Construction

The Designer will comply with the General Principles of Prevention (of accidents) as specified in the First Schedule of the Safety, Health and Welfare at Work (General Application) Regulation and liaise with the Project Supervisor for the Design Stage (PSDP) appointed by the Client and the Project Supervisor appointed for the Construction Stage as required by the "Safety, Health and Welfare at Work (Construction) Regulations, 2013".

4.3 Safety in Use

Parapets will be designed for accidental loading in accordance with IS EN1317, the headroom and cross section will be designed in accordance with TII DN-GEO- 03036 (historical ref. TD 27).

4.4 Lighting

Street lighting are currently in use in the area. It is not envisaged any M&E works associated to this structure.

5. DESIGN ASSESSMENT CRITERIA

5.1 Actions

The structure will be designed in accordance with IS EN 1991 Eurocode 1: Actions on Structures and, in particular, Part 1-1: General Actions, Part 1-3: Snow Loads, Part 1-4 Wind Loads, Part 1- 5 Thermal Actions, Part 1-6 Execution, Part 1-7 Accidental Actions and IS EN 1991 Part 2 Traffic Loads on Bridges as amended by the relevant Irish National Annexes.

5.1.1 Permanent Actions

The following nominal densities will be adopted:

- Reinforced concrete 25 kN/m^3
- Structural steelwork 77 kN/m^3
- Pavement 23 kN/m^3
- Backfill to structures 20 kN/m^3

5.1.2 Snow, Wind and Thermal Actions

Snow action may be ignored due to the geographical location as outlined in IS EN 1990:2002 + NA:2010. Thermal actions Approach 2 will be used in accordance with clause NA.2.3 of the Irish National Annex to IS EN 1991-1-5. Wind load will be assessed in accordance with IS EN 1991-1-4:2005 and the associated National Annex.

5.1.3 Actions relating to Normal Traffic

The structure will be designed for traffic surcharge in accordance with IS EN 1997-1:2005. The surcharge applied is due to normal traffic only.

5.1.4 Actions relating to Abnormal Traffic

None.

5.1.5 Footway Live Loading

The structure will be designed for footway loading in accordance with IS EN 1991-2 load model LM4 (crowd loading). This consists of a uniformly distributed load (q_{fk}) of 5kN/m² and a concentrated load (Q_{fwk}) of 20kN as defined in section 5 of IS EN 1991-2 and the Irish National Annex.

5.1.6 Provision for Exceptional Abnormal Loads

None.

5.1.7 Accidental Actions

Accidental actions will be considered in accordance with I.S. EN 1991-1-7.

5.1.8 Actions during Construction

The design shall take account of any adverse loading during construction as outlined in IS EN 1991-1-6 and its National Annex.

5.1.9 Any Special Loading Not Covered Above

None.

5.2 Authorities Consulted

The following is a list of Authorities to be consulted as part of the scheme:

- Local Authorities – Dublin City Council;
- ESB;
- Irish Water.

5.3 Proposed Departures from Standards

There are no existing departures applied for at this stage of the design process.

5.4 Proposed Methods of Dealing with Aspects not Covered by Standards

Agreed departures to be incorporated into the design – however at this stage no departures have been applied for.

6. GROUND CONDITIONS

6.1 Geotechnical Classification

The existing site investigation information for the area has been taken from the Geological Survey of Ireland (GSi) website and the British Geological Survey (BGS) website, including the Quaternary and Bedrock Geology of Dublin and Depth of Bedrock digital maps.

A GI contract has recently been completed which aims to assess the geology of the site and determine the ground properties and conditions to enable the design of Bus Connects Core Bus Corridors. The GI includes boreholes, trial pits, dynamic probes, standpipes/piezometer installation and monitoring, in-situ testing, geotechnical and environmental laboratory testing and preparation of a factual report, all in accordance with the “Specification and Related Documents for Ground Investigation in Ireland”.

Additional information regarding the geological profile and location of the boreholes at Ballymun Corridor can be found on the Geotechnical Interpretation Report, document No. BCID-ROT-ERW_GI-0304-RP-CR-0001. An extract of the Geotechnical Interpretation Report is included in Appendix 3.

There is not current site investigation information for Ballymun 05. Nevertheless, there is an existing retaining wall in St Mobhi Road on shallow foundation. Therefore, it is assumed that the proposed retaining wall will be on shallow foundations too. Further site investigation shall be undertaken during subsequent design stages to develop the detailed design of this structure.

7. DRAWINGS & DOCUMENTS

7.1 List of All Documents Accompanying the Submission

Appendix 1 – Photographs:

(2No. of photos)

Appendix 2 – Site Location and Drawings

- BCIDD-ROT-STR_KP-0304_XX_00-DR-SS-0001 – CBC 03- Ballymun/Finglas to City Centre Core Bus Scheme – Bridges and Retaining Structures – Key Plan
- BCIDD-ROT-STR_ZZ-0304_XX_00-DR-SS-0009 – Ballymun 05. General Arrangement & Sections.
- BCIDD-ROT-STR_ZZ-0304_XX_00-DR-SS-0010 – Ballymun 05. Longitudinal Section

Appendix 3 – Relevant Extracts from Ground Investigation Report

(8No. of pages) Extract GIR - BCID-ROT-ERW_GI-0304-RP-CR-0001

Appendix 4 – Other Relevant Documentation/Reports

(Not Used)

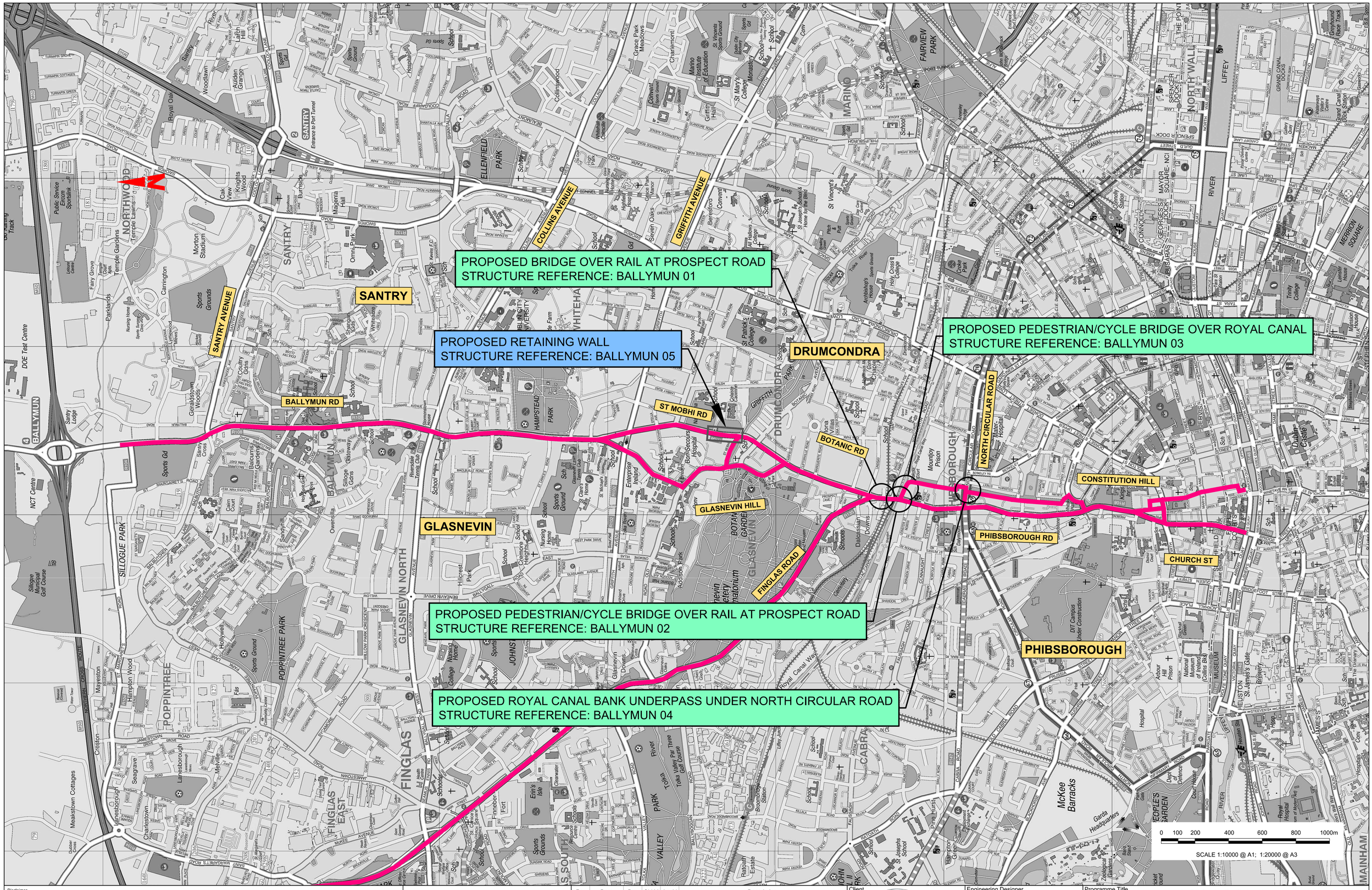
APPENDIX 1
PHOTOGRAPHS

St. Mobhi Road – looking northwards

St. Mobhi Road – Location of the proposed Ballymun 05 retaining wall (in red)

SOURCE: GOOGLE.MAPS

APPENDIX 2
DRAWINGS



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Engineering Designer: ROD Roughan & O'Donovan, TYPSA

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

Drawing Title: CBC 03
BALLYMUN / FINGLAS TO CITY CENTRE CORE BUS CORRIDOR SCHEME
BRIDGES & RETAINING STRUCTURES
KEY PLAN

Drawing File Name	Sheet Number	Status	Rev
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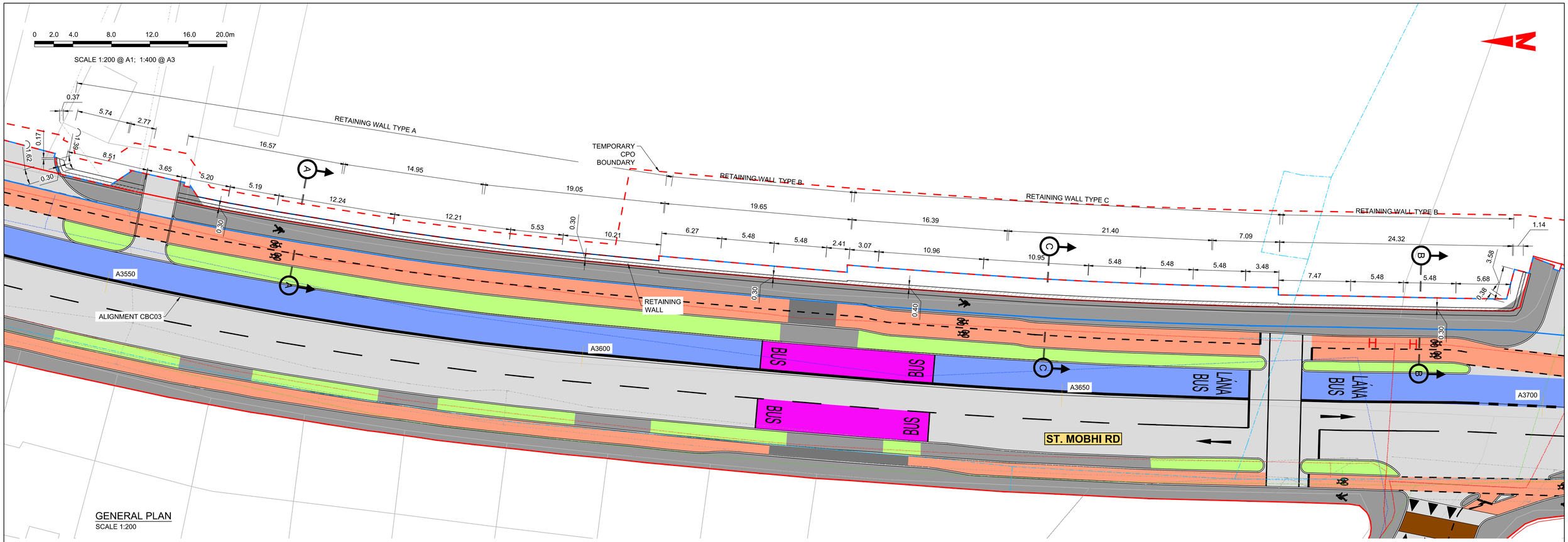

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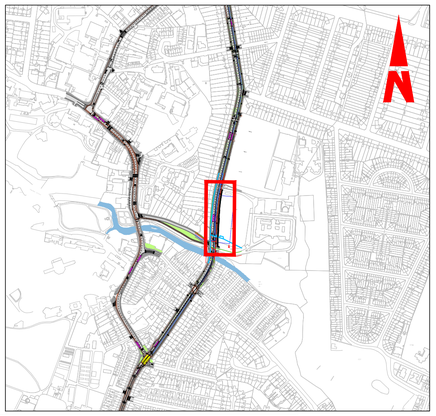

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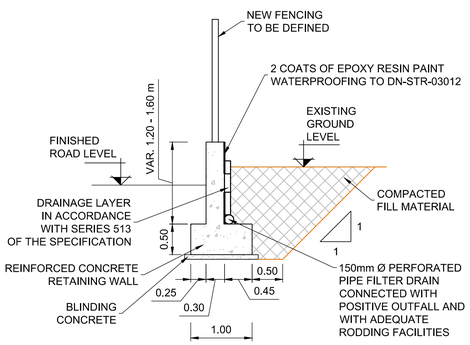

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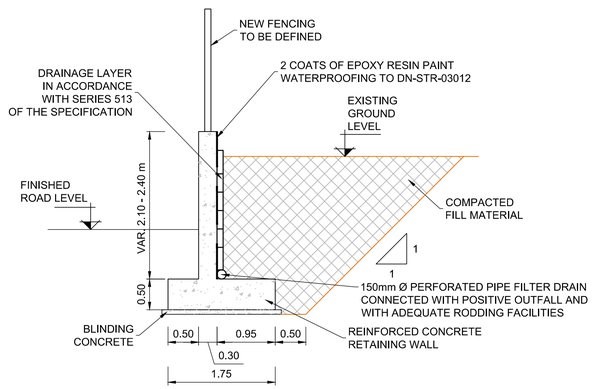

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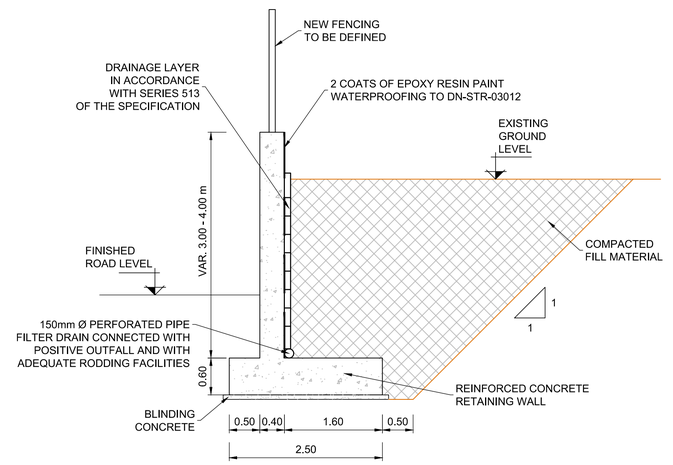

RETAINING WALL TYPE C
SCALE 1:50

*INFORMATION AND DIMENSIONS DRAWN FROM AVAILABLE DRAWINGS PROVIDED BY IANROD EIRANN.

- GASNEVIN ROAD OVERBRIDGE DRAWINGS (SEPT 1894)
- RENEWAL OF PARAPET CROSSGUNS BRIDGE DRAWINGS (26-OCT-1978)

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Programme Title: BUSCONNECTS DUBLIN CORE BUS CORRIDORS INFRASTRUCTURE WORKS

Drawing Title: BALLYMUN / FINGLAS TO CITY CENTRE CORE BUS CORRIDOR SCHEME STRUCTURES BALLYMUN 05. GENERAL ARRANGEMENT & SECTIONS

Drawing File Name	Sheet Number	Status	Rev
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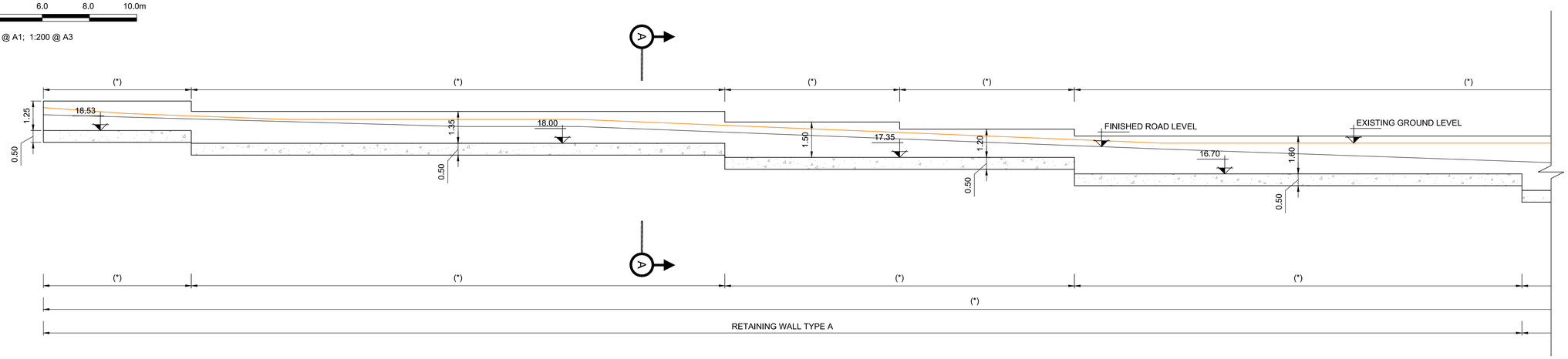

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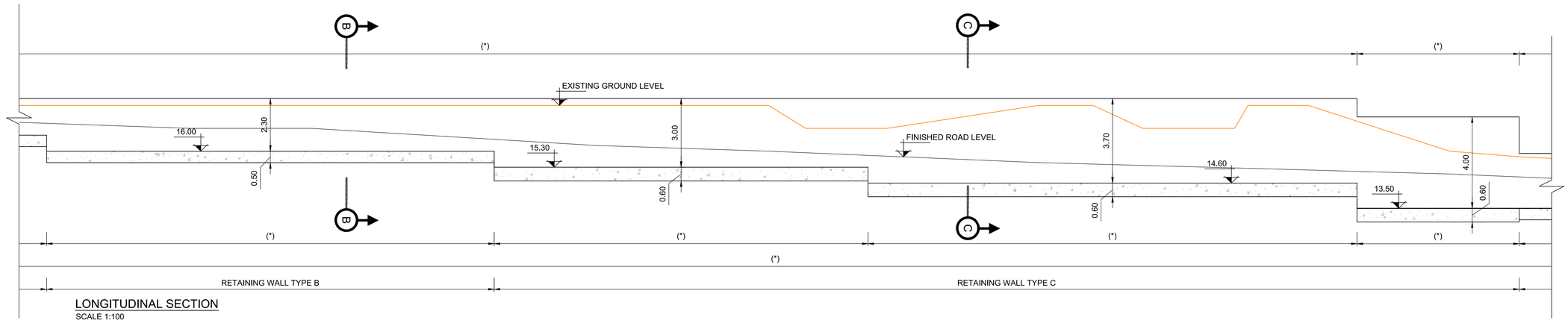

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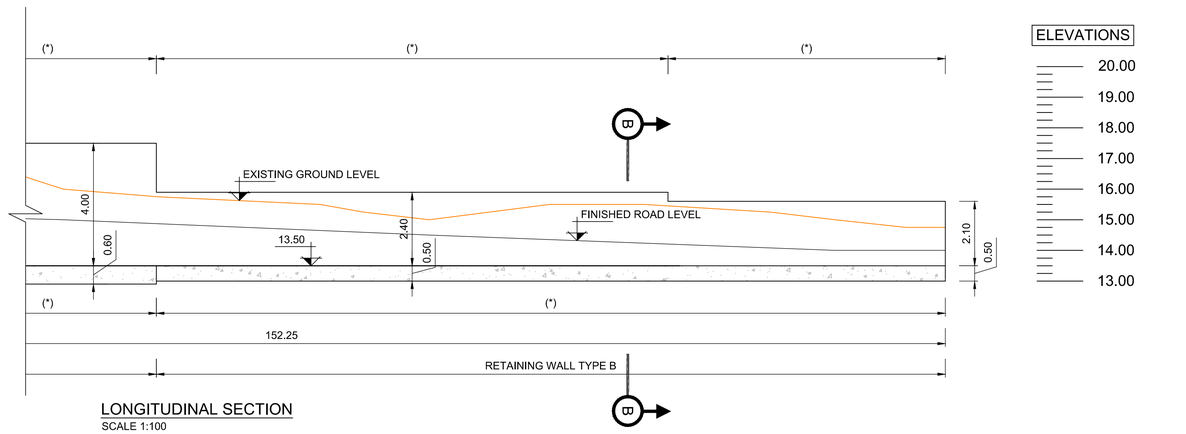
(*) SEE PLAN VIEW FOR DIMENSIONS.



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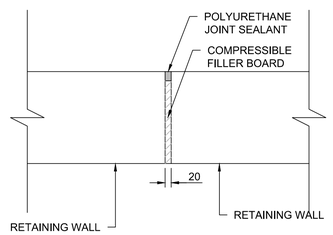

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STRUCTURES
BALLYMUN 05. LONGITUDINAL SECTION

Drawing File Name	Sheet Number	Status	Rev
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APPENDIX 3
RELEVANT EXTRACTS FROM GROUND INVESTIGATION REPORT

1. INTRODUCTION AND DESKTOP REVIEW

The existing site investigation information for the area has been taken from the Geological Survey of Ireland (GSi) website and the British Geological Survey (BGS) website, including the Quaternary and Bedrock Geology of Dublin and Depth of Bedrock digital maps.

The following selection of published papers has found to be of relevance to estimate the lithology and geotechnical properties:

- "Geotechnical properties of Dublin boulder clay". Authors: Long, Michael M and Menkiti, Christopher O. Sept 2007, Géotechnique 57 (7): 595-611. Published by the ICE.
- Ground Investigation Report of the National Pediatric Hospital Project, Dublin. Roughan & O'Donovan Consulting Engineers, January 2015.

1.1 Overview of geotechnical conditions along the Project.

Quaternary sediments cover up to 80% of the Dublin region. Quaternary thicknesses at the city area range from 5 to 20m. Maximum thicknesses are recorded along a Tertiary channel occurring on the north shore of the River Liffey valley, reaching 45m, and along a channel-like feature running along the south margin of the Dodder valley Quaternary sediments, with a thickness of 15 to 25 m.

The most commonly occurring Quaternary deposit in the area has been termed locally as the Dublin Boulder Clay. It is a glacial deposit derived from the Lower Carboniferous Limestone and it is classified by its two main members: the Black Boulder Clay (BkBC) and the Brown Boulder Clay (BrBC). The Brown Boulder Clay is less consolidated and since it overlies the Black Boulder Clay it has been interpreted as its weathered upper layer.

The Upper Brown Boulder Clay (UBrBC) is the outcome of the oxidation of the clay particles in the top 2m to 3m of the UBkBC, resulting in a change in colour from black to brown and a lower strength material. It is usually described as thick stiff to very stiff brown, slightly sandy clay, with rare silt / gravel lenses and some rootlets, particularly in the upper metre.

The Upper Black Dublin Boulder Clay (UBkBC) is a very stiff, dark grey, slightly sandy clay, with some gravel and cobbles. It is typically 4 m to 12 m thick.

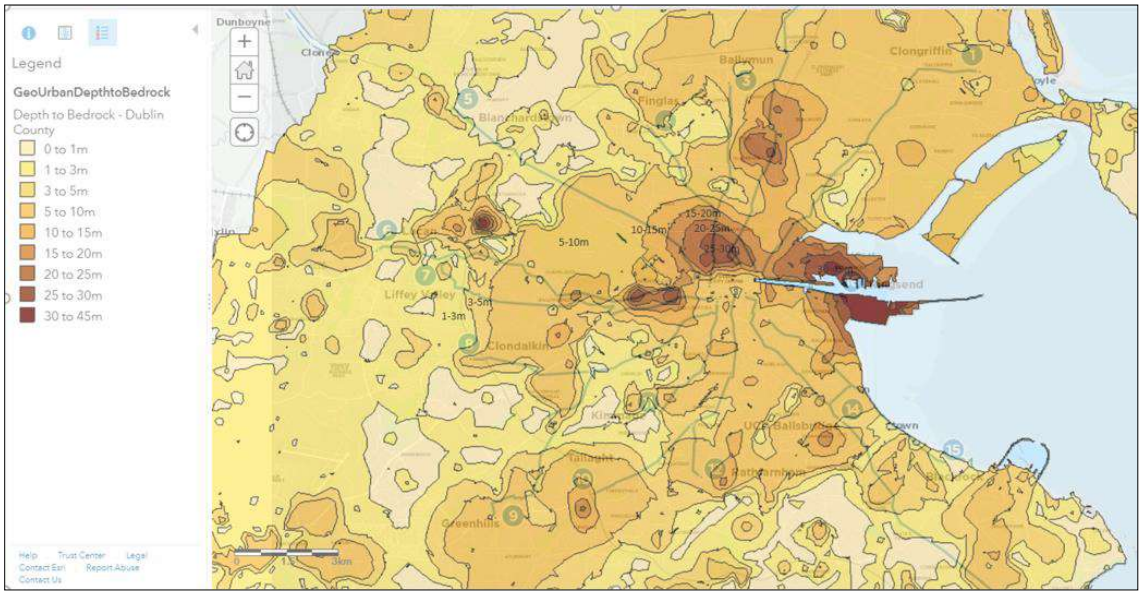
The Lower Brown Dublin Boulder Clay (LBrBC) exists as a 5 m to 9 m thick hard, brown, silty clay, with gravel, cobbles and boulders. It has previously been called the "sandy boulder clay" as it is similar to but siltier than the UBkBC above.

The Lower Black Dublin Boulder Clay (LBkBC) is a patchy layer of hard slightly sandy gravelly clay with an abundance of boulders. Its thickness does not exceed 4 m and is typically less than 2 m.

Note that not all four distinct formations of the Dublin Boulder Clay are always present. The upper two units though have been proven at all investigation sites across the city.

Bedrock close to the surface occurs mostly along the main riverbeds as well as the coastline and the higher ground areas of the Howth peninsula. The bedrock map of Ireland shows a wide variety of rock types which have originated at different periods of geological time. Underlaying the project area consists of Lower Carboniferous Limestone of the Lucan Formation (Calp), which is typically described as a dark grey to black fine grained limestone.

The following image from the Geological Survey Ireland website shows the expected depth to Bedrock.



Depth of Bedrock from the Geological Survey Ireland website

The water pressures correspond to hydrostatic conditions with a groundwater table about 2m below ground level.

- *Summary of Desktop Review.*

The following preliminary lithology and geotechnical properties has been assumed based on the Desktop Review:

Layer	Depth	Thickness	Undrained shear strength, c_u (kPa)
Made ground / Urban / Alluvium	0 to 1 m	1	0
Upper Brown Boulder Clay, UBrBC	1 to 3 m	2	80
Upper Black Boulder Clay, UBkBC	3 to 10 m	7	200
Lower Brown Boulder Clay, LBrBC	10 to 18 m	8	400
Lower Black Boulder Clay, LBkBC	18 to 22 m	4	600
Bedrock	>22 m	N/A	>600

The expected depth to bedrock has been included in Section 2.

2. SUMMARY OF GROUND INVESTIGATION CONTRACT

At the date of this document, there are two GI contracts underway. Lot 1, which includes projects C and D , and Lot 2, which covers A and B projects.

Proposed ground investigation works aim to assess the geology of the site and determine the ground properties and conditions to enable the design of Bus Connects Core Bus Corridors. The GI provides for boreholes, trial pits, dynamic probes, standpipes/piezometer installation and monitoring, in-situ testing, geotechnical and environmental laboratory testing and preparation of a factual report, all in accordance with the "*Specification and Related Documents for Ground Investigation in Ireland*".

At the Project D schemes (Ballymun/Finglas to City Centre, Kimmage to City Centre and Ringsend to City Centre), there are 21 proposed investigation points, consisting of Cable Percussion (CP) and Rotary Core (RC) boreholes as well as few windowless dynamic samples (WS) in restricted space areas. The location of these points can be found in the form of drawings in the "*BusConnects Detailed Ground Investigation – Stage 1 – LOT 1*", February 2020.

In situ tests mainly include standard penetration tests. Laboratory tests mainly include particle size distribution, Atterberg limits, density and moisture content to identify soils and direct shear strength, triaxial CU or UU and uniaxial compression to determine the strength of the soil/rock.

For more details see the "*BusConnects Detailed Ground Investigation – Stage 1 – LOT 1*", February 2020.

For the Ringsend to City Centre Core Bus Corridor Scheme, the following investigation points have been proposed:

Borehole Ref.	Expected Depth to Bedrock	Borehole Depth (m) – Cable Percussion	Borehole Depth (m) – Rotary Core
R3-CP01	15-20m	15	-
R3-CP02	15-20m	15	-
R3-CP03	15-20m	15	-
R3-CP04	15-20m	15	-
R3-CP05	15-20m	15	-
R3-CP06	15-20m	15	-
R3-CP07	15-20m	15	-
R3-CP08	15-20m	15	-
R3-CP09	20-25m	15	-
R3-CP10	20-25m	20	-
R3-CP11	20-25m	20	-
R3-CP12	20-25m	20	-
R3-CP13	20-25m	20	-
R3-CP14	20-25m	15	-

3. SUMMARY OF FACTUAL REPORT

The following factual report was issued as part of the Lot 1 GI:

Detailed Stage 1 Lot 1 Route 3. July 2021 Completed investigation points are as summarised below:

Structure	Borehole Ref.	Expected Depth to Bedrock	Borehole Depth (m) – Cable Percussion	Borehole Depth (m) – Rotary Core	Notes
Ballymun 01	R3-CP01	15-20m	-	-	Cancelled
	R3-CP02	15-20m	-	-	Cancelled
Ballymun 02	R3-CP03	15-20m	7.1	-	
Ballymun 02&03	R3-CP04	15-20m	-	-	Cancelled
	R3-CP05	15-20m	-	-	Cancelled
	R3-CP06	15-20m	-	-	Cancelled
Ballymun 03	R3-CP07	15-20m	6.0	-	

Structure	Borehole Ref.	Expected Depth to Bedrock	Borehole Depth (m) – Cable Percussion	Borehole Depth (m) – Rotary Core	Notes
	R3-CP08	15-20m	4.8	-	Changed to WS03 (Drive-in Windowless Sampler)
Ballymun 04	R3-CP09	20-25m	-	20	Changed to RC01
	R3-CP10	20-25m	-	20	Changed to RC02
	R3-CP11	20-25m	-	20	Changed to RC03
	R3-CP12	20-25m	1.5	-	Changed to WS01 (hand window sample)
	R3-CP13	20-25m	1.0	-	Changed to WS02 (hand window sample)
	R3-CP14	20-25m	9.0	-	

In addition, the following reports have been received to complete the GI performed for Lot1:

- GIR New Metro North (Glasnevin). March 2018. This includes 2 boreholes located among performed boreholes in Route 3.
- MetroLink Phase 4 GI. October 2020. This includes 2 boreholes and 3 inspection pits located among performed boreholes in Route 3.

The GI works undertaken comprise 3 No. Cable Percussion Boreholes to a maximum depth of 9.0m BGL, 3 No. Window Samples and 3 No. Rotary Core Boreholes to a maximum depth of 20.0m BGL; 58 SPT tests at 1 metre intervals alternating with disturbed samples, 2 No. Dynamic probeholes and 4 GWL recordings.

18 disturbed samples were taken at each change of soil consistency or between SPT tests and 1 undisturbed sample (UT100) where ground conditions permit. Geotechnical testing consisted of 19 moisture content, 8 Atterberg limits and 10 Particle Size Distribution. Soil strength testing consisted of 1 UU Triaxial Test, 2 Vane tests and 2 Shear Box.

Environmental & Chemical testing consisted of 23 Suite E samples and 2 PH and Organic matter content tests.

From Glasnevin and MetroLink Phase 4 GI works, 3No. Inspection Pit, 2 No. Cable Percussion Boreholes followed by Rotary Core Boreholes to a maximum depth of 40m BGL, 2 No. Rotary Core Boreholes to a maximum depth of 35.4m BGL; 40 SPT tests at 1 metre intervals alternating with disturbed samples and 6 GWL recordings.

40 disturbed samples were taken at each change of soil consistency or between SPT tests. Geotechnical testing consisting of 40 moisture content, 25 Atterberg limits and 24 Particle Size Distribution. Soil strength testing consisted of 9 CU Triaxial Tests, 3 CU Triaxial Tests with PWP and 2 Shear Box. Rock strength testing included 12 Unconfined Compressive Strength (UCS) testing, 13 Point Load Tests and 3 Brazilian Tests.

4. OVERVIEW OF SOIL CLASSIFICATION

4.1 Made ground

Made Ground deposits were encountered either from the surface or beneath the Topsoil/Surfacing and were present to depths of between 1.40m and 6.50m BGL.

Made ground deposits were described generally as either dark grey / brown, sandy gravelly Clay with occasional cobbles or greyish brown clayey sandy Gravel. In some investigation holes the made ground contained occasional fragments of concrete, ceramic, red brick metal, rubber and wood.

Soil classifies as CLAY of intermediate to high plasticity, with a plasticity index ranging between 17% and 40%.

The Particle Size Distribution tests confirm percentages of sands and gravels ranging between 10% and 42% and 24% and 47%, respectively.

PH and total organic carbon (TOC) were determined at boreholes R03-CP03 and C03-CP08, at 1m and 0.5m depth respectively. Organic matter content (OMC) was estimated from TOC. Average values of PH 7.8, TOC 2.7 % w/w C and OMC 4.6 % w/w were obtained.

Samples R03-WS02 and R03-CP14 showed high values (>6% w/w C) of total organic carbon at Suite E tests. Asbestos was detected at 0.5m depth at borehole R03-CP08.

4.2 Cohesive deposits

Cohesive deposits were encountered beneath the Made Ground and were described typically as brown sandy gravelly CLAY or grey / dark grey sandy gravelly CLAY with occasional cobbles and boulders.

The strength of the cohesive deposits typically increased with depth. In the majority of the exploratory holes, it was firm below 3.0m BGL, stiff below 5.0m BGL and very stiff below 7.0m BGL

The geotechnical testing carried out on recovered soil samples generally confirm the descriptions on the logs and classified the deposits as CLAY of low, with a plasticity index ranging between 14% and 17%.

The Particle Size Distribution tests confirm generally well-graded deposits with percentages of sands and gravels ranging between 14% and 31% and 20% and 56%, respectively, with average values of 22% of sand and 34% of gravel.

4.3 Bedrock

The rotary core boreholes recovered weak to medium strong thinly laminated to thickly bedded grey/dark grey fine-grained LIMESTONE locally interbedded with medium strong dark grey fine grained laminated MUDSTONE.

The depth to rock is of 18.5m BGL. RQD values are very poor but presumably because they belong to the upper weather zone.

5. SUMMARY OF GROUND INVESTIGATION INTERPRETATIVE REPORT

For Ballymun/Finglas to City Centre CBC scheme, the following lithology and soil strength properties has been assumed based on the GI findings:

Layer	Depth (m)	SPT	Undrained shear strength, c_u (kPa)
Topsoil	0 to 0.5 m	-	-
Made Ground: Gravel / Brown Clay (possibly UBrBC) / Grey Clay	0.5 to 4m	8	50
Stiff / Very stiff Grey or Dark Grey Boulder Clay (UBkBC)	4 to 12.5	20-50	250
Very stiff Brown Boulder Clay (LBrBC)	12.5 to 17.5	50	325
Gravel	14 to 18.5	50	325
Limestone	>18.5	-	-

- 2 Vane tests at Made Ground layer UBrBC, defined as brown slightly sandy slightly gravelly Clay have shown Peak shear strength values of about 20 KPa.

- 1 undrained triaxial UU test at UBrBC layer, defined as stiff brown slightly sandy gravelly Clay, has given a shear strength of about 80 KPa.

- 2 Shear Box tests at UBkBC layer, defined as slightly sandy slightly gravelly Clay, shown angles of peak shearing resistant between 32 and 36 degrees and effective cohesion between 5 and 15 kPa.

From Glasnevin project 9 triaxial CU tests. Layers of UBkBC and LBrBC shown values between 600 and 700 kPa. Also 1 triaxial CU from Thameslink project on LBrBC showing a value of 800 kPa.

From Metrolink 2 Shear Box tests, one at Made Ground layer showing an angle of peak shearing resistant of 29 degrees and effective cohesion of 6 kPa, and another at the bottom Gravel layer with an angle of peak shearing resistant of 34 degrees and no effective cohesion.

The geological geotechnical ground profile can be found at Appendix 1.

Ground parameters from in situ and lab tests are shown in Appendix 2.

6. HIDROGEOLOGY

Groundwater was noted during the investigation although the exploratory holes did not remain open for sufficiently long periods of time to establish the hydrogeological regime. However, standpipes were installed to allow the equilibrium groundwater level to be determined.

Groundwater levels recorded during the GI works are summarized below:

Date:	20/4/21	16/6/21
R3-CP01	-	-
R3-CP02	-	10.03
R3-CP03	-	-
R3-CP04	-	-
R3-CP05	-	-
R3-CP06	-	-
R3-CP07	1.29	1.27
R3-CP08	-	-
R3-CP09	-	-
R3-CP10	-	-
R3-CP11	-	-
R3-CP12	-	-
R3-CP13	-	-
R3-CP14	-	1.25

Date:	9/2/18	14/2/18
Glasnevin BH01	9.80	9.80
Glasnevin BH02A	10.10	11.25
Date:	**30/7/20**	**31/7/20**
Metrolink GBH01	8.97-9.06	-
Metrolink GBH02	-	10.47-11.2

7. GEOTECHNICAL INPUT TO STRUCTURES

The following table shows the expected depth to bedrock, based on the data from the Desktop Review, as well as the depth of the encountered bedrock in the GI undertaken.

Note that most of the boreholes were terminated at a shorter length, before encountering the bedrock strata. Therefore, the expected depth to bedrock could not be confirmed.

Structure	Permanent loads / Variable loads (KN)	Borehole Ref.	Expected Depth to Bedrock	Depth to encountered Bedrock	Depth to N_{SPT} values of Refusal	Piles estimated length (m)
Ballymun 01 D=0.5m	454 / 120	-	15-20m	-	-	9.5
Ballymun 02 D=0.5m	424 / 179	R3-CP03	15-20m	-	5m	8.5
Ballymun 03 D=0.5m	82 / 169	R3-CP07	15-20m	-	5m	5.5
		R3-WS03	15-20m	-	5m	5.5
Ballymun 04 D=0.8m	298 / 425	R3-RC01	20-25m	18.5m	9.5m	10.0
		R3-RC02	20-25m	18.5m	6.5m	7.0
		R3-RC03	20-25m	18.5m	8m	8.5
		R3-WS01	20-25m	-	-	-
		R3-WS02	20-25m	-	-	-
		R3-CP14	20-25m	-	5m	6.0
Ballymun 04 D=0.5m	298 / 425	R3-RC01	20-25m	18.5m	9.5m	14.5
		R3-RC02	20-25m	18.5m	6.5m	12.0
		R3-RC03	20-25m	18.5m	8m	12.0
		R3-WS01	20-25m	-	-	-
		R3-WS02	20-25m	-	-	-
		R3-CP14	20-25m	-	5m	11.0

A preliminary number of the characteristic compressive resistance of piles has been obtained following the alternative procedure in accordance with the Eurocode 7 and the Irish National Annex. This procedure makes use of the ground parameters (such as the undrained shear strength, c_u) to estimate the shaft and base compressive resistance of piles.

Cu values have been derived from SPT values obtained in each borehole following the SPT-Cu relationship proposed by Stroud and Butler (1975). Calcs can be found at Appendix 3.

For 0.5m diameter driven piles embedded in the Dublin boulder clay (except for Ballymun 04, where piles diameters are 0.8m), the estimated piles length that satisfies the ULS is as detailed in the table above.

At Ballymun 04 a retaining wall is proposed, for which the following geotechnical parameters derived from the ground investigation works can be used for the design

Route 3 Ballymun 04	**Depth (m)**	**Dry weight (KN/m^3)**	**Undrained shear strength, c_u (kPa)**	**Young's modulus E (MPa)**	**Undrained Young's modulus (MPa)**	**Friction angle φ' (º)**	**Cohesion c' (KPa)**	**Poisson's coefficient (-)**	**Earth pressure coefficient at rest K_0 (-)**	**Horizontal spring stiffness (KN/m^3)**
Made Ground	0 to 4.5m	-	50	25	-	28	0	0.3	1	3,500 – 5,000
Grey Boulder Clay (UBkBC)	4.5 to 12.5	22.5	250	80	100	30	0	0.2	1.3	17,000 – 20,000
Brown Boulder Clay (LBrBC)	12.5 to 17.5	-	325	-	120	35	0	0.2	1.3	20,000 – 25,000
Mudstone	17.5 to 19.5	-	325	-	-	-	-	-	-	-
Limestone	>19.5	25	500	800	1000	45	0	.	-	35,000 – 37,500

APPENDIX 4
OTHER RELEVANT DOCUMENTATION/REPORTS

(Not used)