## Appendix J4

Preliminary Design Report – Structure K04 – Ramp at Windsor Terrace

# 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): Kimmage 04 Walkway & Ramp

Preliminary Design Report

Reference BCIDD-ROT-STR-ZZ_0011-XX_00-RP-CB-0018

Revision L02

Date Jun-2022

**Submitted by**

Signed: ______________________________

Name: Fernando Fernandez

Position: (Structures Team Leader)

Organisation: Roughan & O'Donovan – TYPSA Consulting Engineers

Date: 27-06-2022

**Structures Section confirmation of consultation:**

Signed: ______________________________

Name: ______________________________

Position: ______________________________

Date: ______________________________

# BUSCONNECTS INFRASTRUCTURE DELIVERY – PROJECT D

# PRELIMINARY DESIGN REPORT – KIMMAGE 04

## 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 Kimmage 04 ramp as part of the Busconnects Infrastructure Delivery – Project D.

## 1.2 Background Information

The proposed scheme for Kimmage 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 Kimmage 04 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 bridges.

Photographs of the structure are included in Appendix 1.

It is envisaged that this structure will be part of Kimmage 01B, as approach structure, in subsequent design stages.

## 1.3 Previous Studies

Reports prepared and published for this structure to date include:

- BCID-ROT-ERW-GI_0011-RP-CR-0001 – Geotechnical Interpretive Report: Kimmage Corridors

# 2. SITE & FUNCTION

## 2.1 Site Location

The Kimmage 04 structure is a ramp, running parallel to Windsor Terrace Street. The ramp is required to accommodate a new footpath, as the existing footpath is very narrow and would form a bottleneck with the new footbridge approach. The site location plan is included in Appendix 2.

## 2.2 Function of the Structure

The objective of the new walkway is to provide unimpeded passage for pedestrian along Windsor Terrace Street and connect with the new bridge (Kimmage 01B) over the Grand Canal.

## 2.3 Choice of Location

The location of the structure was chosen to facilitate the proposed Kimmage 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.

The level of the existing carriageway at the top of the ramp is 23.50m and 21.30m at the lower end of the ramp.

## 2.5 Vertical and Horizontal Alignments

Horizontal and vertical road alignments at the ramp location are described below. The proposed general arrangement drawings can be seen in Appendix 2.

*Horizontal Alignment*

The structure follows partially the footpath alignment at the upper section of Windsor Terrace Street and ends within the towpath at the northern bank of the Grand Canal.

*Vertical Alignment*

The proposed structure incorporates a constant gradient of 5.5% to match the new Kimmage 01B bridge level at its western end.

## 2.6 Cross-Sectional Dimensions on the Alignments

The proposed mainline cross section at the structure location is shown in Table 2.1.

**Table 2.1: Kimmage 04 Cross-Section. Earth ramp-embankment**

| Parameter | Value |
|---|---|
| Railing | 0.125 m |
| Footpath | 2.00 m |
| Railing | 0.125 m |
| **Out-to-Out Width** | **2.25 m** |

**Table 2.2: Kimmage 04 Cross-Section. Elevated ramp-structure**

| Parameter | Value |
|---|---|
| Railing | 0.125 m |
| Footpath | 0.970 m |
| **Out-to-Out Width** | **1.095 m** |

## 2.7 Existing Underground and Overground Services

A list of the existing services located in close proximity to the Kimmage 02 bridge is outlined below.

*Low and Medium Voltage Electricity Lines*

No conflicts were found in the vicinity of the structure.

*High Voltage Electricity Lines*

ESB high voltage underground lines are at the location of the proposed structure. Diversion may be required. These may need to be further discussed with ESB.

*Telecommunications*

No conflicts were found in the vicinity of the structure.

*Water Supply*

No conflicts were found in the vicinity of the structure.

*Gas Networks*

Gas mains are present at the vicinity of the structure's location. These may need to be diverted following discussions with Gas Networks Ireland.

## 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 bridge will have minimal effect on the hydrology in the area. The ramp is founded on the Grand Canal bank but outside of the wetted channel section.

## 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 Kimmage 04 ramp consists of two different parts: a structural ramp at the upper level of the street, circa 20.0m length with a gradient of approx. 5.5%; and an earth embankment ramp at the lower level of the street, with a flat section of circa 10.0m and a further sloped section of 20.0m at approx. 5,5% gradient. The overall length of the ramp is approximately 50.0m

## 3.2 Aesthetic Considerations

The walkway form is adopted to protect mature trees at the vicinity of Kimmage 01B. Thus, the elevated ramp removes the need for new foundations in the riverbank area; ensuring the large trees are not impacted by the proposed structure. The depth of the elevated walkway has been minimised as far as practicable to give a slender span-depth ratio.

Furthermore, the embankment ramp in the lower section minimises the ramp foundations further and blends naturally with the riverbank surroundings, in addition to providing a tree root protection system, mitigating any negative effect on adjacent trees. Several small trees shall be removed though.

The width of the walkway meets the intention to design the proposed footpath due to the existing one is very narrow and would form a bottleneck with the new footbridge approach.

The parapets 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 structure is a Category 1 structure.

### 3.3.2 Span Arrangements

The steel structural area has 10No. spans with an average length of 2m. The overall length of the cantilever ramp is 20m.

### 3.3.3 Minimum Headroom Provided

Not applicable.

### 3.3.4 Approaches (incl. Run-on Arrangements)

Not applicable.

### 3.3.5 Foundation Type

The structural section of the ramp consists of a reinforced concrete foundation slab from where the steel structure is cantilevering. The foundation slab will be cast in-situ at the existing footpath location and atop the existing retaining wall, which will require partial demolition. The foundation slab will serve as the back-span and counterweight for the cantilevered section.

The embankment section of the ramp consists of a low earth embankment, or a green-faced retaining wall, with geosynthetics cells, minimising foundation requirements.

### 3.3.6 Substructure

Not applicable.

### 3.3.7 Superstructure

The cantilever section is formed by a steel-tapered primary beam section fixed to the side of the foundation slab; steel longitudinal bracings spanning between the main beams and deck formed by perforated steel sheets.

Geometry and dimensions of these columns are as described on the drawings included in Appendix 2.

### 3.3.8 Articulation Arrangements (Joints and Bearings)

The structure will be designed to be a fully integral frame. There will be no requirement for any articulation of the structure.

### 3.3.9 Vehicle Restraint System

All parapets will comply with TII DN-STR-03034 (historical ref. NRA TD19) and EN 1317. The parapet proposed for this footbridge 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.

### 3.3.10 Drainage

A perforated metal deck is used for the deck of the walkway, thus no drainage system is necessary for the structure.

### 3.3.11 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.
- Contract Documents should make allowance for impregnation and coating of steel beams to prevent corrosion.

### 3.3.12 Sustainability

Life cycle sustainability assessment (LCSA) has been considered for the detailed design of the proposed bridge 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:

- Due to the lightness of steel structures (cantilevered section), the load transmitted to the foundation slab are relatively small. Thus, the foundation slab can be founded on top of the existing retaining wall. Further site investigation will be required to assess the existing retaining wall.
- The earth embankment section of the ramp mitigates any negative effect on existing trees, where this section is proposed to be built in an area where a tree root protection system is required.

- At the end of the structure's service life, the fact that it is made of steel means that it can be 100% recycled, whereas concrete structures need to be taken to a landfill site.
- Concrete is manufactured in Ireland.

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.

### 3.3.13 Inspection and Maintenance

The inspection of bridges 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.

**Superstructure**

Structural steelwork (upper section of the ramp) will require regular inspection and maintenance, with major maintenance (paint system) required every 20 years.

**Substructures**

The substructure of the upper section of the ramp consists of in situ reinforced concrete, which should not incur any substantial maintenance costs.

**Reinforced Earth ramp**

The reinforced earth ramp will require the typical maintenance of a green area. Nevertheless, plants propose to create the green walls on the ramp will aim to minimise regular maintenance and watering.

**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. glass, galvanised steel parapets, etc.).

# 4. SAFETY

## 4.1 Traffic Management during Construction

Traffic management will be required during construction. Pedestrian diversion and total or partial closures will be needed at Windsor Terrace Street during construction.

## 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

Bridge parapets will be designed as pedestrian and cyclist parapets 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

Lighting under the bridge is not required. Lighting over the bridge will be provided in accordance with BS-5489-1.

# 5. COST

## 5.1 Budget Estimate in Current Year (incl. Whole Life Cost)

The estimated cost for the construction of the bridge is 170.000€.

### Basis of Cost Estimate

The cost estimate has been produced on the following basis:

- Figures are given in Euro and are based on 2019 rates (excluding VAT) – TII Schedule of Rates 2019 (CC.GMP.00054);
- Excludes land acquisition and rights of way;
- Excludes preliminaries;
- The Construction Cost Estimate does not include for fees associated with the following:
  - Additional SI and Topo;
  - Environmental Assessment;
  - Detailed Design and Checking;
  - Contract Administration;
  - Site Supervision during Construction.

# 6. DESIGN ASSESSMENT CRITERIA

## 6.1 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.

### 6.1.1 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$^3$

### 6.1.2 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.

### 6.1.3 Actions relating to Normal Traffic

None.

### 6.1.4 Actions relating to Abnormal Traffic

None.

### 6.1.5 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.

### 6.1.6 Provision for Exceptional Abnormal Loads

None.

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

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

### 6.1.8 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.

### 6.1.9 Any Special Loading Not Covered Above

None.

## 6.2 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;
- Waterways Ireland.

## 6.3 Proposed Departures from Standards

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

## 6.4 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.

# 7. GROUND CONDITIONS

## 7.1 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 can be found on the Geotechnical Interpretation Report, document No. BCID-ROT-ERW_GI-0011-RP-CR-0001. An extract of the Geotechnical Interpretation Report is included in Appendix 3.

The site investigation information considered is from Kimmage 01A & 01B. Due to the loadings from the proposed structure, it is considered shallow foundations are to be an appropriate solution.

# 8. DRAWINGS & DOCUMENTS

## 8.1 List of All Documents Accompanying the Submission

**Appendix 1 – Photographs:**

(2No. of photos)

**Appendix 2 – Site Location and Drawings**

- BCIDD-ROT-STR_KP-0011_XX_00-DR-SS-0001 – Kimmage to City Centre Core Bus Scheme – Bridges and Retaining Structures – Key Plan
- BCIDD-ROT-STR_ZZ-0011_XX_00-DR-SS-0008 – Kimmage 04. General Arrangement.

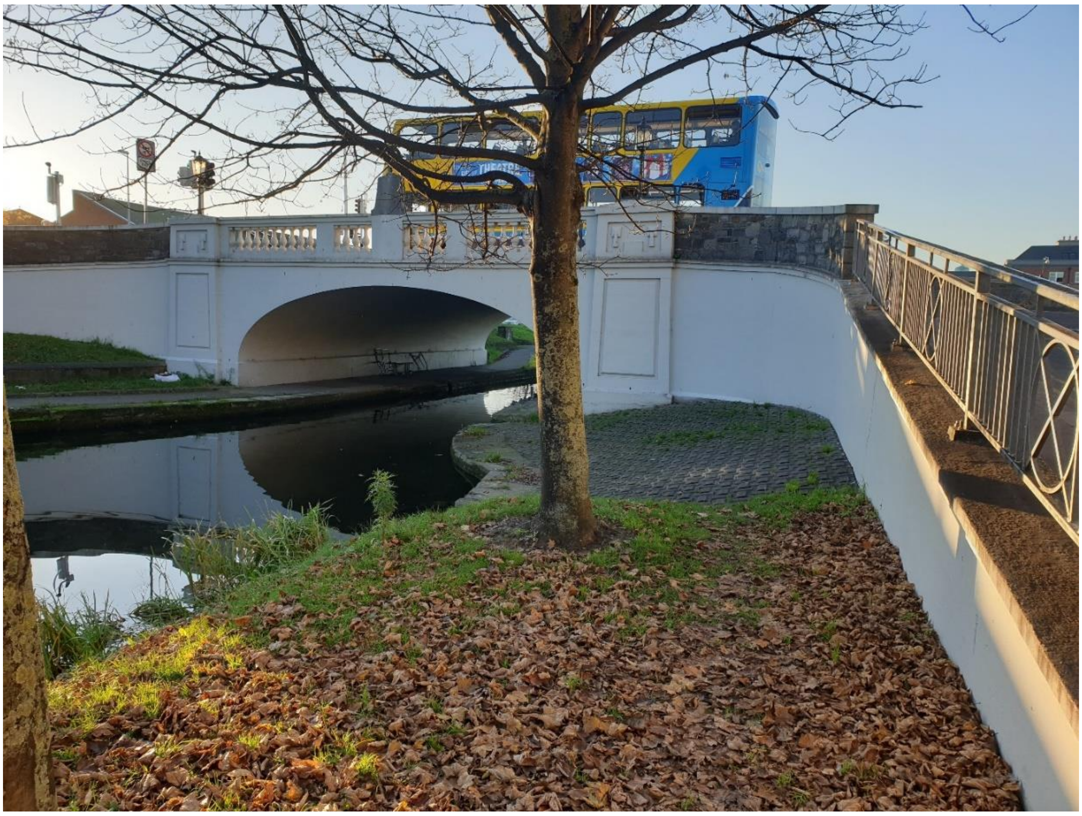
**Appendix 3 – Relevant Extracts from Ground Investigation Report**

(6No. of pages)

**Appendix 4 – Other Relevant Documentation/Reports**

(Not Used)

# APPENDIX 1
# PHOTOGRAPHS



*Existing Robert Emmet Bridge – looking from the East side. Location of proposed Kimmage 04 upper ramp*

*Grand Canal Banks at proposed Kimmage 04 location – lower ramp*

# APPENDIX 2
# DRAWINGS




Project Ireland 2040
Building Ireland's Future

| Rev | Date | Drn | Chk'd | App'd | Description |
|---|---|---|---|---|---|
| L01 | 02/07/2021 | JGE | EFD | SMG | ISSUE FOR APPROVAL |
| L02 | 26/11/2021 | JVG | EFD | SMG | ISSUE FOR PHASE 3: PRELIMINARY DESIGN |

Client: NTA Údarás Náisiúnta Iompair National Transport Authority

Engineering Designer: ROD ROUGHAN & O'DONOVAN TYPSA

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

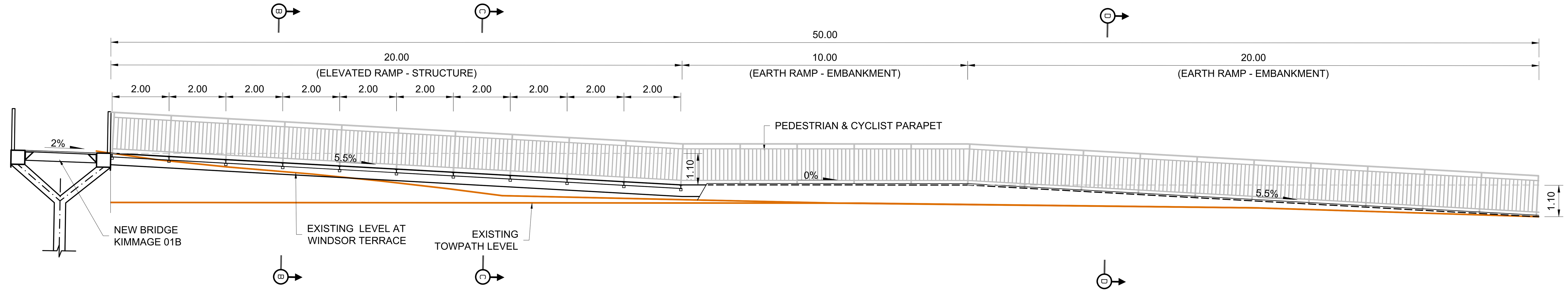
Drawing Title: CBC 11 KIMMAGE TO CITY CENTRE CORE BUS CORRIDOR SCHEME BRIDGES & RETAINING STRUCTURES KEY PLAN

| Date | Scale | Drawn | Checked | Approved |
|---|---|---|---|---|
| 26/11/2021 | 1:10000 @ A1 1:20000 @ A3 | JVG | EFD | SMG |

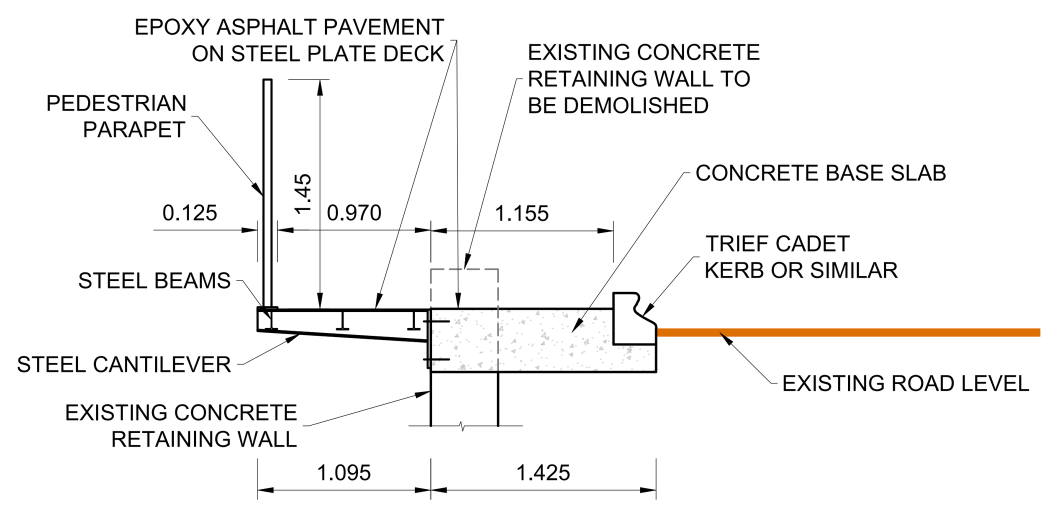
| Project Code | Originator Code | QMS Code | Drawing File Name | Sheet Number | Status | Rev |
|---|---|---|---|---|---|---|
| BCIDD | NTA | | BCIDD-ROT-STR_KP-0011_XX_00-DR-SS-0001 | 01 of 01 | A | L02 |

DO NOT SCALE USE FIGURED DIMENSIONS ONLY

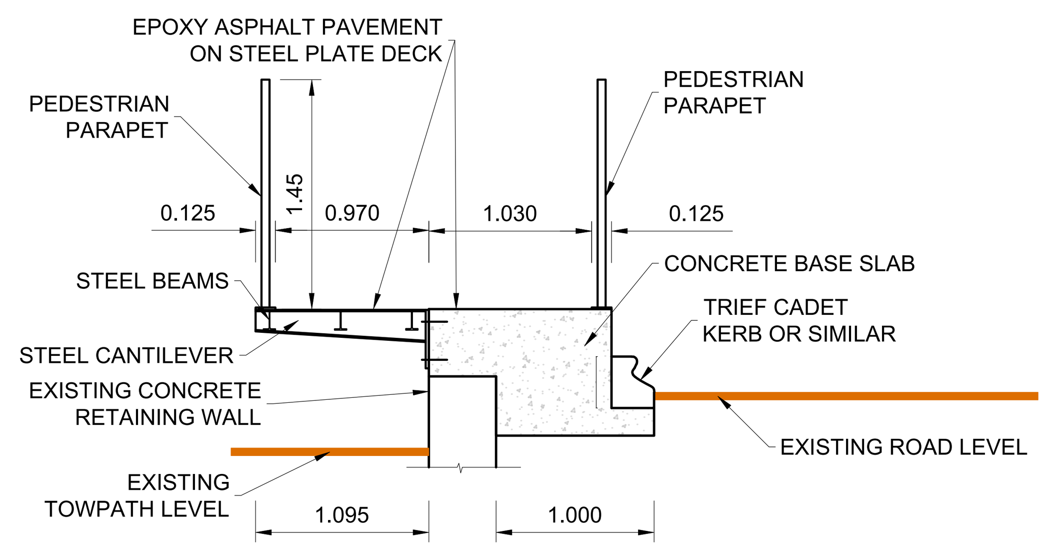

GENERAL PLAN
SCALE 1:100



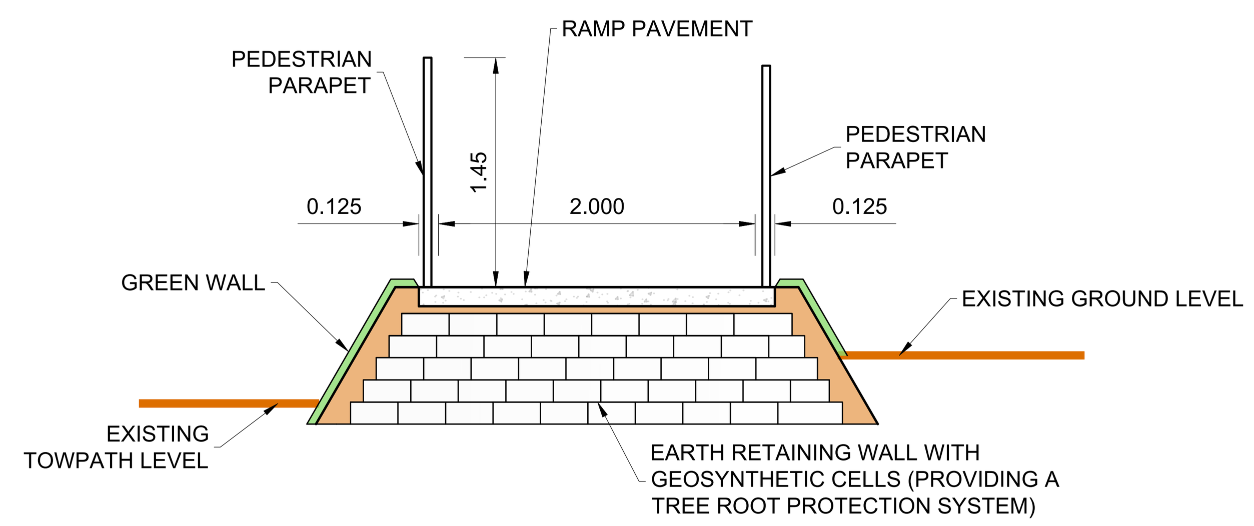

LONGITUDINAL SECTION A-A
SCALE 1:100




SECTION B-B
SCALE 1:40



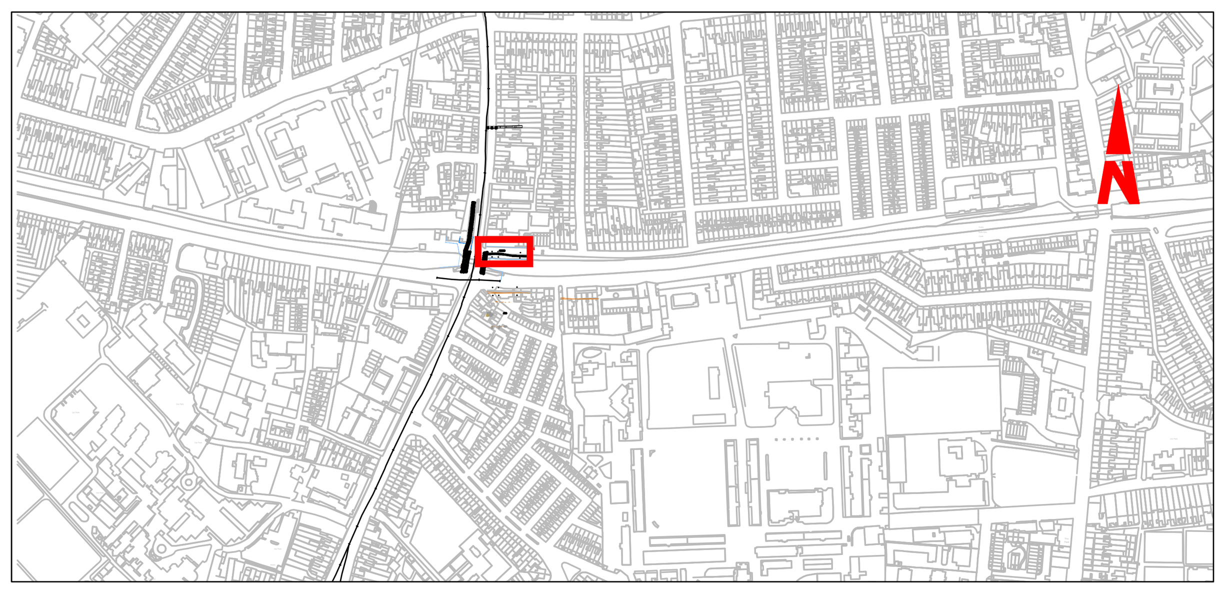

SECTION C-C
SCALE 1:40




SECTION D-D
SCALE 1:40

## NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. THE GENERAL ARRANGEMENT IS INDICATIVELY ONLY.
3. 3. PRIOR TO THE EXECUTION OF THE WORKS, THE CONTRACTOR MUST CHECK ON SITE THE GEOMETRY AND DIMENSIONS OF THE EXISTING STRUCTURAL ELEMENTS. SHOULD THE CONTRACTOR FIND ANY DISCREPANCY WITH THOSE INDICATED IN THE DRAWINGS, THEN IT SHALL BE COMMUNICATE IMMEDIATELY TO THE PROJECT DIRECTOR PRIOR COMMENCING CONSTRUCTION WORKS.
4. ALL BURIED SURFACES TO BE WATERPROOFED IN ACCORDANCE WITH THE TII SPECIFICATION FOR ROAD WORKS.
5. FOUNDATION DETAILS SUBJECT TO CONFIRMATION OR RECEIPT OF G.I.
6. SAFETY BARRIER IN ACCORDANCE WITH DN-REG-03034
7. STRUCTURAL STEEL ELEMENTS:
   - STEEL S355
8. SERVICES SHOWN INDICATIVELY ONLY. THE CONTRACTOR SHALL IDENTIFY THE SERVICES ON SITE PRIOR COMMENCING CONSTRUCTION WORKS.



KEY PLAN



Project Ireland 2040
Building Ireland's Future

| Rev | Date | Drn | Chk'd | App'd | Description |
|---|---|---|---|---|---|
| L01 | 16/04/2021 | JGE | EFD | SMG | PEER REVIEW STAGE B |
| L02 | 26/11/2021 | JVG | EFD | SMG | ISSUE FOR PHASE 3: PRELIMINARY DESIGN |

Client: NTA Údarás Náisiúnta Iompair National Transport Authority

Engineering Designer: ROD TYPSA

Programme Title: BUSCONNECTS DUBLIN
CORE BUS CORRIDORS INFRASTRUCTURE WORKS

Drawing Title: CBC11
KIMMAGE TO CITY CENTRE CORE BUS CORRIDOR SCHEME
STRUCTURES
KIMMAGE 04. GENERAL ARRANGEMENT

| Date | Scale | Drawn | Checked | Approved |
|---|---|---|---|---|
| 26/11/2021 | 1:100 @ A1<br>1:200 @ A3 | JVG | EFD | SMG |

| Project Code | Originator Code | QMS Code | Drawing File Name | Sheet Number | Status | Rev |
|---|---|---|---|---|---|---|
| BCIDD | ROT | | BCIDD-ROT-STR_ZZ-0011_XX_00-DR-SS-0008 | 01 of 01 | A | L02 |

DO NOT SCALE USE FIGURED DIMENSIONS ONLY

\\proyecto.typsa.es\RD5862\3-WIPR\3-2-GRPH\DRW11-KIMMAGE\BCIDD-ROT-STR_ZZ-0011_XX_00-DR-SS-0008.dwg

# 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.

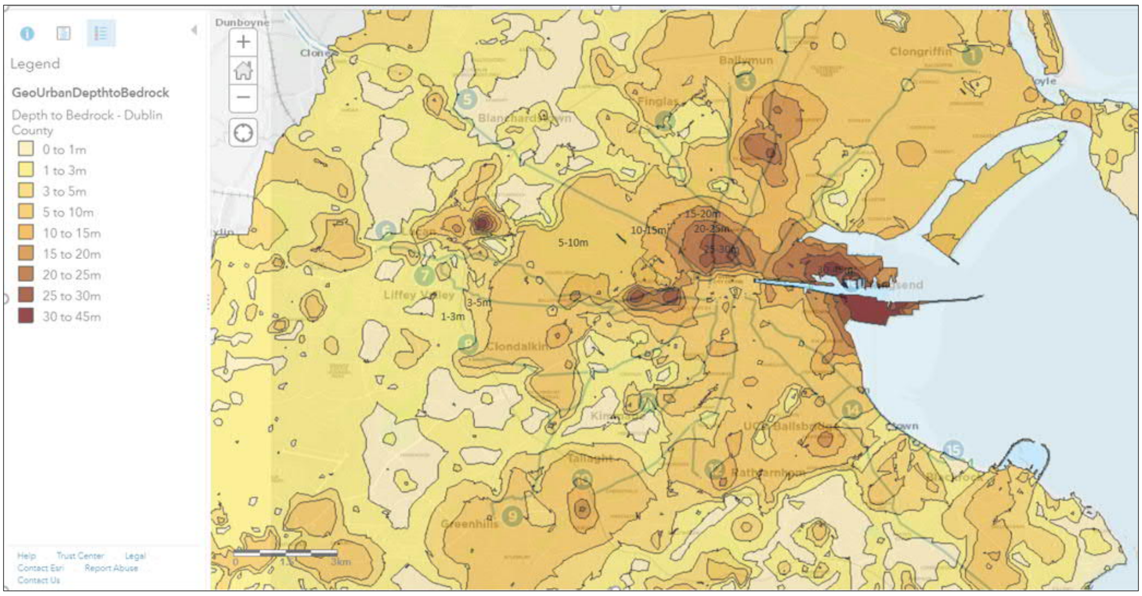
The Lower Brown Dublin Boulder Clay (LBrBC) exists as a 5 m to 9 m thick hard, brown, silty clay, with gravel, cobbles and boulders. It has previously been called the "sandy boulder clay" as it is similar to but siltier than the UBkBC above.

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, cu (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 Kimmage to City Centre Bus Corrido Scheme, the following investigation points have been proposed:

| Borehole Ref. | Expected Depth to Bedrock | Borehole Depth (m) – Cable Percussion | Borehole Depth (m) – Rotary Core |
|---|---|---|---|
| R11-CP01 | 5-10m | 10 | 2 |
| R11-CP02 | 5-10m | 15 | 2 |
| R11-CP03 | 5-10m | 15 | 2 |
| R11-CP04 | 5-10m | 15 | 2 |
| R11-WS01 | 5-10m | 10 | |
| R11-WS02 | 5-10m | 10 | |

# 3. SUMMARY OF FACTUAL GEOTECHNICAL REPORT

The following factual reports have been received as part of the Lot 1 GI:

Detailed Stage 1 Lot 1 Route 11. June 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 |
|---|---|---|---|---|---|
| Kimmage 01 | R11-CP01 | 5-10m | 8.7 | 6.5 to 12.5 | |
| | R11-CP02 | 5-10m | 3.9 | - | Changed to WS02 |
| | R11-CP03 | 5-10m | 6.3 | - | |
| | R11-CP04 | 5-10m | 2.9 | - | Changed to WS03 (Drive-in Windowless Sampler) |
| Kimmage 01 | R11-WS01 | 5-10m | 3.6 | - | |
| | R11-WS02 | 5-10m | | - | Cancelled |

The GI works undertaken comprise 2 No. Cable Percussion Boreholes to a maximum depth of 8.7m BGL, 3 No. Window Samples and 2 No. Rotary Core Boreholes to a maximum depth of 12.5m BGL; 14 SPT tests at 1 metre intervals alternating with disturbed samples and 9 GWL recordings.

10 disturbed samples were taken at each change of soil consistency or between SPT tests. Geotechnical testing consisting of 10 moisture content, 5 Atterberg limits, 1 Bulk Density and 7 Particle Size Distribution. Rock strength testing included 2 Unconfined Compressive Strength (UCS) testing.

Environmental & Chemical testing consisted of 9 Suite E samples and 2 PH and Organic matter content tests.

# 4. OVERVIEW OF SOIL CLASSIFICATION, AS APPLICABLE

## 4.1 Made Ground:

Made Ground deposits were encountered beneath the Topsoil/Surfacing and were present to depths of between 1.50m and 3.70m BGL.

These deposits were described generally as brown, dark brown, grey, dark grey or greyish brown sandy gravelly Clay with occasional cobbles or grey sandy subangular to subrounded fine to coarse Gravel with occasional cobbles and contained occasional fragments of ceramic, concrete, glass, metal, mortar, plastic, red brick and wood.

Soil classifies as CLAY of lower to intermediate plasticity, with a plasticity index ranging between 16% and 18%.

The Particle Size Distribution tests confirm percentages of sands and gravels of about 24% and 31% respectively.

PH and total organic carbon (TOC) were determined at R11-CP03 and C11-WS01 both at 1m depth. Organic matter content (OMC) was estimated from TOC. A PH average value of 8.1 was obtained.

TOC and OMC values at R11-WS01 were 1.8% w/w C and 3.1% w/w respectively. At R11-CP03, total organic carbon test showed high values (>6% w/w C).

Asbestos was detected at 1m depth at boreholes R11-CP03 and R11-CP04.

## 4.2 Cohesive deposits:

Cohesive deposits were encountered beneath the Made Ground or interbedded with Granular Deposits and were described typically as brown, grey, brownish grey or greyish brown sandy gravelly CLAY or as greyish brown or grey slightly sandy gravelly SILT. These deposits had rare, occasional, some or frequent cobble and boulder content.

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

The geotechnical testing carried out on recovered soil samples generally classify the deposits as CLAY of low plasticity, with a plasticity index ranging between 12% and 16%.

The Particle Size Distribution tests confirm generally well-graded deposits with percentages of sands and gravels ranging between 25% and 28% and 27% and 34%, respectively.

## 4.3 Bedrock:

The rotary core boreholes recovered medium strong to 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 varies from 4.40m BGL to 8.90m BGL. The total core recovery is good, typically 100%. The SCR and RQD both are relatively poor but both show an increase with depth in each of the boreholes.

# 5. SUMMARY OF GROUND INVESTIGATION INTERPRETATIVE REPORT

For Kimmage to City Centre 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 | - | - |
| Made Ground: Brown Clay (possibly UBrBC) / Grey Clay | 0.5 to 3.5 | 6 | 40 |
| Stiff Brown Boulder Clay (UBrBC) | 3.5 to 4 | 50 | 325 |
| Stiff Grey Boulder Clay / Very stiff dark Grey Boulder Clay (UBkBC) | 4 to 9 | 30-50 | 250 |
| Limestone | Top level between 5 and 10m | - | - |

No soil strength tests have been performed on Route 11.

2 uniaxial compression tests (rock strength) undertaken within the Limestone have shown base resistant values between 31.3 and 49.5 MPa. This range of values have been sustained by 7 UCS tests, 13 point load tests and 3 Brazil tests done in Glasnevin project and 5 UCS tests done in Metrolink project, in which base resistant values range between 17 and 101 MPa, with an average value around 46 MPa.

# 6. HYDROGEOLOGY, AS APPLICABLE

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 |
|---|---|---|
| R11-CP01 | 1.44 | 1.94 |
| R11-WS02 | 0.47 | 0.40 |
| R11-CP03 | 2.74 | 2.67 |
| R11-CP04 | - | 1.35 |
| R11-WS01 | 0.68 | 0.61 |

# 7. GEOTECHNICAL INPUTS 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 at Routes 3, 11 and 16.

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) |
|---|---|---|---|---|---|---|
| Kimmage D=0.5m | TBC | R11-CP01 | 5-10m | 9m | 8m | - |
| | | R11-WS02 | 5-10m | - | 4m | - |
| | | R11-CP03 | 5-10m | 4.5m | 3m | - |
| | | R11-WS03 | 5-10m | - | 2.5m | - |
| | | R11-WS01 | 5-10m | - | 3.5m | - |

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, cu) 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 the estimated piles length that satisfies the ULS is as detailed in the table above.

# APPENDIX 4
# OTHER RELEVANT DOCUMENTATION/REPORTS

(Not used)