

Appendix E1
Preliminary Sources
Study Report (PSSR)

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Bus Connects Core Bus Corridor Route 8: Clondalkin to
Drimnagh and Route 9: Greenhills to City Centre

National Transport Authority

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1. Introduction

1.1 Scope and Objective of Report

The scope and objective of this Preliminary Source Study Report (PSSR) is to address the geological, geotechnical, geomorphological, hydrogeological and geo-environmental aspects of the Bus Connects Core Bus Corridor, Route 8 Clondalkin to Drimnagh and 9 – Greenhills to City Centre. It also examines the historical development of the area. The PSSR provides a preliminary engineering assessment of the site to inform of likely hazards to construction.

The information contained within this report will be used to scope future Ground Investigations

This report has been prepared in accordance with Managing Geotechnical Risk DN-ERW-03083 (October 2019), Section 6.1, specifically Appendix C.

1.2 Project Overview

In June 2018, the National Transport Authority (NTA) published the Core Bus Corridors Project Report. The report outlined proposals for the delivery of a core bus corridor network across Dublin. The bus corridor network will provide 230km of dedicated bus lanes and 200km of cycle lanes/tracks on sixteen key bus corridors.

AECOM Ireland Limited (AECOM) and Mott McDonald have been awarded Package A, comprising four bus corridor routes:

- Route 1 – Clongriffin to City Centre
- Route 6 – Lucan to City Centre
- Route 8 – Clondalkin to Drimnagh
- Route 9 – Greenhills to City Centre

Route 8 – Clondalkin to Drimnagh and Route 9 – Greenhills to City centre are the focus of this report. The remaining routes are reported under separate cover.

Detailed descriptions of the proposed route are available in Section 4.

2. Sources of Information & Desk Study

The following table summarises the sources of information used within this desk study:

Table 1 Sources of Information used in the Desk Study

Source	Location	Available Information
Geological Survey Ireland (GSI) Spatial Resource	https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228	<ul style="list-style-type: none"> • Bedrock Geology • Quaternary Sediments • Teagasc Soils • Verified Borehole with Logs • Borehole Locations (unverified) • External GSI Geotechnical Boreholes • Groundwater Resources (Aquifers) • Groundwater Vulnerability • Groundwater Recharge • Groundwater Karst Data • Groundwater Wells and Springs • Active Quarries

Source	Location	Available Information
The Geology of Ireland (2 nd Edition)	<i>Holland, C.H. and Sanders, I.S. (2009). The Geology of Ireland (2nd Edition). Dunedin Academic Press.</i>	<ul style="list-style-type: none"> • Bedrock Geology • Structural Geology • Quaternary Geology
Ordnance Survey Ireland (OSI) - Geohive	http://map.geohive.ie/mapviewer.html	<ul style="list-style-type: none"> • Historical Maps • Aerial Photos (1995, 2000, 2005, 2012) • Topographic Maps
Environmental Protection Agency (EPA) Map Viewer	https://gis.epa.ie/EPAMaps/	<ul style="list-style-type: none"> • Waste Facilities • River Network and Flow Direction • Protected Areas
Google Maps	https://www.google.co.in/maps?hl=en&tab=r1	<ul style="list-style-type: none"> • Aerial Photos (2019)
Office of Public Works (OPW) Flood Maps	http://www.floodinfo.ie/map/floodmaps/?smau=iVVJQSqHPRMDv1IN	<ul style="list-style-type: none"> • River Flood Extent • Coastal Flood Extent • Past Flood Events
Bus Connects	https://busconnects.ie/media/1402/busconnects-cbc1-clongriffin-to-city-centre-final-for-web-low-res.pdf	<ul style="list-style-type: none"> • Background and scope for Bus Connects Core Bus Corridor Route 1 • Route Maps

3. Existing Ground Investigations

The following reports, available from GSI Geotechnical Data Viewer, indicate investigations completed with exploratory holes (EH) either on or near to the route.

Table 2. List of Relevant Ground Investigation Reports

GSI Ref.	Report Title	No. of Exploratory Holes Adjacent to Site (GSI Ref. No.)	Year Completed	Soil conditions
5040	Trial Pit Investigation at Cookstown Tallaght for Glan Developments	5 trial pits	2002	0.9 to 1.1 m of Made Ground; overlying Glacial Till
5433	Site Investigation at Belgard Square Tallaght	9 boreholes	2003	1 to 3.8 m of Made Ground; overlying Glacial Till
2556	Proposed shopping Centre, Tallaght	4 boreholes	1977	0.3 m to 0.7 m of Made Ground; overlying soft silty clay to 2 m, overlying Glacial Till
4904	Site Development at Greenhills Road	4 boreholes	2002	1.2 m of organic and peaty soil; overlying Glacial Till
4904	Site Development at Greenhills Road	6 boreholes	2001	0.5 to 1.9 m of Made Ground; overlying Glacial Till
2691	Site Development at Greenhills Road at major Baled Waste Depot	2 relevant trial pits	1994	compact sandy gravels towards Greenhills Road. Illegal dump site on site. 2 trial pits at embankment close to the Greenhills Road . It was not possible to bore at these positions due to heavy rock fill material ,

				however a heavy-duty excavator opened pits through the fill (which was non-organic clay and rock material) into the underlying gravel deposits . The site is in the main reasonably level but lying some 3 to 4 metres below Greenhills Road
115	A site at Greenhills Road, Walkinstown is to be developed as an industrial estate for Dublin County Council.	3 relevant test holes	1997	The records show that limestone bedrock is encountered at shallow depths over most of the site, in some cases directly underlying the topsoil site, in some cases directly underlying the topsoil covering. Stiff or compact clays or gravelly clays are generally found overlying the rock. A notable exception to the general findings was in the area near Greenhills Road in which Borehole D and Trial Pits Nos. 6 and 9 were located. In this area, made ground consisting of paper, timber, rubble, etc. was found extending to a maximum depth of 4.60 metres in Borehole D. Stiff to hard clay was observed underlying the fill.
5738	Proposed LIDL Development at Drimnagh Road	4 boreholes	2005	3 boreholes encountered shallow deposits of Made Ground underlain by Glacial Till. Made Ground extended to 3.5 m in a fourth borehole
6159	Commercial Development at a site at the junction of South Circular Road and Dolphins Barn	2 boreholes	2005	Made Ground extends to 2 m with tarmac, overlying brick, rubble, glass and ash. Below the fill soft to firm grey brown sandy gravelly clay to 4 m (refusal)
6196	residential/commercial development at Cork St	2 boreholes	2005	Made ground to 1.5 m; overlying Glacial Till
778	Patrick St between Dean Street junction to St. Nicholas Place	4 Boreholes	1989	Former course of Poddle River skirts the western side of Patrick Street. Evidence of organic silts below fill between 2.5 and 5 m
4074	Proposed Cycle Path (Killeen - Nangor Road)	13 Boreholes	1999	The investigation has shown deposits of made ground extending to depths of 0.9 m and 2.3 m underlain by Glacial till
4597	Site Investigation at Naas Road and Longmile Road	4 boreholes	2001	The boreholes suggest that some of the site area has been infilled to a depth of approximately 2.5 m. In other areas the upper soils are composed of brown glacial till, overlying Lodgement Till. Angular Limestone fragments were recovered from a depth of 5.9 m in one borehole.

An assessment of ground and groundwater conditions has been completed using available information taken from existing ground investigation reports. Findings from this assessment are used to characterise the route in Section 5 and provide preliminary geotechnical recommendations in section 6.

4. Field Studies

A site walkover was carried out along Greenhills road, Ballymount Avenue and Calmount Road to inform ground investigation scoping.

5. Site Description

5.1 Greenhills to City Centre

5.1.1 Greenhills to City Centre Overview

The Greenhills Core Bus Corridor (CBC) commences on Belgard Square West at the junction with Cookstown Way. From here, the CBC is routed along Belgard Square West and Belgard Square North as far as the junction with Belgard Road. At this point, the CBC enters the Institute of Technology Tallaght campus and follows the existing internal road through the campus, exiting at the existing junction on Greenhills Road. From here, the CBC is routed along the R819 Greenhills Road, Ballymount Avenue, Calmount Road, and Walkinstown Road as far as the junction with the R110 Long Mile Road.

It is proposed to realign the existing Greenhills Road in two locations on this section: along an existing road reservation between Parkview and Treepark Road, and through Ballymount Industrial Estate by way of extending both Ballymount Avenue and Calmount Avenue to connect to Greenhills Road at new signalised junctions.

From the junction of the R110 Long Mile Road and the R819 Walkinstown Road the CBC is routed along the R110 Drimnagh Road, Crumlin Road, Dolphin's Barn, Cork Street, St. Luke's Avenue, The Coombe, and Dean Street to the junction with the R137 Patrick Street. The CBC is then routed along Patrick Street and Nicholas Street to the junction with Christchurch Place where it will join the prevailing traffic management regime in the city centre.

5.1.2 Belgard Square South to Greenhills Road - Belgard Square West, Belgard Square North, Institute of Technology Tallaght Access Road

The Greenhills CBC commences at the existing roundabout junction on Belgard Square South. It is proposed to change the roundabout to a fully signalised junction with improved pedestrian facilities. Belgard Square West is intended to be a bus only route not accessible to general traffic. Between Belgard Square South and Tallaght Cross West / Broadfield Hall access to and from these buildings and neighbouring developments will still be permitted from Belgard Square West. Bus traffic across Old Blessington Road will be controlled by a bus gate traffic light system. Access to and from the Old Blessington Road to Belgard Square West will be permitted.

It is proposed to change the roundabout junction on Belgard Square North at the Tallaght Hospital Entrance and Cookstown Way to a fully signalised junction to accommodate new bus lane and pedestrian facilities. The roundabout junctions at Belgard Square East and at Belgard Road will also be replaced with new signalised junction arrangements. From Belgard Road it is proposed to route the bus corridor through the grounds of the Institute of Technology Tallaght (ITT). It is intended to change one of the inbound lanes on the entry road to a contra-flow bus lane. It is proposed to provide new bus stop facilities within the campus.

The ITT junction with the Greenhills Road is currently an uncontrolled priority junction. It is proposed to upgrade this junction to a fully signalised junction with pedestrian crossing facilities.

5.1.3 Greenhills Road to Walkinstown Roundabout - Greenhills Road, Ballymount Avenue, Calmount Road, back to re-join Greenhills Road

Between the ITT access junction and the junction with Mayberry Road along the Greenhills Road it is intended to provide one bus lane, one traffic lane and a cycle track in both directions. To accommodate the road cross section, it is proposed to utilise limited land take along this section on the west side of the existing Greenhills Road with some limited short sections of land take likely also on the east side.

To improve the operation of the existing junction and minimise land take, it is proposed to introduce a right turn ban from Greenhills Road to the entrance to Harvey Norman store and right turn ban from the Greenhills Road to Hibernian Industrial Estate. Access from Harvey Norman to Greenhills Road will be maintained at the junction. Right turning vehicles for Harvey Norman will be directed to the Airton Road junction. At this junction, vehicles will be able to turn right and access the Harvey Norman store from this road.

Right turning vehicles for the Hibernian Industrial estate will be directed to the next junction (at Agnelli Motor Park) where full access will be maintained.

Between Mayberry Road and Tymon Lane, it is proposed to undertake major changes to the local road network. South Dublin County Council has identified this section of Greenhills Road for upgrade under their current County

Development Plan. It is intended to implement some of these road construction works as part of this scheme. The existing Greenhills Road will be retained as an access road for Park View Estate. A new Greenhills Road will be constructed on the green space south of Birchview Avenue and Treepark Road. Traffic to the Old Greenhills Road will be restricted to local traffic only and movement bans will be proposed to enforce this. This new section of road will be wide enough to accommodate one bus lane, one traffic lane and a cycle track in both directions with new bus stop and pedestrian crossing facilities.

The existing M50 bridge crossing will be retained; however, it will present a width restriction. This crossing may be reviewed in the next design stage. It is currently proposed to maintain one lane of general traffic in each direction. However, bus priority will be achieved through a queue relocation facility on the approaches to the bridge crossing. After the bridge crossing, it is proposed to widen the road again to accommodate one bus lane, one traffic lane and a cycle track in both directions.

At Keadeen Park, it is proposed to close Greenhills Road to traffic. Traffic will be directed on to a new road link connecting the road to Ballymount Avenue. The new road will tie back into the existing road networks at Calmount Road. The junction between Ballymount Avenue and Calmount Road will be upgraded from a roundabout to a signalised junction with improved pedestrian facilities. The bus route will be directed down Calmount Road. The existing road is intended to be widened to incorporate bus and cycle lanes. It is proposed to connect Calmount Road to Greenhills Road with a new link road. It also is proposed to connect the existing Greenhills Road to Calmount Road with a new link road through Calmount Avenue. Some limited land take will be required to construct a new roundabout at this proposed junction.

Between the Calmount Road and Walkinstown Roundabout, it is proposed to maintain one bus lane, one traffic lane and a cycle track in both directions. This will require limited land take on the south side of Greenhills Road. Some current access arrangements along this section of road will need to be reviewed. It is intended to upgrade the existing roundabout junction to incorporate improved pedestrian and cyclist facilities.

5.1.4 Walkinstown Roundabout to Dolphin Road - Walkinstown Road, Drimnagh Road, Crumlin Road

On Walkinstown Road between Walkinstown Roundabout and the Long Mile Road, it is proposed to provide one bus lane and one general traffic lane in both directions. There is insufficient space to accommodate dedicated cycle lanes on this section of road. To accommodate this cross section, it is proposed to utilise land take to west of the Walkinstown Road between Walkinstown Avenue and Kilnarnagh Road. Land take to the east of Walkinstown Road may be required between Kilnarnagh Road and Long Mile Road. It is proposed to introduce a right turn ban from Walkinstown Road to Kilnarnagh Road. Kilnarnagh Road will remain accessible from Walkinstown Road through Walkinstown Drive. It is also intended to introduce a right turn ban for right turning traffic from Walkinstown Road to the southern entrance of the SuperValu supermarket.

To accommodate cyclists on this section of the route, an alternative cycle route is proposed along Bunting Road and St. Marys Road providing a quiet route linking Walkinstown Roundabout with Kildare Road.

It is proposed to upgrade the existing Long Mile Road / Walkinstown Road junction to provide bus priority signal facilities and improved pedestrian crossing. On Drimnagh Road it is proposed to maintain one bus lane, one general traffic lane and one cycle track in both directions. To allow this revised cross section some limited land take from property between Balfe Road and Kildare Road may be required.

On Crumlin Road between Kildare Road and Sundrive Road it is intended to restrict the proposed road cross section to one bus lane and one general traffic lane. Due to width restrictions in the area there is insufficient space to provide dedicated cycle lanes. To accommodate this restricted cross section, it will be necessary to acquire land along Crumlin Road.

To facilitate cyclists, it is proposed to redirect them through Kildare Road. To improve local safety, it is intended to introduce a no entry sign at the junction of Kildare Road and Clonard Road for traffic in both directions. This would prevent general through traffic; however, buses, taxis and cyclists' movements will remain unrestricted along Kildare Road. Eastbound traffic would be directed along Clonard Road, through Downpatrick Road on to Bangor Road. Westbound traffic would also be directed up Clonard Road onto the Crumlin Road. Cyclists would proceed from Kildare Road to Clogher Road and be redirected along Slane Road. From Slane Road, cyclists would travel along Downpatrick Road and on Sundrive Road. On Sundrive Road, a new cycle lane in both directions is to be provided between the junction of Downpatrick Road and Crumlin Road.

At the junction between Crumlin Road and Herberton Road, it is proposed to modify the existing layout to improve the kerb alignments and provide improved pedestrian crossing facilities. On the Crumlin Road between

Herberton Road and Dolphin Road it is proposed to maintain one bus lane and one general traffic lane in both directions. There is insufficient road width on this section to provide dedicated cycle tracks.

5.1.5 Dolphin Road to Christchurch Place - Dolphins Barn, Cork Street, St Luke's Avenue, Dean Street, Patrick Street, Nicholas Street, Christchurch Place

Between Dolphin Road and South Circular Road, it is intended to provide one bus lane, one general traffic lane and one cycle track in both directions. To improve bus priority at the South Circular Road junction, it is proposed to introduce a left turn ban in both directions. To make this turning movement drivers will be directed down Rueben Road and onto Haroldville Avenue or onto Parnell / Dolphin Road.

Between South Circular Road and Ardee Street and on along Dean Street it is proposed to have one bus lane, one general traffic lane and one cycle track in both directions. It is also intended to upgrade the Ardee Street junction with improved pedestrian facilities.

It is proposed to modify the Kevin Street / Dean Street junction to facilitate improved cycle way facilities. There is currently insufficient road width on Dean Street to facilitate bus lanes but bus priority from St. Luke's Avenue will be maintained with a new Bus Only signal.

Between Dean Street Junction and Christchurch Place it is proposed to have one bus lane, one general traffic lane and one cycle track in both directions. The cross section would be accommodated by removing the central median and realigning the existing kerb line. Some on-street loading bays will be maintained between Bride Road and Bull Alley Street. On Christchurch Place the route will join the prevailing traffic management regime in the city centre.

5.2 Clondalkin to Drimnagh Overview

The Clondalkin to Drimnagh Core Bus Corridor (CBC) commences on the R134 New Nangor Road at the junction with Woodford Walk and is generally routed via the R134 along the New Nangor Road as far as the junction with the Naas Road. From here it is generally routed along Naas Road as far as the junction with Walkinstown Avenue. The corridor continues down Walkinstown Avenue on to the R110 Long Mile Road to the junction with Walkinstown Road, where it joins the Greenhills Core Bus Corridor. Priority for buses is provided along the entire route, consisting primarily of dedicated bus lanes in both directions.

5.2.1 Woodford Walk to Naas Road - Nangor Road

The Clondalkin CBC commences at the junction of Woodford Walk and Nangor Road. It is proposed to provide a footpath, cycle track, bus lane, and a general traffic lane in both directions on the Nangor Road. The route will be connected to the adjoining greenway at a number of locations along the Nangor Road. It is intended to change the existing roundabout junction at the Nangor Road Business Centre to a fully signalised junction with improved pedestrian facilities.

To accommodate bus lanes on both sides of the Park West Avenue junction, it is proposed to use limited land take on the south of the junction of existing green space in the Oak Road Business Park and the Western Business Park.

At Willow Grove junction, it is intended to widen the Nangor Road to accommodate the proposed bus lanes and cycle tracks. It is anticipated that this will require some limited land take on the north and south sides of the junction (Westland Park and Entrance to Diageo Bailey Global Supply Centre HGV entrance / Toyota Ireland lands).

To accommodate the city bound bus lane and cycle track, it will be necessary to utilise some limited land take on Nangor Road to the east of Killeen Road.

At the junction with the Naas Road, it proposed to direct the city centre bound bus lane along the left turn slip road, while maintaining the existing number of general traffic lanes through the junction. The Clondalkin bound bus lane is proposed to terminate at the entry to the Maxol filling station, reflecting the current arrangement. An additional bus lane is intended to be introduced on the west side of the junction to assist with bus priority. This proposed arrangement will require the modification of the existing traffic island and kerb alignment through the junction. It is also intended to provide improved cyclist facilities through the junction. These proposed upgrade works will require possible land take adjacent to the junction.

5.2.2 Naas Road to Walkinstown Road via Walkinstown Avenue and the Long Mile Road

On the Naas Road between the Long Mile Road and Walkinstown Avenue, the existing lane arrangement (one bus lane and two general traffic lanes in each direction) will be maintained. It is proposed to improve cycle facilities by segregating cycle lanes from the main carriageway where possible on this section. There is some limited land take proposed at the Robinhood Road junction.

On Walkinstown Avenue, it is proposed to provide a footpath, cycle track, bus lane, and a general traffic lane in each direction. To facilitate this cross section, it is proposed to utilise limited land take on the east side of the road.

After Walkinstown Avenue, the bus corridor is directed on to the Long Mile Road. It is intended to provide a footpath, cycle track, bus lane, and a general traffic lane in each direction. It is anticipated that this proposed modification will be accommodated within the current road boundary. At the Walkinstown Road, this scheme ties with the Greenhills to City Centre CBC scheme.

5.3 Topography

The topography of the site is generally flat with elevations decreasing from South to North from approximately 110 m Ordnance Datum (OD) in Tallaght to 10 m OD in the city centre. The generally topography of the route is shown in Appendix A

5.4 Geology

A review of the sites underlying geology was completed using available data derived from the GSI spatial data viewer. Appendix A provides figures of the recorded superficial and solid geology that underlies the route. A brief summary is provided below.

Made Ground

The majority of the route is mantled by deposits of Made Ground

Alluvium Deposits

Undifferentiated Alluvium associated with the River Camac and although not shown on the mapping, there is potentially alluvium associated with the River Poddle.

Glaciofluvial Deposits

Deposit of glaciofluvial sand and gravel, located in the Greenhills area. Deposits are described as being derived chiefly from Carboniferous limestone.

Till Deposits

The route is generally underlain by Glacial Till deposits known colloquially as Dublin Boulder Clay. Deposits are described as being derived chiefly from Carboniferous limestone.

5.4.1 Bedrock

The GSI Bedrock Geology map (scale 1:100,000) indicates the site is underlain by the Lucan Formation comprising of dark-grey, argillaceous, cherty, spicular micrites and shales, with horizons of graded, skeletal limestones containing ooids and other shallow water grains.

5.4.2 Structural Geology

According to the GSI Bedrock Geology map there are no structural features (e.g. faults, fold axis, etc.) recorded along the proposed routes. Structural measurements taken from surrounding outcrops indicate bedding dips of between 8 and 55 degrees with dip directions typically to the south and south-west.

5.5 Hydrology

Appendix A provides figures of the Surface water features that are encountered along the route.

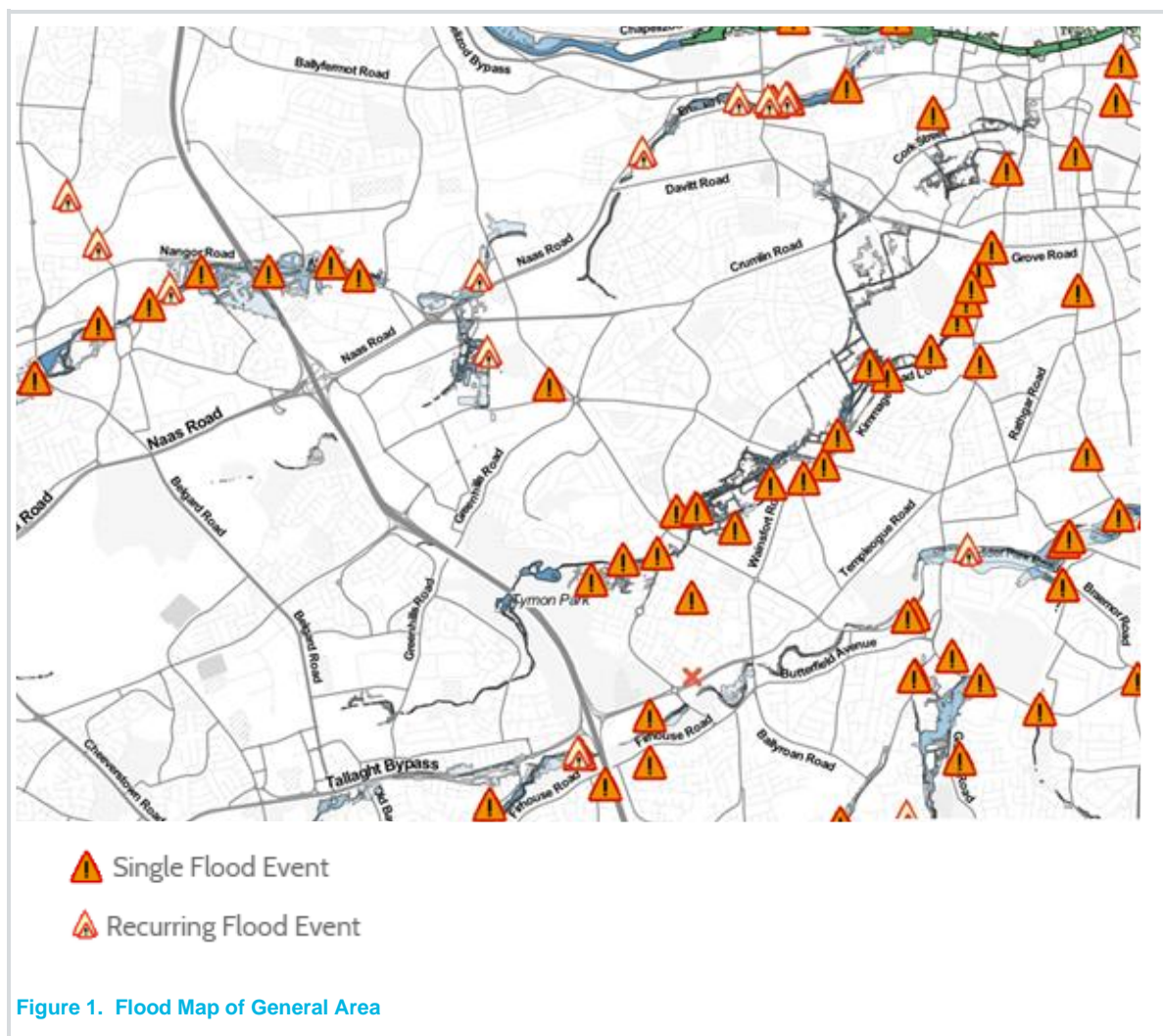
5.5.1 Surface Water Features

The GSI Surface Water Features map indicates that the River Camac and River Poddle are in the vicinity of the route alignment.

5.5.2 Flooding

According to the OPW flood maps (shown below), areas of potential flooding along the route include:

- Medium probability of flooding at the intersection of The Coombe and Clanbrassil Street Lower (R110 and R137)
- Medium probability of flooding at the along Cork St and St Luke's Ave (R110)
- Medium probability of flooding south of the canal along the Crumlin Road to the intersection of Sundrive Road (R110)
- Medium probability of flooding along Sundrive Road (R110)
- Medium probability of flooding along the Naas Road (R810)
- Medium and high probability of flooding along Nangor Road (134)



According to the OPW Past Flood Records there have been several flooding events along the Nangor Road associated with flooding of the River Camac.

5.6 Hydrogeology

Appendix A provides figures of the hydrogeological features that are encountered along the route. The following sections provide a brief summary.

5.6.1 Karst Landforms

According to the GSI Groundwater Karst Data map there are no karst features recorded within 1 km of the route.

5.6.2 Aquifer Classification

According to the GSI Groundwater Resources (Aquifer) map, the Lucan Formation which predominantly underly the site, are classified as Locally Important Aquifers (LI). These formations are moderately productive only in local zones.

Most of the soil permeability across the route and surrounding area is classified as low. The Greenhills road area would be considered high subsoil permeability.

A figure showing the Ground Water recharge is provided in Appendix A.

The site does not lie within a Group Scheme or Public Supply Source Protection Area.

5.6.3 Groundwater Vulnerability

The GSI National Groundwater Vulnerability map for the route is provided in Appendix A. The map indicates that the groundwater vulnerability is variable. The route is generally “Low” to “High” with “Extreme” pockets also encountered.

5.6.4 Karst Landforms

According to the GSI Groundwater Karst Data map (Appendix A) there are no karst features recorded within 1 km of the route.

5.7 Man-Made Features & Historical Development

5.7.1 Mining and Quarrying

According to the GSI Active Quarries and Mineral Locality maps there are no quarrying activities within 1 km of the route.

5.7.2 Statutory Protected Sites

According to the EPA Protected Areas map, the route does not lie within a statutory protected area.

5.7.3 Historic Maps and Aerial Photography

A review of historical maps and contemporary aerial photographs available from the OSI (Geohive) and Google Maps was completed. Findings of this review are summarised in the following table:

Table 3. Historic Maps and Aerial Photography review

Year	Description
Historic Map 6" 1837-1842 (OSI)	<p data-bbox="363 286 708 309">Route 8 – Clondalkin to Drimnagh</p> <p data-bbox="363 331 1388 479">The site is shown to comprise predominantly agricultural land with scattered residential and industrial development. Drimnagh Castle is shown at the eastern end of the site with a Paper Mill being recorded approximately 140m to the north. Drimnagh Lodge is recorded at the eastern end of the existing R134 Nangor Road and Killeen Paper Mills are recorded to the north west of the R134 Nangor Road / Killeen Road Junction. A Glue Manufactory is also recorded approximately 30m to the north of the site at Fox & Geese.</p> <p data-bbox="363 510 1388 613">Three unnamed roads are recorded to coincide with the line of the proposed site; an unnamed road follows the route of the existing R110 Long Mile Road, an unnamed road partially follows the route of the existing R810 Naas Road, and an unnamed road crosses the line of the proposed site at the R134 Nangor Road / Killeen Road Junction.</p> <p data-bbox="363 645 1388 837">The Clondalkin River crosses the line of the proposed site at the existing R134 Nangor Road / Park West Avenue Junction. A large water feature approximately 150m long and recorded as 'Mill Dam' is shown immediately to the north east of this location, with other significant water features, likely associated with the Killeen Paper Mill, being recorded further to the east. A bend in the Clondalkin River is recorded within the vicinity of the site approximately 130m to the west of the R134 Nangor Road / Woodford Walk Junction. East of the R134 Nangor Road / Woodford Walk Junction, the Grand Canal is recorded as running adjacent the line of the proposed site for approximately 540m. A small number of pumps and wells are recorded throughout the site.</p> <p data-bbox="363 869 1388 927">Three gravel pits are recorded approximately 200m to the west and south west of the existing R110 Long Mile Road / R112 Walkinstown Road Junction.</p> <p data-bbox="363 958 708 981">Route 9 – Greenhills to City Centre</p> <p data-bbox="363 1003 1388 1151">To the east of the existing R110 Cork Street / Brickfield Lane Junction, significant residential development is recorded with a Brewery, Distillery, Fever Hospital and Chemical Works also being recorded in the area surrounding the existing R110 Cork Street / R804 Marrowbone Lane Junction. Further to the south west, the land surrounding the line of the proposed site is recorded as predominantly agricultural, with what appears to be scattered residential and farm buildings. A Grave Yard is recorded to the south of the existing Saint Maelruain's Church on Blessington Road.</p> <p data-bbox="363 1182 1388 1240">Six roads are recorded to coincide with the line of the proposed site; Nicholas Street, Patrick Street, Dean Street, Cork Street, Dolphin's Barn Lane and an unnamed road heading south west toward Tallaght.</p> <p data-bbox="363 1272 1388 1375">Two watercourses are recorded as crossing the line of the proposed site: where the unnamed road passes over the Grand Canal to the south west of Dolphin's Barn at the Camac Bridge, and an unnamed watercourse recorded as flowing north at Ballymount Avenue approximately 170m to the southeast of Calmount Road.</p> <p data-bbox="363 1406 1388 1496">There are a number of gravel pits and quarries recorded throughout the site, predominantly in the area surrounding the proposed site between Walkinstown Cross and the R819 Greenhills Road / Ballymount Road Junction. Throughout this area at least six gravel pits are recorded within the immediate vicinity of the proposed site.</p>

Year	Description
Historic Map 25" 1888-1913 (OSI)	<p data-bbox="359 230 710 262">Route 8 – Clondalkin to Drimnagh</p> <p data-bbox="359 309 1396 454">Some development is recorded in the land surrounding the line of the proposed site. A Halfway House is recorded immediately to the south west of the existing R110 Long Mile Road / R819 Walkinstown Road Junction, the Paper Mill to the north of Drimnagh Castle shows some minor signs of development and is now recorded as Drimnagh Paper Mill, and some minor development is recorded at Killeen Paper Mills. The Glue Manufactory at Fox & Geese is no longer shown; however, an unnamed building is still recorded at this location.</p> <p data-bbox="359 495 1396 663">Two additional watercourses are recorded as crossing the line of the proposed site; an unnamed watercourse flowing north at the existing R110 Long Mile Road / R819 Walkinstown Junction and an unnamed watercourse, also flowing north, approximately 500m to the south west of the existing R810 Naas Road / R112 and Walkinstown Avenue Junction. This second watercourse is then recorded as heading north west and running adjacent to the existing R810 Naas Road for approximately 200m. The Clondalkin River is now recorded as the Cammock River and shown to flow east toward the Killeen Paper Mills, and a Lock and Water Works are recorded further to the north at the Grand Canal.</p> <p data-bbox="359 696 1396 770">The area in the vicinity of the three gravel pits previously recorded to the west and south west of the existing R110 Long Mile Road / R112 Walkinstown Road Junction is now recorded as one large gravel pit approximately of 17000m².</p> <p data-bbox="359 804 710 835">Route 9 – Greenhills to City Centre</p> <p data-bbox="359 853 1396 1171">The area surrounding the line of the proposed site to the east of the existing R110 Cork Street / Brickfield Lane Junction remains relatively unchanged. However, more detail is shown on this map with the following features now being recorded: St Patrick's Park and St Patrick's Cathedral to the east of St Patrick's Street, a Brewery and Maltings at the east end of Cork Street, and a Corporation Scavenging Depot, Tannery & Glue Works, Foundry & Engineering Works and a Dye Works. A Bacon Curing Factory is also recorded directly to the south west of the existing R110 Cork Street / Brickfield Lane Junction. Further to the south west significant residential development is recorded between the existing R110 Cork Street / R804 Marrowbone Lane Junction and the R110 Crumlin Road / Herberton Road Junction. City Woolen Mills is recorded directly to the south of Vauxhall Avenue, and a Brick Works, including Kilns, is recorded directly to the north of the site to the west of the existing Keeper Road. The land surrounding the site to further to the south west remains relatively unchanged, with some minor residential development being recorded to the south of the existing Rafter's Lane and in the vicinity of Walkinstown Cross, Greenhills and Tallaght - where a burial ground is also recorded directly to the south of the existing Dublin Technological University.</p> <p data-bbox="359 1205 1396 1279">To the south west of Cork Street, Dolphin's Barn Lane is now recorded as Dolphin's Barn Street, and the easternmost section of the unnamed road between the Grand Canal and St Mary's Road to the west is now recorded as Crumlin Road.</p> <p data-bbox="359 1312 1396 1413">Two additional watercourses are now recorded, with one flowing north, crossing the proposed line of the site at the existing R110 Drimnagh Road / R819 Walkinstown Road Junction, and another flowing east, crossing the line of the proposed site directly to the north west of the existing Tallaght Athletics Club. The Camac Bridge to the south west of Dolphin's Barn is now recorded as Dolphin's Barn Bridge.</p> <p data-bbox="359 1447 1396 1541">The area comprising to the south west of Walkinstown Cross is now recorded as comprising numerous large gravel pits, predominantly adjacent to the south east side of the existing R819 Greenhills Road. The largest of these gravel pits is approximately 500m long. Another smaller gravel pit is recorded further to the south west, to the south of the R819 / Ballymount Road Upper Junction.</p>

Year	Description
6" Cassini 1930s (OSI)	<p data-bbox="363 230 710 262">Route 8 – Clondalkin to Drimnagh</p> <p data-bbox="363 277 1388 400">Some development is recorded to the south east of Drimnagh Castle including residential buildings, a Gown Factory and Landsdown Park. The area to the west of the existing R810 Naas Road / R112 Walkinstown Avenue Junction also shows signs of development, including St Gillian's School and significant road widening to the north east. 38kV and 110kV powerlines are recorded as crossing the line of the proposed site approximately 200m and 500m to the south west of Dimnagh Castle.</p> <p data-bbox="363 436 1388 582">Four additional unnamed watercourses are recorded flowing north on the north side of the proposed route between the R110 Long Mile Road / R819 Walkinstown Road Junction and the R810 Naas Road / R112 Walkinstown Avenue Junction. The westernmost of these watercourses is recorded as crossing the line of the proposed site twice where it follows the existing R112 Walkinstown Avenue. All four of the watercourses are marked 'Rises', possibly indicating that they may be associated with drainage in the area. The area to the north of the Mill Dam and south of the Grand Canal is now recorded as liable to floods.</p> <p data-bbox="363 618 1388 692">A gravel pit is recorded to the south east of St Gillin's School to the west of the existing R810 Naas Road / R112 Walkinstown Avenue Junction. The large gravel pit to the south west of the existing R110 Long Mile Road / R112 Walkinstown Road Junction is now recorded as rough pasture, having likely been infilled.</p> <p data-bbox="363 728 718 759">Route 9 – Greenhills to City Centre</p> <p data-bbox="363 775 1388 1039">To the east of the existing R110 Cork Street / Brickfield Lane Junction the area surrounding the proposed line of the site remains relatively unchanged. The Maltings, Corporation Scavenging Depot, Tannery & Glue Works, Foundry & Engineering Works and Dye Works are no longer recorded, neither is the Bacon Curing Factory; however, no significant changes to the building layout at these locations is noted. Further to the south west, between Dolphin's Barn Bridge and the existing R110 Drimnagh Road / R819 Walkinstown Road Junction, significant residential development is recorded on the land surrounding the line of the proposed site. Further to the south west, two 38kV and one 10kV power lines are recorded as crossing the line of the proposed site at the R110 Drimnagh Road / Comeragh Road Junction, adjacent to the R819 Walkinstown Road / Thomas Moore Road Junction, and at the eastern end of Belgard Square North. A feature recorded as 'Urn Burials (Site of)' is recorded approximately 220m to the south of Walkinstown Cross.</p> <p data-bbox="363 1075 1388 1106">The unnamed road to the west of Dolphin's Barn is now recorded as Crumlin Road and Walkinstown Road.</p> <p data-bbox="363 1142 1388 1182">The majority of the gravel pits to the south west of the site are now shown to be disused and recorded as rough pasture.</p>

Year	Description
Aerial 1995 (OSI)	<p data-bbox="363 230 710 262">Route 8 – Clondalkin to Drimnagh</p> <p data-bbox="363 277 1265 309">It should be noted that the 1995 aerial photography is in black and white and of poor resolution.</p> <p data-bbox="363 338 1388 465">Significant development is recorded throughout the site comprising numerous commercial and industrial buildings of varying sizes. The only area now recorded as being relatively undeveloped is the north section of the R134 Nangor Road to the east of the M50 Motorway. To the west of the M50 Motorway significant residential development is recorded. The 38kV and 110kV powerlines previously recorded to the south west of Dimnagh Castle are no longer visible, neither is Drimnagh Lodge.</p> <p data-bbox="363 495 1388 600">Significant change to the road network throughout the site is recorded, including the dualling of the R110 Long Mile Road and R810 Naas Road, along with the construction of a new section of the R112 Walkinstown Avenue to the north, and the construction of the R134 Nangor Road and M50 Motorway to the west - which includes a bridge structure carrying the M50 Motorway over the R134 Nangor Road.</p> <p data-bbox="363 629 1388 902">The four watercourses previously recorded between the R110 Long Mile Road / R819 Walkinstown Road Junction and the R810 Naas Road / R112 Walkinstown Avenue Junction are no longer visible, with the area now comprising numerous commercial and industrial buildings. Of the three other watercourses recorded as crossing the line of the proposed site only the Cammock River and the unnamed watercourse to the south west of the R810 Naas Road / R112 Walkinstown Avenue Junction are visible. Both of these watercourses appear to have been culverted beneath the line of the proposed site. The unnamed watercourse previously recorded at the R110 Long Mile Road / R819 Walkinstown Road Junction is no longer visible; however, a section is visible approximately 120m to the north indicating that this watercourse has likely also been culverted beneath the site. The section of the Cammock River to the west of the site appears to have been realigned during the construction of the R134 Nangor Road and is now shown to pass under the M50 Motorway to the east.</p> <p data-bbox="363 931 1388 1010">There are no visible signs of any gravel pits or quarries throughout the site with the area of the previously recorded gravel pit to the south east of St Gillin's School now being occupied by a large commercial or industrial complex.</p> <p data-bbox="363 1039 718 1070">Route 9 – Greenhills to City Centre</p> <p data-bbox="363 1086 1388 1234">The area surrounding the site between Nicholas Street and the R110 Crumlin Road / Cooley Road junction remains relatively unchanged, with only minor development being recorded. Further to the south west significant development is recorded, comprising predominantly residential buildings to the north east of Walkinstown Cross and in the north of Kilnamanagh, and predominantly commercial and industrial buildings to the south west of Walkinstown Cross and in the north of Tallaght. The two 38kV and one 10kV power lines are no longer recorded as crossing the line of the proposed site.</p> <p data-bbox="363 1263 1388 1388">Some sections of road are now recorded as dual carriageway, most notably Patrick Street, Dolphin's Barn Street, the north east of the R110 Crumlin Road and the R110 Drimnagh Road. A six-arm roundabout is now recorded at Walkinstown Cross, Ballymount Avenue and Calmount Road appear to be undergoing construction, and the M50 Motorway is now recorded further to the south west, with the R819 Greenhills Road passing over it.</p> <p data-bbox="363 1417 1388 1523">The watercourse previously recorded as crossing the line of the proposed site at the R110 Drimnagh Road / R819 Walkinstown Road Junction is no longer visible; however, a section of this watercourse appears to be visible further to the north indicating that it has likely been culverted beneath the site. Only a small section of the watercourse previously recorded at Ballymount Road is still visible to the south.</p> <p data-bbox="363 1529 1388 1601">The majority of the land surrounding the area previously recorded as comprising gravel pits is now shown to comprise what appears to be commercial and industrial buildings; however, some signs of previous mining or quarrying activities appear to still be visible.</p>

Year	Description
Aerial 2000 (OSI)	<p data-bbox="359 235 710 257">Route 8 – Clondalkin to Drimnagh</p> <p data-bbox="359 302 1388 392">The land surrounding the line of the proposed site shows some signs of development with the most significant being in the area between Park West Avenue and the M50 Motorway. This area is now shown to comprise numerous commercial and / or industrial buildings of varying sizes.</p> <p data-bbox="359 414 766 436">No other significant changes are recorded.</p> <p data-bbox="359 470 718 492">Route 9 – Greenhills to City Centre</p> <p data-bbox="359 515 1388 593">The land surrounding the line of the proposed site appears relatively unchanged, with the only significant features of note being the ongoing construction of Saint Luke’s Avenue in the east and Cookstown Way in the west.</p> <p data-bbox="359 627 1388 728">Further development of the area previously recorded to comprise numerous gravel pits is shown, with some ongoing construction being recorded. The unnamed watercourse at Ballymount Road no longer visible; however, a section of the watercourse running under the M50 Motorway to the south is visible, possibly indicating that further to the north, the watercourse has been culverted beneath the site.</p> <p data-bbox="359 761 766 784">No other significant changes are recorded.</p>
Aerial 2005 (OSI)	<p data-bbox="359 907 710 929">Route 8 – Clondalkin to Drimnagh</p> <p data-bbox="359 952 1388 1120">Some minor development appears to have occurred throughout the site; however, the layout of the buildings remains relatively unchanged, with the only significant development being ongoing construction of a residential complex at the western end of the site. The Luas Red Line light rail line is now recorded as running east along the R810 and R110 Naas Road, coinciding the line of the proposed site between Walkinstown Avenue and Nangor Road, and appears to include some realignment works at the R134 Nangor Road / R110 Long Mile Road Junction. A new junction is also recorded on the R134 Nangor Road directly to the north of Willow Road.</p> <p data-bbox="359 1153 766 1176">No other significant changes are recorded.</p> <p data-bbox="359 1209 718 1232">Route 9 – Greenhills to City Centre</p> <p data-bbox="359 1254 1388 1411">The construction of St Luke’s Avenue in the is east is now shown to be complete, as is the construction Cookstown Way in the west. Some ongoing construction is recorded in the area surrounding the line of the proposed site at Belgard Square West, and construction activities in the area previously recorded to comprise numerous gravel pits are now recorded as complete. The Luas Red Line light rail line is now recorded as running south along Cookstown Way and terminating on Blessington Road at the south western end of the site.</p> <p data-bbox="359 1444 766 1467">No other significant changes are recorded.</p>

Year	Description
Aerial 2019 (Google Maps)	<p>Route 8 – Clondalkin to Drimnagh</p> <p>No significant development of the land surrounding the site is recorded, with the only change of note being the completion of the residential complex to the west of the site.</p> <p>Development along both sides of the route on the R110 Long Mile Road is recorded as predominantly commercial, with two school buildings recorded to the south of Drimnagh Castle. Further to the west, along the R112 Walkinstown Avenue and the R810 Naas Road, the area surrounding the site is shown to predominantly comprise vehicle distribution depots and car showrooms. To the north of the R810 Naas Road the area surrounding the site is shown to comprise various commercial and industrial buildings including a large brewery depot to the east.</p> <p>There are two petrol stations recorded along the proposed line of the site; one on the R112 Walkinstown Avenue and another on the R810 Naas Road.</p> <p>Route 9 – Greenhills to City Centre</p> <p>Some development of the area surrounding the line of the proposed site to the east of the Grand Canal is recorded, most notably residential and commercial buildings at the eastern end of Cork Street, and ongoing residential construction directly to the north of Dolphin's Barn Bridge. Further to the south west of the site some development is recorded in the area previously recorded to comprise numerous gravel pits, and a new section of road is now recorded as running approximately east to west and to the south of Dublin Technological University from the R819 Greenhills Road to the R113 Belgard Road. Development of the land surrounding the line of the proposed site to the north east of Walkinstown Cross is recorded as predominantly mixed residential and commercial, with the land to the south west and north of the M50 Motorway being recorded as predominantly mixed industrial and commercial. Further to the south west, the land surrounding the line of the proposed site to the north of Mayberry Road is recorded as predominantly residential, whereas the land surrounding the line of the proposed site to the south is predominantly mixed industrial and commercial, with the Dublin Technological University being located to the east of the R113 Belgard Road.</p> <p>There are two petrol stations located throughout the site, one directly to the west of Dolphin's Barn Bridge, and another directly to the east of the R110 Crumlin Road / Windmill Road Junction. There is a vehicle scrap yard at the north east end of Calmount Road, and an area recorded as comprising various shipping containers and miscellaneous debris is located at the southern end of Calmount Avenue.</p>

5.7.4 Possible Sources of Contamination along the route

The presence of Made ground along the route means the possibility of contamination. cannot be discounted. Samples for contamination testing shall be taken as part of the intrusive ground investigation.

EPA mapping indicates the following along the route:

- IPPC Facility: surrendered IEL along Greenhills road near intersection of Airton Road
- IPPC Facility: Plateco ZN Limited, Mulcahy Keane Estate, Dublin 12, Dublin
- IPPC Facility: B.G. Flexible Packaging Limited, South Circular Road, Dolphin's Barn, Dublin 8, Dublin
- Waste Transfer Station: Ballymount Baling Station
- Waste Transfer Station: Keywaste Management Limited, Greenhills Road
- Waste Transfer Station: Lawlor Brothers Waste Disposal Limited, JFK Industrial Estate, Naas Road

A historic mill is located at the following locations:

- Corner of Vauxhall Avenue and Dolphin's Barn St.
- North of the River Camac at the intersection of Killen Road and Nangor Road.

There are two petrol stations recorded along the proposed Clondalkin route, one on the R112 Walkinstown Avenue and another on the R810 Naas Road

There are two petrol stations located throughout the Greenhills route, one directly to the west of Dolphin's Barn Bridge, and another directly to the east of the R110 Crumlin Road / Windmill Road Junction. There is a vehicle scrap yard at the north east end of Calmount Road, and an area recorded as comprising various shipping containers and miscellaneous debris is located at the southern end of Calmount Avenue.

5.7.4.1 Historical geotechnical reports with waste ground

Historical report GSI reference 2691 which involved a site to be developed at a major baled waste depot along Greenhills Road states:

“An area of mixed domestic/commercial fill was found in the corner of the site bounded by the distributor road and the Greenhills Road. This probably represents unauthorised dumping into a former gravel pit.”

The report also states:

“The site is in the main reasonably level but lying some 3 to 4 metres below the Greenhills Road, with a steep embankment from the Greenhills Road to the actual development site.”

Another report GSI reference 115 which was at a proposed industrial estate in Greenhills road encountered made ground consisting of paper, timber, rubble, etc. was found extending to a maximum depth of 4.60

The historical maps show the area of Greenhills road north of the M50 was an Esker previously quarried for Sand and Gravel. It is possible that this was infilled with waste material after quarrying operations ceased.

Report 778 along Patricks St describes waste fill associated with the possible filling of the River Poddle.

6. Ground Conditions

Based on a review of the historical reports described in section 2.1. and published literature it

Typical idealised soil conditions to be anticipated along the route as follows:

- Made Ground: Made ground of various composition and thicknesses is to be expected along the entire route; overlying
- Glacial Till: Glacial Till consisting of sandy gravelly silt/clay with low to medium cobble content; occasionally soft to firm to 0.5 m; typically, firm / firm to stiff to maximum of 2.0m (**brown Dublin boulder clay**); and generally underlain by stiff / very stiff / hard soil. High cobble content and occasional boulders are typical below 2.0m bgl. (**black Dublin boulder clay**).
- Glacial and Glaciofluvial gravels: These are potentially dense sandy Gravels associated with the Greenhills esker

6.1 Made Ground

Made ground should be expected throughout the route and may vary from a thin skim to several metres of material.

Highway fill is associated with existing roads or areas of hard standing; it typically comprises general fill of reworked clay/silt/sands and selected fills formed by silty sandy gravels.

Made ground consisting of variable soil composition and waste may be present when widening for additional land take. The possibility of contaminated ground cannot be discounted and should be investigated as part of the intrusive investigation.

Made ground is typically not considered a suitable foundation material and is typically sub-excavated as part of the construction works. Exceptions may be made for low risk lightly loaded at grade construction where the made ground conditions are favourable.

6.2 Alluvium Deposits

There is the possibility for alluvial soil along the route at locations adjacent to the River Camac and River Poddle.

These are recent deposits of waterborne clay, silt, sand and gravel deposited close to watercourses, with the nature of the soil varying laterally and with depth. For the purpose of classification, alluvial deposits are generally split into two types:

- Cohesive (fine grained) alluvium: deposits mainly comprising silts and clays, sometimes peaty/organic, which were frequently soft in consistency.

- Granular (coarse grained) alluvium: deposits mainly comprising sands and gravels, occasionally with low cobble content, and frequently of loose relative density.

In many cases, the alluvial clays and silts are inter-bedded with alluvial sands or gravels.

6.3 Till Deposits

The Glacial Till is typical of the drift cover in much of the Dublin area, comprising boulder clay, a lodgement till deposited during the last ice age, about 10,000 years ago. Farrell et al. (1995) made the distinction between the 'Brown Boulder Clay' and the 'Black Boulder Clay', stating that the Brown Boulder Clay was a weathering product of the Black Boulder Clay, and is broadly similar to it in terms of particle size distribution.

The brown Dublin boulder clay generally consists of:

- sandy gravelly silt/clay with low to medium cobble content; occasionally soft to firm to 0.5 m; typically, firm / firm to stiff to maximum of about 3 m
- Plasticity Indices ranging from Non- Plastic to about 15
- An undrained shear strength of approximately 50 kPa is typically achievable assuming it is not excessively weathered, corresponding to a CBR % of about 2.0.

The black Dublin Boulder clay is found underlying the brown Dublin Boulder Clay and consists of:

- Generally stiff / very stiff / sandy gravelly silt/clay with high cobble content and occasional boulders are typical below 2.0m bgl.
- SPT blow counts are generally greater than 30 increasing to refusal within 1-2 m from the top of the stratum.
- BS8002 (British Standards Institute, 1994) can be used to relate plasticity index to θ' crit, the critical state angle of shearing resistance. Adopting a plasticity index of 15% for soils at greater than 1 m depth, Table 2 of BS8002 provides a "conservative" value for θ' crit of 30°. The relationship published by Knappet & Craig (Craig's Soil Mechanics, 8th Edition, 2012) provides a θ' crit of approximately 32°.

Published case studies of construction in Dublin Boulder Clay report peak values of the angle of shearing resistance of 30 - 38°. The gravel content of the soils would provide additional frictional resistance, due to interlock, and there is likely to be some long-term effective cohesion.

6.4 Glaciofluvial Deposits

Glaciofluvial deposits of sand and gravels are likely to be present along Greenhills Road which is located near the Greenhills Esker, a ridge of sediment deposited by a stream that ran under, over, or within a glacier. Eskers can contain a wide variety of materials, with coarse-grained soils generally prevalent. Associated sands and gravels along the Greenhills Road, northeast of the esker are probably part of an associated ice marginal fan. The sands and gravels within the feature are comprised chiefly of limestone clasts.

The area to both side of Greenhills Road was historically mined for Sand and Gravel. Consequently, the road is approximately 7m higher than the surrounding ground with steep side slopes.

Where glaciofluvial gravels are located near surface, this may negate the need for capping in the road structure providing they display a CBR greater than 15%.

6.5 Bedrock

Bedrock was not proven in the historical ground investigation reports

7. Preliminary Engineering Assessment

7.1.1 General

The following sections provide **preliminary** geotechnical recommendations for the proposed development, based on the currently available published information.

Geotechnical designs should be conducted in compliance with Eurocode 7 Part 1 and its Irish National Annex (National Standards Authority of Ireland, 2005a, and 2005b): abbreviated as EC7.

7.1.2 Earthworks

7.1.2.1 General & Selected fills

General granular and cohesive fills will be classified in accordance with Table 6/1 and Table 6/2 of TII Specification for Road Works (CC-SPW-00600 series). Selected fills will be classified in accordance with relevant sections of TII CC-SPW.

7.1.2.2 Re-use

There is not expected to be significant amount of reuse of material along the route due to a lack of proposed cut areas.

An assessment of the reusability of material will be made as part of the geotechnical reporting.

7.1.2.3 Engineering Fill Materials

Engineering Fill will be required on this project for the construction of embankments and retaining structures.

The primary types of fill materials required have been identified as follows:

- General Granular Fill (Class 1)
- General Cohesive Fill (Class 2) – consisting of fine-grained Glacial Till of adequate remoulded undrained shear strength. It is anticipated that this will require importation due to the lack of borrow areas along the route.
- Selected well graded granular material (Class 6A) –for use below water if required.
- Selected uniformly graded granular material (Class 6C) - for use as a starter layer if required.
- Selected granular fill (Class 6N1) –for use as a fill to structures.
- Selected granular fill (Class 6N2) –for use as a fill below structures.

The above granular fills will be formed by natural sand and gravel, crushed rock or recycled materials, imported from quarries in the locality.

7.1.2.4 Embankments

Embankments will be constructed with acceptable fill material derived generally from off-site quarries and where available on-site borrow areas. Embankment slopes will generally be constructed at an inclination of 2H:1V where there is sufficient space.

At the geotechnical reporting stage, analysis will be performed for both short term and long-term conditions as appropriate to confirm adequate stability of proposed side slope angles. Analyses will be carried out, using specialist software, applying two-dimensional Limit Equilibrium Methods in accordance with Eurocode 7 using characteristic design parameters. The design is considered safe if the calculated Factors of Safety for Combination 1 and 2 are both greater than unity (i.e. the Degree of Utilisation is less than 100%). Where the resultant factor of safety does not exceed this target, the design will be considered unacceptable.

The critical section will generally occur at the highest section of the embankment provided that ground and/or groundwater conditions do not differ significantly along the length of the embankment. In such cases more than one typical design section may be required for consideration of slope stability for the whole earthwork area.

Drainage measures will ensure significant surface water flow is not directed into the embankment, potentially causing softening of the fill material and increasing porewater pressure.

Consideration should be given to the avoidance of extending the Greenhills Road embankments, where possible. Although currently stable, the existing steep slopes would not be compliant with present day EC7 guidance and requirements. Where widening of Greenhills Road is unavoidable, retaining structures should be relied upon.

7.1.2.5 Cuttings

Cuttings for widening are anticipated to be generally shallow along the route. Cuttings at a maximum slope angle of 2H:1V should be achievable to most soil types. The presence of fine-grained alluvium or water bearing soils may require flatter slopes.

Slope stability analyses will be carried out in a similar manner to that described above in relation to embankments.

Cuttings shall incorporate appropriate in-slope drainage to manage and control water, including groundwater issues onto slope faces: e.g. herring-bone drains, counterforts and granular surface drainage layers. The sources of seepage and areas of potential seepage shall be observed for a period before applying topsoil, as they may not become active until sometime after exposure especially in periods of sustained dry weather.

Where there is insufficient room for permanent cuttings, consideration may be given to retaining walls, embedded retaining walls or soil nailing.

7.1.3 Pavement Design

The preparation of the subgrade and the construction of the pavement foundation shall comply with the Specification for Road Works (National Roads Authority, 2011)

Areas of made ground and soft, highly compressible or organic soil will not be suitable as subgrade and will be excavated as part of the construction works.

The performance of any subgrade in a road pavement depends on its strength in both the short and long term. Subgrades which are of low plasticity clayey or silty soils are highly susceptible to changes in moisture content. Glacial Till formations that are not adequately protected are subject to deterioration. Prior to carrying out a ground investigation, an average equilibrium CBR of 2.5% could be assumed, requiring a capping layer thickness of 400 mm, with 150 mm sub-base layer for new road construction (TII DN-PAV-03021).

Laboratory CBR testing of silty boulder clay soils can often provide unexpectedly low results, often attributed to dilatancy, migration of water from granular lenses, or excess pore water pressures within the remoulded specimen following its preparation. In addition to laboratory CBR tests, the ground investigation will include in-situ measurement of CBR using the Dynamic Cone Penetrometer.

Quality control testing shall be undertaken during construction, to confirm that the CBR of the exposed subgrade conforms with the design value. The testing shall be conducted using the Dynamic Cone Penetrometer: test method and frequency as described in Interim Advice Note 73/06 (Highway Agency, 2009)

It is important that, before construction of pavements, the excavated surface should be proof-rolled by at least two passes of a smooth-wheeled vibratory roller having a minimum mass per metre roll width of 2,100 kg, or other suitable method agreed with the Designer. Any soft fine-grained layers should be removed, or the capping thickness varied to be consistent with the quality of the exposed subgrade.

7.2 Structures

The following are a list of structures potentially required along the route:

- Retaining walls associated with widening along Belgard Square North
- Retaining walls associated with widening along Greenhills Road from Institute of Tallaght Technology (ITT) access road to beyond Mayberry Road
- Retaining walls associated with construction of the proposed New Greenhills Road
- A proposed vehicle bridge along Greenhills road over the M50
- Possible retaining structures for the proposed new Link between Greenhills Road to Ballymount Avenue
- Possible retaining structures for the proposed new Link between Greenhills Road to Calmount Road
- Retaining Walls associated with the widening of Greenhills Road
- Proposed Cycle and Pedestrian Bridge proposed at Long Mile road

7.2.1 Foundations

An allowable bearing pressure of 150 kPa may be achievable in brown Dublin Boulder Clay provided the minimum acceptable undrained shear strength of the soils at the excavation base is 80 kPa. The Glacial Till in the Dublin area generally shows an increase in strength with depth.

Allowable bearing pressures in excess of 250 kN/m² may be feasible on the black Dublin boulder clay.

Allowable bearing pressures in glacial sands and gravels will be a function of the relative density of the underlying material; for a medium dense deposit, allowable bearing pressures in the order of 150 kN/m² may be feasible.

The excavation level required for each foundation should be confirmed by inspection and in-situ testing at the base of the excavation.

ST1 (lean mix) concrete should be used to backfill the excavation to the underside of the structural concrete foundation to minimise softening of the moisture susceptible Glacial Till. The alternative approach of using a well-graded, well-compacted granular fill could be problematic given that the confined base area of the foundation excavation would restrict the operation of compaction equipment.

Horizontal loads will be resisted by a combination of passive pressure on the vertical faces of the foundations and friction between the bottom of the foundation and the supporting soil. The passive pressure and frictional resistance can be estimated using a characteristic angle of shearing resistance of 30° for the Glacial Till and characteristic weight density of 21.5 kN/m^3 .

Piled foundations may be considered feasible for heavily loaded structures or areas where excavation for shallow footings are considered uneconomical.

In areas of relatively shallow bedrock, piles may be designed as end bearing, deriving most of their capacity from a rock socket in the underlying bedrock. In areas of deeper bedrock, friction piles are achievable with the piles deriving most of their capacity through shaft adhesion with the Glacial Till.

A geotechnical investigation consisting of cable percussion boreholes in the Glacial Till/Gravels and follow on rotary Geobor S coring in the very stiff to hard Glacial Till and underlying bedrock will be carried out to inform pile design.

7.2.2 Retaining Structures

Where the construction of stable full height embankment side slopes is not possible due to space constraints, strengthened earthworks or retaining walls (gravity or cantilever) may be required.

Similarly, where a stable cutting slope is not possible due to lack of land take, retaining walls (gravity, cantilever or embedded) or stabilisation methods such as soil nailing may be considered.

A characteristic angle of shearing resistance of 30° and characteristic weight density of 21.5 kN/m^3 can generally be adopted for the Glacial Till when calculating active and passive pressures, and wall and base friction.

Using the guidance of BS8004 (British Standards Institution, 2015), a characteristic critical state angle of shearing resistance for the sand and gravel deposits can be derived from the combination of the following:

- $30^\circ + \text{"contribution from angularity of the particles (0-4}^\circ\text{)" + "contribution the soil's particle size distribution (0-4}^\circ\text{"}$

A characteristic peak angle of shearing resistance can be derived by including the contribution from the soil's relative density ($0-9^\circ$) to the above equation.

The earth pressures arising from imported backfill to structures should be based on its measured properties. A characteristic angle of shearing resistance of 35° is appropriate for well graded, well compacted, granular material along with a characteristic weight density of 20 kN/m^3 .

Annex C of EC7 (National Standards Authority of Ireland, 2005a) provides charts and equations to allow calculation of earth pressure coefficients for various design values of angle of shearing resistance, wall friction and backfill slope angle.

Unless drainage is installed, and maintained during the life of the development, structures should also allow for hydrostatic pressures arising from groundwater. Additional lateral pressures caused by loadings on the retained surface, and by compaction equipment used during backfilling, should be considered in the stability and structural design of retaining structures.

7.2.3 Soil Chemistry

Table C1 of BRE Special Digest 1 (Building Research Establishment, 2005) will be used to determine the Design Sulfate (DS) Class and the class necessary to meet the Aggressive Chemical Environment for Concrete (ACEC) requirements.

Part D of BRE Special Digest 1 provides guidance on the design of underground cast in-situ concrete: the maximum free-water / cement ratio, minimum cement content and cement types.

7.3 Contaminated Land

The possibility of contaminated ground cannot be discounted due to the presence of Made Ground and historical land use along the proposed route.

Contamination testing and Waste Acceptance Criteria testing will be carried out as part of the geotechnical field investigation.

8. Comparison of Project Options and Risks

8.1 Geotechnical Category

The site has been designated a Geotechnical Category 2 project in accordance with the TII Publication No. DN-ERW-03083, Managing Geotechnical Risk.

This section contains the initial Geotechnical Risk Register established for the scheme. The register highlights the geotechnical design risks to be addressed in the design and construction, the consequence of those risks together with the measures taken to mitigate those risks. The identified risks will be taken forward and addressed within the preliminary and detailed design, and construction information.

Table 4 Geotechnical Risk Assessment

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk
		P	I	R		
1	Difference between assumed ground conditions and those encountered during construction.	4	5	20	ULS failure of the bridge or retaining walls. Potential for higher settlement magnitudes and/or settlements of a more time dependent nature. Increased maintenance.	Ground Investigation to determine soil conditions along route. Inspection of formation by Geotechnical Engineer to verify design assumptions. Proof rolling of formation and removal of any soft spots identified. Preloading of sub-soil and review of settlement monitoring data and hold period. Conservative parameters adopted for design.

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk	
		P	I	R			
2	Potential presence of fine-grained compressible material at depth resulting in longer term settlement	4	5	20	Long term settlement impact to structures due to consolidation settlement of fine-grained layers	Ground Investigation to determine soil conditions at settlement sensitive structures. Preload embankment constructed with review of settlement monitoring data and hold period to ensure majority of settlement complete and anticipated residual settlement negligible.	1
3	Presence of Made Ground	4	5	20	Scheme located within heavily developed urban area. Soft/poorly compacted ground resulting in subsidence. Variable ground conditions over relatively small areas. Differential settlement. Risk of contaminated ground.	Ground investigation to determine presence, likely thickness and composition of Made Ground. Design to mitigate effects of made Ground.	2
5	Subgrade deformation	3	4	12	Pavement serviceability problems. Reduced ride quality	Ground investigation to determine subgrade quality and appropriate design CBR values. Construction control and adequate drainage.	1

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk	
		P	I	R			
6	Widening into steep Embankment	4	5	20	ULS failure or localised sloughing of existing embankment during construction or operation.	Ground Investigation to determine ground conditions. Existing embankment side slopes at angles steeper than currently permitted by EC 7 guidance. Avoid widening into embankment where possible. Flatten slope or provide retaining wall where widening unavoidable.	2
7	Widening adjacent to existing properties with grade change	4	5	20	Potentially widening into an adjacent property with a grade change may require a retaining structure	Ground Investigation to determine ground conditions. Retaining structures to be designed in accordance with EC 7. If temporary anchors required, may need a temporary easement. Potential temporary CPOs required to construct retaining structures in adjacent properties.	2

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk	
		P	I	R			
8	Possible high groundwater table above founding levels	4	5	20	Danger to construction personnel. Difficulty in compaction of Class 6N and construction of foundations. Dewatering of potentially contaminated groundwater required during construction.	Ground Investigation to determine groundwater conditions along route. Contractor to be informed of risk and provision to be allowed for dewatering and temporary drainage measures. Excavation levels reduced to minimum possible to achieve design requirements.	2
9	Presence of contaminated groundwater/soils.	5	4	20	Danger to construction personnel, particularly if groundwater is encountered during excavations. Potential transfer of contamination off-site and to watercourses.	Ground Investigation to determine soil conditions and presence of any potential contamination. Waste Acceptance Criteria determination to be carried to determine suitable disposal sites.	5
10	Possible presence of buried foundations and structures	4	4	16	Additional excavation required to remove historical foundations, buried structures. Possible differential settlements if not identified / removed.	Ground Investigation to determine soil conditions at structure locations. Review of historical maps when structure footprint finalised	2

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk	
		P	I	R			
11	Presence of recorded / unrecorded utility services on site.	3	5	15	Rupture of services causing electrocution, asphyxiation, spraying of sewage. Risk of death or serious injury.	Contractor to determine location of all underground services and arrange provide for any necessary diversions with the relevant statutory undertakers prior to undertaking ground investigation Contractor to instigate safe systems of work to avoid damaging / encountering services. Vigilance on site during excavations. Permit to dig system.	1
12	Historical unrecorded shallow mining	2	5	10	Potential presence of voids / shafts.	Historical quarrying in certain areas along the route. Contractor to remain vigilant during works and have safe systems in place.	1

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk
		P	I	R		
13	Operatives/staff working close to/in excavations.	4	5	20	Risk of collapse of excavation. Danger to construction personnel.	Excavation depths kept to minimum required by design. Temporary excavations to be designed by Contractor to ensure safety of site staff. This may require benching or temporary supports. Safe system of work to be applied.

Table 5. Risk Rating

Impact (I)	Scale	Time	Probability (P)	Scale
Very High	5	> 10 weeks on completion	Very Likely	5
High	4	> 1 week on completion	Likely	4
Medium	3	> 4 weeks, < 1 week on construction	Probable	3
Low	2	1 to 4 weeks on activity, none on completion	Unlikely	2
Very Low	1	1 week on activity, none on completion	Negligible	1

