Appendix E

Geotechnical Report

PSSR

Preliminary Sources Study Report (PSSR)

Bus Connects Core Bus Corridor 1: Clongriffin to City Centre

National Transport Authority

Project number: 60599126

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Prepared for:

National Transport Authority

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1. Introduction

1.1 Scope and Objective of Report

The scope and objective of this Preliminary Sources Study Report (PSSR) is to address the geological, geotechnical, geomorphological, hydrogeological and geo-environmental aspects of the Bus Connects Core Bus Corridor, Route 1 – Clongriffin to Dublin City Centre (location map presented in Appendix A). It also examines the historical development of the area. The PSSR provides a preliminary engineering assessment of the route to inform of likely hazards to construction.

The information contained within this report will be used to scope future Ground Investigations and to inform the Preferred Route Concept Design and Route Selection Report.

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 1 from Clongriffin to Dublin city centre is the focus of this report. The remaining routes (6, 8 and 9) are reported under separate cover.

The scheme will provide a continuous bus lane in each direction as well as maintaining two general traffic lanes. In addition, there will be provision for safe cycling facilities, segregated where possible from vehicular traffic. To facilitate this, it is anticipated that construction works will need to comprise:

- Limited widening of the existing route to accommodate new bus lanes, cycle tracks and pedestrian footpaths along the Malahide Road (R107). Where possible this widening will occur in the central median. Where this is not an option widening will typically occur in adjacent residential front gardens and public amenity spaces.
- New road construction and upgrading of partially constructed road in the northernmost portion of the route.
- Upgrading of existing junctions to accommodate the proposed design.

The emerging preferred option for Route 1 has an approximate length of 10kms, 6kms of which will comprise new cycle lanes.

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	• Bedrock Geology • Quaternary Sediments • Teagasc Soils

Source	Location	Available Information
		• 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
The Geology of Ireland (2nd Edition)	*Holland, C.H. and Sanders, I.S. (2009). The Geology of Ireland (2nd Edition). Dunedin Academic Press.*	• Bedrock Geology • Structural Geology • Quaternary Geology
Ordnance Survey Ireland (OSI) - Geohive	http://map.geohive.ie/mapviewer.html	• Historical Maps • Aerial Photos (1995, 2000, 2005, 2012) • Topographic Maps
Environmental Protection Agency (EPA) Map Viewer	https://gis.epa.ie/EPAMaps/	• Waste Facilities • River Network and Flow Direction • Protected Areas
Google Maps	https://www.google.co.in/maps?hl=en&tab=rl1	• Aerial Photos (2019)
Office of Public Works (OPW) Flood Maps	http://www.floodinfo.ie/map/floodmaps /?smau=iVVJQSq HPRMDv1IN	• 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	• Background and scope for Bus Connects Core Bus Corridor Route 1 • Route Maps

3. Existing Ground Investigations

According to the GSI Geotechnical Data maps (Appendix A) there have been twelve ground investigations completed with exploratory holes (EH) either on or adjacent to the route. A total of eight of these reports have sufficient information to be included in this study. A summary of these reports is presented in the following table:

Table 2. List of Relevant Ground Investigation Reports

GSI Ref.	Report Title	No. of EH adjacent to route	Year Completed	Soil Conditions
7446	Report on a Site Investigation at Temporary School Site, Lusk	1	2008	The trial pits revealed TOPSOIL overlying mottled sandy gravelly CLAY in a soft to firm condition. This material is underlain by brown gravelly CLAY with cobbles and boulders, which is in a firm to stiff condition. Very stiff black gravelly CLAY was noted at depths of 2.4m and 2.6m.

GSI Ref.	Report Title	No. of EH adjacent to route	Year Completed	Soil Conditions
7240	Report on a Site Investigation for Fairview Park, Proposed Changing Facility	2	2008	Boreholes revealed MADE GROUND, composed of black sandy CLAY containing demolition waste. This material overlies stiff black gravelly CLAY at depths of 4.3m. Trial pits revealed black gravelly CLAY FILL intermixed with demolition waste.
6845	Dublin Port Tunnel Vol 5 (Part 1) Site Investigation Data Reports	2	1995	In summary, the overburden soils at the site predominately comprise the following sequence: MADE GROUND (at 1.10m); very dense dark grey to black SAND and GRAVEL; stiff dark grey CLAY with much gravel (at 5m); very stiff dark grey sandy gravelly CLAY; Argillaceous LIMESTONE (from 13m to 16.8m).
5937	Report on a Site Investigation for a Development at Kavanaghs Public House, Fairview, Dublin	1	2005	Loosely compacted MADE GROUND underlies surface concrete to a depth of 1.1m. Soft silty CLAY extends from 1.1m to 2.4m and overlies medium dense brown clay bound GRAVEL (grading to firm gravelly CLAY in places). Very stiff black gravelly CLAY (black BOULDER CLAY) is present below 3.6m. This stratum was penetrated to refusal at 6.4m.
5564	Report on a Site Investigation for a Development at Donaghmede	8	2004	The borings reflect a high degree of consistency with surface TOPSOIL overlying firm to stiff brown gravelly CLAY. At approximately 2.2m below ground very stiff grey gravelly CLAY was noted and boreholes were terminated in this stratum at depths between 6m and 6.5m.
5228	Grange Road Donaghmede Draft Ground Investigation Report	4	2003	The ground conditions generally consisted of the following units: Topsoil; sandy, gravelly CLAY/SILT with occasional cobbles and boulders; sandy, medium coarse GRAVEL with occasional cobbles; sandy gravelly CLAY with cobbles and boulders.
4356	Report on a Site Investigation for Balgrtiffin Residential Development	3	2001	In summary, the overburden soils at the site predominately comprise the following sequence: soft to firm brown slightly sandy slightly gravelly CLAY with cobbles and boulders; stiff to very stiff black slightly sandy slightly gravelly CLAY with cobbles and boulders.
411	Donnycarney Church	3	1965	In summary, the overburden soils at the site predominately comprise the following sequence: TOPSOIL; soft brown BOULDER CLAY (encountered at 1.4m to 2.75m); hard brown BOULDER CLAY (encountered at 2.3m to 2.7m); very hard black BOULDER CLAY (encountered at 3.96m to 5.36m); and broken rock at 4.57m.

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 and provide preliminary geotechnical recommendations.

4. Field Studies

No field studies have been undertaken for this report.

5. Site Description

5.1 General

The route comprises approximately 10km of proposed new bus corridor route between Clongriffin Park and Ride, and Clontarf Road in Dublin's city centre. Much of the route runs north-east for approximately 5.7km along the existing Malahide Road (R107). This section extends from the junction of Clontarf Road and Malahide Road (to the south) to the junction of Mayne River Avenue and Malahide Road (to the north). At which point the route turns east towards Clongriffin Park and Ride for a further 2km. The route is predominantly at grade.

A location map is presented in Appendix A.

5.2 Proposed Route Overview

Sections 5.2.1 to 5.2.3 detail the proposed route alignment at the time of drafting of this report. The following route descriptions were taken from the Bus Connects Clongriffin Brochure (Appendix B).

The Core Bus Corridor (CBC) commences at Clongriffin DART Station and is routed via Clongriffin Main Street which will be extended to join the Malahide Road at a new junction to the north of Clare Hall Junction. The CBC is then routed via Malahide Road to the junction with Marino Mart/Fairview. From here the CBC ties into a separate project, Clontarf to City Centre Cycle Scheme currently proposed by Dublin City Council.

5.2.1 Clongriffin DART Station to Malahide Road via Clongriffin Main Street

At Clongriffin DART Station, it is proposed to retain the existing pedestrian, bus stop and bus turnaround facilities. It is intended to route buses through Clongriffin Main Street. No works are proposed for this existing section of Main Street. Existing bus and cycle infrastructure will be maintained. It is proposed to extend Main Street between the Hole in the Wall Road and Belmayne Avenue. A new section of road between Main Street and the Malahide Road will be constructed with a new junction to the north of Clare Hall junction incorporating bus lanes in both directions. A bus and cycle only section will be provided at this junction. General traffic will not be permitted to use this access. Access to Main Street for general traffic will remain unchanged through Belmayne.

5.2.2 Mayne River Avenue to Gracefield Road – Malahide Road

The CBC is then proposed to be routed along the Malahide Road to the junction with the R105 at Marino Mart/Fairview. The following junctions are intended to be upgraded to provide bus priority and enhanced pedestrian and cyclist facilities:

- Malahide Road/ R139 Clarehall Avenue
- Malahide Road/ Entrance to Clarehall Shopping Centre
- Malahide Road/ Blunden Drive/ Priorswood Road
- Malahide Road/ Tonglegee Road/Brookville Crescent
- Malahide Road/ Gracefield Road

At Clarehall Avenue, it is proposed to modify this junction by removing the existing left turn slip road on each approach. It is intended to replace these slips roads with dedicated left turn lanes. On the northbound approach on the Malahide Road, it is proposed to extend the bus lane to the stop line.

Between Clarehall Avenue and Blunden Drive, a single bus lane and two general traffic lanes will be maintained. The left slip road into the Clarehall Shopping Centre is intended to be removed; however, a dedicated left turn lane will be provided to service this traffic movement.

It is proposed to upgrade the existing roundabout on Blunden Drive to a fully signalised junction. Between Blunden Drive and Greencastle Road, it is intended to maintain a single bus and general traffic lane in each direction. An additional pedestrian crossing will be provided as part of a new bus stop facility between these junctions.

Between Clarehall Avenue and Santry River crossing, it is proposed to utilise limited land take from adjacent green spaces/ car parking areas to facilitate these infrastructure improvements.

At the junction of Tonglegee Road/Brookville Crescent, it is intended to remove the existing left turn slip roads and modify the junction to include for left turn lanes. Accommodation will be made for the future provision of cycle facilities on Tonlegee Road and Brookville Crescent as part of these proposed junction modifications.

Between Tonglegee Road junction and Gracefield Road junction, it is intended to retain the single bus and general traffic lane in each direction. A north bound segregated cycle track will be provided between the Malahide Road and Brookville Park. South bound cyclists are proposed to be redirected on to St. Brendan's Avenue. Cyclists can then re-join the Malahide Road at Gracefield Road.

It is intended to modify the existing roundabout at Gracefield Road to a fully signalised junction.

5.2.3 Gracefield Road and Clontarf Road – Malahide Road

Between Gracefield Road and Clontarf Road junctions, it is proposed to upgrade the following junctions on the Malahide Road:

- Malahide Road/Collins Avenue
- Malahide Road/Copeland Avenue/Griffith Avenue
- Malahide Road/Clontarf Road

Between Gracefield Road junction and Killester Avenue, it is intended to provide a continuous bus lane with a single general traffic lane in each direction. Dedicated cycle tracks and footway facilities will be maintained through this section. To accommodate this, limited areas of land take between these junctions is proposed. The proposed works may also require the removal of existing trees currently located between the existing road and footpath.

Between Killester Avenue junction and Collins Avenue, it is proposed to maintain the road cross section. The existing road between these junctions required widening to accommodate the desired lane widths and bus stop facilities. This may require land take from the surrounding green space in Thorndale Grove and Mayfield Park. It is also proposed to utilise land take from private properties between Mayfield Park and Collins Avenue.

Between Collins Avenue Junction and Griffith Avenue Junction, it is proposed to remove the existing left turn slip road from Collins Avenue East Road. Again, it is intended to provide a continuous bus lane with a single general traffic lane in each direction. Currently, there are no continuous dedicated cycle tracks in both directions on this section of the Malahide Road. This issue is proposed to be addressed by road widening works. This widening may involve land take between Donnycarney Church and Clancarthy Road, Clontarf Golf Club and Bowling Club grounds, Nazareth House.

Between Griffith Avenue junction and Clontarf Road junction, it is proposed to continue the bus and general traffic lanes in both directions. There are currently only three traffic lanes on this section of road. To facilitate the new four lane arrangement, it is intended to utilise limited land take from adjacent properties at the following locations:

- Between Copeland Avenue and Marino Avenue
- Between Charlemont Road and Crescent Place
- Between Brian Road and St. Aidan's Park

Because of the significant additional impacts on private properties, if cycle tracks were to be included on this section of the Malahide Road, it is intended to redirect cyclists through a parallel, less trafficked route along Brian Road, Carleton Road and Haverty Road. Cyclists will then re-join Marino Mart and tie-in with the Clontarf to City Centre Cycle Scheme. The proposed bus lane works will tie into the existing bus facilities on Clontarf Road.

5.3 Topography

The topography of the route is flat to gently undulating with elevations increasing from south to north from approximately 10m to 30m Ordnance Datum (OD) over a distance of approximately 5.7km. Where the route turns to the east at its northernmost extent (junction of Mayne River Avenue and Malahide Road) elevations steadily decrease towards the east from 30m to 10m OD over a distance of approximately 2km.

A topographic map is presented in Appendix A.

5.4 Geology & Geomorphology

A review of the routes' underlying geology was completed using available data derived from the GSI spatial data viewer. The following is a summary of the recorded superficial and solid geology that underlies the route.

5.4.1 Superficial Deposits

The GSI Quaternary Sediments and Teagasc Soils maps (Appendix A) indicate the route is underlain by the following deposits:

Made Ground

According to the Teagasc Soils map almost the entire route is mantled by deposits of Made Ground. These deposits extend to the east and west of the route for several kilometres and can be attributed to urban development within the Dublin city area.

Aeolian Deposits

The GSI Quaternary Sediments map records Aeolian deposits along the southern extent of the route in the area of Marino Crescent. These deposits are composed of windblown sands. Immediately south of these deposits and outside of the route area, are silts and clays associated with estuarine sediments.

The Teagasc Soils map does not record these Aeolian deposits but rather a covering of Made Ground.

Alluvium Deposits

The GSI Teagasc Soils map indicates a narrow (approx. 40m wide) south-east trending ribbon of Alluvium flanking the Santry River. These deposits bisect the route near the junction of Greencastle Road and Malahide Road.

An additional narrow (approx. 30m wide) ribbon of Alluvium is recorded bisecting the route at the junction of Mornington Grove and Malahide Road. Located approximately 1.3km south of the Santry River, these deposits are recorded on the GSI Quaternary Sediments map but not on the Teagasc Soils map. It is possible that they are overlain by Made Ground. There are no rivers recorded on contemporary maps which can be attributed to these deposits.

Glaciofluvial Deposits

The GSI Teagasc Soils map indicates a relatively small (approx. 80m wide by 900m long) east-west trending deposit of glaciofluvial sand and gravel, located along Main Street Clongriffin at the northern extent of the route. Deposits are described as being derived chiefly from Carboniferous limestone.

Till Deposits

The GSI Teagasc Soils map records Till deposits at three separate locations – at Marino and Coolock to the south and middle of the route respectively and extensive coverage to the north of the route beyond the junction of Blunden Drive and Malahide Road. Deposits are described as being derived chiefly from Carboniferous limestone.

In contrast the GSI Quaternary Sediment map indicates most of the route is directly underlain by Till deposits. However, it is likely that most of these deposits are mantled by Made Ground as evidenced by the Teagasc Soils map.

5.4.2 Bedrock

The GSI Bedrock Geology map (scale 1:100,000) (Appendix A) indicates the route is underlain by a sequence of Carboniferous limestone rocks comprising the following formations:

Lucan Formation

This extends from the southern extent of the route to the junction of Danieli Road and Malahide Road and takes up approximately half of the southern end of the scheme.

The Lucan Formation comprises dark-grey, argillaceous, cherty, spicular micrites and shales, with horizons of graded, skeletal limestones containing ooids and other shallow water grains.

Outcrops/subcrops of Lucan Formation are recorded approximately 2.2km to the south-east of the route within the grounds of Clontarf Golf Course.

Tober Colleen Formation

This extends for approximately 1.5km across the middle portion of the route between Danieli Road and Malahide Road junction (to the south) and Greencastle Road and Malahide Road junction (to the north).

The Tober Colleen Formation comprises dark-grey, calcareous, commonly bioturbated mudstones and subordinate thin micritic limestones.

Malahide Formation

This underlies the remaining northern half of the route extending from the junction of Greencastle Road and Malahide Road to Clongriffin Park and Ride (northern extent of the proposed route).

The Malahide Formation comprises dark-grey argillaceous bioclastic limestone and shale. This formation is commonly referred to as the Upper Argillaceous Bioclastic Limestone (Upper ABL).

5.4.3 Structural Geology

There are no faults recorded along the proposed route. However, a series of north-east trending synclinal and anticlinal axis cross the middle and northern extent of the route respectively and are an indication of regional folding.

Structural measurements taken from surrounding outcrops indicate bedding dips of between 15 and 35 degrees with dip direction varying.

5.5 Hydrology

5.5.1 Surface Water Features

According to the GSI Surface Water Features map (Appendix A) only one water feature (Santry River) crosses the route at the junction of Green Castle Road and Malahide Road. This river, which is culverted below the Malahide Road, flows in a south-easterly direction following the topography and emptying into the sea at North Bull Island to the east of the route.

5.5.2 Flooding

The Office of Public Works (OPW) Flood Maps (Appendix A) indicates the Santry River is not liable to flooding in the vicinity of the route. However, approximately 500m south-east of where the river crosses the route there is a Medium Probability (1 in a 100 chance per year) that the lands immediately adjacent to the Santry River will become flooded.

Records of coastal flooding are limited to the southern extent of the route. OPW Flood Maps indicates a Medium Probability (1 in a 100 chance per year) of coastal flooding in the area immediately south of the routes' southern boundary. However, there is a Low Probability (1 in a 1000 chance per year) of coastal flooding which extends into the route affecting Clontarf Road and the southern extent of Marino Crescent.

5.5.3 Past Flood Events

According to the OPW Past Flood Records map (Appendix A) five flood events have been recorded within 500m of the route. The following table summarises these occurrences:

Table 3. Summary of Past Flood Events

Distance from route	Area	Year	Cause
On site (Malahide and St Brigid's Roads)	Artane, Dublin 5	December 1954	Possible overwhelming of the Naniken Culvert during a heavy storm flow. Resulting in the flooding of the Malahide and St Brigid's Roads in the vicinity of Artane. The Naniken River Culvert passes beneath the route near the junction of Mornington Grove and Malahide Road, coinciding with a river shown on historic OSI maps.
On site (Malahide Rd.)	Donnycarney, Dublin 5	June 1963	Persistent and heavy rainfall resulting in road closures and evacuation of houses.
Approx. 50m east of site (Collins Av.)	Donnycarney, Dublin 5	August 2008 and July 2009	Recurring flooding. Persistent and heavy rainfall resulting in the overwhelming of the Wad River Culvert. This culvert crosses the route at the junction of Collins Avenue and Malahide Road and runs roughly parallel with Collins Avenue. The Wad River is shown on historical OSI mapping prior to being culverted (pre 1940s)

Approx. 200m west of the site (Collins Av.)	Donnycarney, Dublin 5	July 2009	Persistent and heavy rainfall resulting in road closures and evacuation of houses.
Approx. 500m east of the site (Clanmoyle Road)	Donnycarney, Dublin 5	October 2011	Recurring flooding. “The source of the flood waters was the Wad River. Water from the river ran into Collins Avenue and then Clanmoyle Road and ponded around the houses”. Flooding has occurred 3 times over a four-year period. Flood depths of 1m recorded.

Findings from this review indicate the route has experienced past flood events at Donnycarney and Artane. The flood events appear to be the result of heavy rainfall resulting in the overwhelming of two culverts, both of which pass beneath the route.

5.6 Hydrogeology

5.6.1 Aquifer Classification

According to the GSI Groundwater Resources (Aquifer) map (Appendix A), the Lucan and Malahide Formations, which predominantly underly the route, are classified as Locally Important Aquifers (LI). These formations are moderately productive only in local zones.

The Tober Colleen Formation, which crosses the central portion of the route, is classified as a Poor Aquifer (PI) and is described as being generally unproductive except for local zones.

Soil permeability across the route and surrounding area is low; consequently, the groundwater recharge is estimated by the GSI to be between 23mm and 61mm per year.

According to the GSI wells and springs map (Appendix A) there is one spring and three boreholes located within 1km of the route. These are summarised in the following table:

Table 4. Review of GSI Well and Springs

Type	Name (GSI Reference)	Distance from route	Comment
Spring	St Brendan’s Well (3223SWW005)	150m	Located on the southern banks of the Santry River.
Borehole	BH1 (2923SEW033)	250m	Monitoring well for industrial use. 16.5m deep. Bedrock not encountered.
Borehole	BH2 (2923SEW032)	250m	Monitoring well for industrial use. 15.0m deep. Bedrock not encountered.
Borehole	N/A (3223SWW001)	450m	Well for industrial use. Described as having a “Good” yield of 196m^3/day. Depth of hole 52.7m. Depth to bedrock 10m.

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

5.6.2 Groundwater Vulnerability

The GSI National Groundwater Vulnerability map (Appendix A) indicates that most of the proposed route lies within an area of “Low” groundwater vulnerability.

However, the southern 2.3km of the scheme lies within an area of “Moderate” to “Extreme” groundwater vulnerability. It should be noted that rock is recorded at or near surface to the east of the route at this location.

Two localised areas of “Moderate” to “High” groundwater vulnerability are recorded along the route in the Coolock and Clongriffin areas respectively.

5.6.3 Karst Landforms

According to the GSI Groundwater Karst Data map (Appendix A) there are no karst features recorded within the route. However, a spring is recorded 1.2km north of the route, located within an area underlain by an inlier of Waulsortian Limestone.

5.7 Man-Made Features & Historical Development

5.7.1 Mining and Quarrying

According to the GSI Active Quarries and Mineral Locality maps (Appendix A) there are no mining or quarrying activities within the route. However, there are two recorded mineral occurrences of lead within 1km of the route. These are located to the east of route near the junction of Howth Road (R105) and Ashbrook. One of these mineral locations is recorded as being the site of a disused lead mine (GSI Mineral Location Reference – 5,316.00).

5.7.2 Statutory Protected Sites

According to the EPA Protected Areas map (Appendix A) and the GSI Irish Geological Heritage Sites map, the route does not lie within a statutory protected area. However, the southern extent of the route does lie within 500m of the River Tolka Estuary, which is recorded as a Special Protection Area (SPA), Special Area of Conservation (SAC), proposed Natural Heritage Area (pNHA) and Nutrient Sensitive Area (NSA).

5.7.3 Contaminated Land

According to the EPA mapping (Appendix A) there are no recorded chemical monitoring points, dump sites or waste facilities within 1km of the route.

5.7.4 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 5. Historic Map and Aerial Photograph Review

Year	Description
Historic Map 6" 1837-1842 (OSI)	An unnamed road follows the route of the existing Malahide Road (R107), coinciding with the line of the proposed route. This road briefly diverges from the existing line of the Malahide Road at two locations in the areas of Coolock and Darndale. There are four water courses that cross the route (Malahide Road). One of which is the Santry River at Coolock Bridge. The remaining three are located near the junction of Collins Avenue and Malahide Road (now the Wad River Culvert), the junction of Mornington Grove and Malahide Road (now the Naniken River Culvert) and the junction of Newtown Road and Malahide Road. It should be noted that these additional water courses are not recorded on contemporary maps, however OPW records indicate the first two are now culverted beneath the route. The latter has either been diverted, removed or culverted beneath the route at some point. All recorded water courses flow to the south-east. The land to either side of the route is predominantly agricultural fields with occasional small wooded areas. There is a large partially wooded area to the west of the route along its southern extent named on the map as "Marino". This area contains an assortment of small buildings, gardens and a narrow pond (approx. 300m long) all of which are interconnected by tracks. There is only a small number of buildings recorded along the length of the route with most development occurring to the south (typically residential properties but including schools, religious buildings and Artaine Industrial School). The northern section of the route between the junction of Mayne River Avenue and Malahide Road, and Clongriffin Park and Ride is almost entirely made up of agricultural fields, which is only crossed once by an unnamed road. A small number of quarries and gravel pits are recorded within 1km of the route. However, there are no records of any quarry activity on or immediately adjacent to the route. A pump house and site of an old lead mine is recorded approximately 900m south-east of the route. The adjacent property, "Silverfields House" is likely named due to the occurrence of sulphide minerals in the surrounding area. No other mining activity is recorded closer to the route. Approximately 600m to the east and running roughly parallel to the route, the construction of the Dublin to Drogheda Railway line is recorded as being in progress. This railway line is constructed on embankment.

Year	Description
Historic Map 25" 1888-1913 (OSI)	The unnamed road, which coincides with the line of the route is now called Malahide Road. Increased development has occurred to the south of the route with the occurrence of several terraced residential properties between the area of Clontarf Road and Copeland Avenue. The central and northern sections of the route remain relatively unchanged with only minor residential development (most obvious in the Coolock area). The railway line to the east of the route is completed and is now named the "The Great Northern Railway (Ireland)". O'Brien's Institute and St. Mary's College now sit on the land to the west of the route, previously known as "Marino". Much of the woodland in this area remains. An electricity sub-station is recorded at the southern extent of the route at the junction of Clontarf Road and Malahide Road. The pump house and old lead mine are no longer recorded.
6" Cassini 1930s (OSI)	Significant residential development to the south of the route with the occurrence of predominantly terraced buildings in the area once known as "Marino". The area around St. Mary's College and O'Brien's Institute is now recorded as "Recreation Ground". Further school and church buildings have been developed in this area. Clontarf Golf Course is now recorded to the immediate east of the route between what is now Collins Avenue East and Copeland Grove. There is an increase in development around the central portion of the route (mainly residential). An "Electricity Power House" is now recorded to the south of Artaine Industrial School. A poultry farm is recorded to the immediate east of the route at the junction of Newtown Road and Malahide Road.
Aerial 1995 (OSI)	It should be noted that the 1995 aerial photography is in black and white and of poor resolution. Nearly all of the route is surrounded by urban development with the southern half of the route being predominantly residential terraced properties and the northern half of the route being a mix of residential and commercial buildings. The northernmost section of the route is mainly surrounded by agricultural fields but with some residential and commercial development under construction to include construction of the R139 road. A narrow green-belt flanks the Santry River. Recreational grounds now surround what was once the Artaine Industrial School. Additional recreational grounds lie east of the route near the junction of Elm Mount Road and Malahide Road. The alignment of the Malahide Road is as existing. Several new junctions are now present along this road to include two large roundabouts at the junctions of Ardlea Road and Priorswood Road. The Malahide Road comprises single carriageway from the southern extent of the route to the junction of Ardlea Road and is dual carriageway from here until the northern extent of the route. This dualled section is mainly separated by a grassy median of varying width.
Aerial 2000 (OSI)	Further development around the northernmost portion of the route comprising mainly residential buildings and to a lesser extent commercial building. The R139 road is now fully constructed with a large roundabout at its junction with Malahide Road. Land north of the R139 is mainly agricultural comprising both arable and pasture fields. Out of the five surface water features that crossed the route, as recorded in the historic mapping, only the Santry River is now visible. The remining streams/rivers are now covered by urban development to include public amenity spaces, car parks and residential/commercial buildings. It is unclear whether these have been culverted, diverted or removed completely. No significant changes to the central and southern portions of the route.
Aerial 2005 (OSI)	Construction of both commercial and residential buildings underway in the area surrounding Clongriffin Park and Ride (northern extent of route) this also includes construction of Main Street. The central median along the dualled section of the Malahide Road is planted with trees. No other significant changes observed.

Year	Description
Aerial 2019 (Google Maps)	Significant residential development observed to north of the R139 (northern extent of route). Main Street is now substantially complete along with a number of north south link roads that service this area. Clongriffin Park and Ride and train station are now complete. Development of recreation grounds have occurred in this area to include Father Collins Park. A narrow 400m long pond makes up the central portion of this park, with its southern end immediately adjacent to the route. A series of halting sites and possible scrap yards are located approximately 100m north-west of the route near the junction of Belcamp Land and Malahide Road. To the immediate east and south of these areas are a series of fields (possibly used for recreational purposes) which bound the west side of Malahide Road at this location. There are now intermittent sections of dual carriageway along the Malahide Road between the junctions of Griffith Avenue (to the south) and Collins Avenue (to the north) separated by a paved median planted with trees. There is a total of five petrol station forecourts along the length of the route (all on the Malahide Road). No other significant changes observed.

5.7.5 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 indications no sources of contamination along the route.

The Geohive map viewer indicates the following:

- There are no quarries or gravel pits recorded on or adjacent to the route.
- There is an electrical substation located at the southern end of the route at the junction of Clontarf Road and Malahide Road, which is a potential source of Polychlorinated Biphenyls (PCBs).

There is a possibility for contamination associated with the petrol stations along the route.

6. Ground Conditions

Based on a review of the historical reports described in Section 3 and published literature, 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. These typically mantle deposits of Dublin Boulder Clay.
- **Alluvium Deposits** – These deposits cross the route at the locations of the Santry River and Naniken River (culverted).
- **Glaciofluvial Deposits** – Medium dense to dense sand and gravel deposits were encountered in Report 5228 (along Main Street, Clongriffin). These are shown to be underlain by stiff Dublin Boulder Clay.
- **Glacial Till** – Glacial Till deposits are anticipated throughout most of the route. These deposits typically consist of soft/soft to firm brown Dublin Boulder Clay (weathered till) over stiff to very stiff black Dublin Boulder Clay (unweathered till). These deposits are predominantly mantled by Made Ground of varying thicknesses.

6.1 Made Ground

Made ground should be expected throughout the route and may vary from a thin layer (typically surfacing materials) to several metres of variable materials.

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 excavated and replaced as part of the construction works. Exceptions may be made for low risk lightly loaded at grade construction where investigation shows that 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 Santry River and Naniken River (culverted).

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 Glaciofluvial Deposits

These deposits are the result of glacial meltwater flowing along the valleys of the main rivers or historical rivers in the area. A previous investigation has encountered these deposits to depths of up to 3m along Main Street, Clongriffin. They comprise medium dense to dense inter-bedded sand and gravel deposits. These are in turn underlain by Glacial Till.

The glaciofluvial deposits encountered along Main Street are generally overlain by soft to firm clay to depths of between 0.70m and 1.0m.

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%

6.4 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 50kPa is typically achievable assuming it is not excessively weathered corresponding to a CBR of about 2%

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 1-2m from the top of the stratum.
- BS8002 (British Standards Institute, 1994) can be used to relate plasticity index to ϕ'_{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 ϕ'_{crit} of 30°. The relationship published by Knappet & Craig (Craig’s Soil Mechanics, 8th Edition, 2012) provides a ϕ'_{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.

6.5 Bedrock

The superficial deposits across the route area are typically underlain by dark grey argillaceous limestones and shales belonging to the Lucan, Tober Colleen and Malahide Formations. No outcrops are recorded within are adjacent to the route.

Available geotechnical reports indicate depth to bedrock varies from 3.9m to 16.8m.

6.6 Groundwater

Available geotechnical reports indicate groundwater was encountered at depths of between 1m and 13m.

7. Preliminary Engineering Assessment

7.1 General

The following sections provide preliminary geotechnical recommendations for the proposed route, 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.

7.2 Classification and Acceptability for Re-use

General granular and cohesive fills will be classified in accordance with Table 6/1and 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.

7.3 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.

7.4 Engineering Fill Materials

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

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.

7.5 Embankments

Embankments (if required) will be constructed with acceptable fill material derived generally from off-site quarries and where available from on-site borrow areas. Embankment slopes are generally constructed at an inclination of 2.5H:1V for embankments less than 6 m except where constraints dictate a steeper slope of 2H:1V.

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 are 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.

7.6 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.

7.7 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, capping layer thickness of 400mm with 150mm 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.

7.8 Structures

The following sections provide preliminary geotechnical recommendations for the proposed route, 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.

7.8.1 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 250kN/m^2 may be feasible on the black Dublin boulder clay.

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 21.5kN/m^3.

Piled foundations (if required) 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 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.

7.8.2 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 21.5kN/m^3 can generally be adopted for the Glacial Till when calculating active and passive pressures, and wall and base friction.

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 20kN/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.

7.8.3 Soil Chemistry

Table C1 of BRE Special Digest 1 (Building Research Establishment, 2005) will be used to determine the Design Sulphate (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.

7.9 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: reference Section 5.7.5.

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

8. Geotechnical Risks

8.1 Geotechnical Category

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

8.2 Geotechnical Risk Register

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 within the construction information.

Table 6. Geotechnical Risk Assessment

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk	Residual Risk Rating (See matrix below)		
		P	I	R			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.	1	5	5
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	5	5

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk	Residual Risk Rating (See matrix below)		
		P	I	R			P	I	R
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	10
4	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	5	10
5	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	2	10
6	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	4	8
7	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	1	5	5

Risk Reference	Description of Risk	Initial Risk Rating (See matrix below)			Consequence	Control Measures to Reduce Risk	Residual Risk Rating (See matrix below)		
		P	I	R			P	I	R
						Contractor to instigate safe systems of work to avoid damaging / encountering services. Vigilance on site during excavations. Permit to dig system.			
8	Historical unrecorded shallow mining/quarrying	2	5	10	Potential presence of voids/shafts/infilled ground.	Contractor to remain vigilant during works and have safe systems in place.	1	5	5
9	Flooding - Heavy persistent rainfall resulting in culverts/storm system becoming overwhelmed.	2	5	10	Flooding of works area: – during construction posing a risk to site personnel and equipment – after construction resulting in deterioration of the proposed route and risk to the general public.	Consultation with OPW and Dublin City Council regarding condition of existing foul and stormwater system. Drainage engineers to undertake a detailed review of the proposed route.	1	5	5
10	Hard dig conditions resulting from shallow bedrock	3	4	12	Time and cost delays caused by excavatability issues.	Ground investigation to determine presence of shallow bedrock (particularly in areas where excavation is anticipated). If shallow bedrock is encountered an excavatability assessment should be completed.	1	4	4
11	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.	1	5	4
12	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	4	4

Table 7. Risk Rating

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

Probability (P)	Scale
Very Likely	5
Likely	4
Probable	3
Unlikely	2
Negligible	1

RISK (R) = PROBABILITY (P) x IMPACT (I)

Appendix A – Maps

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Location Map

Legend

720000

Scale: 1:50,000

Geological Survey Ireland

PSI Licence

0 0.35 0.7 1.4 mi

0 0.5 1 2 km

Map Centre Coordinates (ITM) 720,612 739,048

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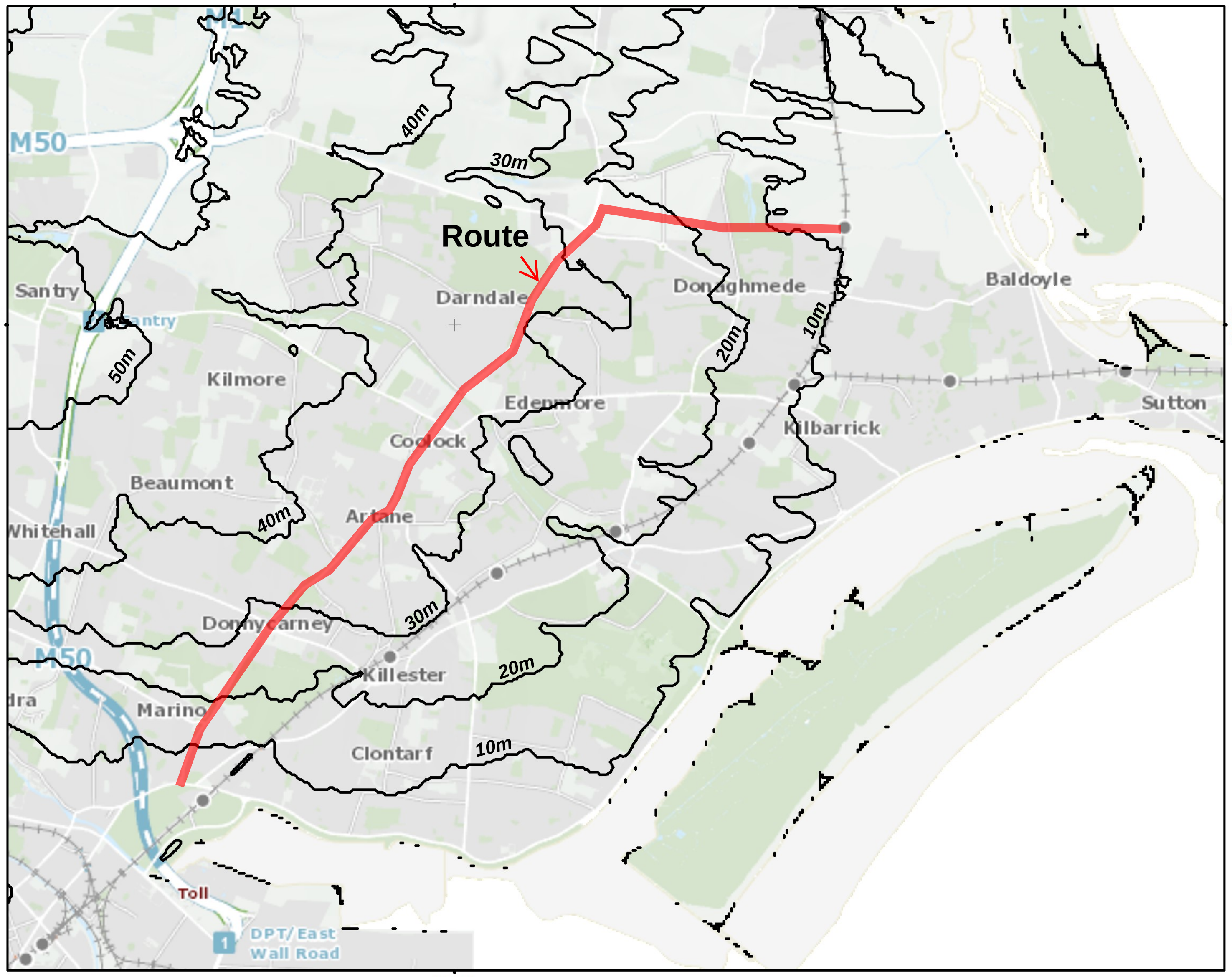
Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Topographic Map

Legend

— EPA Contours

720000



720000

Scale: 1:50,000

Geological Survey Ireland

N W E S

0 0.35 0.7 1.4 mi

0 0.5 1 2 km

Map Centre Coordinates (ITM) 721,280 738,704
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Subsoils (Quaternary Sediments)

720000

Legend

Quaternary Sediments

SYMBOLOGY

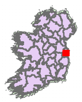
- A, Alluvium
- Ag, Alluvium (gravelly)
- As, Alluvium (sandy)
- Embankment
- GLs, Gravels derived from Limestones
- Mbs, Marine beach sands
- Mesc, Esturine silts and clays
- Rck, Bedrock outcrop or subcrop
- TLs, Till derived from limestones
- TdlMr, Tidal Marsh
- Urban
- Ws, Windblown sands
- Wsd, Windblown sands and dunes

Scale: 1:50,000

Geological Survey Ireland

0 0.35 0.7 1.4 mi

0 0.5 1 2 km



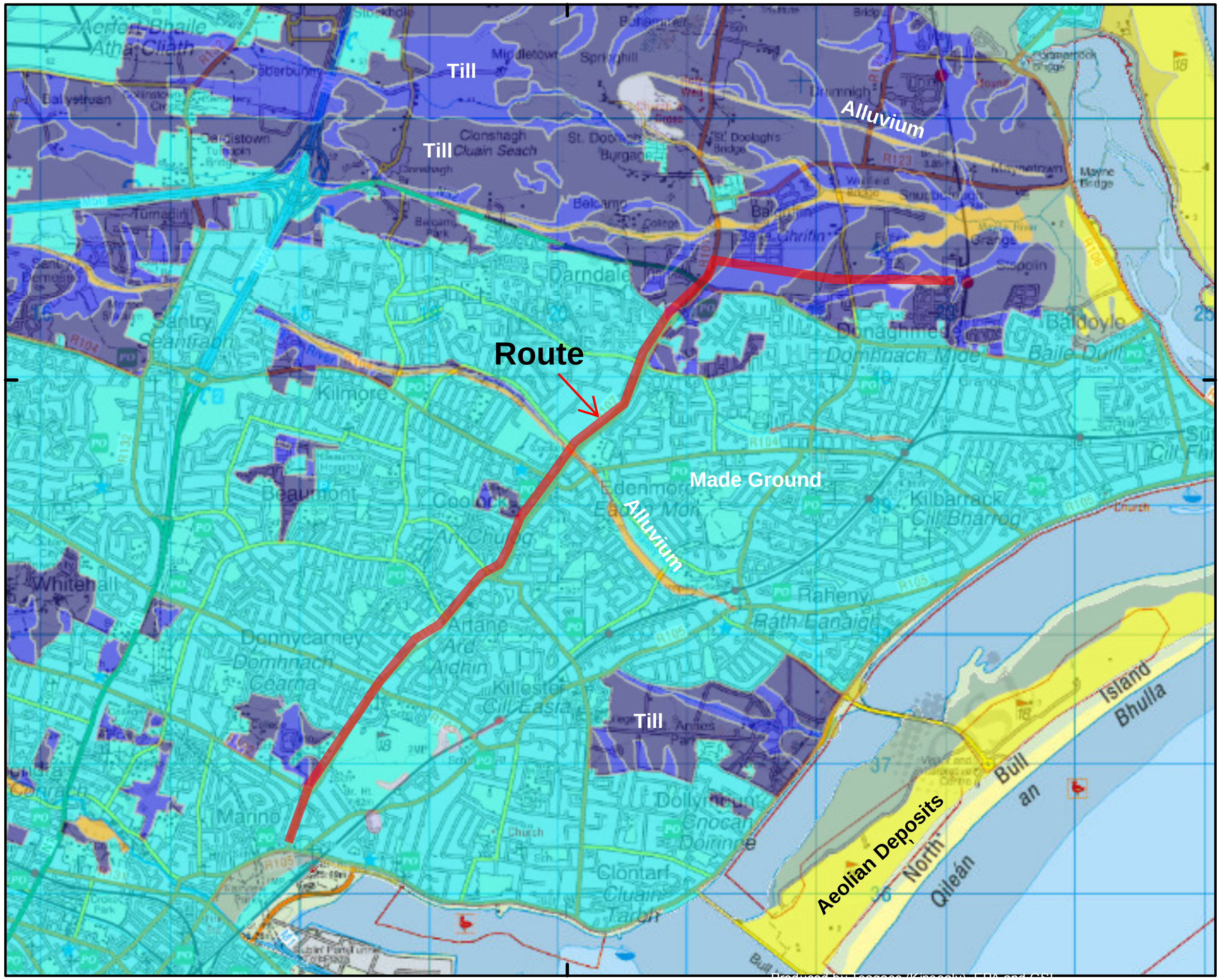
Map Centre Coordinates (ITM) 720,395 739,262

22/11/2019 13:44:53

Teagasc Soils Map

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

720000



Legend

Teagasc Soils

- AminDW - Deep well drained mineral (Mainly acidic)
- AminPD - Mineral poorly drained (Mainly acidic)
- AminPDPT - Peaty poorly drained mineral (Mainly acidic)
- AminSW - Shallow well drained mineral (Mainly acidic)
- AminSP - Shallow poorly drained mineral (Mainly acidic)
- AminSPPT - Shallow peaty poorly drained mineral (Mainly acidic)
- AminSRPT - Shallow, rocky, peaty/non-peatymi... complexes (Mainly acidic)
- BminDW - Deep well drained mineral (Mainly basic)
- BminPD - Mineral poorly drained (Mainly basic)
- BminPDPT - Peaty poorly drained mineral (Mainly basic)
- BminSW - Shallow well drained mineral (Mainly basic)
- BminSP - Shallow poorly drained mineral (Mainly basic)
- BminSPPT - Shallow peaty poorly drained mineral (Mainly basic)
- BminSRPT - Shallow, rocky, peaty/non-peatymi... complexes (Mainly basic)
- BktPt - Blanket peat
- FenPt - Fen peat
- RsPt - Raised Peat
- Cut - Cutover/cutaway peat
- AlluvMIN - Alluvial (mineral)
- AlluvMRL - Alluvial (marl)
- Lac - Lacustrine type soils
- Scree - Scree
- AeoUND - Aeolian undifferentiated
- MarSands - Marine sand and gravel
- MarSed - Marine/estuarine sediments
- Made - Made ground
- Water - Water
- Unclass

Scale: 1:50,000

Geological Survey Ireland

PSI Licence

0 0.35 0.7 1.4 mi
0 0.5 1 2 km

Map Centre Coordinates (ITM) 720,334 739,148
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Bedrock Geology 100k

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Legend

- Strike and dip of bedding, right way up
- Bedrock Outcrops 100 ITM 2018
- Anticlinal Axis
- Fault
- Synclinal Axis
- Lucan Formation
- Malahide Formation
- Tober Colleen Formation
- Waulsortian Limestones

Scale: 1:50,000

Geological Survey Ireland

0 0.35 0.7 1.4 mi
0 0.5 1 2 km

Map Centre Coordinates (ITM) 720,395 739,262
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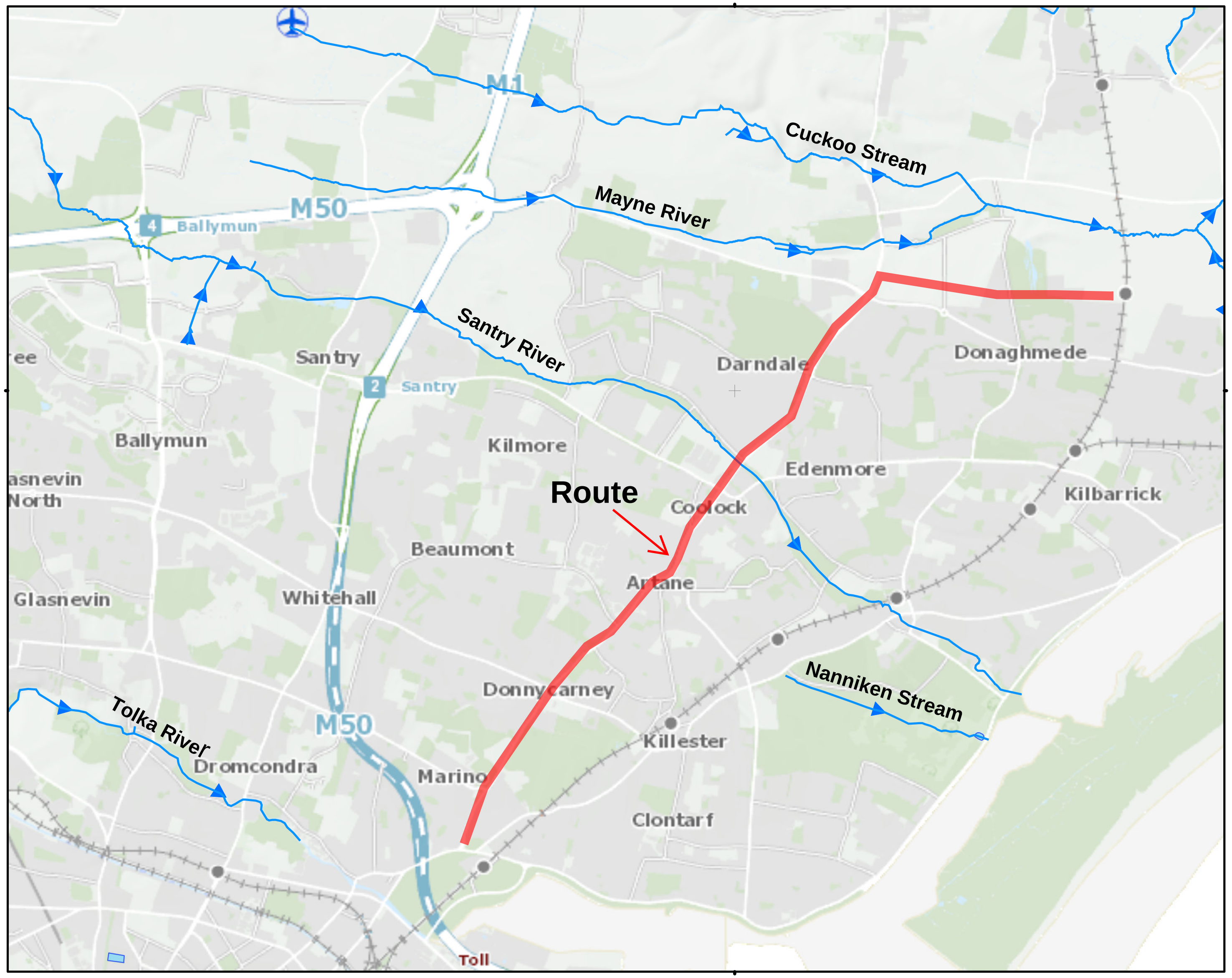
Surface Water Features

Legend

- River Network and River Flow Direction Arrows
- Lake Segments



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Geological Survey Ireland

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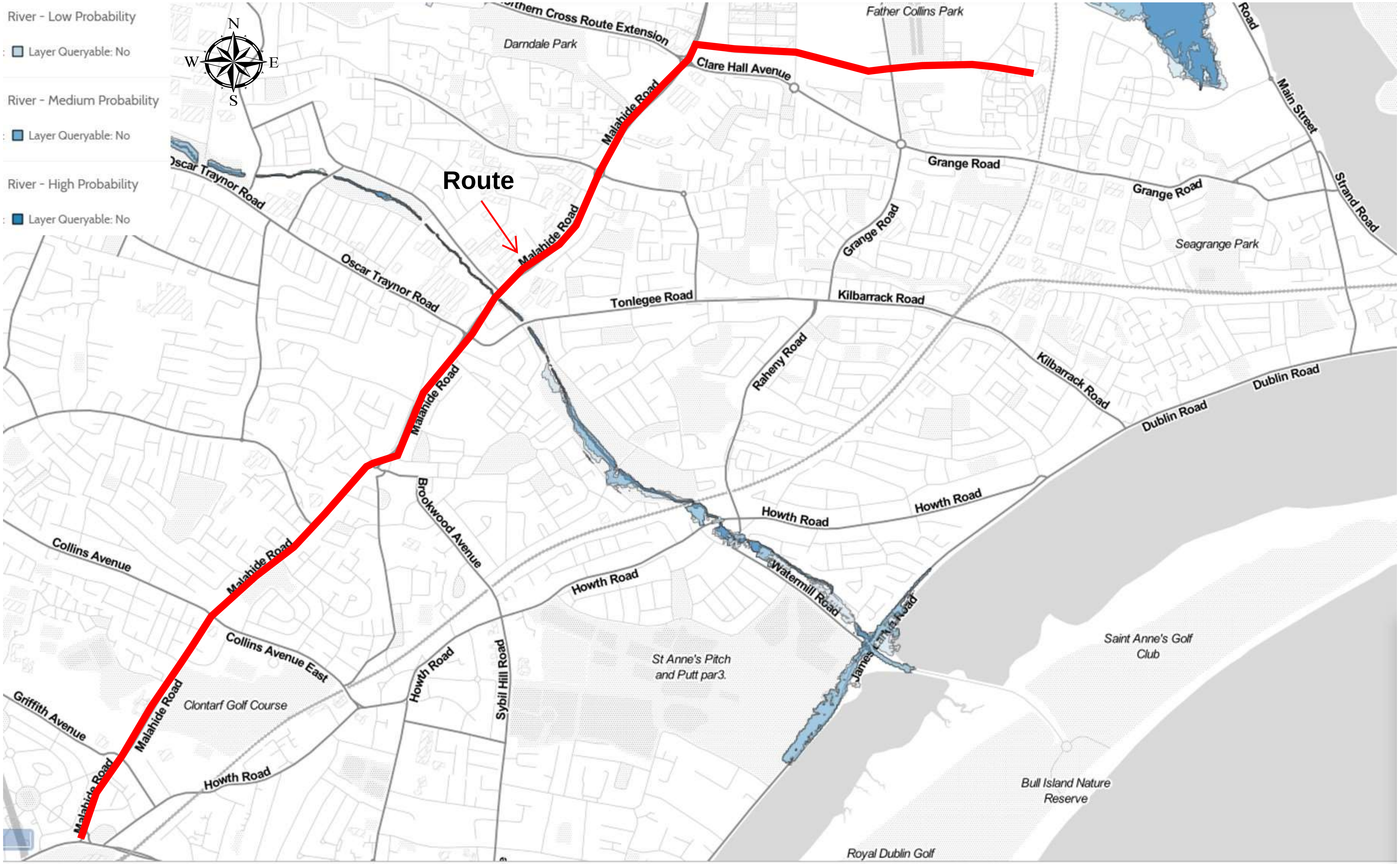
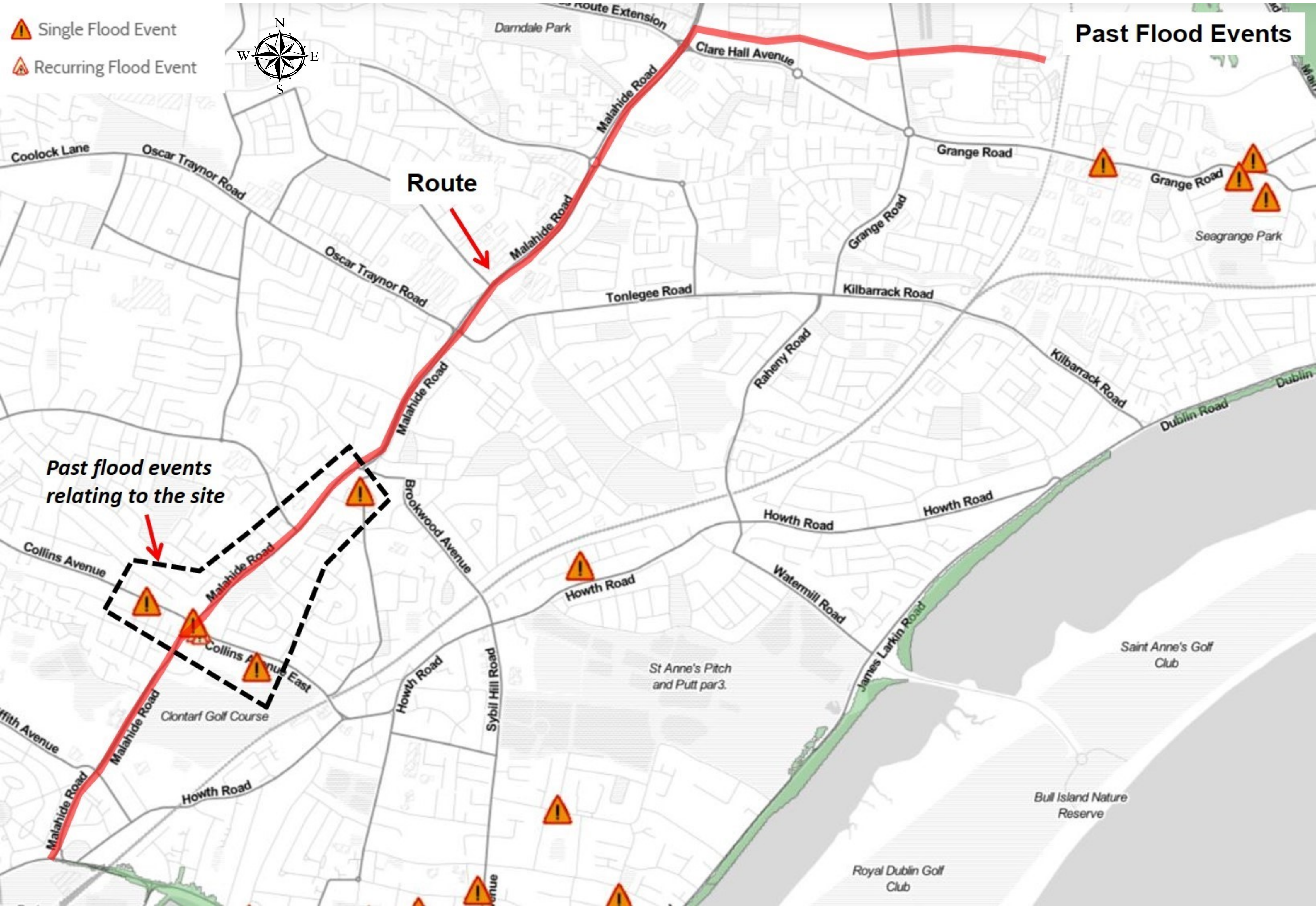
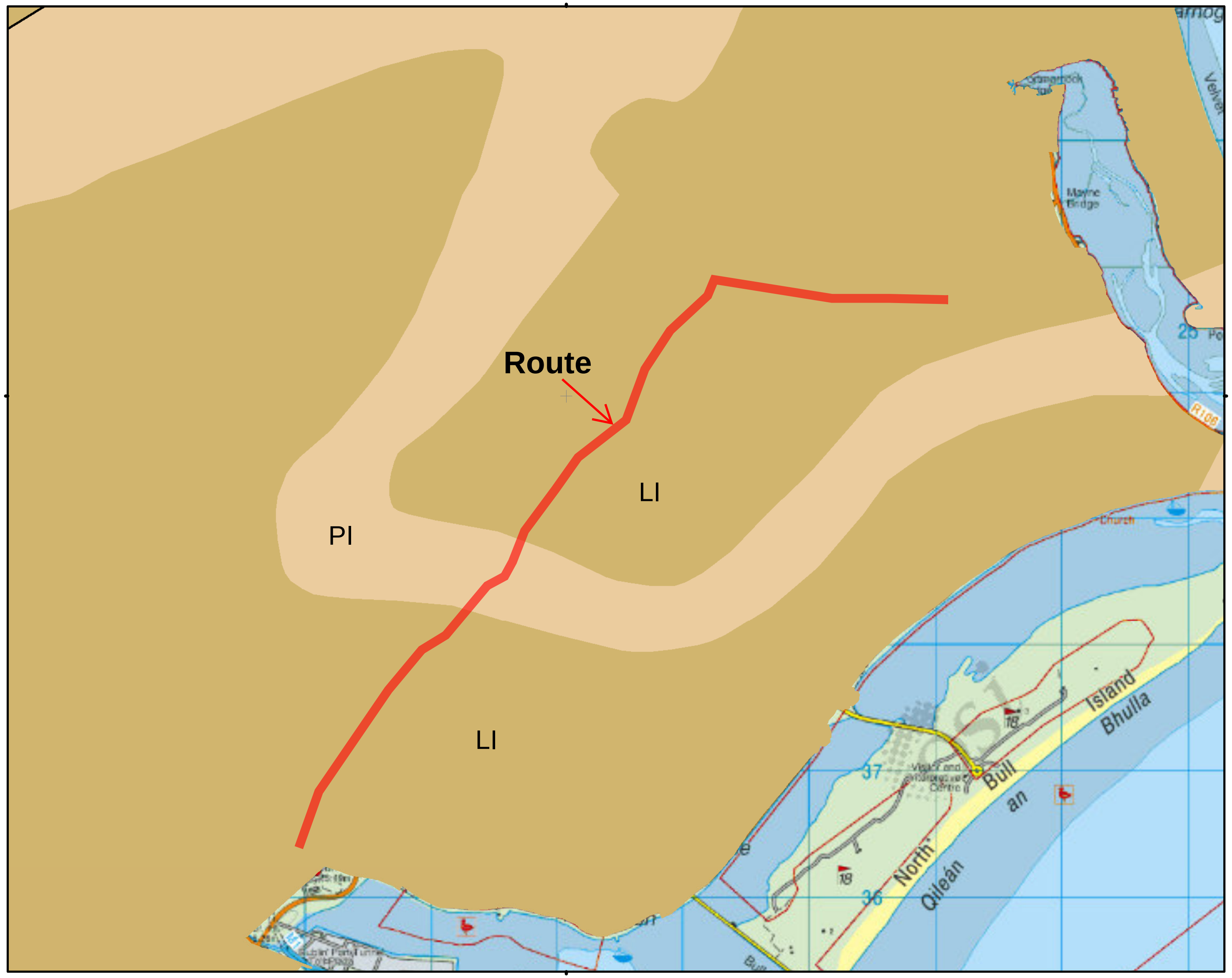


River - Low Probability
Layer Queryable: No
River - Medium Probability
Layer Queryable: No
River - High Probability
Layer Queryable: No
N
W
E
S
Route
Northern Cross Route Extension
Darndale Park
Father Collins Park
Clare Hall Avenue
Malahide Road
Oscar Traynor Road
Grange Road
Main Street
Strand Road
Seagrange Park
Tonlegee Road
Kilbarrack Road
Raheny Road
Dublin Road
Howth Road
Brookwood Avenue
Watermill Road
James Larkin Road
Collins Avenue
Collins Avenue East
Griffith Avenue
Clontarf Golf Course
Sybil Hill Road
St Anne's Pitch and Putt par3.
Saint Anne's Golf Club
Bull Island Nature Reserve
Royal Dublin Golf



Past Flood Events
Single Flood Event
Recurring Flood Event
N
S
E
W
Route
Past flood events relating to the site
Darndale Park
Clare Hall Avenue
Malahide Road
Grange Road
Coolock Lane
Oscar Traynor Road
Seagrange Park
Tonlegee Road
Kilbarrack Road
Raheny Road
Dublin Road
Howth Road
Brookwood Avenue
Collins Avenue
Collins Avenue East
Watermill Road
James Larkin Road
Saint Anne's Golf Club
St Anne's Pitch and Putt par3.
Clontarf Golf Course
Sybil Hill Road
Bull Island Nature Reserve
Royal Dublin Golf Club

Groundwater Resources (Aquifers)



Legend

- Bedrock Aquifer Faults
- LI - Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- PI - Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones

Scale: 1:50,000

Geological Survey Ireland

0 0.35 0.7 1.4 mi
0 0.5 1 2 km

Map Centre Coordinates (ITM) 720,395 739,262
22/11/2019 14:00:59

Subsoil Permeability

Legend

Subsoil Permeability

PERM

- High
- Low
- Not mapped

Scale: 1:50,000

Geological Survey Ireland

Map Centre Coordinates (ITM) 720,395 739,262
22/11/2019 14:07:00

Groundwater Wells and Springs

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Legend

Groundwater Wells and Springs

720000

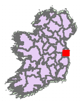
720000

Scale: 1:50,000

Geological Survey Ireland

N
W E
S

0 0.35 0.7 1.4 mi
0 0.5 1 2 km



Map Centre Coordinates (ITM) 720,395 739,262
22/11/2019 14:58:01

Groundwater Vulnerability

Legend

National Groundwater Vulnerability Ireland

VULNERABILITY

- Rock at or near Surface or Karst
- Extreme
- High
- Moderate
- Low

Scale: 1:50,000

Geological Survey Ireland

0 0.35 0.7 1.4 mi
0 0.5 1 2 km

Map Centre Coordinates (ITM) 720,395 739,262
22/11/2019 14:00:09

Groundwater Karst Data

Legend

Scale: 1:50,000

Geological Survey Ireland

0 0.35 0.7 1.4 mi
0 0.5 1 2 km

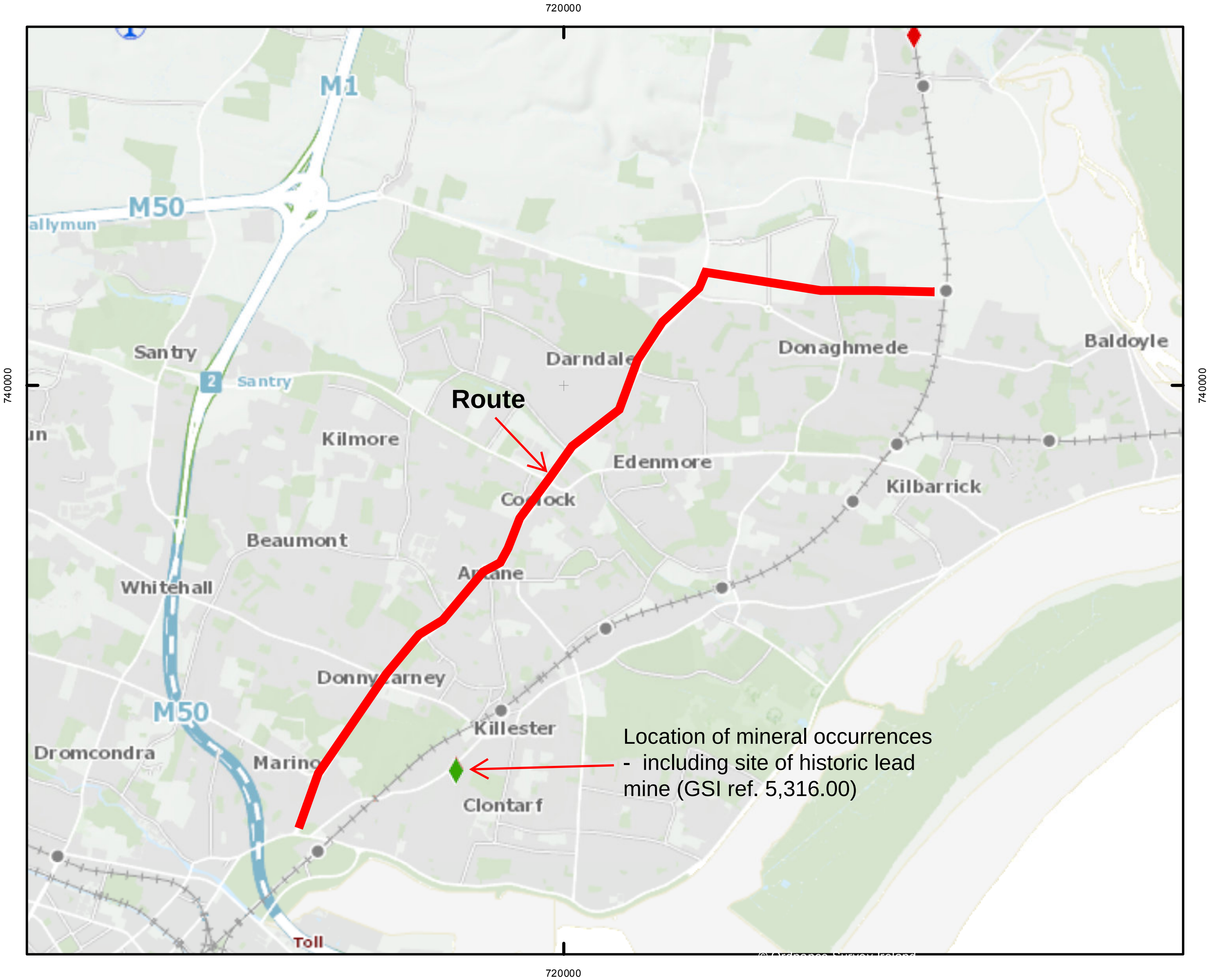
Map Centre Coordinates (ITM) 720,395 739,262
22/11/2019 14:01:59

Active Quarries and Mineral Localities

Legend

Mineral Localities

- Metallic
- Non-metallic



Scale: 1:50,000

Geological Survey Ireland

PSI Licence

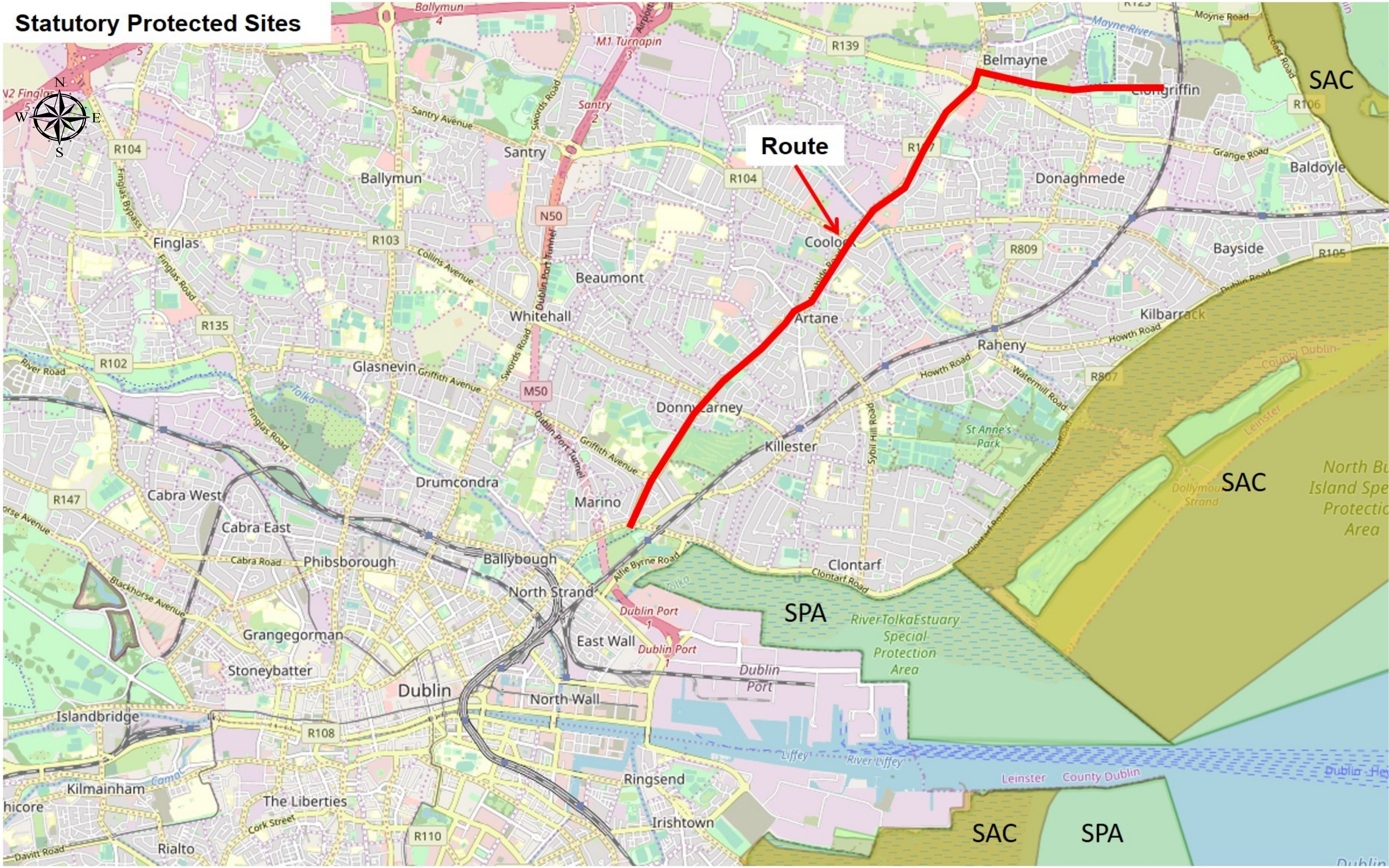
0 0.35 0.7 1.4 mi

0 0.5 1 2 km

Map Centre Coordinates (ITM) 720,334 739,148

12/3/2019, 11:41:52 AM

Statutory Protected Sites



Geological Heritage

Legend

Heritage Site Audited Boundaries

Heritage Sites Unaudited Boundaries

720000

740000

720000

740000

Scale: 1:50,000

Geological Survey Ireland

PSI Licence

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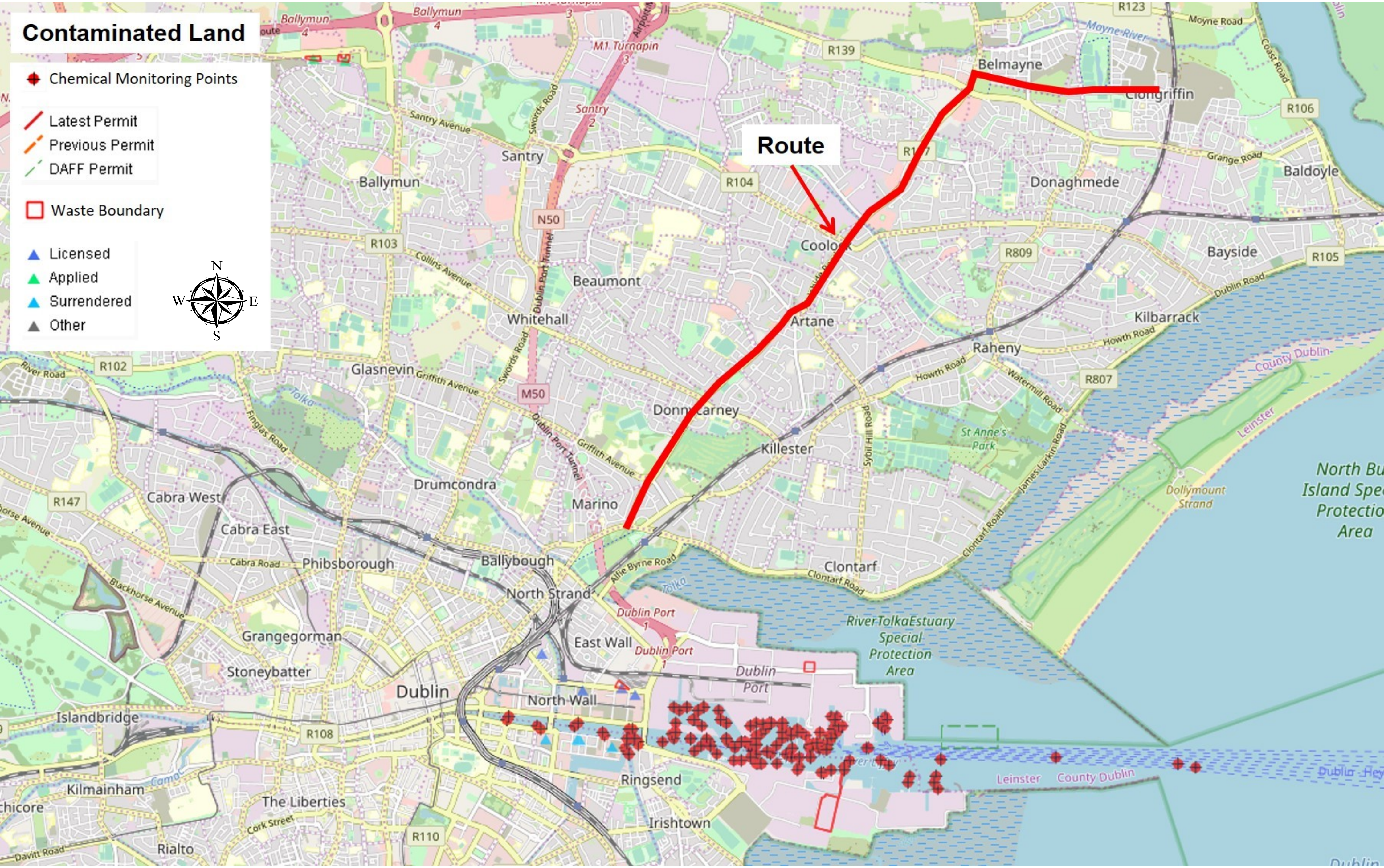
0 0.5 1 2 km

Map Centre Coordinates (ITM) 720,460 738,583

12/3/2019, 12:03:40 PM


Contaminated Land
Chemical Monitoring Points
Latest Permit
Previous Permit
DAFF Permit
Waste Boundary
Licensed
Applied
Surrendered
Other
N
W
E
S
Route
Belmayne
Clongriffin
Santry
Ballymun
Beaumont
Whitehall
Coolock
Artane
Donaghmede
Baldoyle
Bayside
Kilbarrack
Raheny
Glasnevin
Donnycarney
Killester
Drumcondra
Marino
Cabra West
Cabra East
Phibsborough
Ballybough
North Strand
Clontarf
East Wall
Grangegorman
Stoneybatter
Dublin
North Wall
Dublin Port
Islandbridge
Kilmainham
Ringsend
The Liberties
Irishtown
Rialto
St Anne's Park
Dollymount Strand
River Tolka Estuary Special Protection Area
County Dublin
Leinster
R123
R139
R106
R104
N50
R103
R809
R105
M50
R102
R807
R147
R108
R110

Appendix B – Bus Connects: Clongriffin Route Brochure

The Clongriffin to City Centre CBC – EPR Public Consultation November 2018 is available from the NTA BusConnects Website, and can be accessed by clicking on the links below:

https://busconnects.ie/media/1402/busconnects-cbc1-clongriffin-to-city-centre-final-for-web-low-res.pdf aecom.com

NTA

Údarás Náisiúnta Iompair
National Transport Authority

National Transport Authority
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Dublin 2
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Project Ireland 2040
Building Ireland's Future