Basement Impact Assessment (BIA)

Swords Road and Santry Avenue, Dublin 9

Report No. B2125-AYE-GEO-R001

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Contents

[1] Introduction

[1.1] Scope

Ayesa has been requested by DBFL Consulting Engineers (DBFL) to complete a Basement Impact Assessment (BIA) for the proposed mixed-use, high-density development at Swords Road and Santry Avenue, Dublin 9. As part of Dublin City Council's (DCC) Dublin City Development Plan 2022-2028, a BIA shall accompany all planning applications that incorporate a basement. This report complies with the basement impact requirements of DCC.

This BIA provides information on the ground and groundwater conditions at the site. It further assesses the impact of the proposed basement on the groundwater regime and neighbouring structures. The purpose of this assessment is to identify the potential short and long-term impacts, inform as to whether the proposed basement is acceptable and identify appropriate mitigating measures that can be integrated into the development.

[1.2] Site Location and Description

The proposed development site is located at the intersection of Santry Avenue (R104), Swords Road (R132) and Church Lane in the northern suburb of Whitehall in Dublin City. Santry Park lies to the north of the site. The eastern portion of the site faces onto Swords Road and a row of small retail units. The recently built Santry Place apartment complex adjoins the site to the south. A number of multi-bay commercial units are located opposite the site to the west in Santry Avenue Industrial Estate.

The present-day c. 1.5-hectare site is occupied by Chadwicks (c. 4197m^2), which is the Santry branch of this established home improvement store. The remaining portion of the site is largely vehicle parking and goods storage.

The site location and aerial view are indicated in Figures 1.1 and 1.2 below.

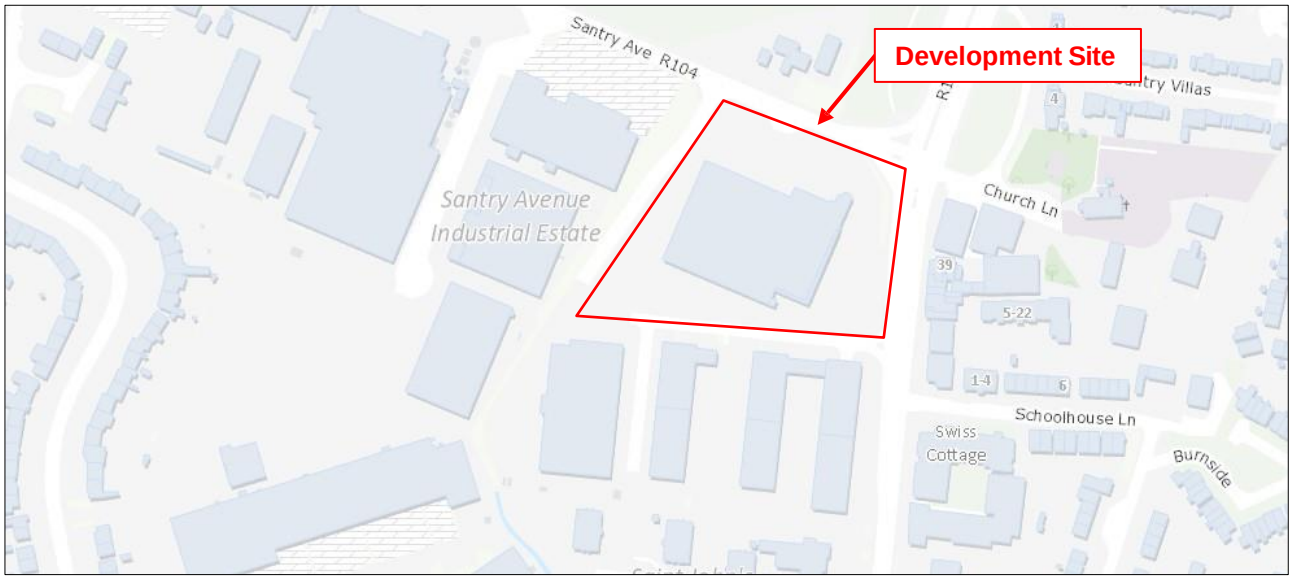


Figure 1.1: Site Location (ref. OSI)

Figure 1.2: Aerial View (ref. Google Maps)

[1.3] Proposed Development

The proposed development will involve the construction of 4 no. residential apartment blocks consisting of 321 no. apartments. The 4no. blocks will be subdivided into Blocks A, B, C, D, E, F and G. They will also incorporate 5no. commercial / retail units, community facility and residential amenity area at ground floor level. The development works are outlined as follows:

- Demolition of the existing buildings on-site.
- Block A is a 7-14no. storey building consisting of 51no. apartments with 2no. commercial units on the ground floor. The adjoining Block B is a 7no. storey building consisting of 38no. apartments with 2no. commercial units and a refuse storage area at ground floor level.
- Block C is a 7no. storey building consisting of 53no. apartments with 2no. refuse storage areas at ground floor level. The adjoining Block D is a 7-10no. storey building consisting of 44 no. apartments with a commercial unit / café on the ground floor.
- Block E is a 7-10no. storey building consisting of 49no. apartments with a community facility, switchroom, substation and refuse area at ground floor level. The adjoining Block F is a 7no. storey building consisting of 52no. apartments with a refuse storage area and bicycle storage area at ground floor level.

- Block G is a 7no. storey building consisting of 34no. apartments with a refuse storage area and bicycle storage area at ground floor level.
- Surface level parking will be provided with 36no. car parking spaces and 58no. bicycle parking spaces.
- The development will include open and communal space, landscaping, boundary treatment and residential amenity unit between Blocks A and D.
- The basement will primarily provide parking facilities. These will include 161no. car parking spaces, 10no. motorbike parking spaces, 672 bicycle parking spaces. Internal access to the basement area will be provided from Blocks A & B, C & D and E & F. The floor area of the proposed basement will be 5471m^2.
- The proposed development will provide all ancillary works above and below ground that include mechanical and electrical plant rooms, substations, public lighting, servicing, signage and water attenuation facilities.

The basement floor plan is displayed in Figure 1.3 below.

Figure 1.3: Basement Floor Plan (ref. Davey & Smith Architects Layout ID: D1809.P05)

[1.4] Report Limitations

The conclusions and recommendations made in this report are limited to those on the basis of the desk study completed. The results of this work should be viewed in the context of the determinate range of data sources consulted. No liability can be accepted for information relating to other data sources or conditions not revealed during the course of this study.

The ground movement assessment and hydrogeological findings presented in this report are considered predictions. They should be verified and confirmed at detailed design stage following final selection of construction methodologies and details.

No site-specific ground investigation and groundwater monitoring have been completed at the time of writing. The ground investigation report provided to Ayesa pertains only to the adjoining land area to the south of the development site. A site-specific ground investigation incorporating a groundwater monitoring regime is recommended. The monitoring should be completed over an extended period to record any seasonal variations in groundwater level. Should actual groundwater levels encountered on-site differ from those assumptions formed in this report, a revision to this report will be required. Additionally, the foundation details of adjacent properties should be investigated and confirmed where possible during the site-specific ground investigation.

[2] Desktop Survey

[2.1] General

Ayesa has consulted a comprehensive range of online information resources to complete the desk study of the development site. Among these include the Geological Survey Ireland (GSI), Ordnance Survey Ireland (OSI), National Inventory of Architectural Heritage (NIAH) and National Planning Application Database (NPAD).

[2.1.1] Bedrock Geology

The bedrock geology of site is that of the Lucan Formation (LU), which is described as dark grey argillaceous and cherty limestone and shale. This formation is comprised of dark grey to black, fine-grained, occasionally cherty, micritic limestones that weather paler, usually to pale grey. There are rare dark coarser grained calcarenitic limestones, sometimes graded, and interbedded dark grey calcar. The beds are predominantly fine-grained distal turbidites in the north Dublin Basin. This formation is intermittently exposed on the coast between Rush and Drumanagh Head. It ranges from 300-800m in thickness.

The bedrock geology relative to the development site is detailed in Figure 2.1 below.

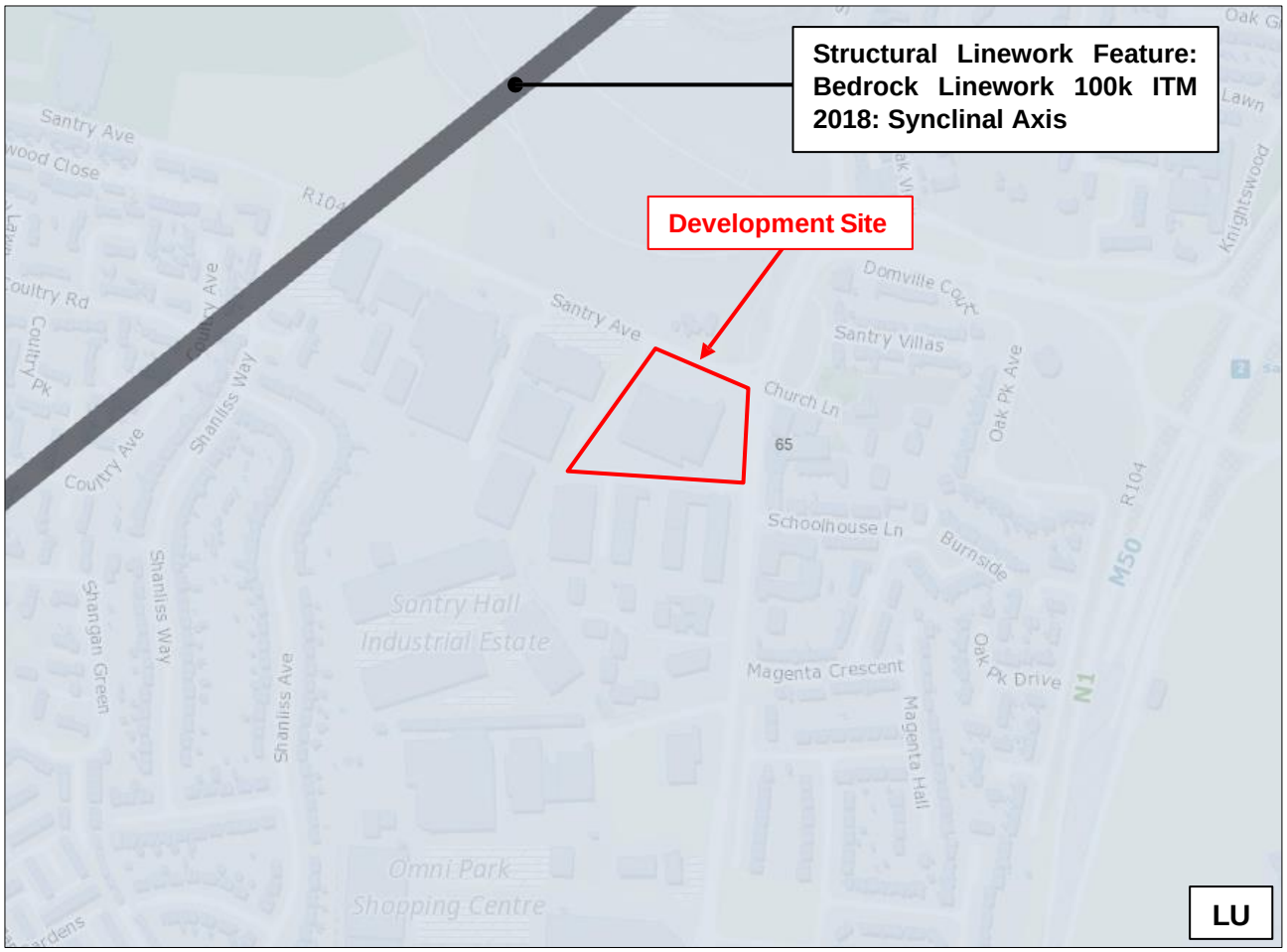


Figure 2.1: Bedrock Geology (ref. GSI)

[2.1.2] Bedrock Depth

The depth to bedrock ranges from 10-15m BGL.

The variation in bedrock depth in the area relative to the development site is displayed in Figure 2.2 below.

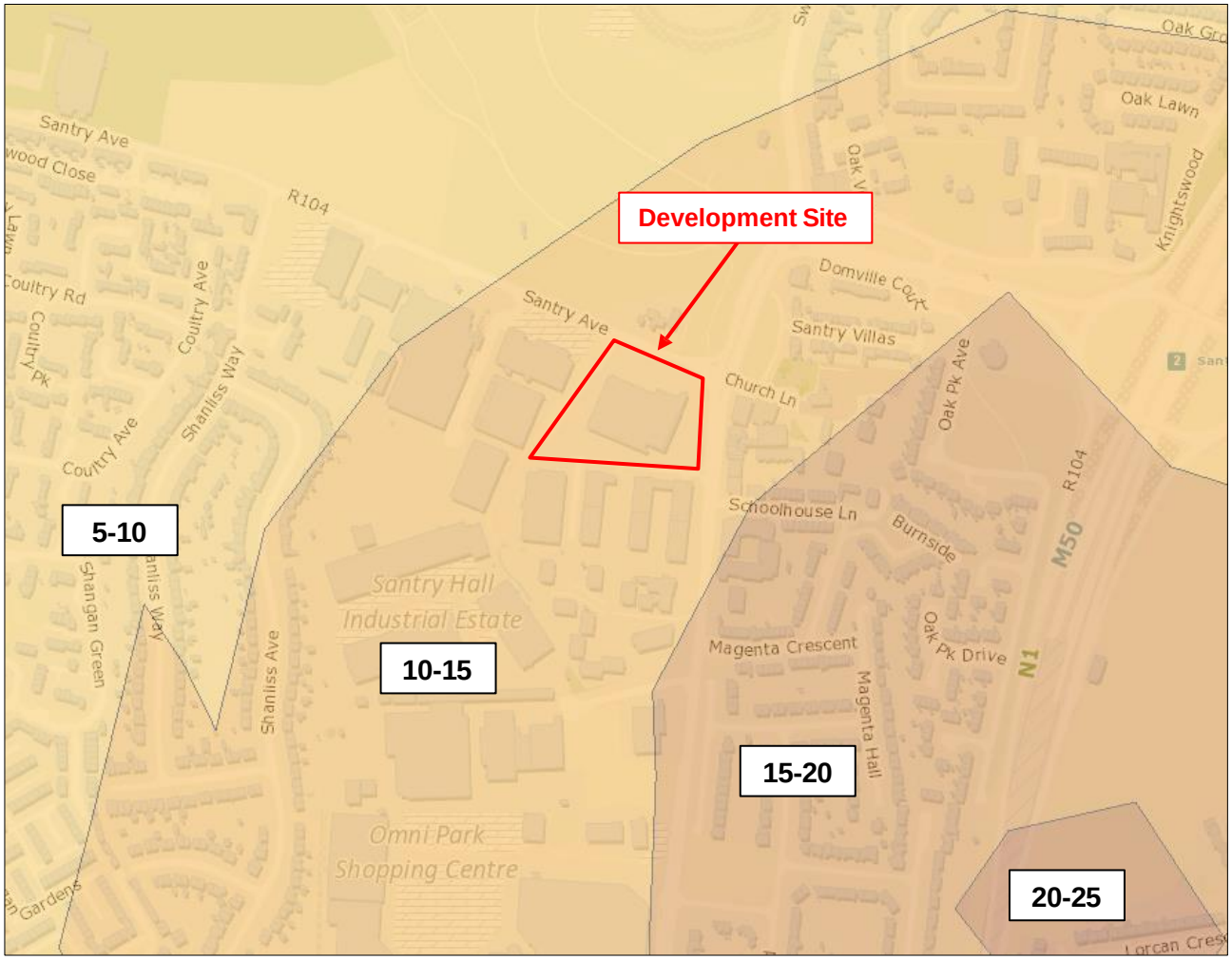


Figure 2.2: Depth to Bedrock (ref. GSI)

[2.1.3] Quaternary Sediments

The lithological description of the quaternary sediments is that of Till derived from limestones (TLs).

The quaternary sediments map relative to the development site is detailed in Figure 2.3 below.

Figure 2.3: Quaternary Sediments (ref. GSI)

[2.1.4] Groundwater

The subsoil is described as Made Ground of low permeability (L). The area is designated as low vulnerability (L).

The bedrock aquifer is a locally important aquifer (LI) in which the bedrock is moderately productive only in local zones. It has a recharge coefficient of 20%, an average recharge rate of 60mm/year, a maximum recharge capacity of 200mm/year and an average recharge range of 51-100mm/year.

The groundwater resources map relative to the development site is detailed in Figure 2.4 below.

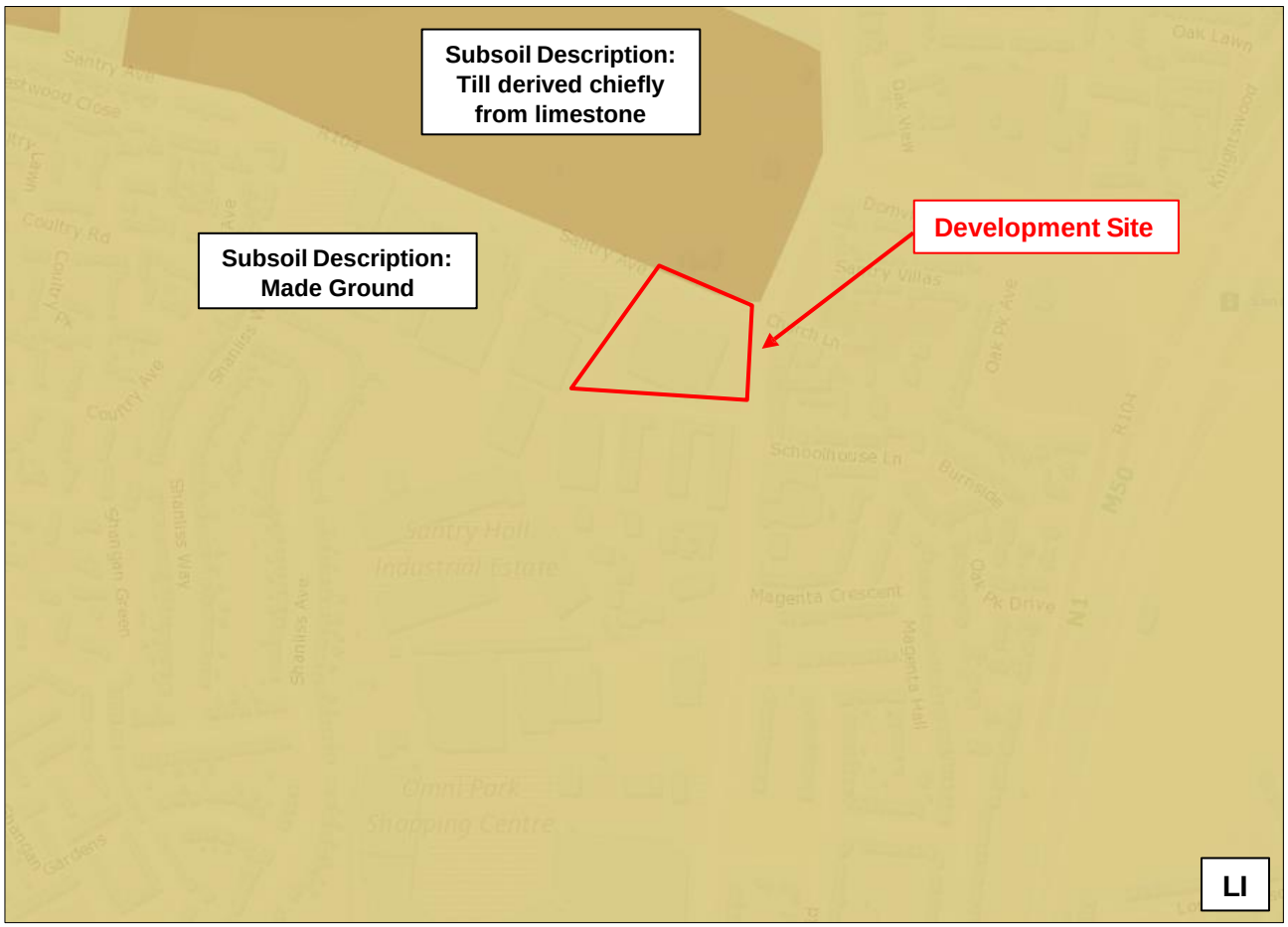


Figure 2.4: Groundwater Resources (ref. GSI)

[2.1.5] Historical Ground Investigations

There are a number of historical geotechnical sites in the locality, which are of relevance to the development site. The details of these site investigations are as follows:

- *Residential Community Centre (Report ID: 5022):* This site investigation report was completed by IGSL Ltd. on behalf of Barry & Partners Consulting Engineers in October 2002. The project was a community centre and residential development at Coolock Lane. The report contains information relating to an introductory discussion on existing ground conditions, standard penetration tests (CPT), soil classification tests, laboratory test results, 4no. trial pit logs and 6no. borehole logs.

- *Well – Santry Village (Old Map Record) (Report ID: 704):* This two-page document consists only of a brief note on a well in Santry Village and an accompanying location drawing.

- *Santry Avenue Trial Pit Investigation (Report ID: 1059):* This document is a report on a trial pit investigation for Dublin Corporation at Santry Avenue. It is dated August 1983. The fieldworks were completed by IGSL Ltd. and consist of the excavation of 6no. trial pits. The report discusses subsoil conditions and contains an exploratory hole layout plan and trial pit records.

- *Ballymun Coultry Park Residential / Commercial (Report ID: 6466):* This ground investigation was completed by IGSL Ltd. on behalf of Arup Consulting Engineers in December 2004. The fieldworks primarily consist of the excavation of 5no. trial pits and geotechnical and environmental testing. The trial pit records and processed test results are detailed in the report in addition to 2no. site plan drawings.

The location of the geotechnical sites relative to the present development site is demarcated in Figure 2.5 below.

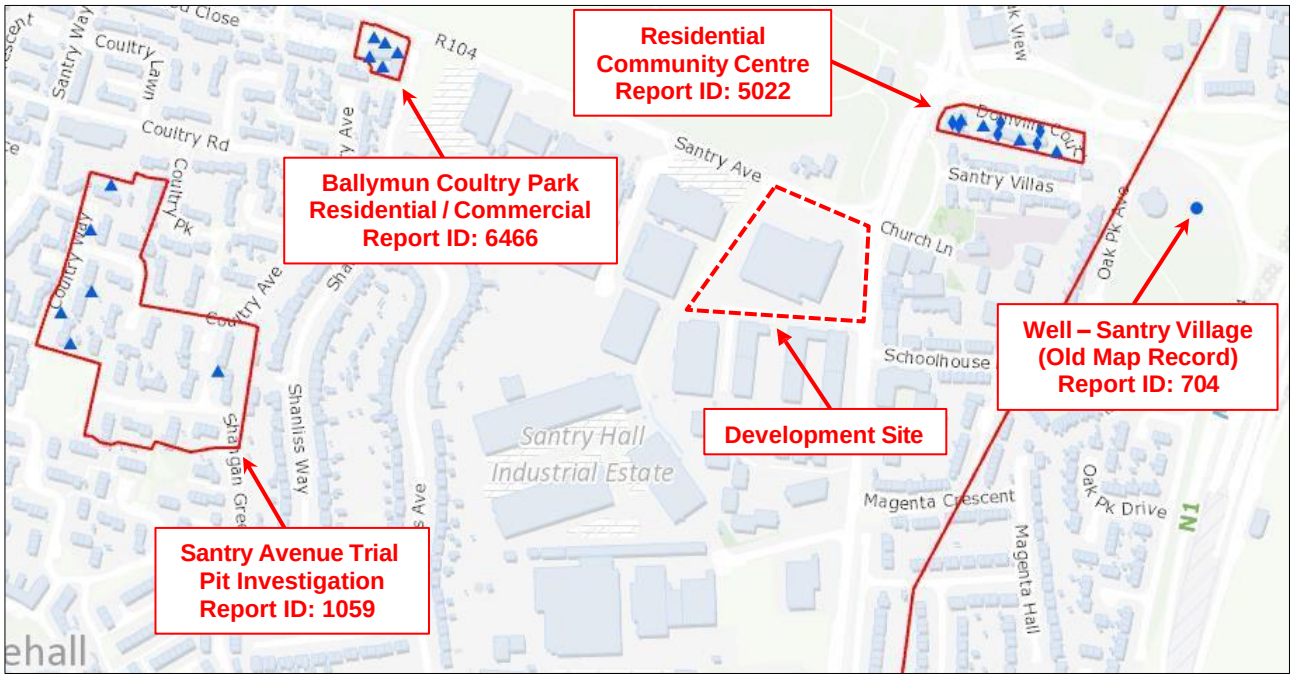


Figure 2.5: Historic Geotechnical Boreholes & Sites (ref. GSI)

[2.2] Adjacent Structures

The land use and building functionality of the area is dominated by high-density, mixed-use commercial, light industrial and residential development.

- *Santry Avenue:* A small cluster of single-storey buildings is located to the north of the proposed development site near Santry Park.
- *Santry Avenue Industrial Estate:* 2no. multibay buildings are located to the west of the development site. These 3-bay, 2-storey buildings consist of office and retail / commercial units.
- *Santry Place:* An apartment complex adjoins the southern perimeter of the development site. This 7-storey building has recently been completed. A 2-bay, 2-storey commercial / light industrial building lies to the southwest of the development site also.
- *Swords Road / Schoolhouse Lane / Church Lane:* This area consists of a row of small 2-storey retail units to the east of the development site.

The locations of the adjacent structures relative to the development site are displayed in Figure 2.6 below.

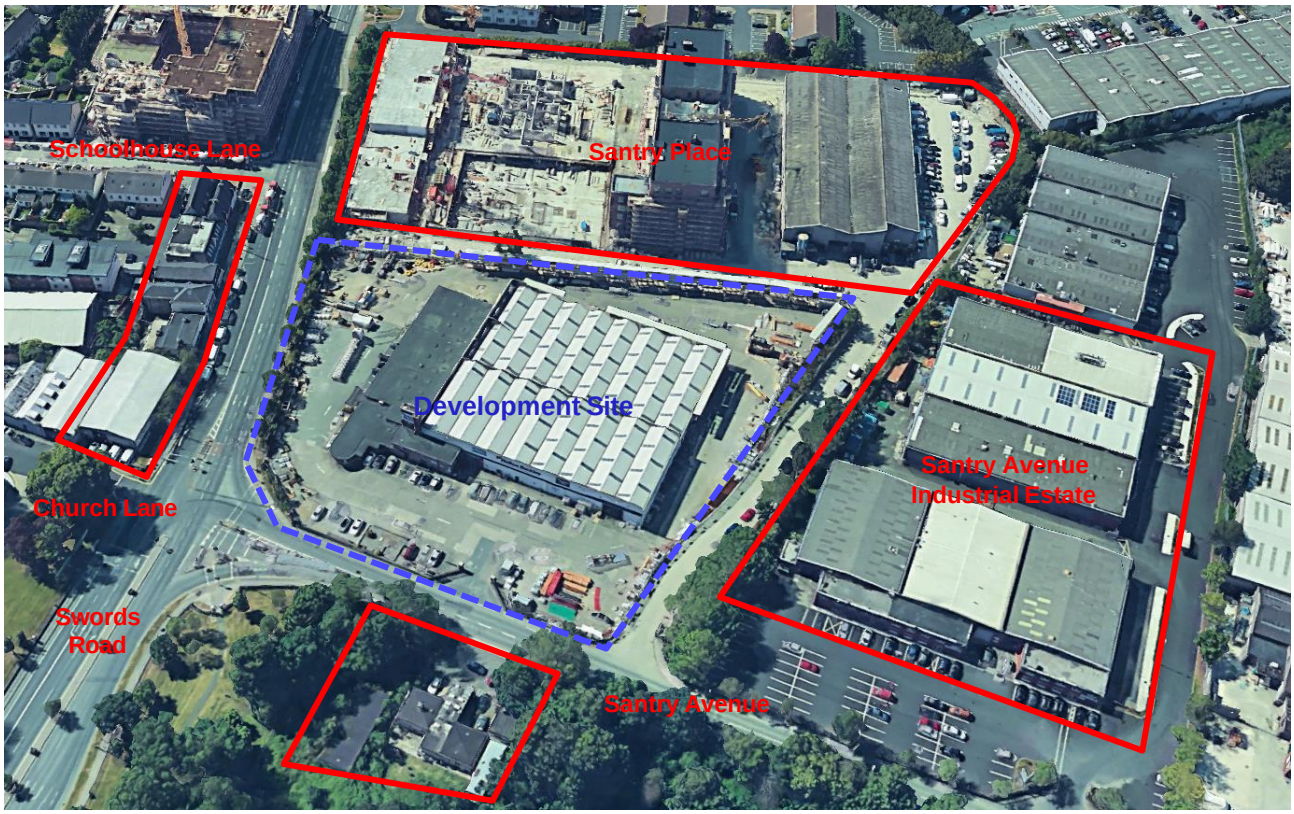


Figure 2.6: 3-Dimensional South-Facing Aerial View (ref. Google Maps)

[2.3] Protected Structures

The National Inventory of Architectural Heritage (NIAH) online resources were consulted to identify protected structures in the vicinity of the site. No protected structures were located.

A site was identified approximately 100m east of the development site. This pertains to St. Pappan's Church and encompasses a graveyard monument, holy well and ecclesiastical residence. However, this site is well outside the zone of influence of the proposed development.

The results are displayed in Figure 2.7 below.

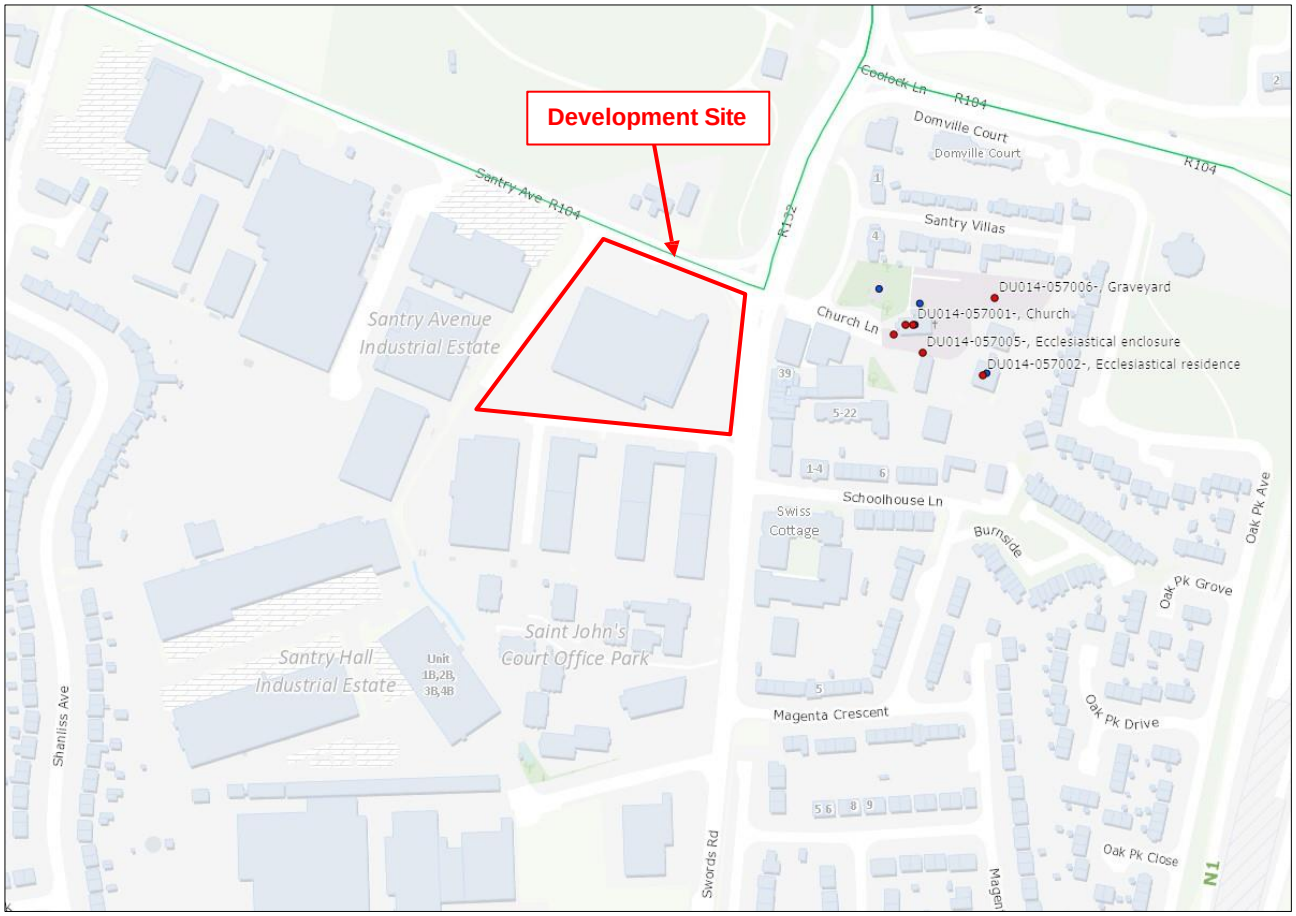


Figure 2.7: Nearby Protected Structures (ref. NIAH)

[2.4] Nearby Basements

Ayesa has investigated the presence of existing and proposed basements nearby. The National Planning Application Database (NPAD) was accessed to identify developments with basements / substructures, which might interact with the proposed basement. The relevant planning applications in the vicinity of the site from 2010 onwards are indicated in Figure 2.8 on the following page and detailed as follows:

- *Planning Application Reference Numbers 2532/18, 2044/18, 4491/17:* This proposed development involved the demolition of the former Swiss Cottage Bar and Restaurant and associated outbuildings and the construction of a five-storey building.

This development will comprise of 2no. retail units, 1no. café / restaurant unit, 1no. takeaway unit at ground floor level, signage, 89no. apartments with balconies / terraces, new vehicular and pedestrian access, 70no. bicycle spaces on Schoolhouse Lane, Swords Road and courtyard area, bin store, substation, landscaping, footpath upgrades, boundary treatment and all ancillary site and engineering works to facilitate the development. The basement area will incorporate 100no. car parking and 45no. bicycle parking spaces and plant room. The area of the site is 4706m^2. These planning applications were deemed invalid or refused.

- *Planning Application Reference Numbers 4549/22, 2543/21, 2737/19 & 2713/17:* The earliest planning application 2713/17 sought to develop 5no. 4-5-storey mixed-use blocks, which incorporated a basement car park (c. 3988m^2). This was accessible by a ramp under Block A. The basement area primarily accommodated a total of 122no. car parking spaces, 100no. bicycle parking spaces and plant. Planning application 2737/19 involved further modifications to the earlier permission by increasing the height of the blocks to 5-7no. storeys, change of unit type and increase the number of apartments and office space. The basement car park was to be extended by 1273m^2 to include 52no. additional car parking spaces, more bicycle parking and a new emergency escape route to the surface. A later planning application 2543/21 sought modifications to include 3no. 7-10-storey buildings for residential, commercial and office use. This was refused. The final application 4549/22 involved the development of 3no. 7-storey blocks and greater provision for residential apartments, parking, open space and ancillary works.

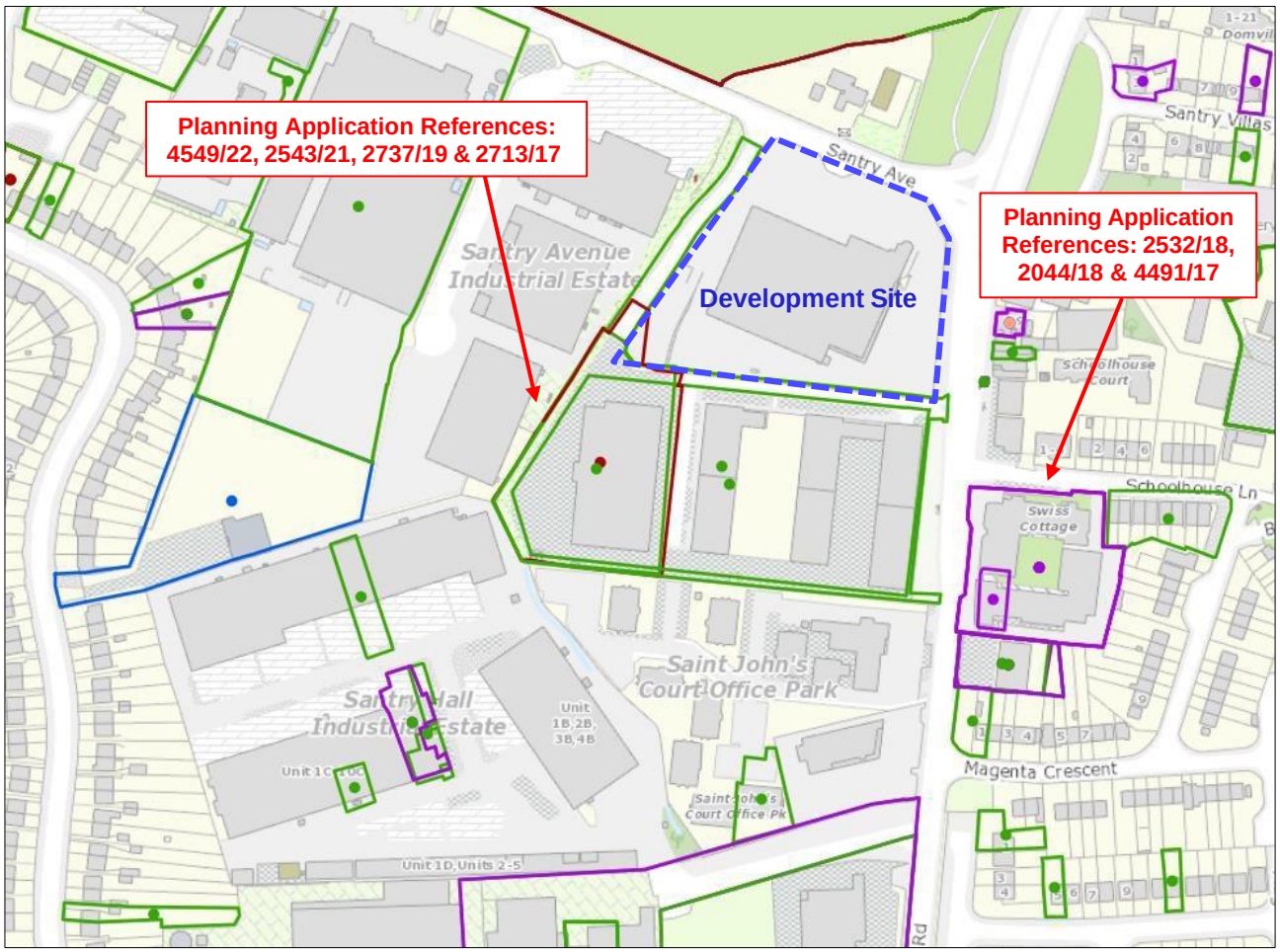


Figure 2.8: Nearby Planning Applications Incorporating Basements / Substructures (ref. NPAD)

[3] Ground Conditions

[3.1] Site Investigation Information

A ground investigation was completed by Ground Investigations Ireland Ltd. (GII) on the instructions of DBFL Consulting Engineers Ltd. (DBFL). However, this ground investigation is confined to the land at Santry Place, which adjoins the development site to the south. The contents of this report will be used to ascertain subsurface conditions and geotechnical parameters for the development site.

The site investigation procedures were reportedly in accordance with *Eurocode 7 Part 2: Ground Investigation and Testing I.S. EN 1997-2:2007* and *B.S. 5930:2015*. The investigative fieldworks undertaken during the months of January and February 2019 were comprised of the following:

- Observation of existing conditions on-site
- Excavation of 3no. trial pits to a maximum depth of 3.1m BGL
- Excavation of 3no. cable percussion boreholes to a maximum depth of 10.0m BGL
- Excavation of 1no. rotary core boreholes to a maximum depth of 9.7m BGL
- Geotechnical and environmental laboratory testing

The layout of the exploratory holes is indicated in Figure 3.1 below.

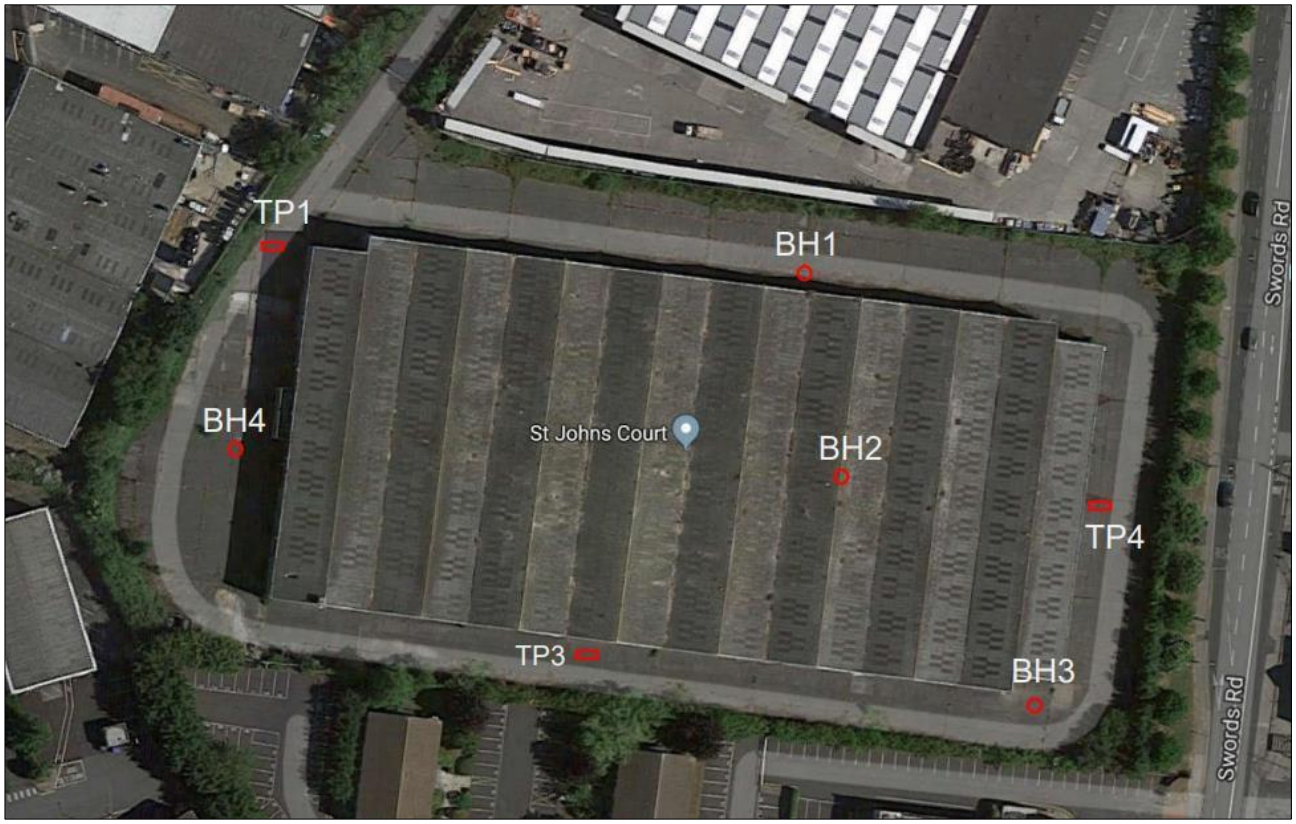


Figure 3.1: Exploratory Hole Locations (ref. GII Report - Project No. 8347-01-19)

[3.2] Ground Profile

On reviewing the contents of ground investigation, the ground profile of the site was as follows:

- ***MADE GROUND:*** The surficial layer was composed of a 200mm deep reinforced concrete slab overlying FILL material. This was described as grey, brown, slightly sandy, clayey, angular to subangular Gravel, which contained occasional cobbles in certain areas of the site. This further progressed to brown, grey, slightly sandy, gravelly Clay material with occasional angular cobbles. Fragments of brick and scrap metal were also encountered.

- ***CLAY:*** A layer of firm to stiff, brown, grey, slightly sandy, slightly gravelly CLAY underlaid the MADE GROUND layer. This CLAY material layer contained occasional subangular to rounded cobbles. This proceeded to stiff and eventually very stiff, dark grey, slightly sandy, slightly gravelly CLAY material with occasional cobbles and rare boulders.

Boreholes BH4 and BH4A-C were abruptly terminated at shallow depths due to the possible presence of a concrete slab at 0.4-1.0m BGL. Similar boulder obstructions were encountered in trial pits TP01 and TP03-04 at depths of 2.5-3.1m BGL. Elsewhere, the maximum excavation depths of boreholes BH1-3 and RC04 ranged from 9.7-10.0m BGL. No bedrock was encountered on completion of these aforementioned exploratory holes.

[3.3] Ground Profile

The following ground profile was adopted based on the findings of the site-specific ground investigation and detailed in Table 3.1 below. The depth and layer thickness of the strata encountered were both variable and irregular.

Table 3.1: General Ground Profile

Stratum	Depth (m BGL)	Layer Thickness (m)
MADE GROUND	0.0	0.4 - 3.0
FIRM CLAY	0.6 - 1.8	0.4 - 1.0
FIRM / STIFF CLAY	1.0 - 2.8	0.3 - 1.2
STIFF CLAY	1.8 - 3.0	0.4 - 2.0
VERY STIFF CLAY	1.6 - 5.0	-

[3.4] In-situ Testing

[3.4.1] Standard Penetration Tests

Standard penetration tests (SPT) were completed in the boreholes. The test procedure consisted of a 50mm diameter thick wall sampler tube driven into the soil by a 63.5kg weight from a drop height of 760mm. The N-value was recorded as the number of blows required to drive the tube 300mm following an initial penetration of 150mm.

The N-values from each borehole were plotted against the depth BGL for each material layer. A design line was then inserted. This facilitated geotechnical parameters to be determined for each material layer.

The SPT (N) plot is displayed in Figure 3.2 below.

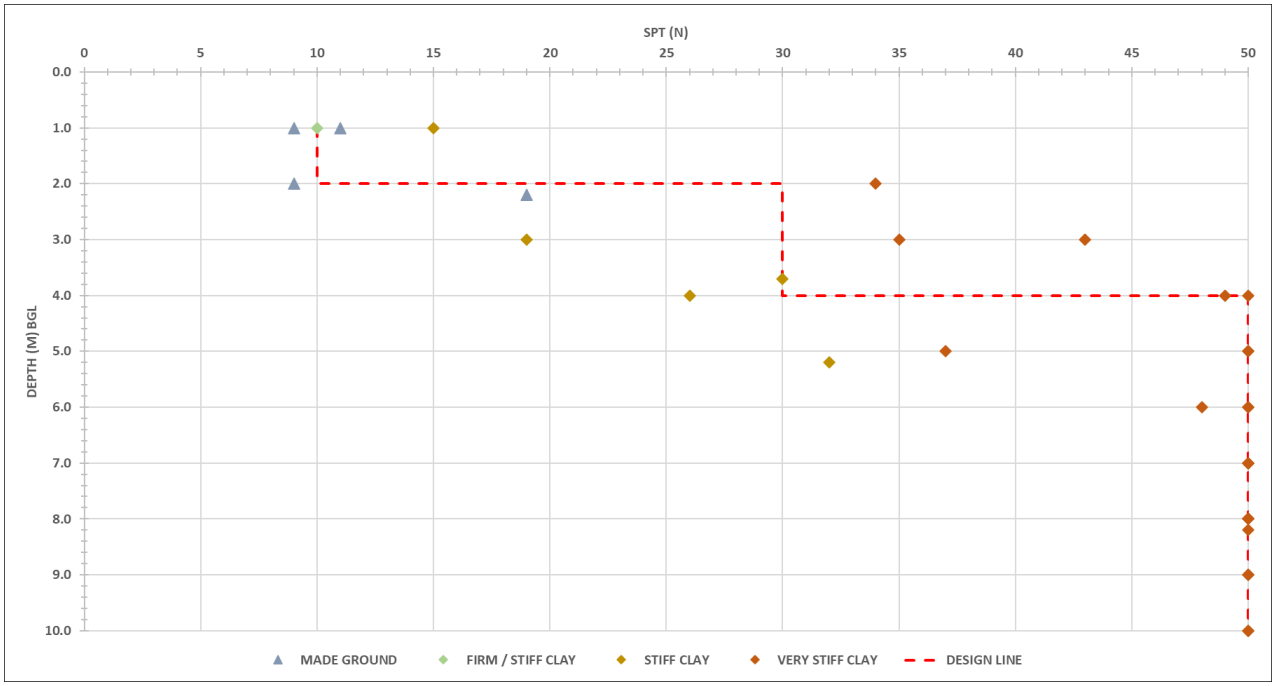


Figure 3.2: SPT (N) Plot

[3.5] Characteristic Geotechnical Parameters

The resultant SPT (N) plot was used to determine various geotechnical parameters based on published correlations and relationships for the underlying ground conditions. As shown in Figure 3.3 below, the undrained shear strength c_u of the cohesive material can be calculated on the basis of the Stroud (1974) correlation, where $c_u = 4\text{-}6N$. A correlation of $c_u = 5N$ was chosen.

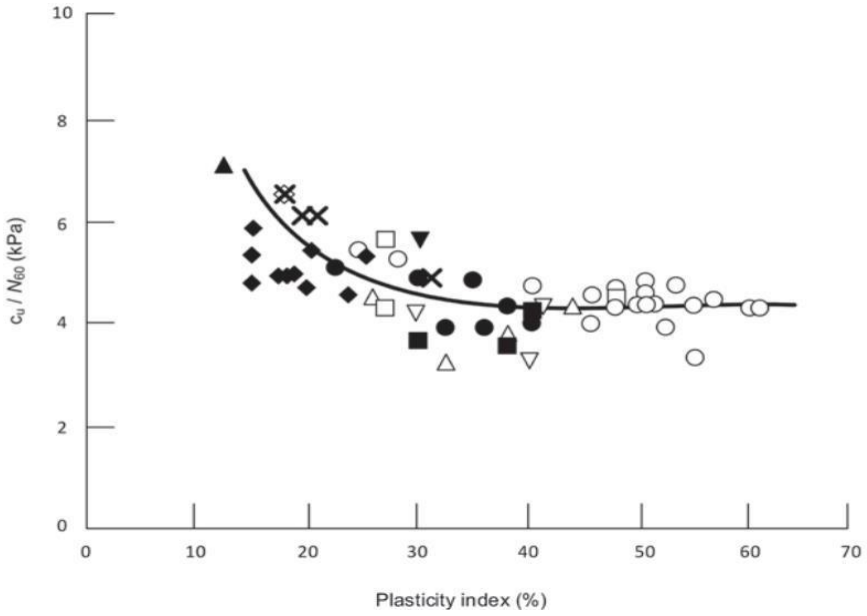


Figure 3.3: Stroud (1974)

For cohesive soils, an estimation of the angle of shearing resistance ϕ' was developed using the relationship proposed by Terzaghi, Peck and Mesri (1996) as shown in Figure 3.4 below. For high plasticity soils, ϕ' typically varies from 25-30°.

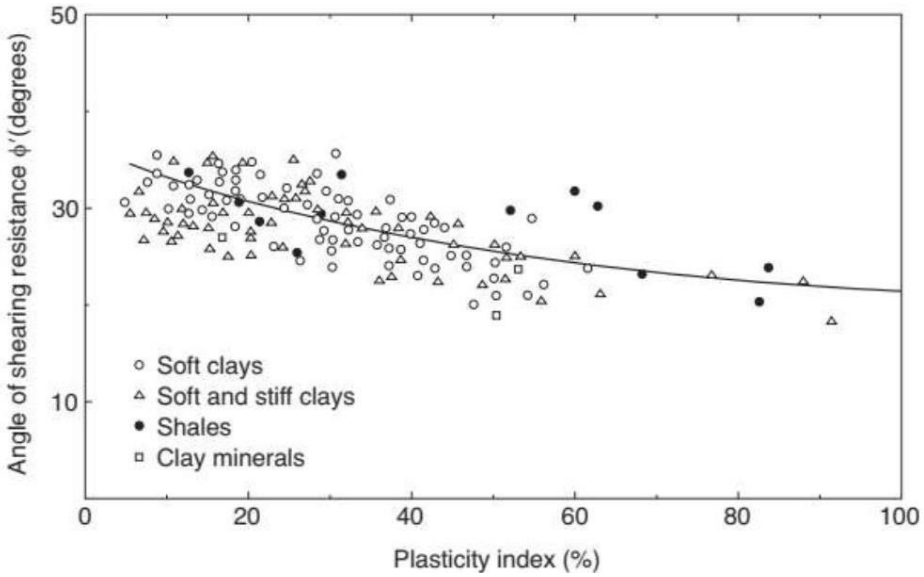


Figure 3.4: Terzaghi, Peck & Mesri (1996)

The soil stiffness modulus *E* was also approximated using relationships as set out in CIRIA C760 and based on research conducted by Stroud & Butler (1975), Duncan (1976) and Jamiolkowski (1979). The undrained soil stiffness modulus E_u was based on $E_u = 250 \times c_u$ for normally consolidated soils to $E_u = 600 \times c_u$ for over-consolidated soils as per Figure 3.5 below. The drained stiffness modulus *E'* for cohesive soils was calculated assuming 66% of the undrained stiffness modulus where $E' = 66\% E_u$.

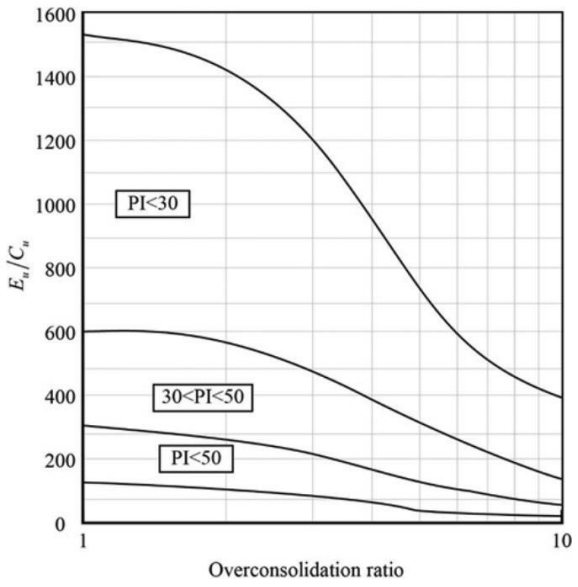


Figure 3.5: Relationship between E_u/c_u versus OCR

[3.6] Characteristic Geotechnical Parameters

Based on the interpretation of the site-specific ground investigation and the various published correlations as described above, the following characteristic geotechnical parameters were derived for the various strata and detailed in Table 3.2 below.

Table 3.2: Characteristic Soil Parameters

Stratum	SPT (N)	γ (kN/m³)	ϕ' (˚)	c_u (kPa)	E_u (MPa)	E' (MPa)
MADE GROUND	10	19	30	50	30	20
STIFF CLAY	30	18	34	150	90	60
VERY STIFF CLAY	50	18	36	250	150	100

It was assumed that variable conditions existed in the overburden and that the proposed development substructure will be founded in the very stiff CLAY layer. It is the responsibility of the Contractor to notify Ayesa of any variations to actual ground conditions encountered on-site.

[3.7] Groundwater

A slotted standpipe with a pea gravel surround was installed in the rotary cored borehole RC04 at a depth of 9.7m BGL extending up to 1.0m BGL. A plain standpipe was then installed at a depth of 1.0m BGL to GL. This section had a bentonite seal and a flush cover. No groundwater ingress or strikes were recorded on the borehole log. Blowing sand was noted at the depth of 6.7m BGL. This frequently occurs in boreholes below the water table.

No groundwater was encountered in the cable percussive boreholes BH1-3 or trial pits TP03 and TP04. However, groundwater was recorded at a depth of 2.6m BGL in trial pit TP01. Stable conditions were observed in all trial pit excavations.

The exploratory holes did not remain open for a sufficient period to establish the hydrogeological regime. Groundwater levels can vary with seasonal and precipitation patterns, local drainage and nearby construction activity. It is recommended that further groundwater monitoring measures are implemented sitewide to address to address this issue. As such, a groundwater level of 1m BGL was chosen based on conservative engineering judgement.

[3.8] Chemical Testing

Chemical testing was conducted by Exova Jones Environmental on the 23rd of January 2019 as part of the site-specific ground investigation. A total of 8no. samples were taken from the trial pits TP1, TP3 and TP4 at depths ranging 0.4-3.0m BGL. The laboratory test results were reviewed for the purpose of assessing the risk of chemical attack on buried concrete.

The pH level and sulphate concentrations attained are detailed in Table 3.3 below.

Table 3.3: pH Level & Sulphate Concentration

Trial Pit No.	TP1	TP1	TP1	TP3	TP4	TP4	TP4	TP4
Depth (m)	0.40	0.4	1.00	1.50	1.00	1.00	2.00	3.00
pH	12.15	12.15	9.05	8.81	10.99	11.35	8.06	8.26
Sulphate as SO_4 (2:1 Ext) (mg/l)	-	-	20.2	21.3	-	-	< 1.5	< 21.9
Sulphate as SO_4 (mg/l)	-	8.0	-	-	-	4.7	-	-

The pH level varies from 8.06-12.15, while the sulphate as SO_4 concentrations range from < 1.5mg/l to 21.3mg/l. Therefore, the design sulphate classification for the site as per BRE Special Digest 1 is DS-1, while the ACEC (Aggressive Chemical Environment for Concrete) classification is AC-1.

In accordance with *I.S. EN 206-1:2013*, a minimum XA2 exposure class is required for the buried concrete as there is a substantial amount of surficial MADE GROUND material. Additionally, the concrete will be in contact with water below groundwater level, which will lead to a wet and rarely dry environment. This requires an XC2 exposure class designation.

[4] Hydrogeology

[4.1] Geology and Hydrogeology of Dublin

This part of Dublin City is underlain by the Lucan Formation (LU). It is classified by the GSI as a Locally Important (LI) aquifer, which is moderately productive only in local zones as shown in Figure 4.1 below. In general, the subsoil permeability in the Lucan Formation is low with an average recharge of 60mm/year.

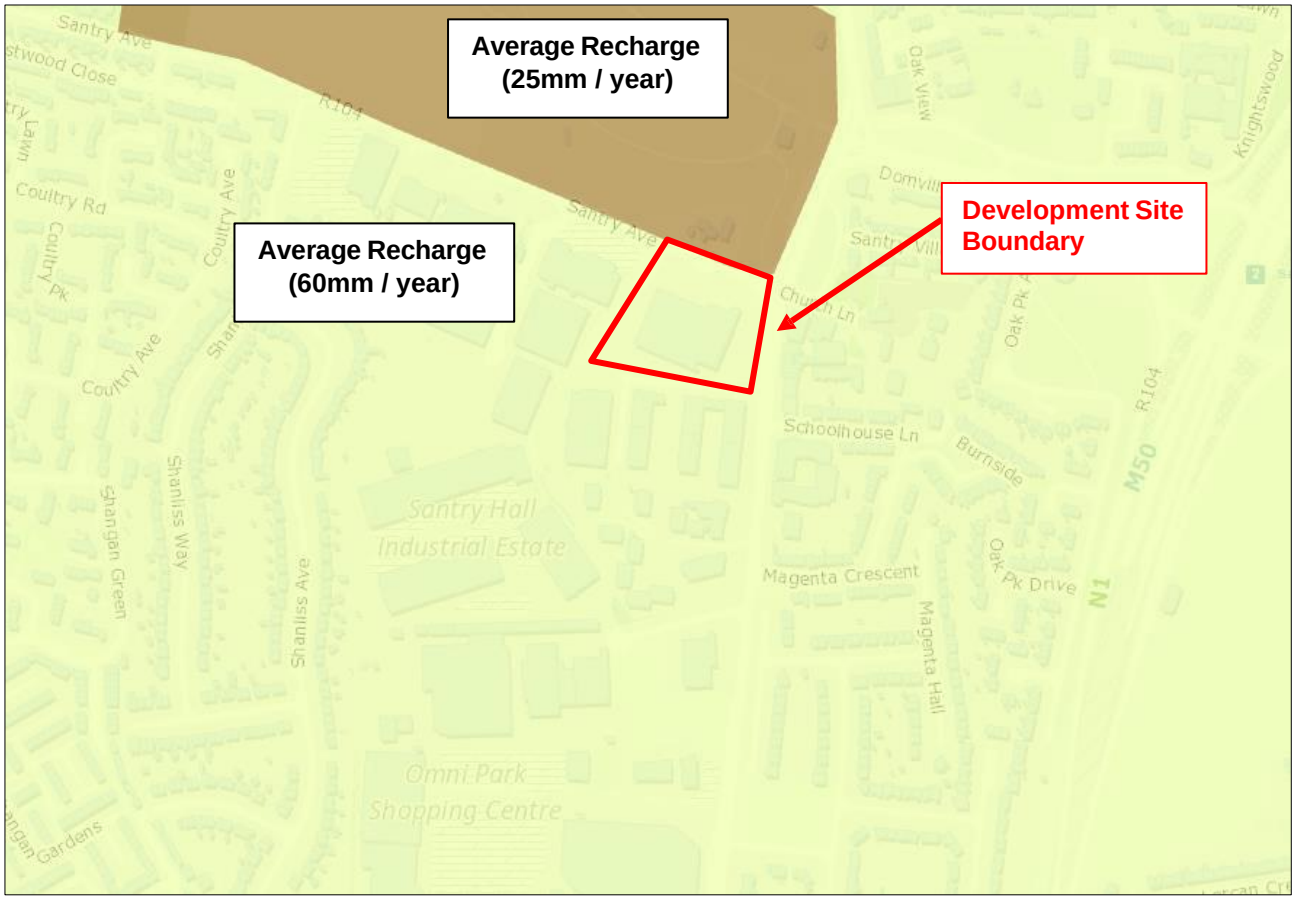


Figure 4.1: Groundwater Recharge (Source: GSI)

The flow of groundwater in rock aquifers is dependent on the network of fractures and its properties such as density of fracture, direction, length, width and the connectivity between the network of fractures. Fracture lengths can vary accordingly from a few metres to hundreds of metres (Comte et al., 2012). When fractures are present in rocks, it will change the flow pattern of groundwater because the water is trapped inside the fractures and thereby moves along the direction of the fracture. Additionally, fractured rock aquifer characteristics such as transmissivity and storage will differ greatly depending on the length and width of the fracture.

A layer of glacial-fluvial sand and gravel can be found along the channels / floodplains of the Liffey, Dodder and Santry Rivers in Dublin City. In addition, the Boulder Clay material can contain unconnected sand and gravel lenses, but their lateral and vertical extents are also limited. This medium to highly permeable material is expected north of the proposed site due to its proximity to the Santry River. However, this should not affect the project.

Groundwater flow in the bedrock is confined by the layer of Boulder Clay that is likely present below the Made Ground strata. Rainfall is not expected to recharge the groundwater to the bedrock level due to the low permeability of the subsoil (Misstear, Brown and Daly, 2009). Conversely, this stratum will not suffer any issues, which may arise from surface activities such as contamination and oil spills as the liquid will not leach easily through the subsoil to the aquifer below.

[4.2] Detailed Assessment of Adjacent Structures on Groundwater Levels

The impact of deep basement construction within Dublin City Centre has not yet been studied or investigated thoroughly. However, a small number of major developments such as the former Metro North (also known as MetroLink today) were requested by An Bord Pleanála (ABP), whereby a hydrogeologist was appointed to carry out a study on the potential impact of its proposed underground station boxes on surrounding groundwater flow and levels. The former alignment of Metro North traverses areas, which had low permeability geology (Made Ground overlying Dublin Boulder Clay and Limestone bedrock). It also passes through areas, where there are layers of alluvial deposits above the Dublin Boulder Clay such as in the Parnell Square area. The proposed underground station boxes for the Metro North project had average dimensions of 25m deep, 30m wide and 165m long. Professor William Powrie from the University of Southampton, UK was appointed to carry out the study and his conclusions were as follows:

- Where basements are found in low permeability tills such as sandy gravelly CLAY (Dublin Boulder Clay) that are present at the proposed development, there is no impact on the groundwater regime since it is evident that there is very little water flow in these low permeability horizons regardless of their porosity.

[4.3] Impact of the proposed development on the groundwater regime

The proposed basement area is approximately 87m long and 100m in wide at its furthest extents with a floor level to ceiling height of 2.8m. The excavation of the basement will be 4m BGL and it will be founded in the stiff / very stiff, slightly sandy, slightly gravelly CLAY stratum. The excavated material will consist of MADE GROUND and firm / stiff / very stiff CLAY. This very stiff CLAY material has a very limited ability to transmit groundwater due to its low permeability characteristic and is an aquitard / aquiclude rather than an aquifer. Therefore, the proposed basement is not likely to impede or block groundwater flow as it will be founded within the stiff / very stiff CLAY stratum.

[4.4] Groundwater Extractions / Well Data

Several groundwater extractions are believed to exist within the Dublin City Centre area close to the proposed basement. Groundwater well records for the area were obtained from the GSI spatial resources database and are detailed in Figure 4.1 on the following page.

The nearest well locations are known to varying degrees of accuracy by up to 0.5-2.0km in plan. A total of 2no. wells have been identified at approximate distances of 1.3km and 1.8km from the site. One was for domestic use only, while the use of the other was unknown. None of the wells are noted to be used for potable water supply.

- GSI Name: 2923NEW015
  - Well Type: Borehole
  - Drill Date: December 29, 1899
  - Locational Accuracy: Up to 500m
  - Depth: 48.8m
  - Use: Industrial use
  - Distance from proposed development: 1.3km

- GSI Name: 2923NEW016
  - Well Type: Borehole (Casing diameter 150mm)
  - Drill Date: December 29, 1899
  - Locational Accuracy: Up to 500m
  - Depth: 35.4m
  - Use: Domestic use only
  - Distance from proposed development: 1.5km

- GSI Name: 2923NEW036
  - Well Type: Borehole
  - Drill Date: August 1, 1988
  - Locational Accuracy: Up to 500m
  - Depth: 91.4m
  - Use: Industrial use
  - Distance from proposed development: 1.7km

- GSI Name: 2923NEW037
  - Well Type: Borehole
  - Drill Date: August 1, 1988
  - Locational Accuracy: Up to 500m
  - Depth: 122m
  - Use: Industrial use
  - Distance from proposed development: 1.7km

- GSI Name: 2923NEW061
  - Well Type: Borehole
  - Drill Date: August 1, 1988
  - Locational Accuracy: Up to 200m
  - Depth: 91.4m
  - Use: Industrial use
  - Distance from proposed development: 1.9km

- GSI Name: 2923SEWW024
  - Well Type: Borehole (Casing diameter 168mm)
  - Drill Date: March 16, 1998
  - Locational Accuracy: Up to 2km
  - Depth: 90m
  - Use: Unknown
  - Distance from proposed development: 1.8km

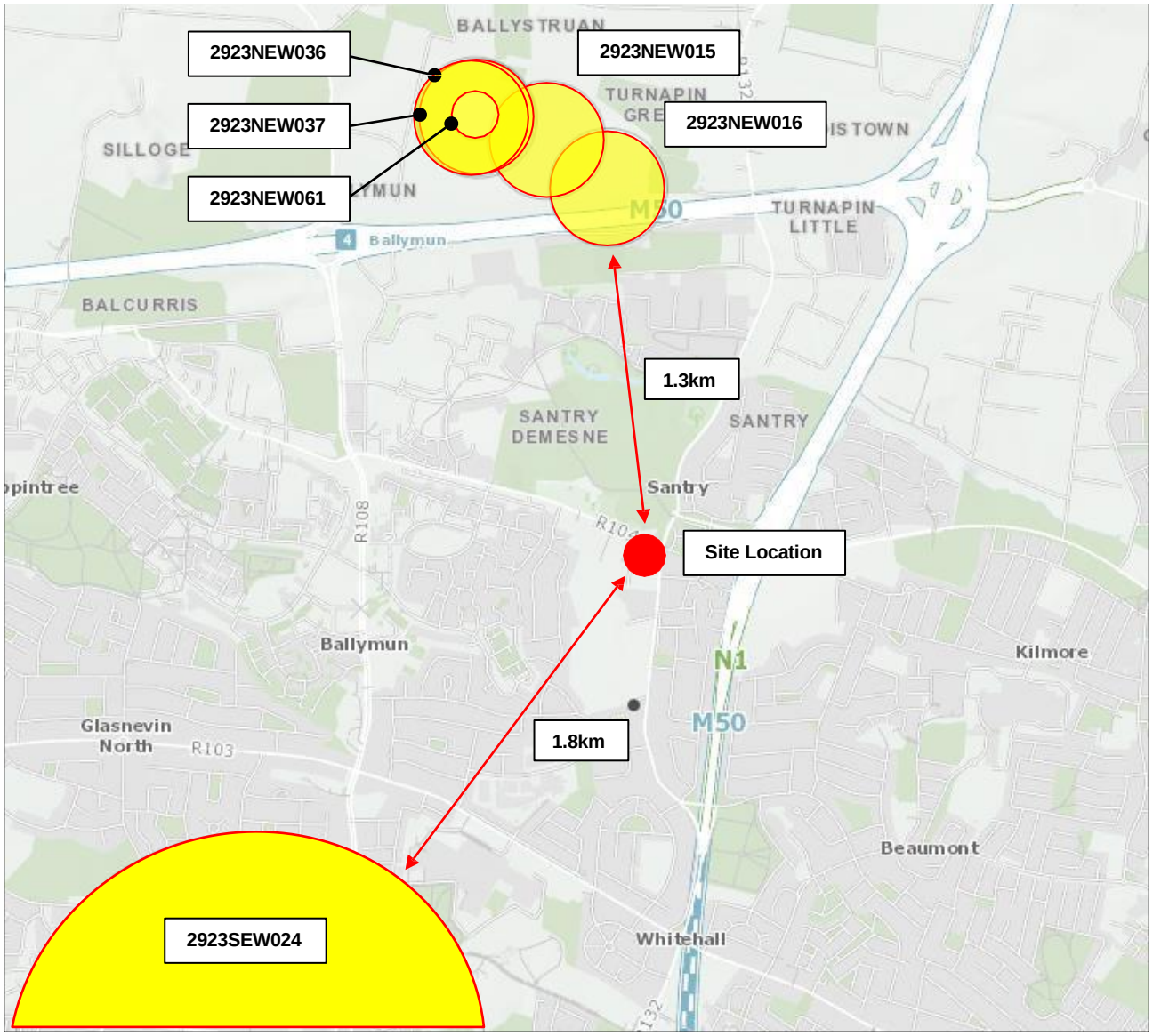


Figure 4.1: Groundwater Extractions / Well Data (Source: GSI)

[4.5] Groundwater Flow

Groundwater within the Dublin City Centre area is reported to flow in a general eastward direction and either contributes to the various rivers flowing within the Dublin area or discharges directly into the sea at Dublin Bay. Figure 4.2 below illustrates the general direction of groundwater flow in this west-to-east direction, which mirrors the direction of flow of the River Liffey.

Although the site in question is to the north and outside the extents of the map displayed in Figure 4.2 below, the inserted groundwater flow lines would also likely indicate a northwest-to-southeast groundwater flow direction.

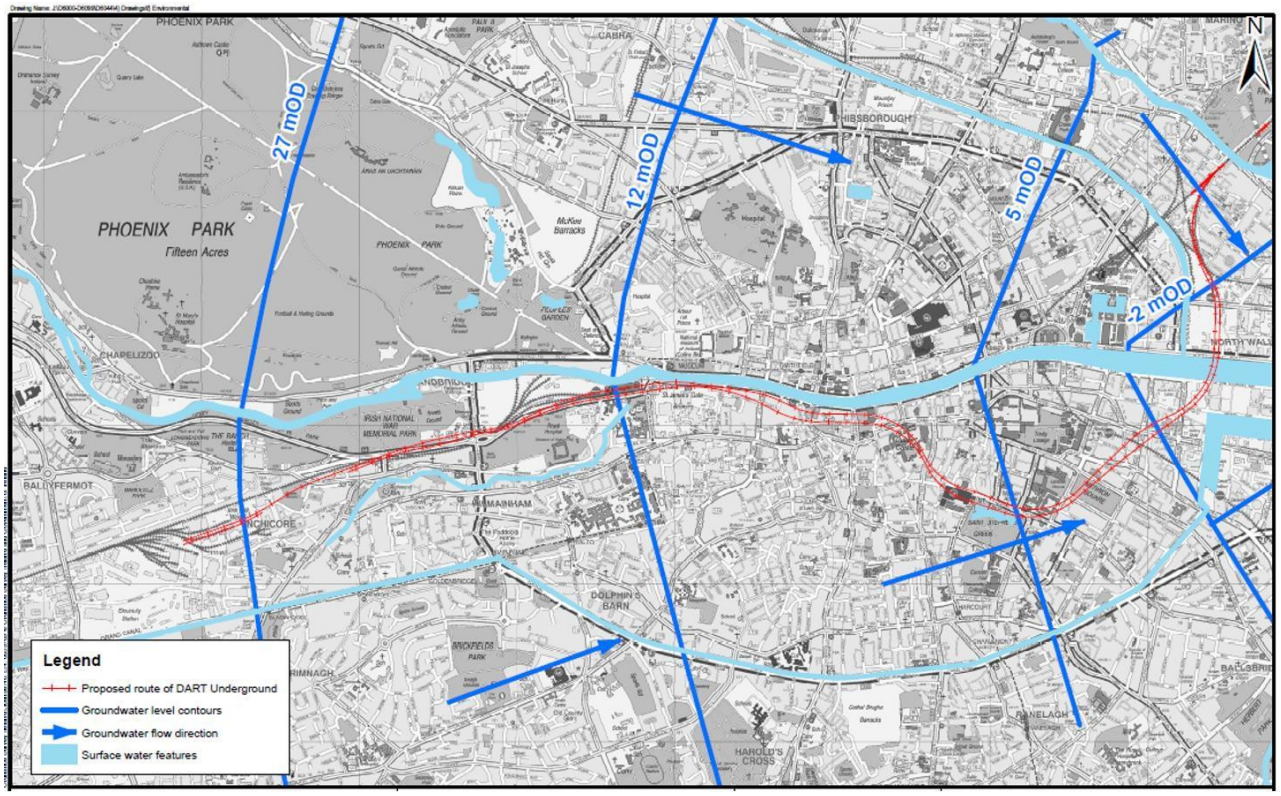


Figure 4.2: Groundwater Level Contours and Flow Lines in Dublin City Centre

(excerpt from Environmental Impact Statement for DART Underground)

[4.6] Karst Features

A review of the GSI online karst map was completed to determine if any localised karst features were recorded close to the site. No karst features such as caves, valleys or swallow holes were noted within the area. This is broadly in agreement with Farrell and Wall (1990), who suggest that minimal solution cavitation and weathering of the Dublin limestone is due to its argillaceous (fine-grained) component. While recognising that the bedrock surface would have undergone weathering to some extent, Farrell and Wall (1990) state that the weathered zone is generally limited to less than 1m within the upper layer of the bedrock.

[4.7] Cumulative Impact of Nearby Basements

As detailed above, there was an identified sizable basement structure, which forms part of the recently built apartment complex at Santry Place to the south of the site. Based on this and the groundwater flow impediment, scenario C1-C3 illustrated in the DCC Guidance Document is considered applicable.

Please note that no site-specific groundwater monitoring was undertaken to date. It is recommended that a groundwater monitoring regime be implemented on-site. This will facilitate any subsequent reviews to this section based on these new findings.

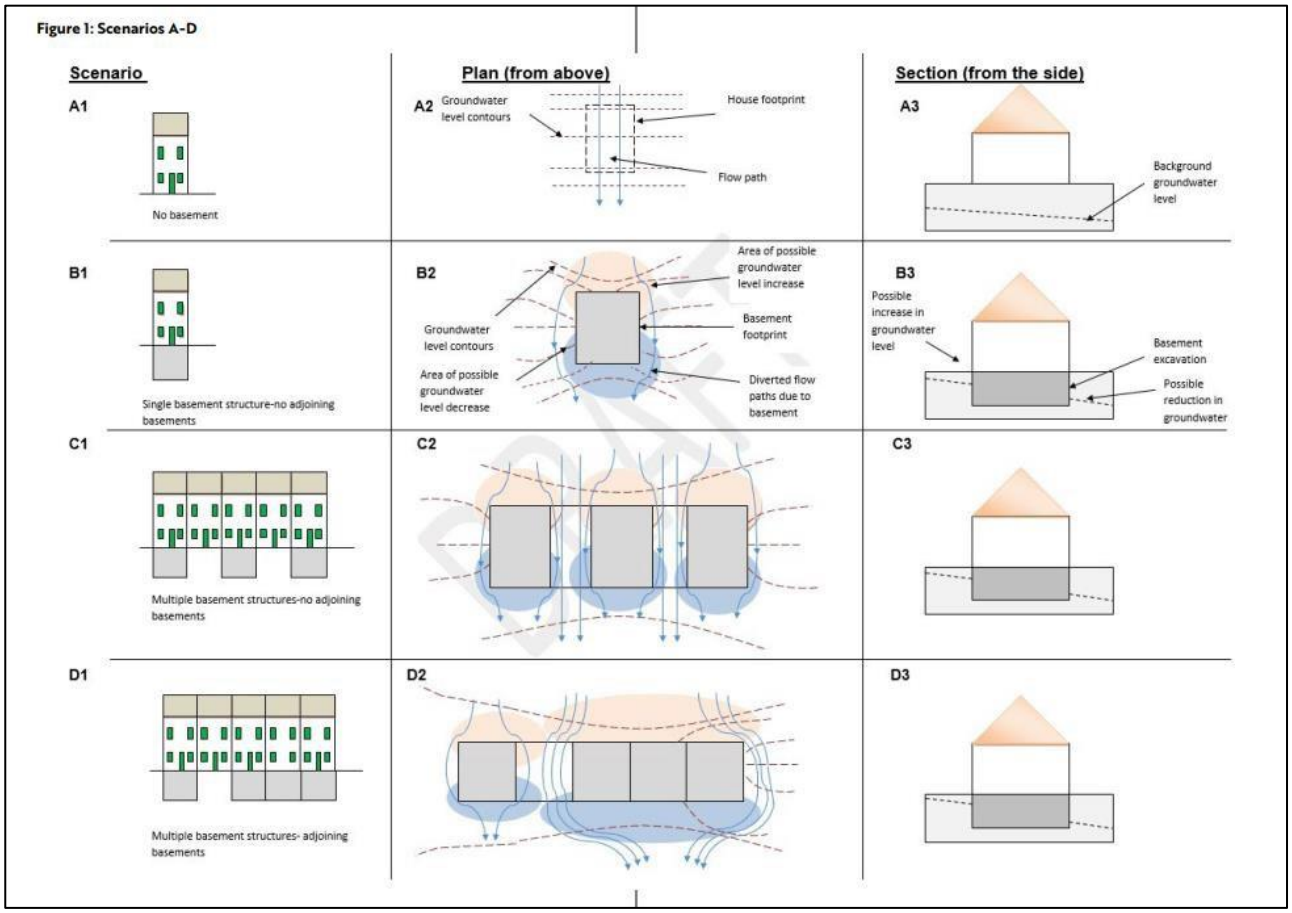


Figure 4.3: Cumulative Effects of Basement Construction on Groundwater

(ref. Draft Dublin City Development Plan Appendix 9 – Figure 1)

[4.8] Temporary Groundwater control

The installation of pumps shall be required to keep the excavation area dry during the course of the works. This can most likely be attributed to the accumulation of surface water runoff within the excavation footprint. Minimal pumping arrangements should be sufficient.

[5] Ground Movement Assessment

[5.1] General

Ayesa has completed a preliminary ground movement assessment of the proposed basement substructure. This substructure will be founded within the stiff / very stiff CLAY strata. The excavation depth is approximately 4.0m BGL. It is proposed to install a secant piled wall to facilitate the excavation works.

The following ground movement mechanisms have been assessed:

- *Ground movements within the basement (heave & settlement):* The ground movements within the basement are a result of the unloading of the formation soils, which will generate ground movement. This could affect adjacent foundations. Stress relief will initially cause short-term heave following which the soils will be subject to structural loading from the substructure. This mechanism considers the existing stress conditions, stress and weight of soil removed and design loads from the new structural slab and pad / strip foundations. Short-term movements in the form of heave are associated with undrained conditions. The long-term movements are associated with drained conditions. Based on the over-consolidated nature of the Dublin Boulder Clay, the ground movements associated with heave and settlement are considered nominal and have not been included within this assessment.
- *Ground movements surrounding the basement:* It is proposed to install a secant piled wall to facilitate the construction of the basement. Ayesa has completed an assessment of the ground movements based on that of the excavation in front of a low stiffness wall (CIRIA C760 Fig. 6.15 (b). These were derived from a number of historic case studies.

[5.2] Software

The assessment of ground movements within and surrounding the excavation area has been completed by means of the geotechnical modelling software application OASYS XDisp. This software suite is commonly used within the ground engineering industry and considered to be an appropriate tool for this analysis. The XDisp software has been used to predict ground movements likely to arise from the construction of the proposed basement. This includes the settlement of the ground in the form of vertical movement and the lateral or horizontal movement of the soil caused by the excavation.

[5.3] Adjacent Structures

It is expected that the basement will be excavated using the following techniques:

- It is expected that most of the proposed basement will be excavated using open cut excavation techniques where there is adequate clearance between the basement edge and the boundary line.

- At some local areas, where the basement is close to the boundary line, an embedded retaining wall will likely be required to facilitate the basement excavations. These have been accounted for in the ground movement and damage assessment carried out as part of the BIA.

Pre-existing ground movement curves in accordance with CIRIA 760 were used to model the proposed development and the adjacent buildings in the XDisp model. This facilitated the assessment of the ground movement and impact on neighbouring buildings. The movement curves utilised for the analysis were those of “excavation in front of low stiffness wall in stiff clay” for the initial stage of the basement construction, which is considered conservative for the site conditions and excavation proposals.

The nearest adjacent structures to the proposed basement are:

- *Santry Avenue:* No definitive information has been provided on the foundations of this cluster of buildings. Based on the information in the desk study as discussed in Section 2.2, there is no evidence available to suggest that these buildings have basements and the foundations are likely to consist of pads and a ground floor slab with the slab cast approximately at ground level. However, the XDisp model has conservatively been modelled as strip foundations, so ground movements have been assessed at a depth of 1mBGL.

- *Swords Road:* No definitive information has been provided on the foundations of this row of low-density retail units. Based on the information in the desk study as discussed in Section 2.2, there is no evidence available to suggest that these buildings have basements and the foundations are likely to consist of pads and a ground floor slab with the slab cast approximately at ground level. However, the XDisp model has conservatively been modelled as strip foundations, so ground movements have been assessed at a depth of 1mBGL.

- *Santry Place:* No definitive information has been provided on the foundations of the apartment complex building. Based on the information in the desk study as discussed in Section 2.2, there is evidence available to suggest that this building has a sizable basement and the foundations are likely to consist of a ground floor slab with the slab cast approximately at 4m BGL. However, the XDisp model has conservatively been modelled as a slab foundation, so ground movements have been assessed at a depth of 4mBGL.

- *Santry Place & Santry Avenue Industrial Estate:* No definitive information has been provided on the foundations of the multi-bay commercial units. Based on the information in the desk study as discussed in Section 2.2, there is no evidence available to suggest that these buildings have basements and the foundations are likely to consist of pads and a ground floor slab with the slab cast approximately at ground level. However, the XDisp model has conservatively been modelled as strip foundations, so ground movements have been assessed at a depth of 1mBGL.

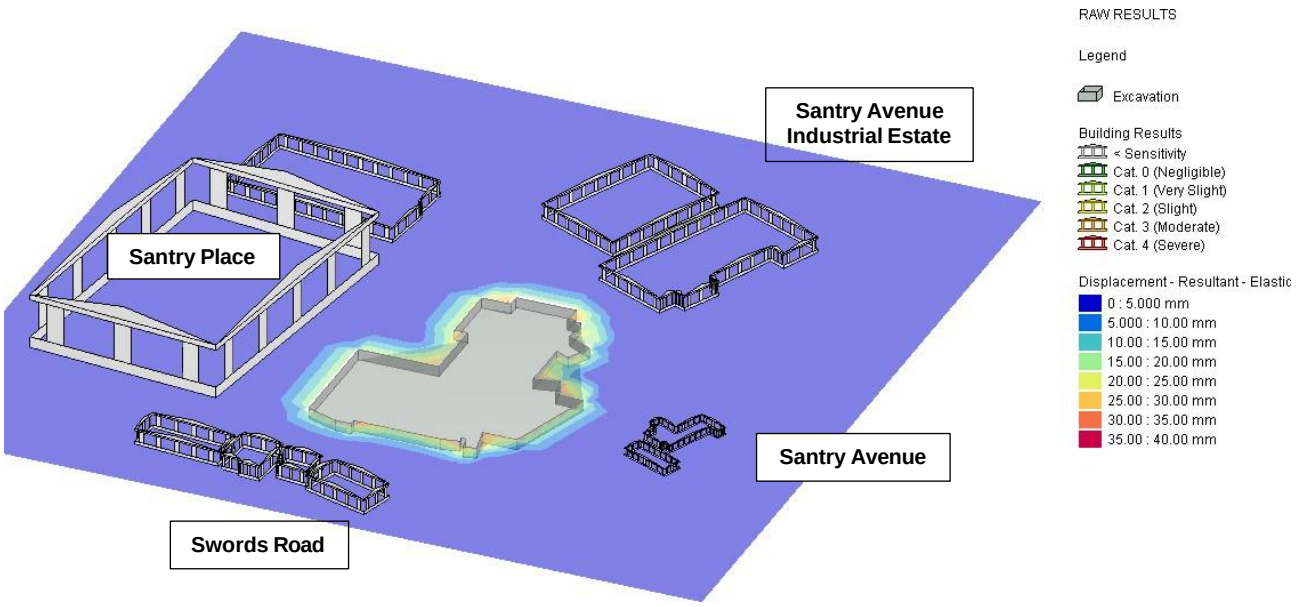


Figure 5.1: XDisp output of adjacent building damage due to basement excavation

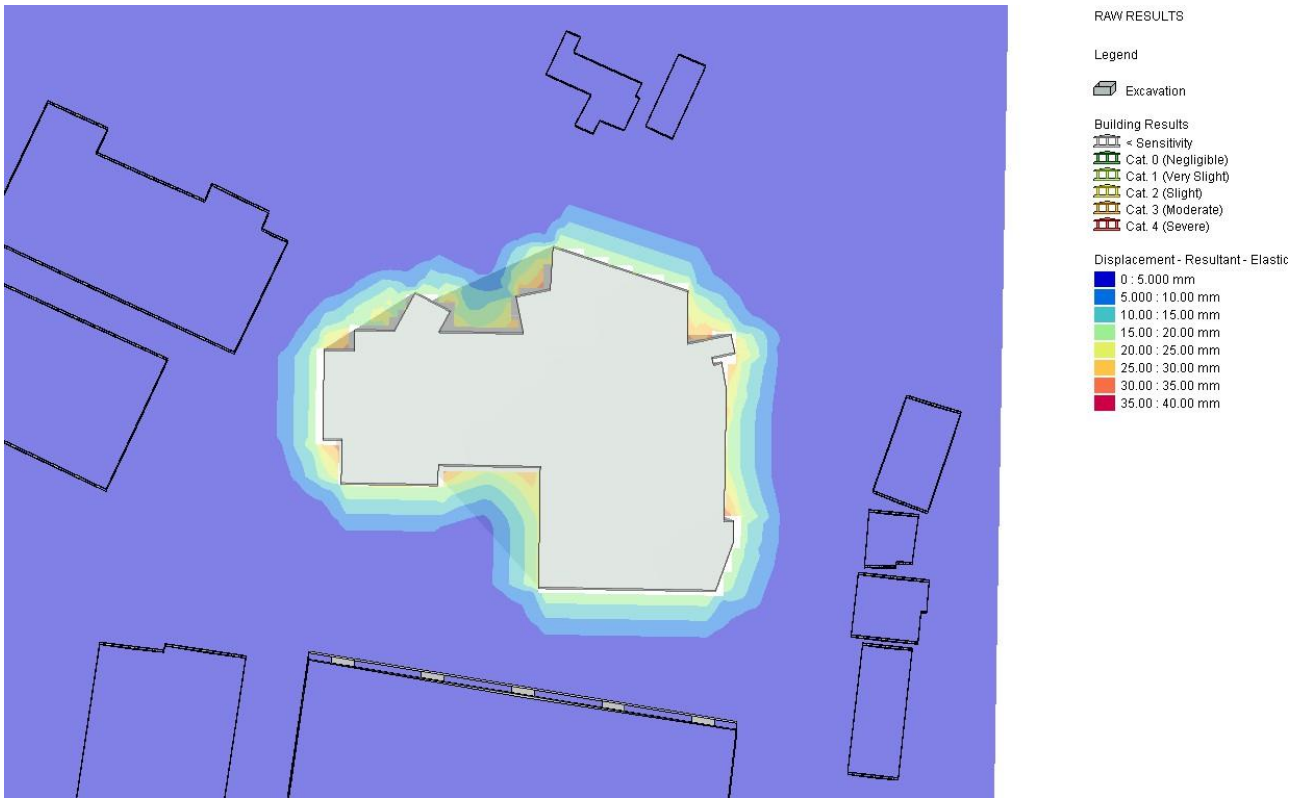


Figure 5.2: Plan of XDisp output of ground movement due to basement excavation

[5.4] Damage Impact Assessment

A damage impact assessment of the neighbouring structures has been completed based on the classifications stated in Table 6.4 of CIRIA report C760 (formally C580). These classifications have been extracted and shown in Table 5.1 below. They are based on the method of damage assessment outlined by Burland et al. (1977), Boscardin and Cording (1989) and Burland (2001).

Table 5.1: Table 6.4 of CIRIA C760: Classification of visible damage to walls (after Burland et al. (1977), Boscardin and Cording (1989) & Burland (2001)

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain, ε_{lim} (%)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible	<0.1	0.0 to 0.05
1 Very slight	**Fine cracks that can easily be treated during normal decoration.** Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection	<1	0.05 to 0.075
2 Slight	**Cracks easily filled. Redecoration probably required.** Several slight fractures showing inside of building. Cracks are visible externally and **some repointing may be required externally** to ensure weathertightness. Doors and windows may stick slightly.	<5	0.075 to 0.15
3 Moderate	**The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable lining. Repointing of external brickwork and possibly a small amount of brickwork to be replaced.** Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5 to 15 or a number of cracks >3	0.15 to 0.3
4 Severe	**Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows.** Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Services pipes disrupted.	15 to 25, but also depends on number of cracks	>0.3
5 Very severe	**This requires a major repair, involving partial or complete rebuilding.** Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	Usually >25, but depends on numbers of cracks	

The movements resulting from the wall installation and basement excavation phases have been calculated using the XDisp modelling software. This has assessed the likely damage to adjacent structures. The results are summarised in Table 5.2 below.

Table 5.2: Damage Impact Assessment Results

Structure Location	Category of Damage (Table 5.1 Above)
Santry Avenue	Cat. 0 (Negligible)
Swords Road	Cat. 0 (Negligible)
Santry Place	Cat. 0 (Negligible)
Santry Avenue Industrial Estate	Cat. 0 (Negligible)

[5.5] Monitoring of Ground Movements

The predictions of the ground movements given here are considered preliminary and are subject to the detailed design solutions implemented at the construction stage (i.e. rigidity of wall, quality of construction and installation techniques, groundwater control measures, finalized bearing pressures from permanent works etc.). The predictions given here are however considered appropriate estimations for the preliminary BIA.

During construction, the predictions of ground movement based on the ground movement analysis should be checked by monitoring the retaining wall system and if required, adjacent properties and structures. Traditional pile walls can be monitored using inclinometer systems to ensure the lateral wall deflections are as per the design predictions.

It is recommended that condition and foundation-level check surveys of adjacent existing structures should be carried out before and after the proposed works. The precise monitoring strategy will be developed at a later stage and it will be subject to discussions and agreements with the owners of the adjacent properties and structures.

[6] Summary and Recommendations

Ayesa has completed the basement impact assessment (BIA) for the proposed mixed-use, high-density development along Santry Avenue and Swords Road, Dublin 9. The assessment was completed on behalf of DBFL Consulting Engineers.

The assessment was completed by analysing the ground conditions and hydrogeology of the site and subsequently modelling the basement using the software package XDisp. The assessment included a damage impact assessment on the nearby buildings based on empirical ground movement curves from CIRIA C760 6.15 A & B guidance, assumed ground conditions and adjacent foundation details.

It is expected that most of the proposed basement will be excavated using open cut excavation techniques where there is adequate clearance between the basement edge and the property boundary line. At some local areas, where the basement is close to the boundary line, an embedded retaining wall will likely be required to facilitate the basement excavations. These have been accounted for in the ground movement and damage assessment carried out as part of the BIA.

The ground movement analysis has concluded that the predicted damage to the neighbouring properties would be deemed negligible.

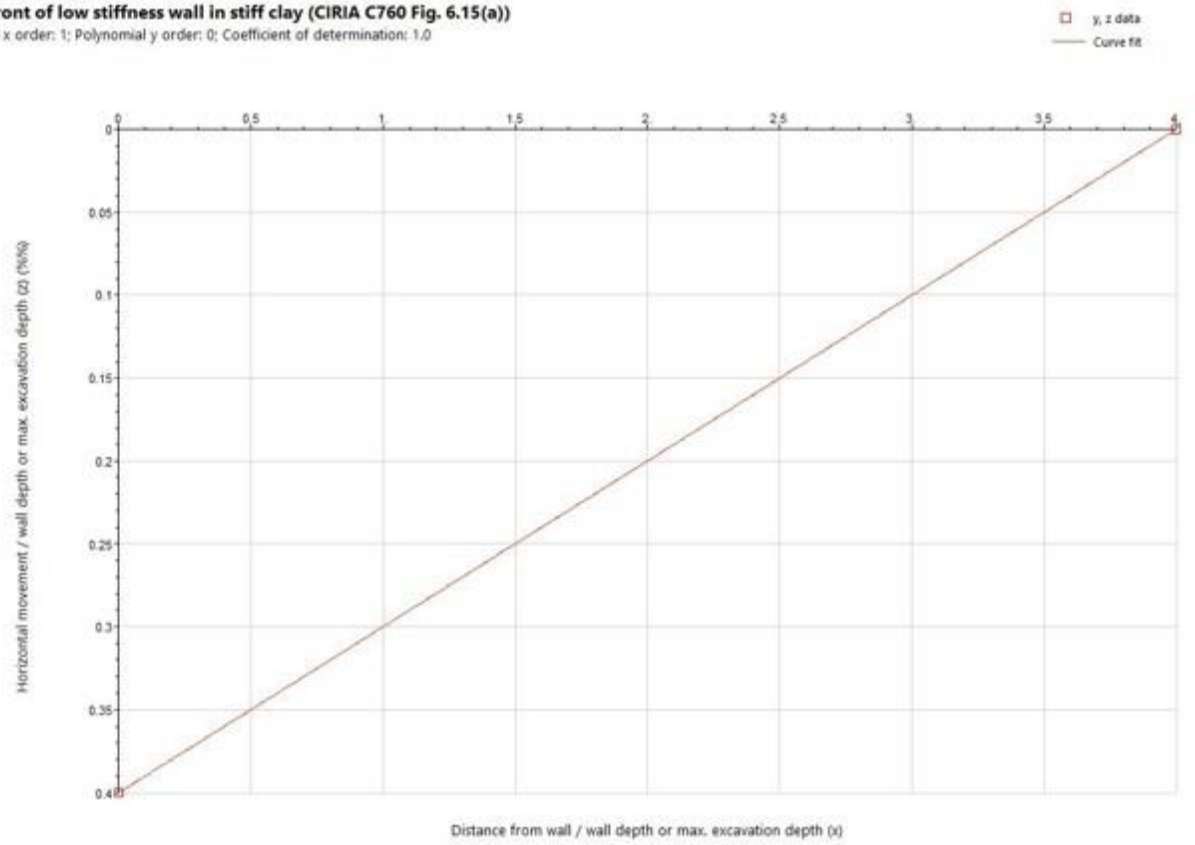
The predictions of ground movements given are considered preliminary based on the information provided. Based on the clearances outlined, an open-cut excavation should be feasible with adequate clearance to the adjacent existing structures. Should the clearance be less than indicated and to avoid excessive damage to the existing structures, an embedded retaining wall may be required in localised areas. This requirement shall be reviewed during the construction stage by the design team.

Additionally, the BIA is based on assumed ground conditions and adjacent foundation details. These are to be investigated and confirmed during a site-specific ground investigation.

Appendix A: XDISP Results

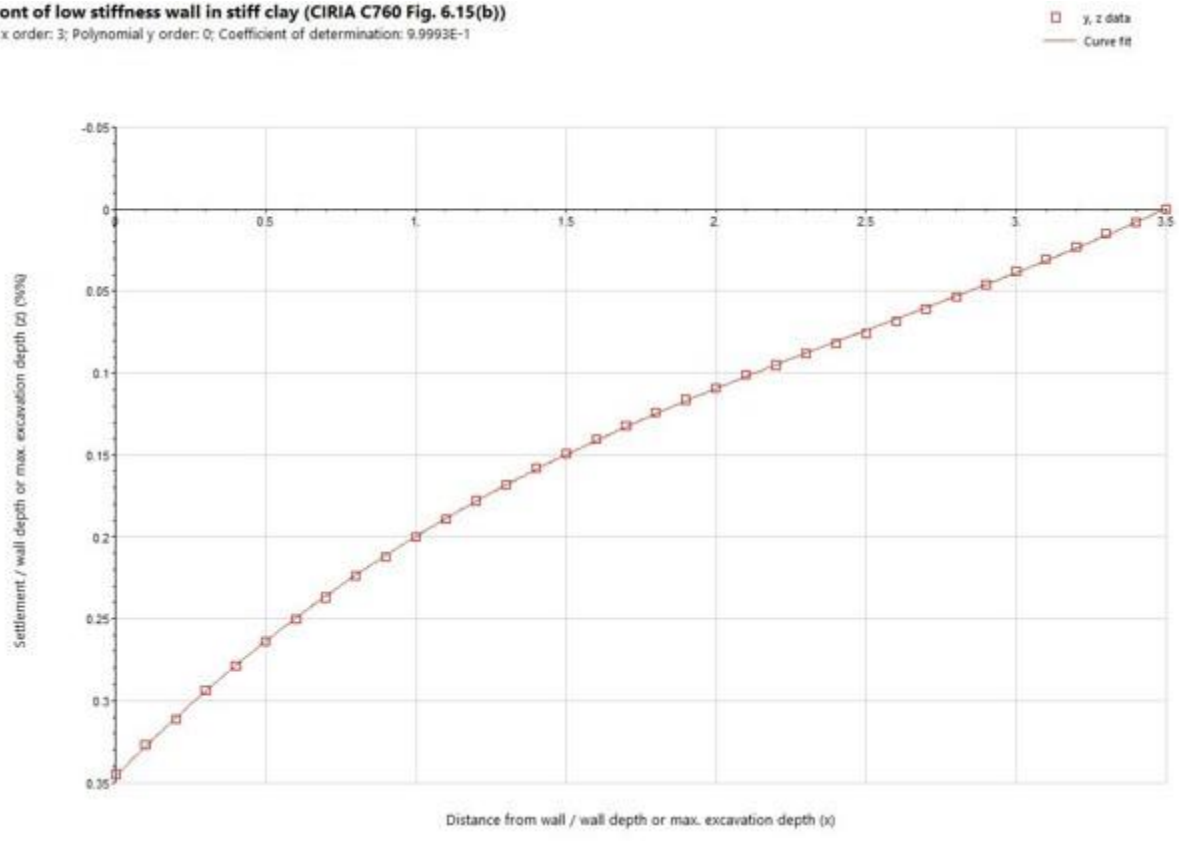
Exc. in front of low stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))

Polynomial x order: 1; Polynomial y order: 0; Coefficient of determination: 1.0



Exc. in front of low stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))

Polynomial x order: 3; Polynomial y order: 0; Coefficient of determination: 9.9993E-1

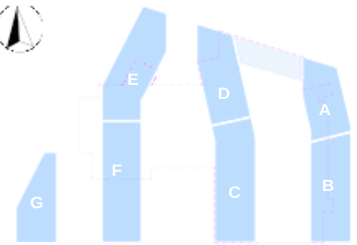


Specific Building Damage Results - Critical Segments within Each Building

Stage: Ref.	Stage: Name	Specific Building: Ref.	Specific Building: Name	Parameter	Critical Sub-Building	Critical Start Segment
						[m]
0	Base Model	0	SANTRY AVENUE	All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
		0	SWORDS ROAD	All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
		0	SANTRY PLACE	All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
		0	SANTRY IND. EST.	All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		
				All vertical displacements are less than the limit sensitivity.		

Appendix B: Plan & Section Drawings

N



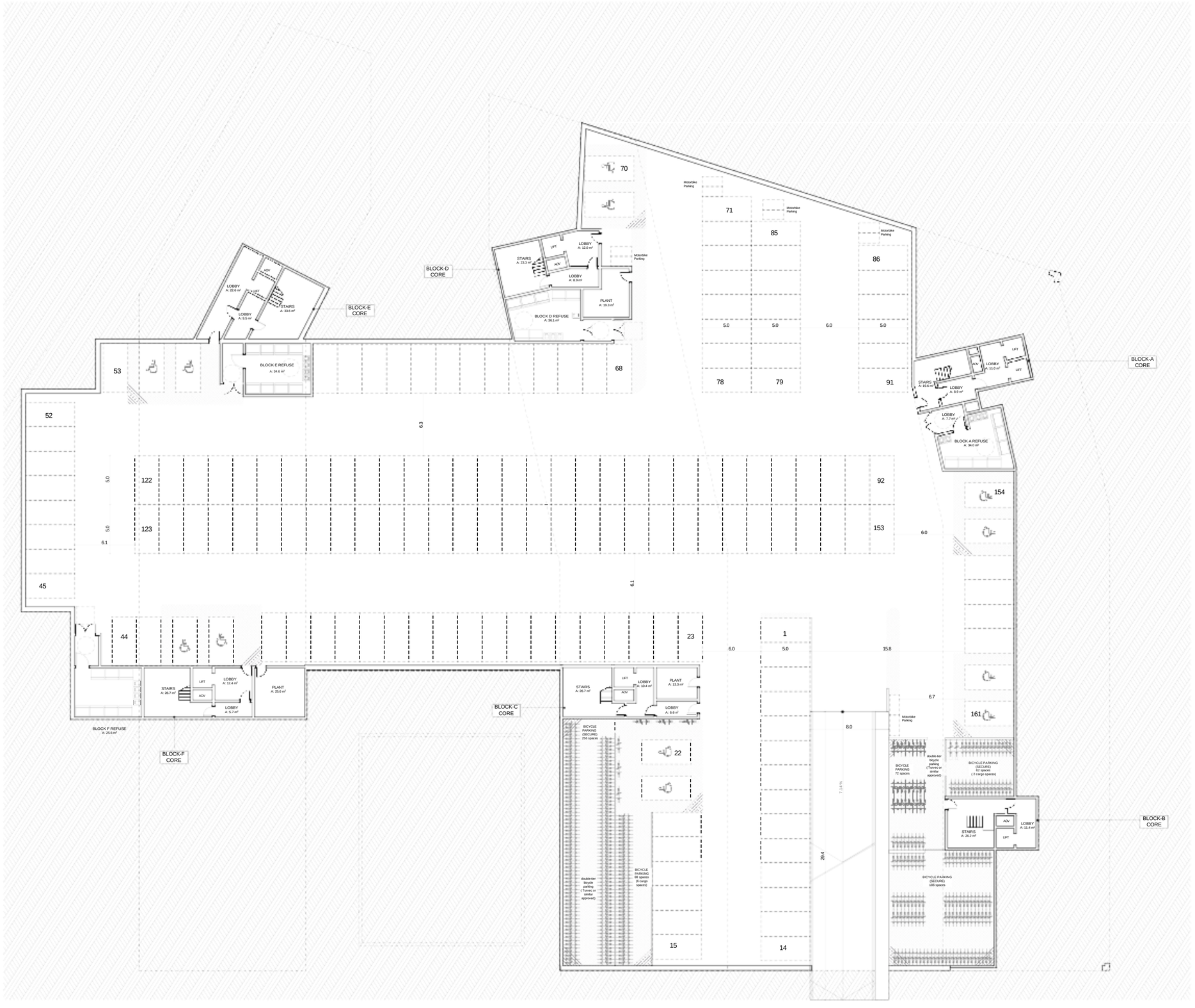
Basement Parking Schedule

161 no. car parking spaces
Note: 50% include EV charging points)

10 no. motorbike parking spaces

664 no. bicycle parking spaces
(9 cargo spaces)

Floor Area
5470.8 sqm



Basement
S C A L E : 1:200

N

RIAI | Planning Drawings | DAVEY + SMITH ARCHITECTS

DAVEY + SMITH ARCHITECTS Unit 13,THE SEAPOINT BUILDING, 44-45 CLONTARF ROAD, CLONTARF, DUBLIN 3 I PH: 01 2447638 I EMAIL: info@davey-smith.com I WEB: www.davey-smith.com

Layout ID:	D1809.P05	Scale:	1:200, 1:1250
Project:	Santry Avenue LRD, Santry, Dublin 9	Job No:	D1809
Drawing Name:	Basement Level	Series:	Planning Drawings
		Date:	23/02/2024
		Status:	
		Revision:	