Balscadden Development, Howth, Co. Dublin

Geotechnical Report

Balscadden GP3 Ltd.

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Contents

1 Introduction

1.1 Summary

ByrneLooby have been requested by Balscadden GP3 Ltd. to provide geotechnical design services for the proposed development at Balscadden Road. The engineer for the scheme is Waterman Moylan Consulting Engineers.

These services include the specimen design of two embedded retaining walls, located along the southern and western elevations. The proposed solution for each of the retaining walls is a secant pile wall with an additional row of buttress piles installed on the southern elevation. The secant pile walls have been designed to serve the following purposes:

- A temporary works element to facilitate the construction of the basement/topographical changes by providing temporary lateral support, accommodating soil, groundwater and any temporary surcharge pressures;
- A permanent works element to support long term lateral soil and surcharge pressures.

The design requirements of the secant pile wall have been determined in accordance with the design principles of *IS EN 1997-1:2004 Eurocode 7: Geotechnical Design – Part 1: General Rules* and with respect to the Irish National Annex to this document which was published in 2005. Guidance, where relevant, will be sought from CIRIA C760 and the ICE Specification for Piling and Embedded Retaining Walls which are recognised by EC7 as non-conflicting complementary information (NCCI). The design of the secant pile walls is subject to construction detailed design.

Additional services include an assessment of ground movements and building impact assessments along the southern, western and northern elevation, where an open cut excavation is proposed to form the basement, an assessment of the change in stresses applied to an existing sewer that runs through the site and an assessment of recommended remedial works along the southeastern elevation. All of the above assessments and designs are subject to construction stage detailed design.

1.2 Limitations

The information, views and conclusions drawn concerning the site are based, in part, on information supplied to ByrneLooby by other parties. ByrneLooby have proceeded in good faith on the assumption that this information is accurate. ByrneLooby accepts no liability for any inaccurate conclusions, assumptions or actions taken resulting from any inaccurate information supplied to ByrneLooby by others.

The designs outlined in this report are subject to a construction detailed design in advance of the construction works.

1.3 Layout of Report

As outlined above, this report has been produced to outline the geotechnical aspects of the proposed development.

The structure of this report corresponds to the various elements outlined above, and the key tasks summarised below:

- Section 4 describes the ground conditions at the site including a desk based study and a review of the various phases of ground investigation;
- Section 5 describes the design of the Southern Boundary Retaining Wall including a summary of ground movement predictions;
- Section 6 describes the design of the Western Boundary Retaining Wall including a summary of ground movement predictions;
- Section 7 describes the open cut excavation along the northern boundary, required to facilitate the construction of the Block B Basement;
- Section 8 describes the Building Impact Assessment completed on adjacent properties to the proposed Southern Boundary Embedded Retaining Wall, Western Boundary Embedded Retaining Wall and the Northern Boundary open cut excavation;
- Section 9 describes proposed remedial works along the eastern elevation;
- Section 10 covers an assessment of the proposed foundation loadings on the Howth Sewer Tunnel.

1.4 References Used

The following is a non-exhaustive list of technical guidance documentation used on the assessment:

- CIRIA C760 Guidance on Embedded Retaining Wall Design
- Burland, J.B., and Wroth, C.P. (1974) *Settlement of buildings and associated damage*, State of the art review. Conf on Settlement of Structures, Cambridge, Pentech Press, London
- Boscardin, M.D., and Cording, E.G., (1989). *Building response to excavation induced settlement*. J Geotech Eng, ASCE
- Burland, Standing J.R., and Jardine F.M. (eds) (2001), *Building response to tunnelling, case studies from construction of the Jubilee Line Extension London*, CIRIA Special Publication 200.

2 Site Location, Description and Development History

2.1 Site Location

The site is located between Abbey Street and Balscadden Road in Howth, as shown in Figure 2.1, in the north of Howth. The area surrounding the site is a mixture of residential and commercial premises.

Figure 2.1: Site Location (ref. Google Maps)

Balscadden Road is located to the east of the site and Balscadden Bay Beach is located to the east of this. Asgard Park, a residential development of two-storey developments, is located directly to the south of the site. Residential dwellings are located to the west of the site along Abbey Street. Martello Tower is located directly north of the site. North of this are a number of commercial premises on East Pier and north of this is Howth Pier.

2.2 Site Description

The site is partially developed with a former leisure centre and hardstanding area to the middle and north of the site.

There are significant topographical changes across the site, with the site sloping steeply from an elevation of approximately +20m OD across the site to approximately +35m OD to the rear of the sports hall. These topographical changes will require significant earthworks and retaining walls, the design of which are outlined in this report.

Additionally, the historical Howth Sewer Tunnel passes under the site.

Figure 2.2: Topographical Changes Across the site

3 Proposed Development

The proposed development relates to lands located to the south of the Martello Tower on Balscadden Road & the former Baily Court Hotel, Main Street, Howth, County Dublin. The development will consist of the demolition of existing structures on the proposed site including the disused sports building and the former Baily Court Hotel buildings and the construction of a residential development set out in 4 no. residential blocks, ranging in height from 2 to 5 storeys to accommodate 180 no. apartments with associated internal residential tenant amenity and external courtyards and roof terraces, 1 no. retail unit and 2 no. café/retail units. The site will accommodate car parking spaces at basement level and bicycle parking spaces at basement and surface level. Landscaping will include new linear plaza which will create a new pedestrian link between Main St and Balscadden Rd to include the creation of an additional 2 no. new public plazas and also maintains and upgrades the pedestrian link from Abbey Street to Balscadden Road below the Martello Tower. Please see the accompanying Statutory Notices for a more detailed description.

The schedule of accommodation is set out in the Table below.

Table 3.1: Schedule of Accommodation

Apartment Type	1 - Bed	2 - Bed	3 - Bed	Studio	**Total**
Block A	-	2	-	-	2
Block B	51	57	18	-	126
Block C	8	28	7	-	43
Block D	3	2	-	4	9
Total	62	89	25	4	180

The proposed development and blocks are shown in Figure 3.1.

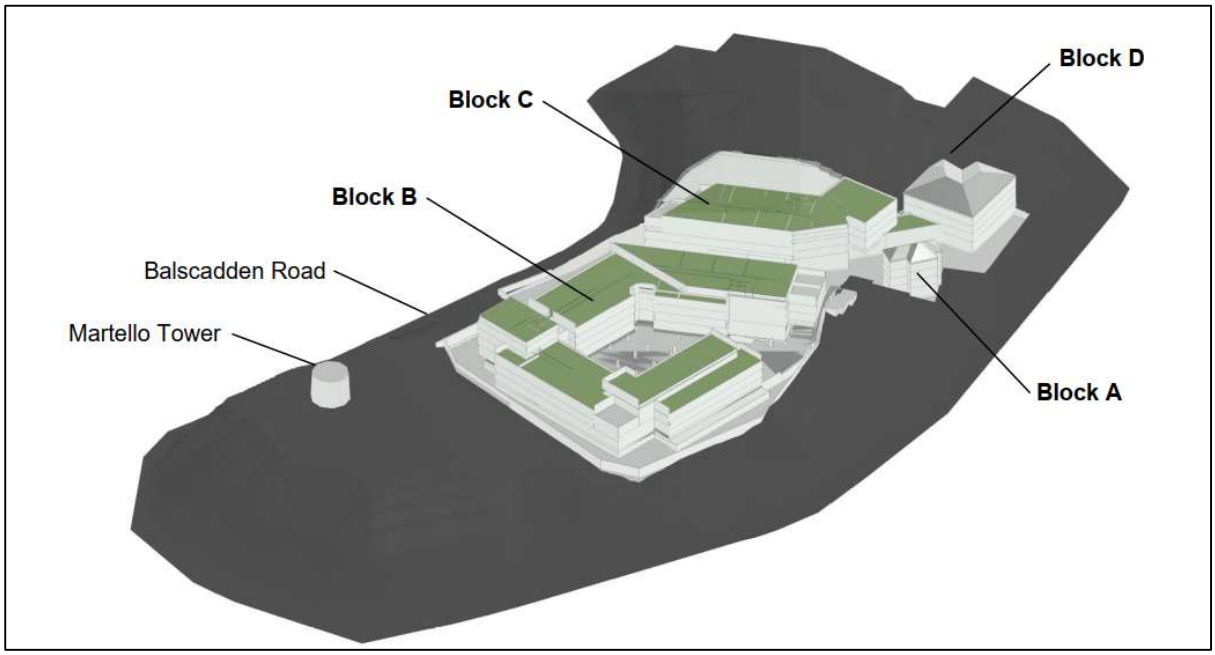

Figure 3.1: Proposed Development

As shown in the Figure above, it is proposed to reduce ground levels throughout the site. To allow this, retaining walls will be required in the south and west of the site.

In the south of the site, ground level will be reduced from +35m OD to a SSL of +24.3m OD.

4 Ground Conditions

4.1 Desk Study

ByrneLooby have carried out a desk-based study to establish the quaternary and bedrock geology and the hydrogeology. The following sources were consulted during the desk-based study:

The Geological Survey of Ireland (GSI) online data set public viewer to find:

- Bedrock Map 1:100,000
- Quaternary Sediments Map
- Historical Ground Investigation

4.1.1 Bedrock Geology

The GSI generalised 1:100,000 bedrock map shown in Figure 4.1 identifies the bedrock at the north of the site to be The Ballysteen Formation, while the bedrock in the south of the site is identified as the Elsinore Formation. A fault runs through the site in an east to west direction.

The Ballysteen Formation is described as irregularly bedded and nodular bedded argillaceous limestones with calcareous shales, while the Elsinore Formation is described as a polymict melange of quartzite, greywacke, siltstone, mudstone and sandstone.

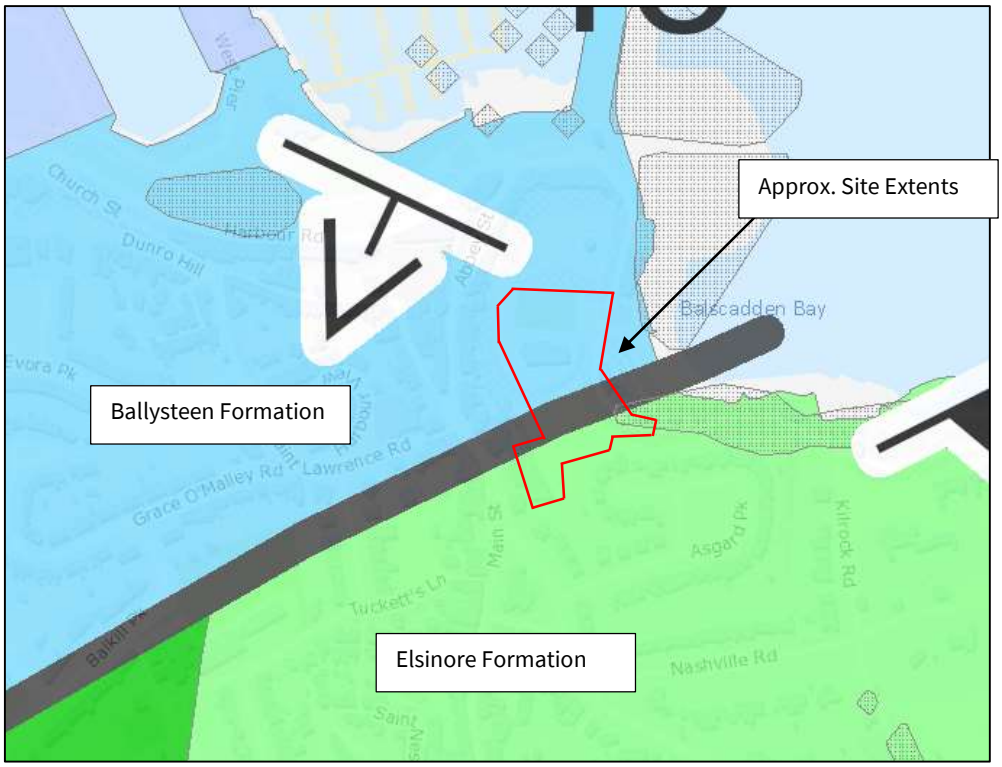

Figure 4.1: Bedrock Geology 1:100,000 Map (ref. GSI)

4.1.2 Quaternary Sediments

The GSI Quaternary Sediments map, Figure 4.2, identifies Gravels derived from Limestones throughout the site. The area to the south is identified as Till derived from Limestones and the area to the west is identified as Gravels derived from Lower Palaeozoic sandstones and shales.

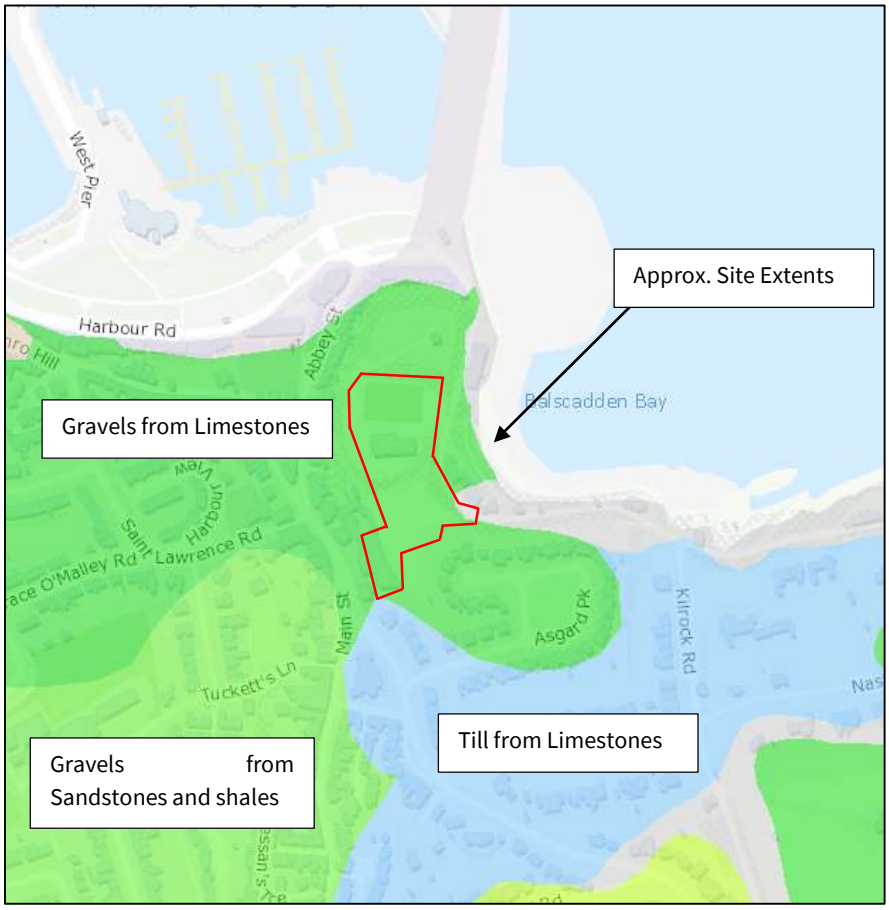

Figure 4.2: Quaternary Sediments Map (ref. GSI)

4.1.3 Historical Ground Investigations

Consultation of the GSI website has been carried out to review historical exploratory holes carried out in the vicinity. This has been shown in Figure 4.3.

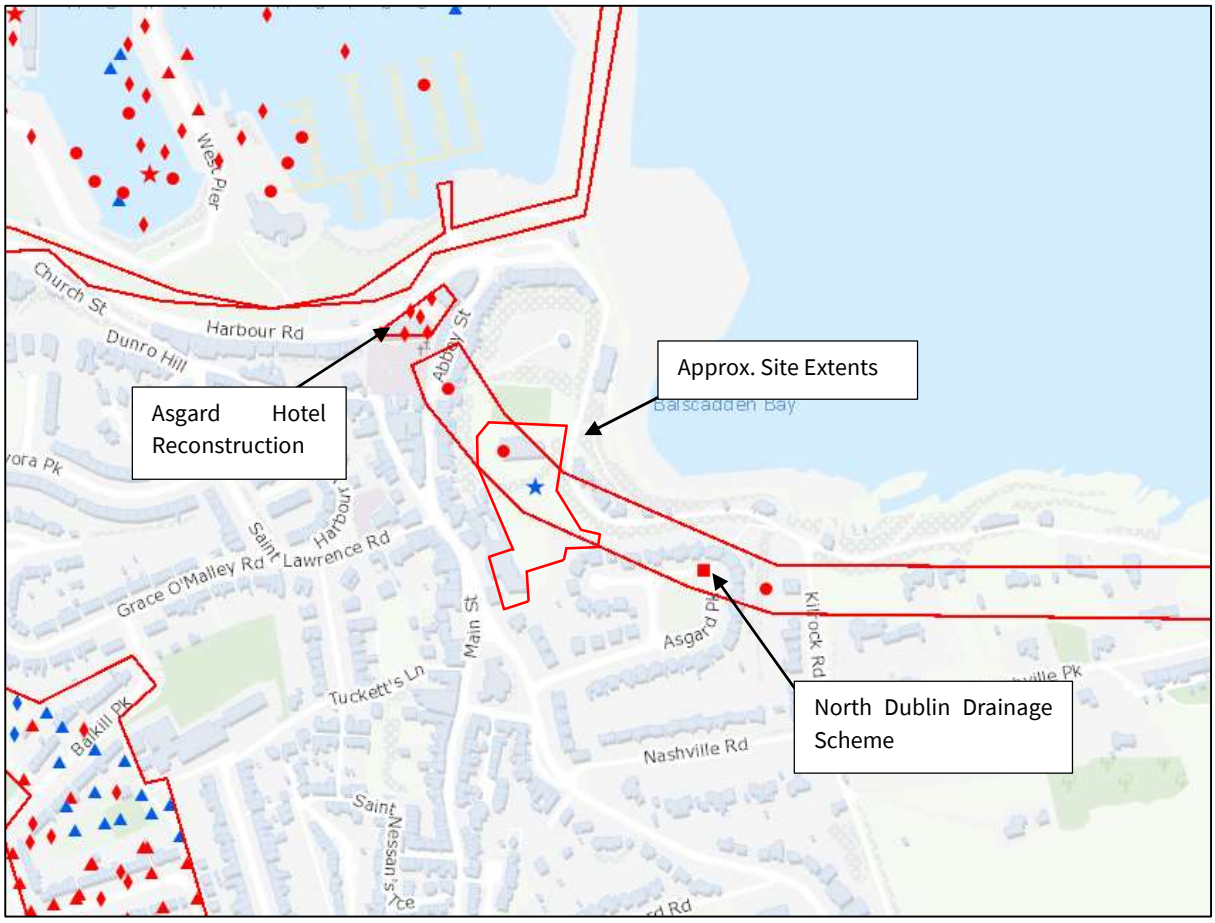

Figure 4.3: Historical SI

The boreholes completed on the site as part of the North Dublin Drainage Scheme encountered ground conditions comprising GRAVEL overlying CLAY overlying LIMESTONE Bedrock.

4.2 Site Specific Ground Investigations

The following site specific ground investigations carried out at the site have been made available to ByrneLooby for review:

- Site Investigations Ltd., Balscadden Howth, Dublin 13, Site Investigation (July 2021)
- Site Investigations Ltd., Balscadden Howth, Dublin 13, Site Investigation (November 2017)
- Ground Investigations Ireland., Balscadden Howth Ground Investigation Report (November 2017)
- Site Investigations Ltd., Howth – Cluxton Site Investigation (July 2015)

4.2.1 Site Investigations Ltd, Balscadden Howth – 2021

Site Investigations Ltd. completed a ground investigation with fieldwork taking place in July 2021. The ground investigation consisted of:

- 3No. Cable Percussion Boreholes to a depth of 17.2m bgl;
- 3No. Trial Pits; and
- Geotechnical Laboratory Testing.

The exploratory hole plan is shown as Figure 4.4.

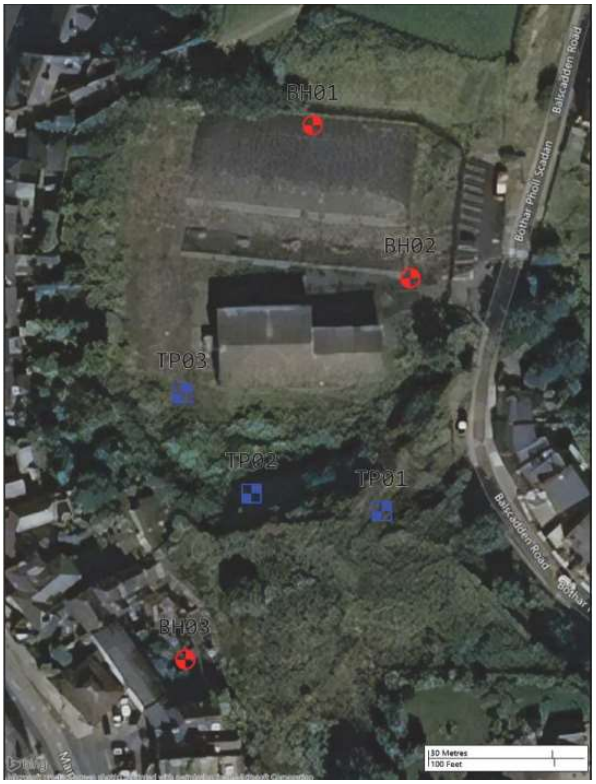

Figure 4.4: Site Investigation 2021 Exploratory Hole Plan

4.2.2 Site Investigations Ltd, Balscadden Howth - 2017

Site Investigations Ltd. completed a ground investigation with fieldwork taking place in September and October 2017. The ground investigation consisted of:

- 1No. Cable Percussion Borehole to a depth of 20m bgl; and
- Geotechnical Laboratory Testing.

The exploratory hole plan is shown as Figure 4.5.

Figure 4.5: Site Investigation 2017 Exploratory Hole Plan

4.2.3 Ground Investigations Ireland, Balscadden Howth – 2017

Ground Investigations Ireland completed a ground investigation with fieldwork taking place in November 2017. The ground investigation consisted of:

- 3No. Trial Pits
- 3No. Soakaways

The exploratory hole plan is shown as Figure 4.6.

Figure 4.6: Ground Investigations Ireland 2017 Exploratory Hole Plan

4.2.4 Site Investigations Ltd, Balscadden Howth - 2015

Site Investigations Ltd. completed a ground investigation with fieldwork taking place in July 2015. The ground investigation consisted of:

- 4No. Trial Pits
- 4No. Boreholes
- Geotechnical Laboratory Testing.

The exploratory hole plan is shown as Figure 4.7.

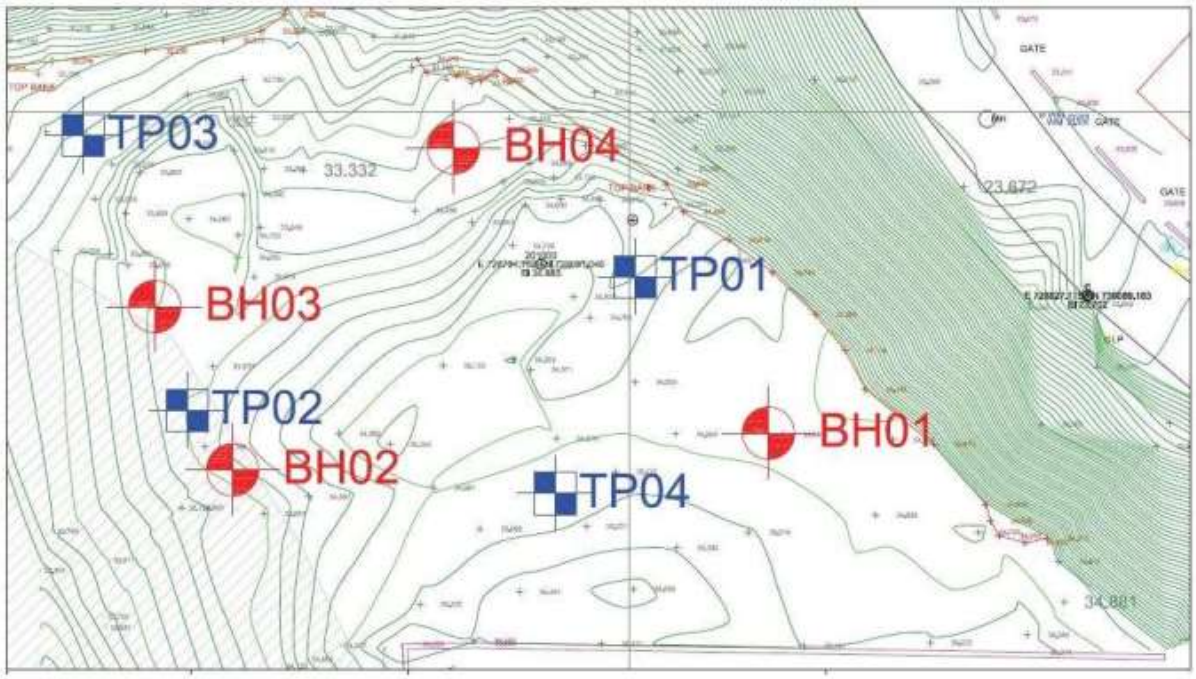

Figure 4.7: Site Investigation 2015 Exploratory Hole Plan

4.3 Ground Conditions

The ground conditions encountered during the ground investigations generally comprised Topsoil overlying medium dense SAND overlying very stiff CLAY. A 1.2m thick layer of stiff CLAY was encountered underlying the topsoil in BH-GDG-01 (Site Investigations 2017).

The medium dense SAND was described as medium dense silty very gravelly SAND with bands of sandy gravel. The very stiff CLAY was described as very stiff slightly sandy slightly gravelly silty CLAY.

Bedrock was not proven in any of the boreholes.

4.4 General Ground Profiles

The following ground profiles have been used as part of the design of the various elements.

Table 4.1: Design Ground Profile 1 – Southern Extents

Strata	Depth (m bgl)	Elevation (m OD)	Thickness (m)
Medium Dense SAND	0	+35.0*	19.5
Very Stiff CLAY	19.5	+15.5	N/A

*Ground Level varies

Table 4.2: Design Ground Profile 2 – Northern Extents

Strata	Depth (m bgl)	Elevation (m OD)	Thickness (m)
Loose to Medium Dense SAND/ GRAVEL	0	+20.0	6.0
Medium Dense SAND	6.0	+14.0	4.0
Very Stiff CLAY	10.0	+10.0	N/A

Table 4.3: Design Ground Profile 3 – Western Extents

Strata	Depth (m bgl)	Elevation (m OD)	Thickness (m)
Loose to Medium Dense SAND/ GRAVEL	0	+27.5	2.5
Medium Dense SAND	2.5	+25.0	12.0
Very Stiff CLAY	17.5	+10.0	N/A

4.5 Groundwater

Groundwater strikes were not encountered in any of the boreholes completed as part of the previous phases of investigation.

As part of the 2017 investigation, a groundwater installation was installed into BH-GDG-01 with four groundwater monitoring visits completed in October 2017. However, the installation was dry on each visit.

Minerex were engaged to prepare a Hydrogeological Assessment Report for the proposed development. This assessment included groundwater monitoring through a combination of manual measurements and continuous monitoring with the use of data loggers. As outlined in their report,

included as Appendix B, Borehole BH-GDG-01 was dry throughout the monitoring period. The recorded groundwater levels in BH01 and BH02 are shown as Figure 4.8.

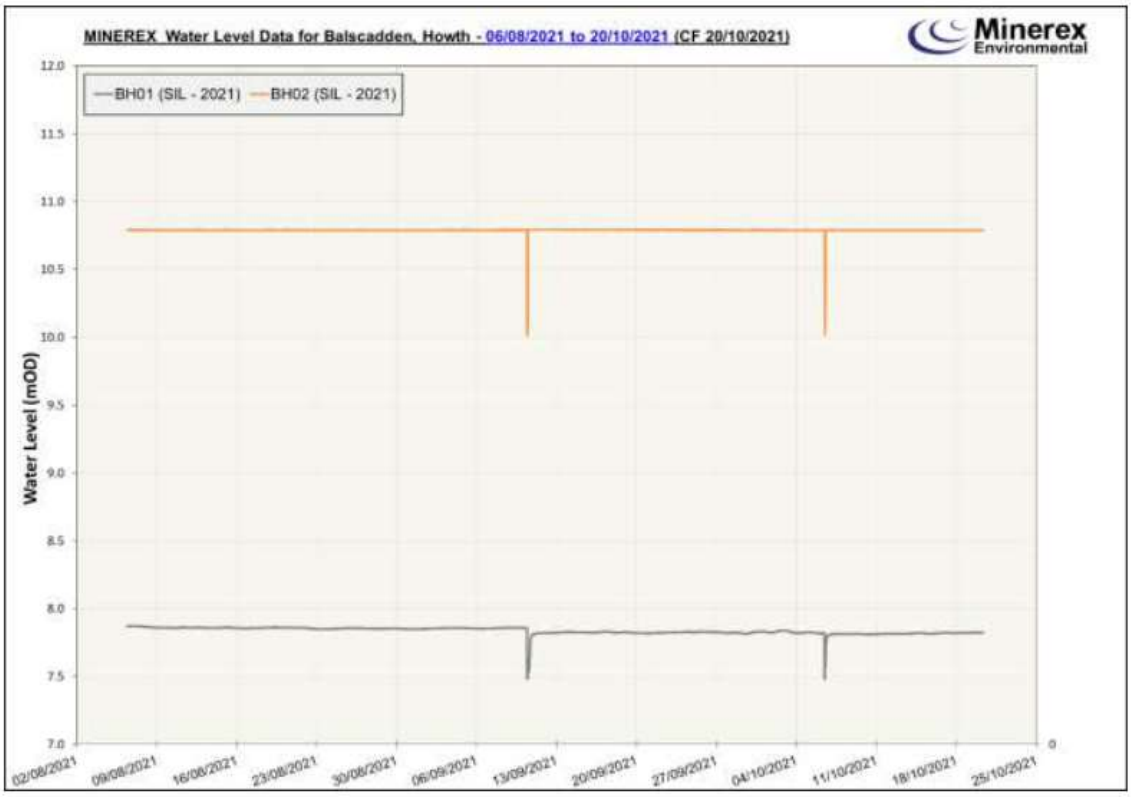

Figure 4.8: Groundwater Monitoring

Based on the above groundwater monitoring, a conservative groundwater level of 12m OD has been proposed as a design groundwater level.

Further information regarding groundwater levels can be found in Appendix B.

4.6 Soil Testing

4.6.1 Standard Penetration Testing (SPT)

The SPT 'N' values have been plotted against elevation. These have been split out into two separate plots based on the topographical changes across the site and are shown in Figure 4. and Figure 4.. The characteristic soil parameters can be estimated by correlating the SPT 'N' values recorded in the boreholes with various soil parameters, based on published relationships.

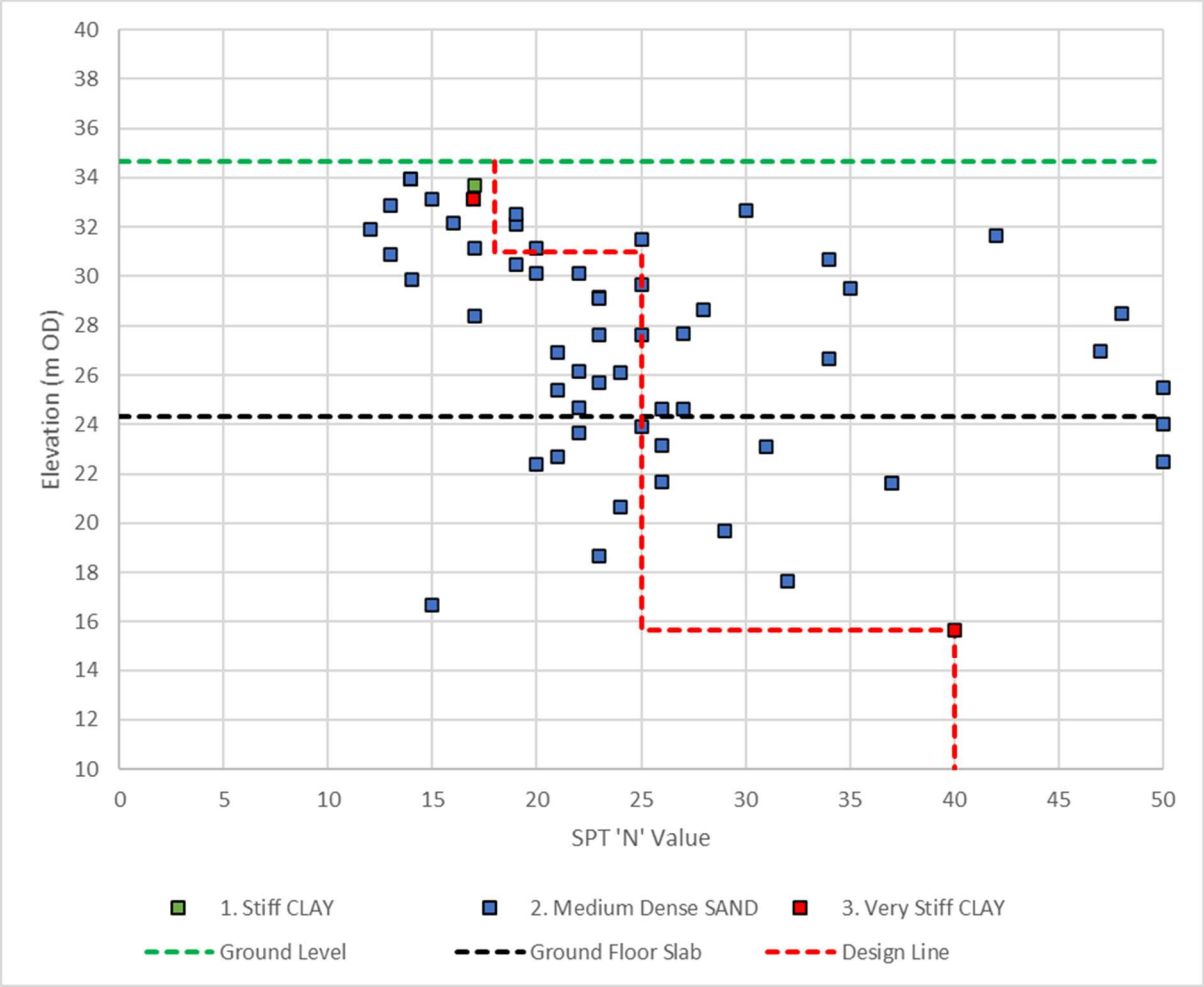

Figure 4.9: SPT Data – Southern Elevation

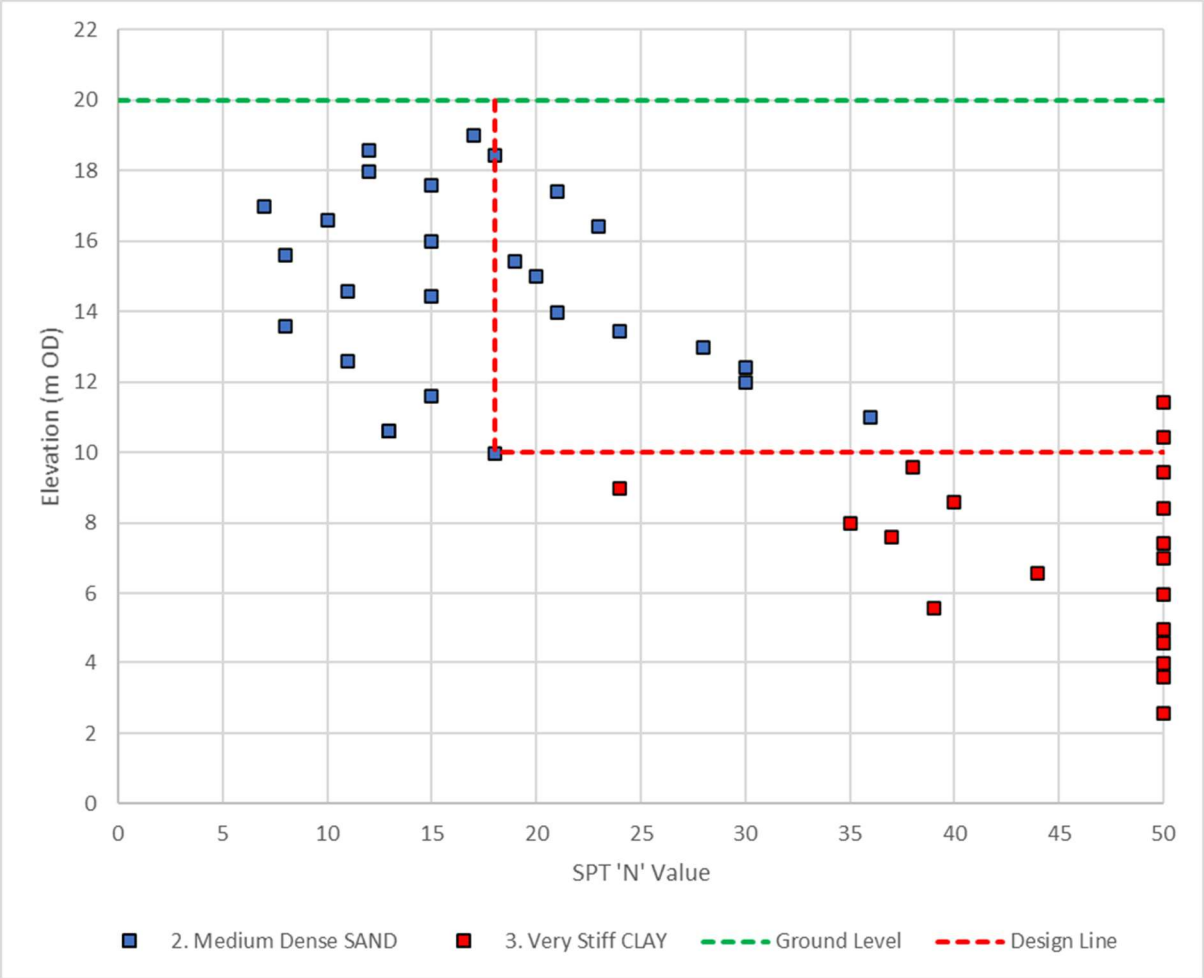

Figure 4.10: SPT Data – Northern Elevation

The following correlations were made:

- The internal angle of friction of the granular materials can be calculated after the relationship published by Peck, with Figure 4. below detailing Peck's relationship between SPT 'N' values and the angle of shearing resistance.
- The undrained shear strength of the cohesive material can be calculated based on the Stroud correlation, $C_u = f_1N$, shown in Figure 4.. The parameter f_1 is related to the plasticity index of the material. In the absence of Atterberg limit tests, f_1 is to be taken as 5.
- The stiffness of cohesive soils can also be approximated using relationships as set out in CIRIA C760. The soil stiffness modulus is based on 600 × C_u for the undrained case and 66% of this value for the drained case. For granular soils, the stiffness has been taken as 2000 × 'N'.

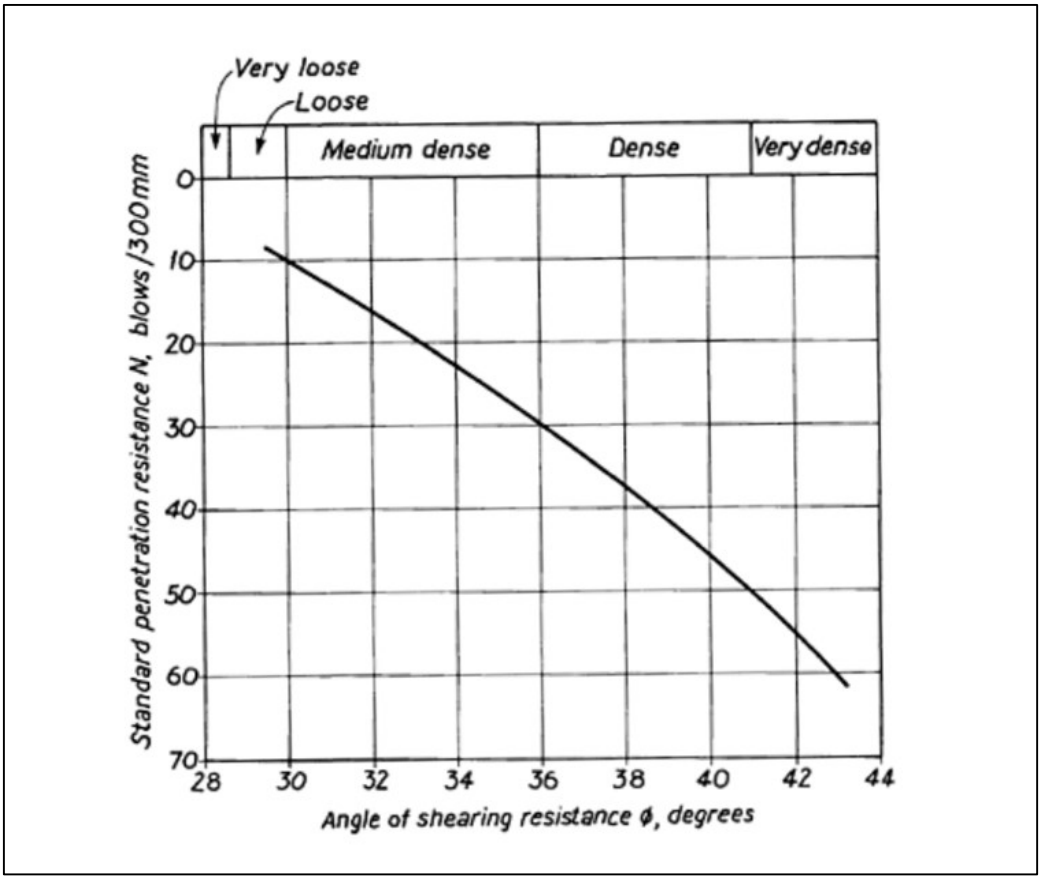

Figure 4.11: Peck's Relationship between SPT 'N' and angle of Shearing Resistance

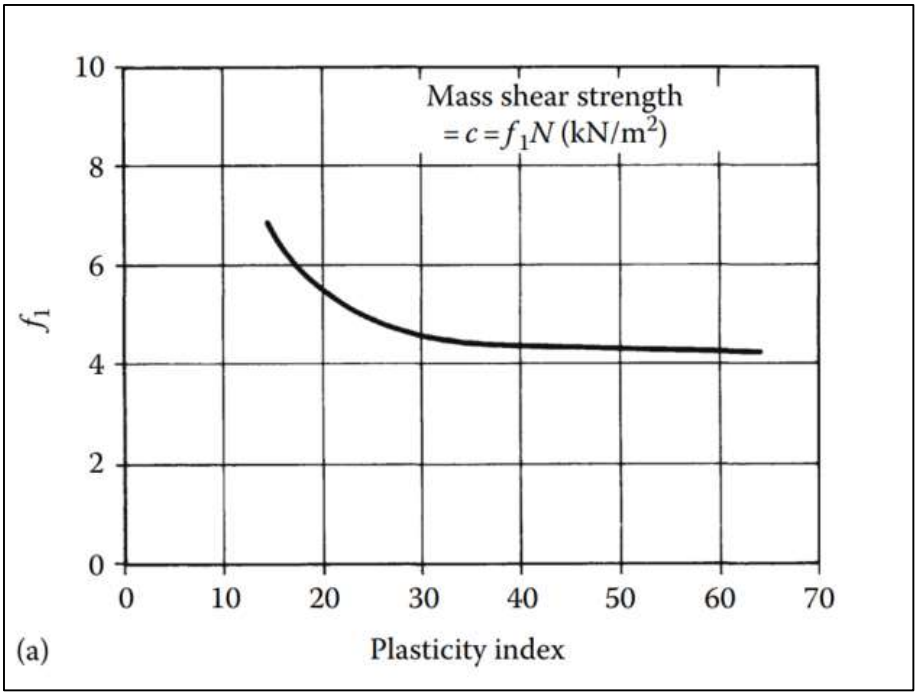

Figure 4.8: Stroud's (1975) Relationship between SPT 'N' and undrained shear strength.

4.6.2 Particle Size Distribution Tests (PSDs)

A series of particle size distribution tests were completed as part of the various phases of investigation. The results of the tests are summarised in Figure 4.9.

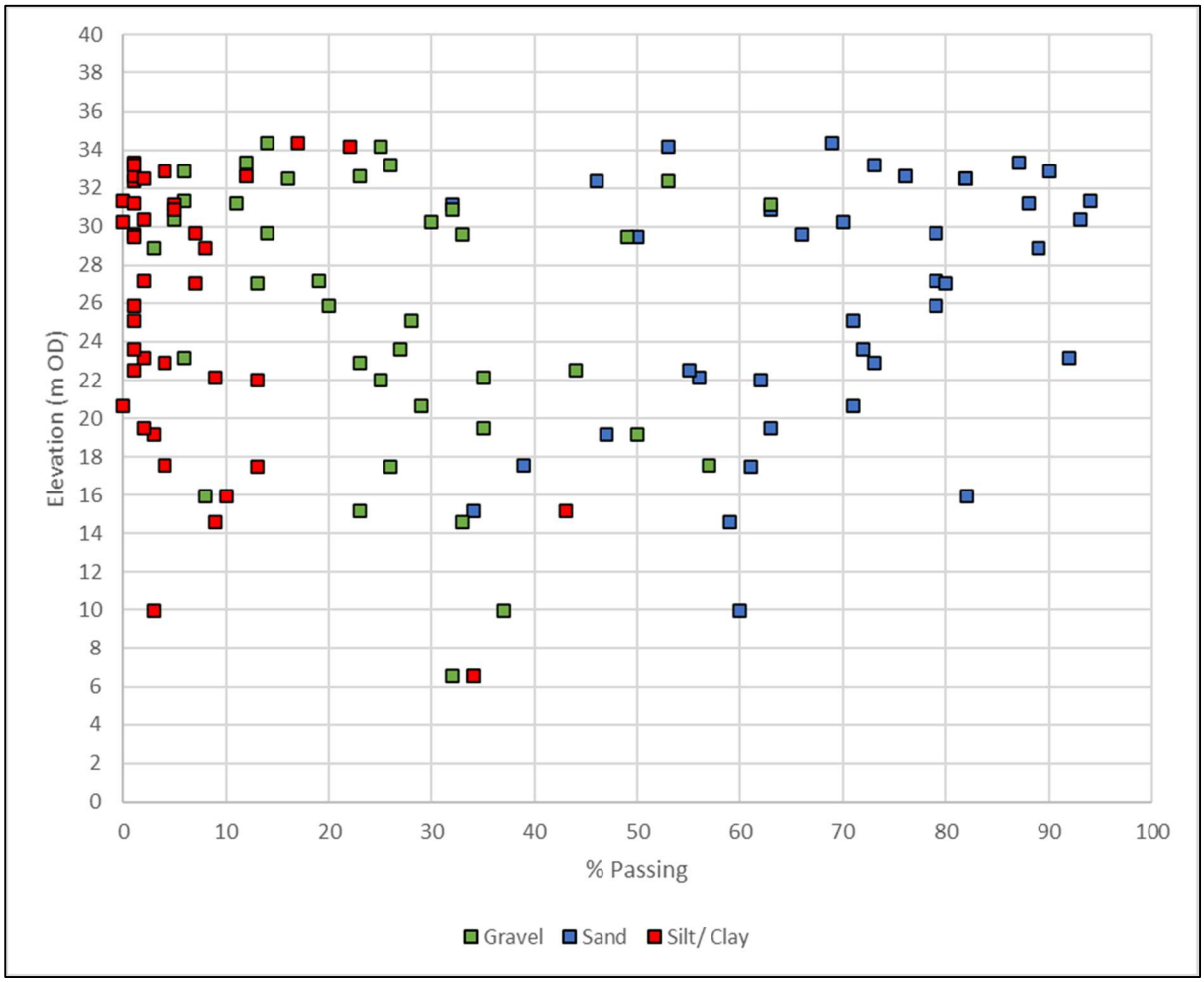

Figure 4.9: Particle Size Distribution Test Results

4.7 Characteristic Geotechnical Parameters

Based on the interpretation of the above ground investigation data, the following characteristic geotechnical parameters have been calculated and used in the subsequent analysis.

Table 4.4: Characteristic Geotechnical Parameters

Strata	SPT 'N'	γ (kN/m^3)	ϕ' (Degrees)	c' (kPa)	c_u (kPa)	E' (MPa)	Eu (MPa)
Medium Dense SAND 1	18	18	32	-	-	35	-
Medium Dense SAND 2	25	18	34	-	-	50	-
Very Stiff CLAY 1	40	19	38	-	200	80	120
Very Stiff CLAY 2	50	19	38	-	250	100	150

5 Southern Boundary Retaining Wall

5.1 Summary

Based on significant elevation changes across the site, a retaining wall will be required along the southern elevation. An indicative section is shown as Figure 5.1 and proposed layout shown as Figure 5.2. The proposed retaining wall solution is a secant pile wall with additional buttress piles installed to the rear of the secant pile wall to limit pile wall deflections.

The secant pile wall is to be supported in the permanent condition by the ground floor slab. Although a step is shown in the below section, it is understood that the slab will be continuous from Block C at a level of +24.3mOD. In the temporary condition raking props will be installed. The SSL of the basement slab is +24.3m OD and is 500mm thick. Based on this the design has been based on a formation level of +23.7m OD.

The basement of Block C is to be formed by additional temporary works such as an embedded retaining wall. This is to be completed rather than an open cut excavation so as to maintain the passive resistance of the secant pile wall. The proposed offset from the secant pile wall to the Block C basement is in the order of 15m.

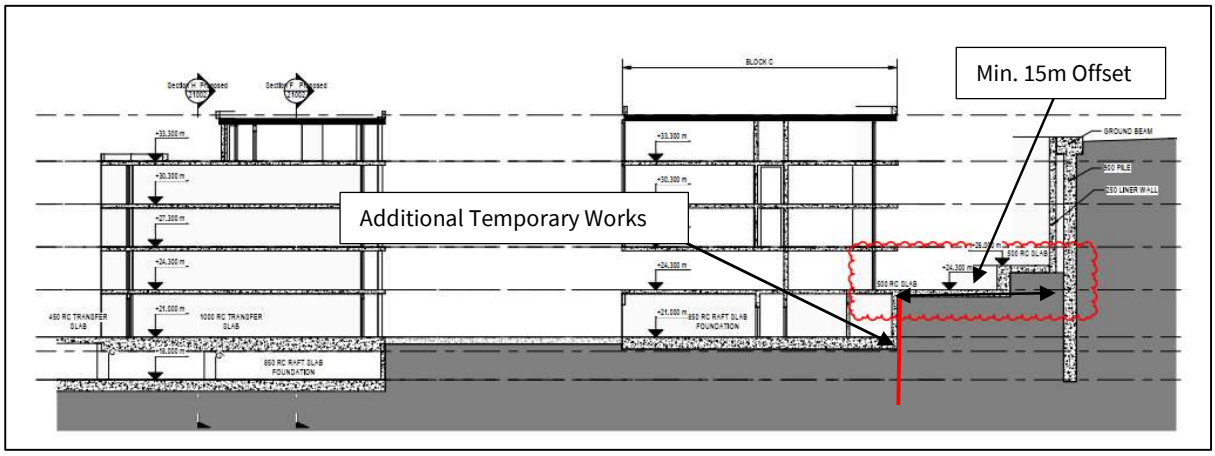

Figure 5.1: Southern Boundary Indicative Section

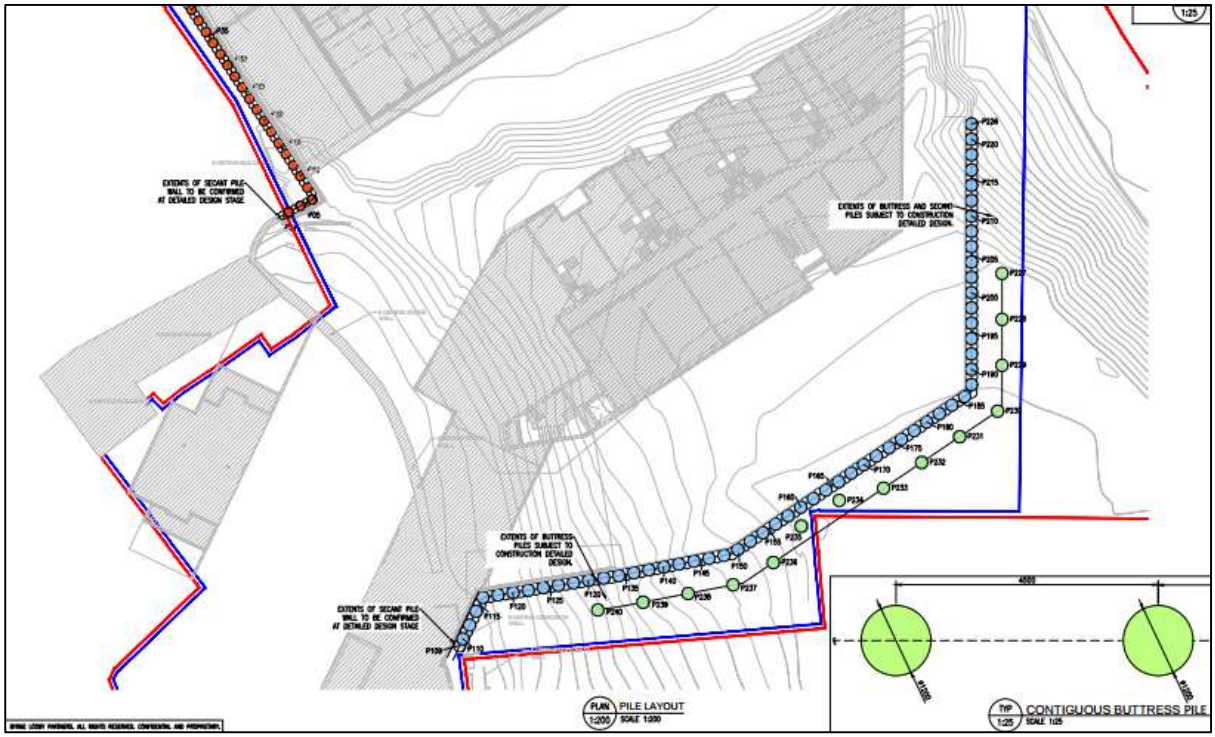

Figure 5.2: Proposed Secant Pile Wall Layout

5.2 Wall Sections

The secant pile wall has been designed based on the following pile arrangement, in a hard-firm pile arrangement:

- 1,200mm diameter reinforced male piles, installed at 1,500mm centres;
- 1,200mm diameter unreinforced female piles, installed at 1,500mm centres;
- 1,200mm diameter reinforced buttress piles, installed at 4,500mm centres offset at 3m from the secant pile wall.

The buttress piles have been modelled as being connected with the secant pile wall by a capping beam (with fixity against rotation at the pile heads). The buttress piles act in tension and bending to limit the lateral movement of the secant pile wall.

The ground level along the secant pile wall elevation varies to a maximum level of approximately +35m OD. Based on this, one wall section has been analysed based on the maximum retained height (11.3m in the temporary case). Where the ground level reduces along the west of the wall, a refinement of the design may be completed during the detailed construction design, which will reduce the number of buttress piles.

5.3 Pile Installation Level

The secant pile wall is to be installed from existing ground levels (approximately +35m OD). A suitable piling platform and access to the piling locations will need to be constructed in advance of piling works. This level will be stepped where ground level reduces along the secant pile wall alignment.

5.4 Construction Sequence

The following construction sequence has been modelled in the design of the secant pile wall section for the southern elevation:

1. Construct piling platform and form suitable access for piling rig;
2. Install buttress piles;
3. Install female unreinforced secant piles to design toe lengths;
4. Install male reinforced secant and buttress piles to design toe lengths;
5. Complete initial excavation and construct capping beam;
6. Excavate to underside of temporary prop;
7. Install temporary raking prop and construct thrust blocks;
8. Excavate to formation;
9. Install additional temporary works and construct basement;
10. Construct ground floor slab extending to secant pile wall;
11. Remove temporary raking prop, following approval from structural engineer;
12. Construct crib wall or architectural feature in front of secant pile wall.

Please note the crib wall (or architectural feature) is proposed for architectural purposes and is not designed to provide any additional passive restraint.

5.5 Surcharge

A uniformly distributed variable load of 10kPa over the entire ground surface from the rear face of the retaining wall has been adopted. As per CIRIA C760, this accounts for normal vehicle traffic and for plant up to 30 tonne loaded weight, and is considered conservative.

An additional load case has been carried out to assess the condition whereby the adjacent properties have constructed a development at the end of their gardens in the long-term conditions, within 10m of the secant pile wall. This has been modelled as a strip load over a foundation width of 1m and a load of 100kN/m^2.

However, based on the results the load case where the 10kPa UDL is applied is considered the most onerous case.

5.6 Support

The analysis has been based on a temporary prop being installed at an elevation of +32.5m OD. Following excavation to formation, it is proposed to extend the ground floor slab to support the secant pile wall in the permanent condition. The ground floor slab is shown at an elevation of +24.3m OD.

Following the construction of the secant pile wall, an architectural wall, crib wall or gabion wall etc, is to be constructed in front of the piles. The additional benefit of this support has not been considered in the design of the secant pile wall.

5.7 Groundwater

Based on the findings of the hydrogeological assessment, completed by Minerex, a groundwater level of 12m OD has been used in the analysis.

As per CIRIA C760, when determining groundwater pressures the designer should check the following have also been considered:

- Change to water pressures due to long term climatic variations

Additionally, the designer should determine water pressures representing the most unfavourable values, which could occur in:

- Extreme or accidental circumstances at each of the wall's construction sequence and throughout its design life. An example of an extreme or accidental event may be a burst water main close to the wall.

To account for the above cases, the following measures have been included in the design:

- Firm piles to only extend to 1m below formation. This will allow groundwater flow between the male piles below formation.
- Construction of weep holes through the female piles. Weep holes are to consist of pipes (typically 50mm diameter) through an enlarged opening (in the order of 90mm diameter), with the annulus sealed. A filter stocking is to be installed around the pipe to prevent any migration of fines which could cause additional settlement.

In the analysis, groundwater has been taken as +12m OD. An accidental case, whereby groundwater rises to +22m OD and a minimum equivalent fluid pressure (MEFP) over the full height of the wall has also been considered in the long-term stage (ie. Following construction of slab).

5.8 Pile Wall Stiffness

The stiffness of the pile wall is calculated based on the recommendations provided within CIRIA C760, from the formula K=0.7 x (EI/s) for the short-term stiffness per meter of the wall.

E is the short-term young's modulus of concrete, taken as $30x10^6$ kN/m^2 for the hard piles and $20x10^6$ kN/m^2 for the firm piles (for C8/10 concrete). I is the second moment of area of the piles and s is the centre to centre spacing of the piles. The factor of 0.7 accounts for shrinkage and cracking of the concrete over a short-term period. A factor of 0.5 accounts for the long-term shrinking and cracking effect.

The calculated stiffness values are shown in Table 5.1.

Table 5.1: Southern Boundary Secant Pile Wall Stiffness Values

Wall Type	Pile Type	Design Short Term EI (kNm²/m)	Design Long Term EI (kNm²/m)
Southern Boundary Secant Pile Wall	1,200mm Hard Piles @ 1,500mm c/c	1,425,026	1,017,876
	1,200mm Firm Piles @ 1,500mm c/c	64,960	-
	1,200mm Hard Piles @4,500mm c/c (Buttress)	475,009	339,292
	Combined Stiffness per m run	**1,964,995**	**1,357,168**

5.9 Standards and Software

The geotechnical design of the retaining wall has been carried out in accordance with IS EN 1997-1:2005 Eurocode 7: Geotechnical design – Part 1: General Rules and with respect to the Irish National Annex to this document (INA-EC7), which was published in 2007. The recommendations of CIRIA C760 are also considered. The structural design has been carried out in accordance with IS EN 1992-1-1:2005 and the Irish National Annex.

The Oasys software package FREW has been used to calculate the required minimum toe level and loads of the piled wall. A finite element model analysis has been carried out using the Plaxis 2D software to calculate expected displacements.

The adjacent basement excavation (to be constructed with additional temporary works) has been modelled conservatively in FREW as a sloped batter from the initial excavation level, while in Plaxis the additional temporary works have been modelled as sheet piles to account for any reduction in passive resistance.

5.10 Design Limit States

An Ultimate Limit State (ULS) design has been completed in accordance with IS EN 1997 to assess the stability and loads on the wall. Calculations for Design Approach 1 Combination 1 and Design Approach 1 Combination 2 have been completed as allowed in the Irish National Annex. A serviceability limit state (SLS) analysis has also been carried out to assess likely wall deflections. The following partial factors have been applied as outlined in Table 5.2.

Table 5.2: EC7 Loading Combination and Partial Factors

Limit State / Parameter	ULS C1 Analysis	ULS C2 Analysis	SLS Analysis
Angle of Friction (applied to tan ϕ')	1.00	1.25	1.00
Effective Cohesion	1.00	1.25	1.00
Undrained Shear Strength	1.00	1.40	1.00
Soil Stiffness	1.00	1.00	1.00
Reduction in Level of Resisting Ground	Excluded*	Excluded*	Excluded
Passive Softening	Excluded	Excluded	Excluded
Factor on Effects of Surcharge (Variable) Actions	1.11	1.30	N/A
Factor on Effects of Soil and Water Actions	1.35	1.00	N/A

*No allowance for overdig has been included in the ULS analysis. As a result, careful management of the excavation works by the contractor will be required.

5.11 ULS Analysis Results

The results of the ULS analysis are summarised in Table 5.3.

Table 5.3: ULS Analysis Results

Wall Type	Pile Bending Moment (kNm/m Run)		Pile Shear Force (kN/m Run)		Min. Male Pile Toe Level for Stability (m OD)
	ULS C1 Bending	ULS C2 Bending	ULS C1 Shear	ULS C2 Shear	
Southern Boundary Secant Pile Wall	1,453	1,430	385	383	17.0

5.12 SLS Analysis Results

A SLS analysis has been completed using the Finite Element Analysis software Plaxis 2D. The results of the short term analysis are shown as Figure 5.3 and Figure 5.4, with the long term analysis shown in Figure 5.5 and Figure 5.6, which shows pile head movement of less than 40mm.

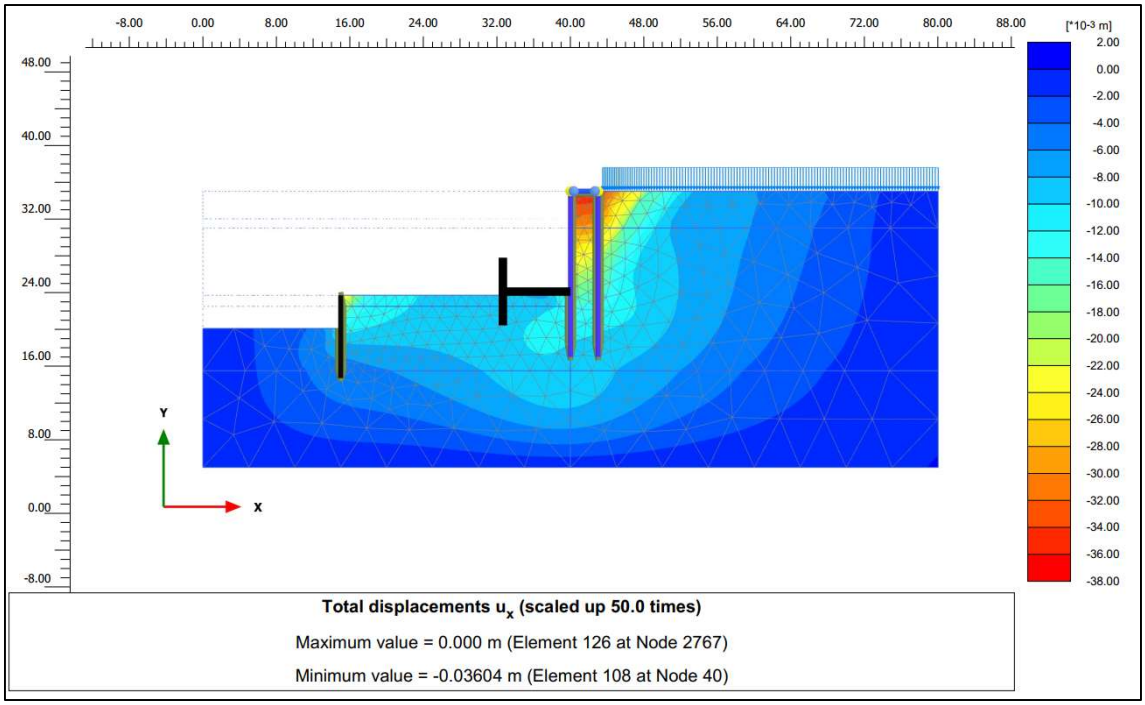

Figure 5.3: Southern Elevation Short Term Horizontal Movement

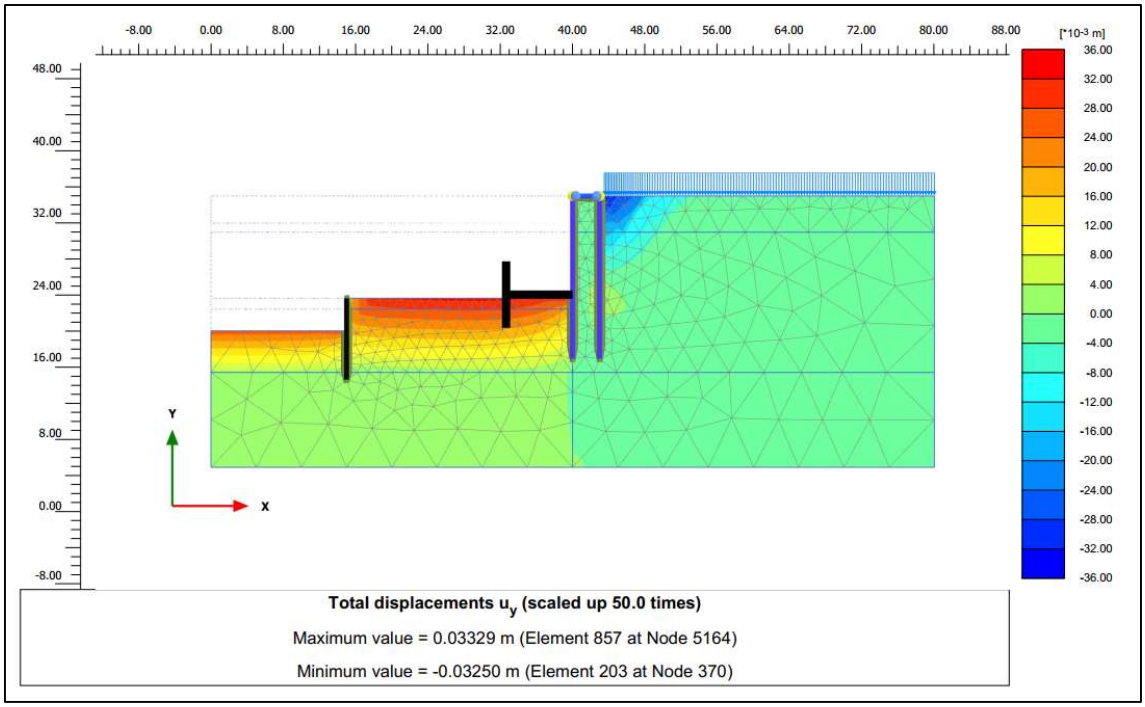

Figure 5.4: Southern Elevation Short Term Vertical Movement

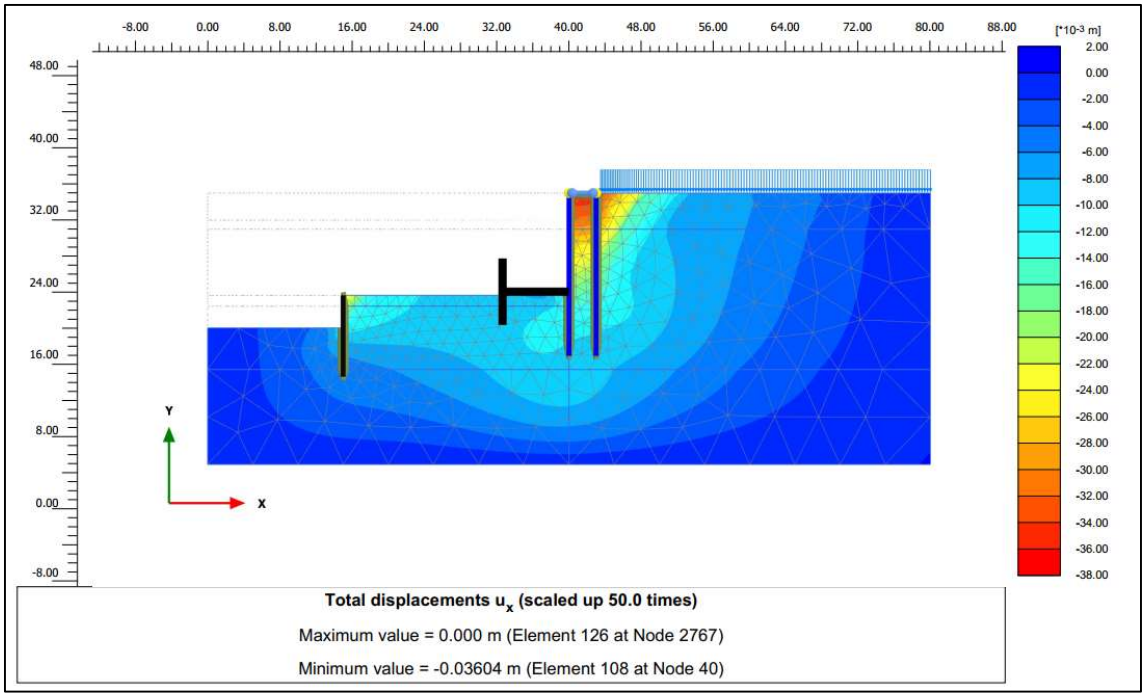

Figure 5.5: Southern Elevation Long Term Horizontal Movement

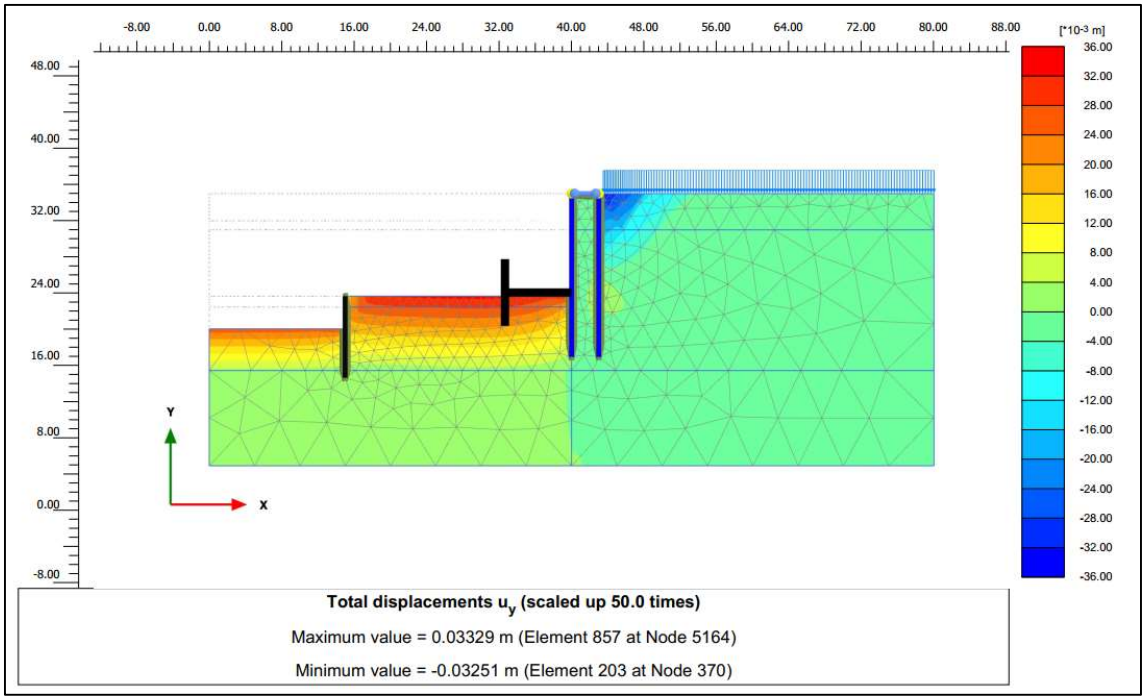

Figure 5.6: Southern Elevation Short Term Vertical Movement

5.13 Ground Movement Assessment

An assessment of the ground movements and a building damage assessment has been carried out and is outlined in Section 9.

5.14 Main Reinforcement

ByrneLooby have carried out an assessment of the required main reinforcement in accordance with IS EN 1992-1-1:2004, based on the bending moments detailed above. This has calculated that a minimum area of steel of 1.3% for the secant piles and 1.3% for the buttress piles.

The above assessment is considered conservative and may be refined during the construction detailed design.

5.15 Monitoring Methodology

Movement and vibration monitoring shall be implemented for the works as follows:

5.15.1 Vibration Monitoring

The use of a secant pile wall with installation by CFA/Bored piling techniques has the advantage over sheet pile installation as vibration of the sheet piles can cause densification of coarse-grained soils close to the piles which in turn can cause ground surface settlement.

Vibration monitoring will be completed during the pile installation for the duration of the piling works. A pre-determined limit will trigger an alarm alerting the site team and stopping the works. An investigation can then take place to determine what activity caused the levels of vibration to exceed the safe limit. Safeguarding measures can then be implemented to permit the work to progress again safely. A vibration monitoring and inspection plan will be drawn up and implemented at construction stage.

5.15.2 Movement Monitoring

A movement monitoring and inspection plan will be drawn up and implemented at construction stage. It is important to combine a number of techniques to achieve a robust monitoring strategy. The processes recommended include inclinometers and target surveying.

Inclinometers measure the lateral displacement of the piles with a number of inclinometers installed along the wall alignment. An initial set of baseline readings are recorded prior to the excavation works commencing. The movement of the piles relative to the baseline reading is then measured as the excavation progresses.

Target points will also be set up on the piles to monitor the movement as the excavation works progress.

Additionally, settlement monitoring is recommended on the retained side of the wall. A suitable number of settlement points will be regularly monitored to monitor any movement that takes place. It is recommended that settlement monitoring points are extended to all site boundaries adjacent to the secant pile wall.

Trigger limits are to be set for the wall movement with an action plan and contingency measures proposed should the movements exceed the trigger limits. The proposed trigger limits and contingency measures are outlined in Table 5.4 and Table 5.5 and are based on the various stages of the construction sequence.

Table 5.4: Identification of Trigger Levels – Excavate to Formation (Prior to Temp. Prop Removal)

Trigger	Pile Head Movement	Action
Green	<18mm	No Action Required. Proceed with proposed construction sequence.
Amber	<22mm	Contact engineer. Frequency of monitoring to be increased.
Red	>26mm	Contact engineer immediately. Works to be suspended. Contingency Plan to be implemented and construction sequence may need amendment.

Table 5.5: Identification of Trigger Levels – Following Removal of Temp. Prop

Trigger	Movement	Action
Green	<28mm	No Action Required
Amber	>32mm	Contact engineer. Frequency of monitoring to be increased.
Red	>36mm	Contact engineer immediately. Works to be suspended. Contingency Plan to be implemented.

6 Western Boundary Retaining Wall

6.1 Summary

Based on elevation changes, a retaining wall will be required along the western elevation, directly adjacent to the site boundary. An indicative section is shown as Figure 6.1. The proposed wall solution is a secant pile wall.

The secant pile wall is to be supported in the permanent condition by the basement, first floor and second floor slabs. The SSL for the basement slab is +18.0m OD and is 850mm thick. Based on this the design has been based on a formation level of +17m OD. The wall will be support in the temporary condition, until the permanent works have been constructed, by temporary propping.

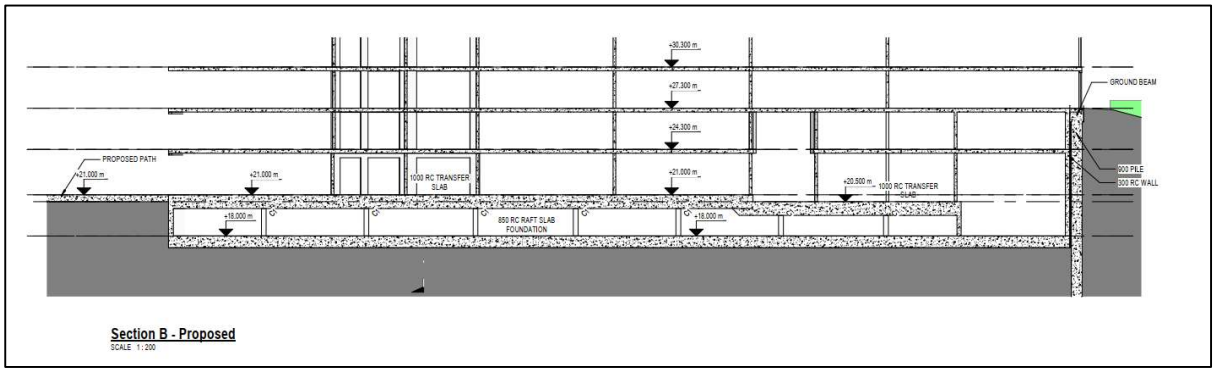

Figure 6.1: Western Boundary Indicative Section

6.2 Wall Sections

The secant pile wall will consist of the following pile arrangement, in a hard-firm pile arrangement:

- 900mm diameter reinforced male piles, installed at 1,300mm centres;
- 900mm diameter unreinforced female piles, installed at 1,300mm centres.

The ground level along the secant pile wall elevation varies to a maximum level of approximately +27.5m OD. Based on this, one wall section has been analysed based on the maximum retained height (11.5m in the temporary case). Where the ground level reduces along the north of the wall, a refinement of the design may be completed during the detailed construction design.

6.3 Pile Installation Level

The secant pile wall is to be installed from existing ground levels (approximately +27.5m OD). This level may reduce along the northern section of the secant pile wall run. A suitable piling platform and access to the piling locations is to be constructed in advance of piling works.

6.4 Construction Sequence

The following construction sequence has been modelled in the design of the secant pile wall for the western elevation:

1. Construct piling platform and form suitable access for piling rig;
2. Install female unreinforced secant piles to design toe lengths;
3. Install male reinforced secant piles to design toe lengths;
4. Complete initial excavation;
5. Install temporary raking prop and construct thrust blocks;
6. Excavate to formation;
7. Construct Basement Raft slab at +18m OD;
8. Construct first floor slab at 24.3m OD;
9. Remove temporary raking prop;
10. Construct second floor slab at 27.3m OD.

Alternatively, the secant pile wall could be back propped with temporary propping following construction of the basement raft slab, to allow removal of the upper temporary prop prior to the construction of the first floor slab at 24.3m OD.

6.5 Topography

The ground level on the retained side reduces to a retaining wall with a top of wall level of approximately +25.5m OD. The retaining wall is located directly adjacent to an existing single storey building. This change in slope on the retained side has been modelled as a surcharge.

6.6 Surcharge

An existing single storey building is located adjacent to the proposed secant pile wall at an offset of approximately 2m. The building has been modelled as having strip footings which have been modelled as having a UDL of 50kN/m^2 spread over a foundation width of 0.6m.

Additionally, a surcharge has been applied to the wall to account for the sloping level between the secant piled wall and the building.

6.7 Support

The analysis has been based on a temporary prop being installed at an elevation of +25m OD. Following excavation to formation, it is proposed to extend the basement floor slab to support the secant pile wall in the permanent condition. The basement floor slab is shown at an elevation of +18m OD. Additionally, the first and second floor slabs will support the secant pile walls in the permanent case.

6.8 Pile Wall Stiffness

The pile wall stiffness has been calculated using the same processes as outlined in Section 5.7.

The calculated stiffness values are shown in Table 6.1.

Table 6.1: Western Boundary Secant Pile Wall Stiffness Values

Wall Type	Pile Type	Design Short Term EI (kNm^2/m)	Design Long Term EI (kNm^2/m)
Western Boundary Secant Pile Wall	900mm Hard Piles @ 1,300mm c/c	520,255	371,611
	900mm Firm Piles @ 1,300mm c/c	32,757	-
	Combined Stiffness per m run	553,012	371,611

6.9 Standards and Software

The same standards and software have been used in the design of the western retaining wall as outlined in Section 5.9.

6.10 Design Limit States

The Same Design Limit States have been used in the design of the western retaining wall as Section 5.10.

6.11 Groundwater

A groundwater level of +12m OD has been used in the analysis, as outlined in the Minerex assessment. It is proposed to install female piles to a minimum depth of 1m below formation. This will allow groundwater flow below this elevation. An additional case has been carried out in the long term to account for an increase in groundwater level to a level of +20m OD and a minimum equivalent fluid pressure (MEFP) over the full height of the wall.

6.12 ULS Analysis Results

The results of the ULS Analysis are summarised in Table 6.2

Table 6.2: ULS Analysis Results

Wall Type	Pile Bending Moment (kNm/m Run)		Pile Shear Force (kN/m Run)		Min. Male Pile Toe Level for Stability (m OD)
	ULS C1 Bending	ULS C2 Bending	ULS C1 Shear	ULS C2 Shear	
Western Boundary Secant Pile Wall	480	530	173	164	11.5

6.13 SLS Analysis Results

A SLS analysis has been completed using the Finite Element Analysis software Plaxis 2D. The results of the short term analysis (prior to temporary prop removal) are shown as Figure 6.2 and Figure 6.3, with the long term analysis shown in Figure 6.4 and Figure 6.5, which shows pile head movement of less than 20mm.

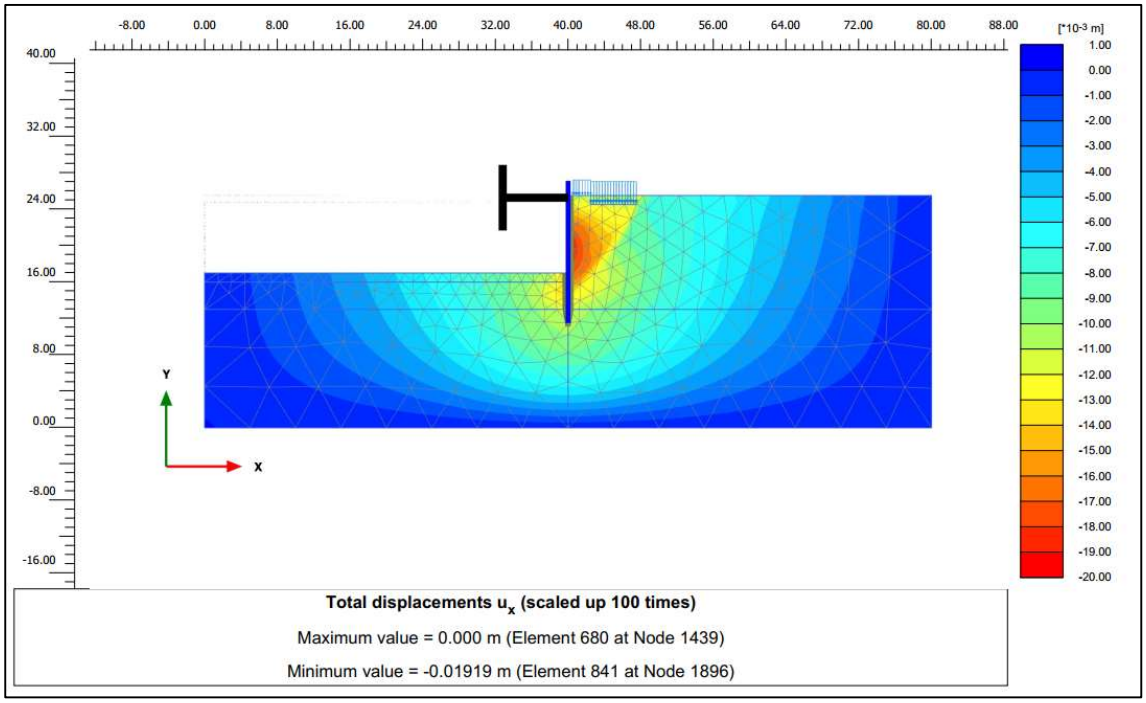

Figure 6.2: Western Elevation Short Term Horizontal Movement

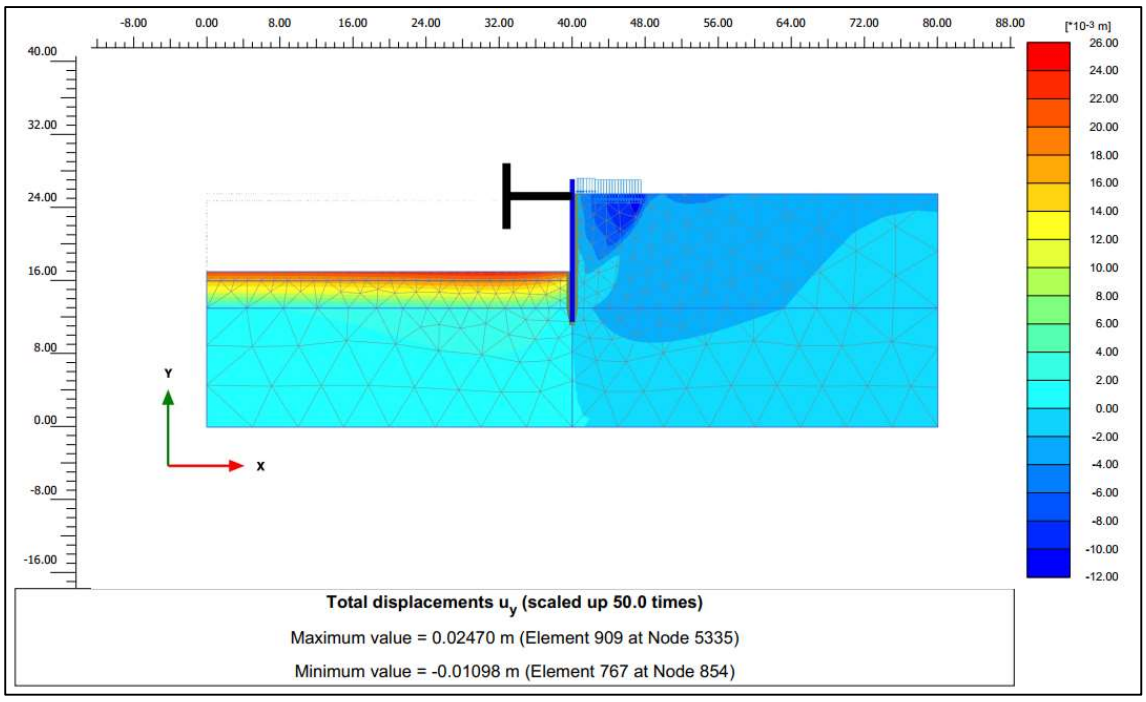

Figure 6.3: Western Elevation Short Term Vertical Movement

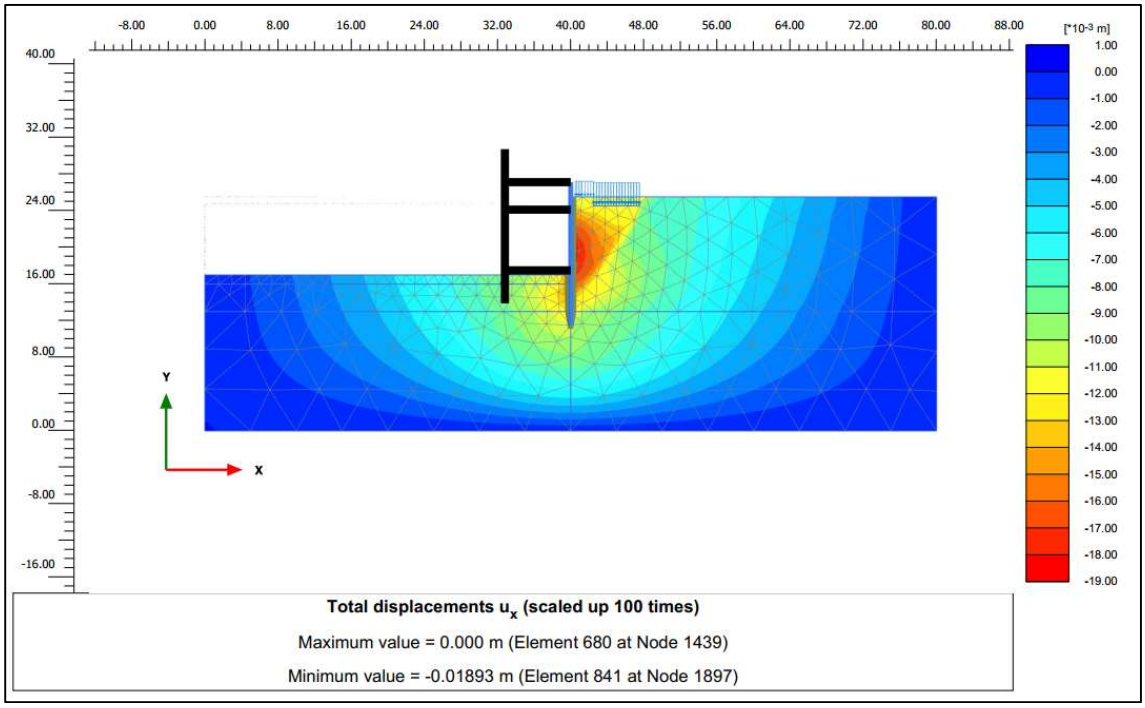

Figure 6.4: Western Elevation Long Term Horizontal Movement

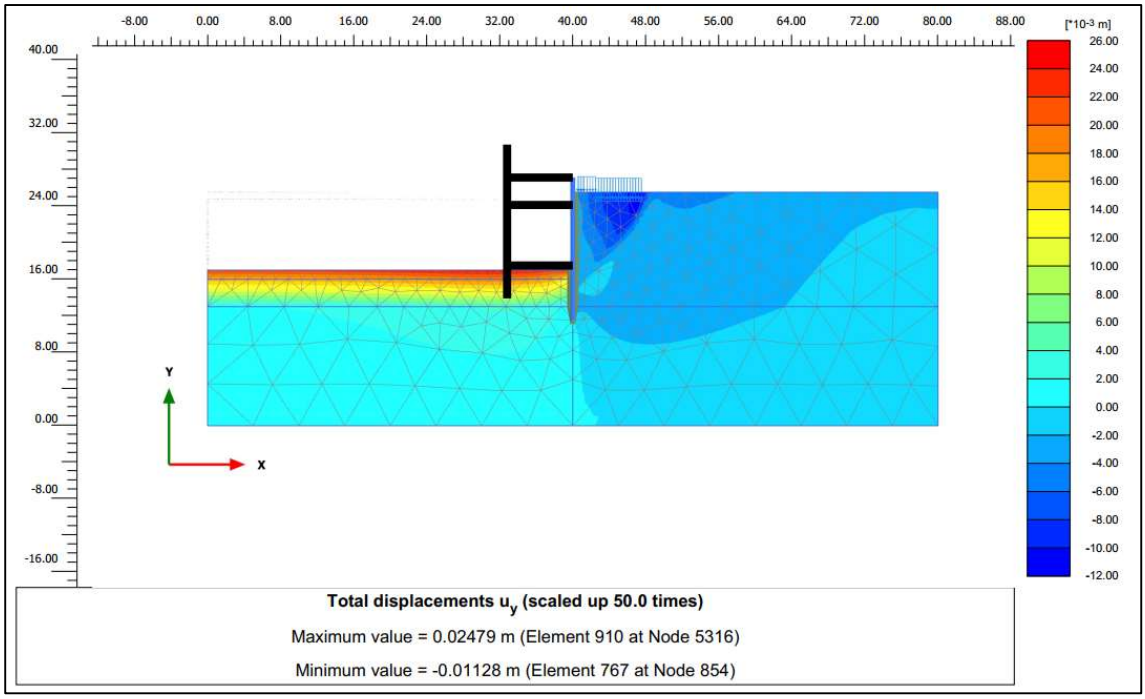

Figure 6.5: Western Elevation Long Term Vertical Movement

6.14 Main Reinforcement

ByrneLooby have carried out an assessment of the required main reinforcement in accordance with IS EN 1992-1-1:2004, based on the bending moments detailed above. This has calculated that a minimum area of steel of 1.0% for the secant piles. The above assessment may be refined during construction detailed design.

6.15 Monitoring Methodology

6.15.1 Vibration Monitoring

The vibration monitoring outlined in Section 5.15.1 is to be implemented for the western wall secant pile wall also.

6.15.2 Movement Monitoring

Like the southern elevation a monitoring programme and trigger levels is to be implemented. The proposed trigger levels for the various stages of the construction sequence are outlined in Table 6. and **Error! Reference source not found.**.

Table 6.4: Identification of Trigger Levels – Excavate to Formation (Prior to Temp. Prop Removal)

Trigger	Movement	Action
Green	<12mm	No Action Required. Proceed with proposed construction sequence.
Amber	>16mm	Contact engineer immediately. Frequency of monitoring to be increased.
Red	>20mm	Contact engineer immediately. Works to be suspended. Contingency Plan to be implemented and construction sequence may need amendment.

Table 6.4: Identification of Trigger Levels – Excavate to Formation (Prior to Temp. Prop Removal)

Trigger	Movement	Action
Green	<12mm	No Action Required. Proceed with proposed construction sequence.
Amber	>16mm	Contact engineer immediately. Frequency of monitoring to be increased.
Red	>20mm	Contact engineer immediately. Works to be suspended. Contingency Plan to be implemented and construction sequence may need amendment.

7 Northern Boundary Open Cut Excavation

7.1 Background

The Martello Tower is a military installation that was constructed over 200 years ago to withstand expected artillery fire. It is understood that the walls of Martello Tower are approximately 8ft thick (2.5m). Arising from concerns regarding the potential impact of the earthworks associated with the proposed development, an assessment of the ground movements on the Martello Tower has been completed.

The revised proposal for Block B is offset from the site boundary. Based on the offset, it is proposed to construct the basement using open cut excavation techniques. The proximity of the Block B basement to the northern site boundary is shown in Figure 7.1 and Figure 7.2, with the red line representing the site boundary and the blue line representing the development boundary.

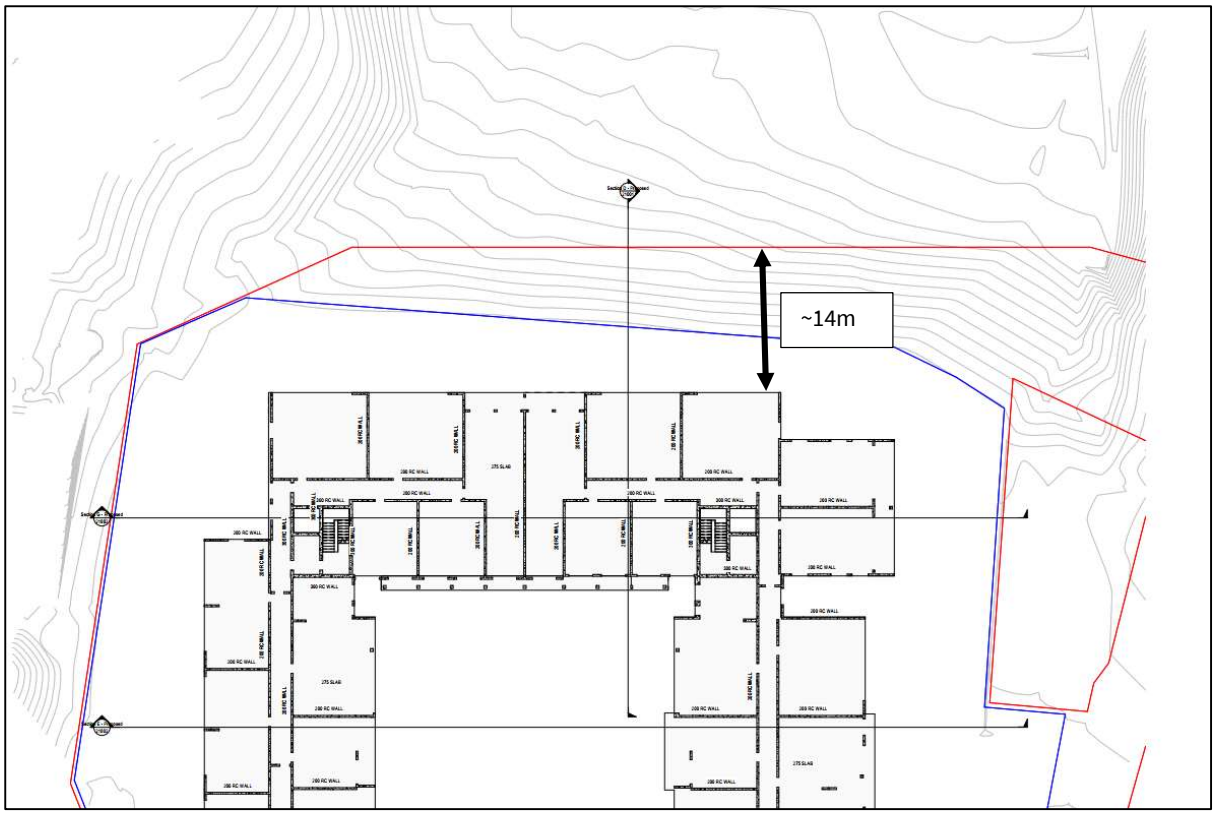

Figure 7.1: Block B Basement Layout

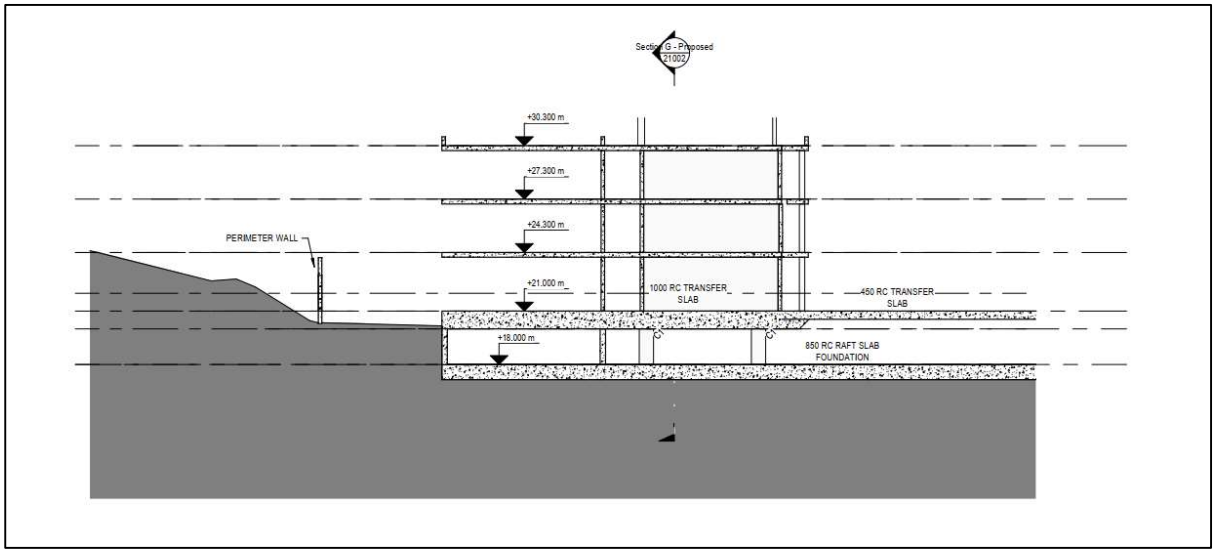

Figure 7.2: Block B Basement Section

7.2 Basement Construction Works

Based on the offset from the proposed basement to the site boundary, it is proposed to construct the basement using open cut excavation techniques along this elevation. The open cut excavation batters will be subject to temporary works detailed design but are expected to be in the order of 1.5H:1V.

7.3 Ground Movements

Based on concerns regarding the basement's construction, ground movements associated with the excavation works and their impact on the adjacent Martello Tower, ByrneLooby have undertaken a building damage assessment. The assessment has been undertaken using ground movement curves caused by the lateral deflection of an embedded retaining wall, which are based on default values within CIRIA C760, which are derived from a number of historic cases. This is considered conservative, as the ground movements generated from open cut excavations will be significantly less and the assessment is considered worst-case. The ground movement curve used in the assessment is the 'Ground Surface Settlement due to excavation in front of a wall in Sand' as shown in Figure 7.3.

Ground level for the assessment has been taken for the higher ground level north of the site boundary (+25m OD), which based on Figure 7.2, has resulted in increased settlements. The predicted ground settlements are shown in Figure 7.4.

The results of the building damage assessment are shown in Section 8.

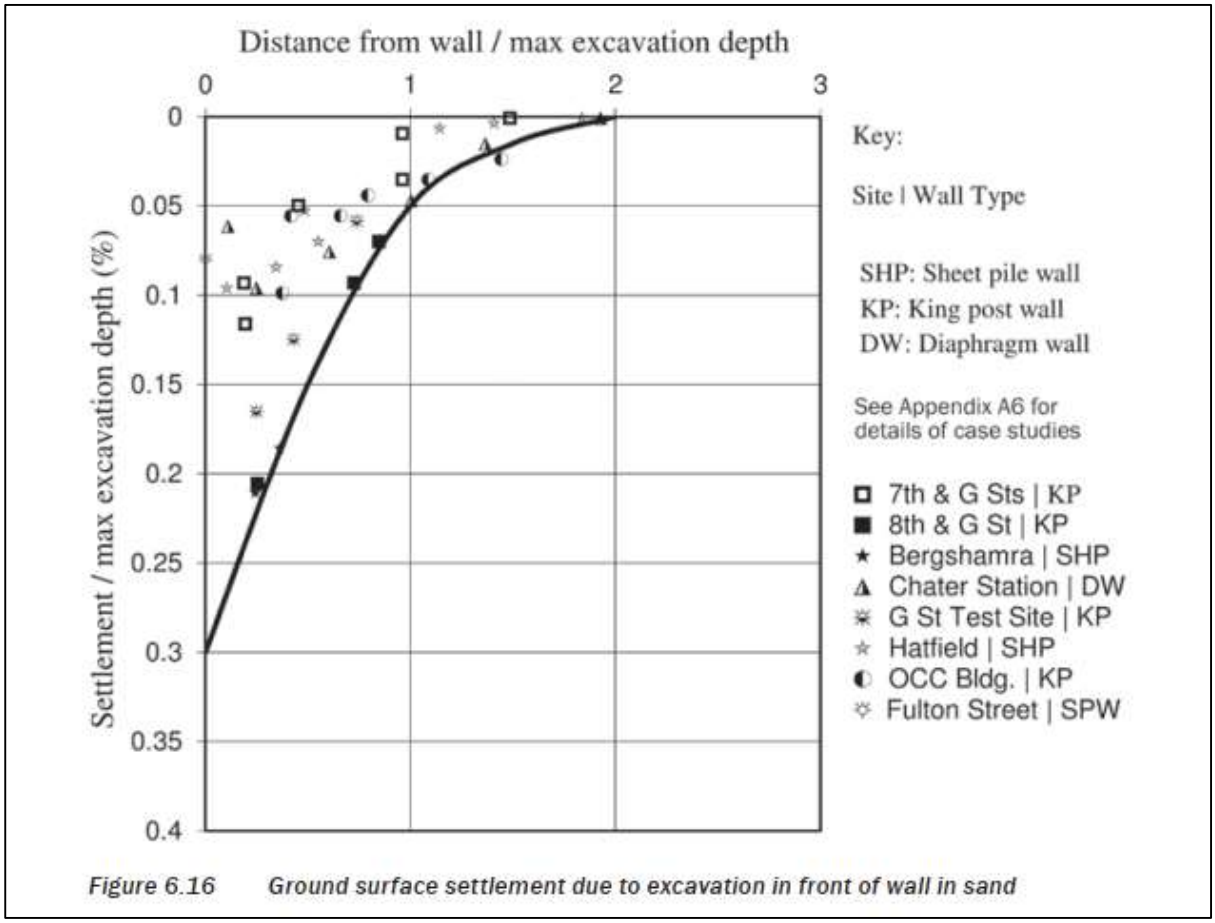

Figure 7.3: Ground Surface Settlement due to excavation in front of wall in sand (CIRIA C760 Fig. 6.16)

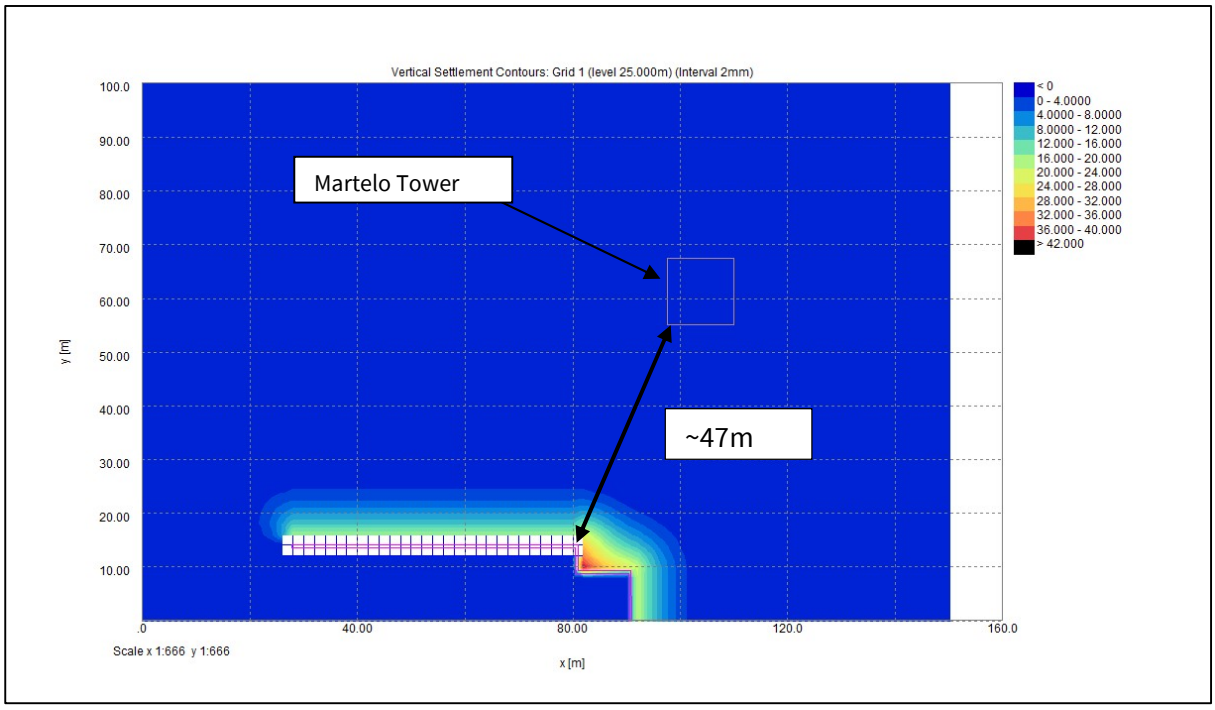

Figure 7.4: Predicted Ground Surface Settlement

8 Building Impact Assessment Methodology

8.1 Basis of Movement

8.1.1 Mechanisms Explored

ByrneLooby have carried out a number of preliminary ground movement assessments associated with the proposed construction techniques at the site. These have been carried out along the southern, western and northern elevations. This section outlines the methodologies used in the assessments with the results of the assessments outlined in the following sections.

The assessments have been based on the ground movements caused by the excavation adjacent to the proposed secant pile wall along the southern and western elevations and the open cut excavation along the northern elevation.

No additional allowance for ground movements caused by wall installation have been included, as per Ciria C760, which details that there are unlikely to be any significant ground movements arising from the installation of a cast in situ wall in stiff ground where the water table is low and workmanship is good.

8.1.2 Software Used

For the southern and western boundaries, the ground movement was assessed by using finite element (FE) software package Plaxis 2D, as outlined earlier in this report.

Following an assessment of the ground movements, the damage impact assessment was undertaken using the X-Disp software package from OASYS. This software is commonly used within the ground engineering industry and is considered to be appropriate tools for this analysis. The X-Disp program has the ability to assess surrounding infrastructure in line with the Burland Damage Impact Assessment (2001) and provide a damage category as necessary. The ground movement obtained by Plaxis 2D were imported into XDisp to allow the damage rating to be assessed.

The ground movements assessed along the northern elevation, caused by open cut techniques, have conservatively been based on empirical ground movements outlined in Ciria C760 caused by embedded retaining walls. This is considered conservative and a worst-case assessment.

8.2 Ground Movement Analysis

8.2.1 Southern Elevation

The predicted ground movements along the southern elevation, adjacent to the secant pile wall have been outlined in Section 5. For the basis of the ground movement analysis only the long-term analysis (worst-case analysis) has been considered. These ground movements have been presented as Figure 8.1 and Figure 8.2. Although, vertical settlements of 2.5mm are recorded at a distance from the wall, these are caused by the application of the 10kPa UDL rather than any impact of the basement excavation.

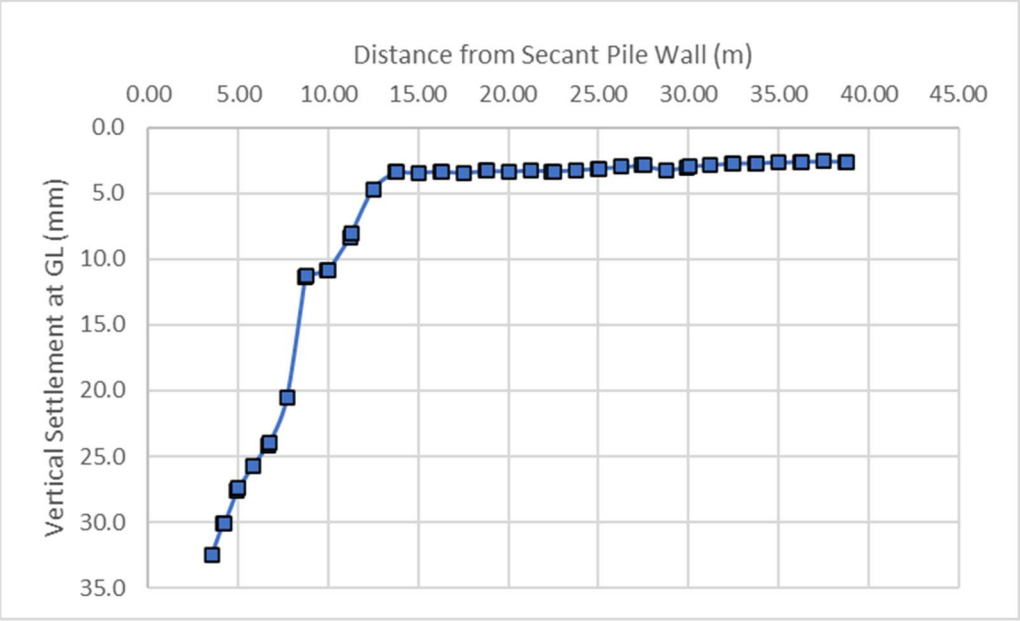

Figure 8.1: Southern Boundary Vertical Settlement

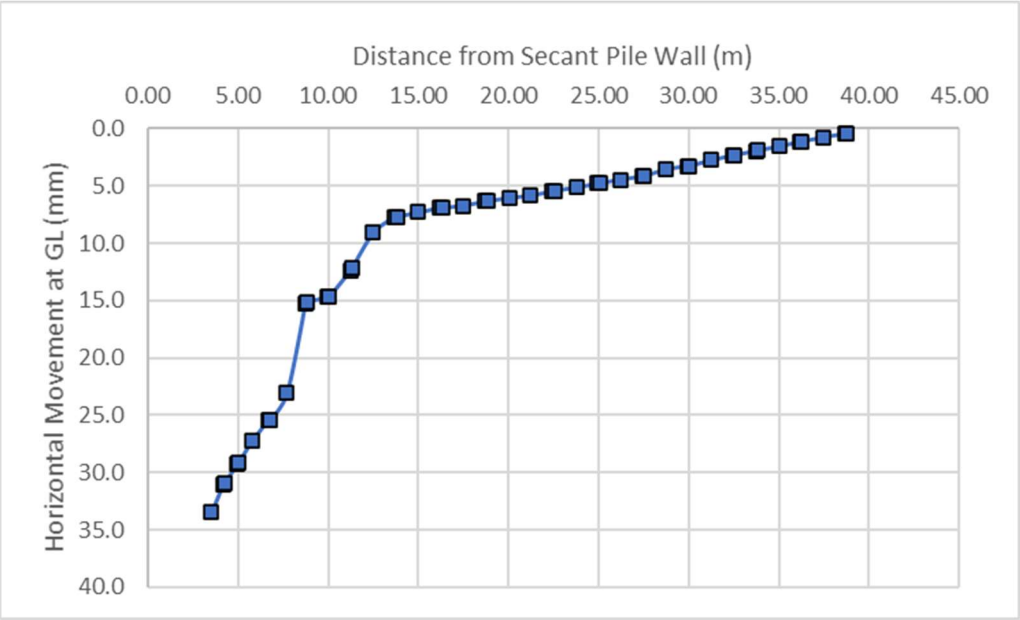

Figure 8.2: Southern Boundary Horizontal Movement

8.2.2 Western Elevation

The predicted ground movements along the western elevation, adjacent to the secant pile wall have been outlined in Section 6. For the basis of the ground movement analysis only the long-term analysis (worst-case analysis) has been considered. These ground movements have been presented as Figure 8.3 and Figure 8.4 and are the calculated movements at the adjacent Building's foundation level, which is assumed as 1m bgl (+24.5m OD).

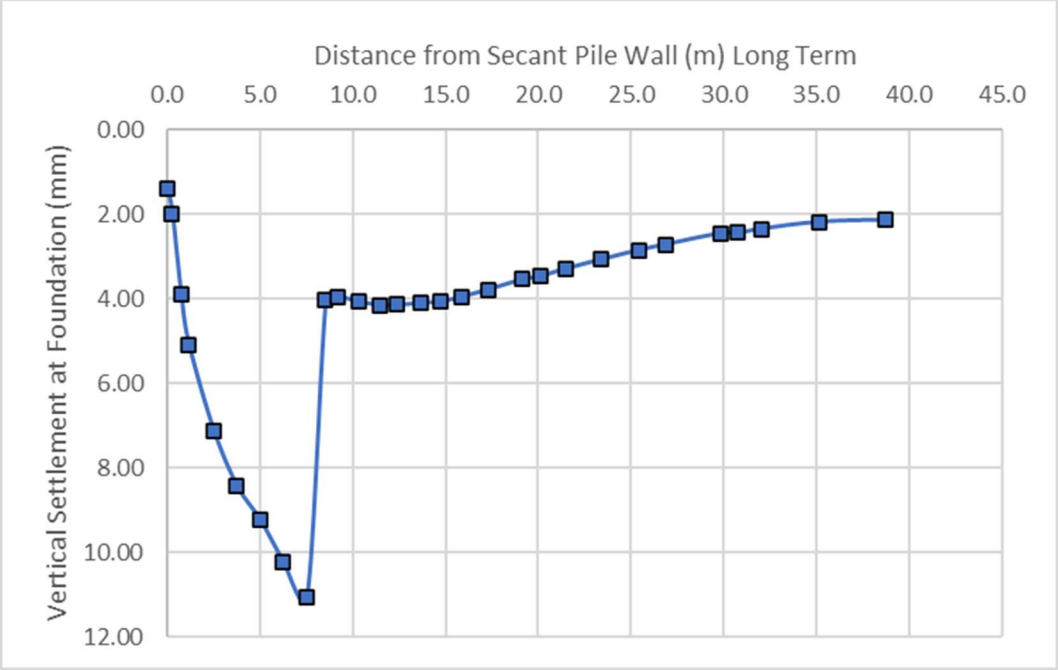

Figure 8.3: Western Boundary Vertical Settlement

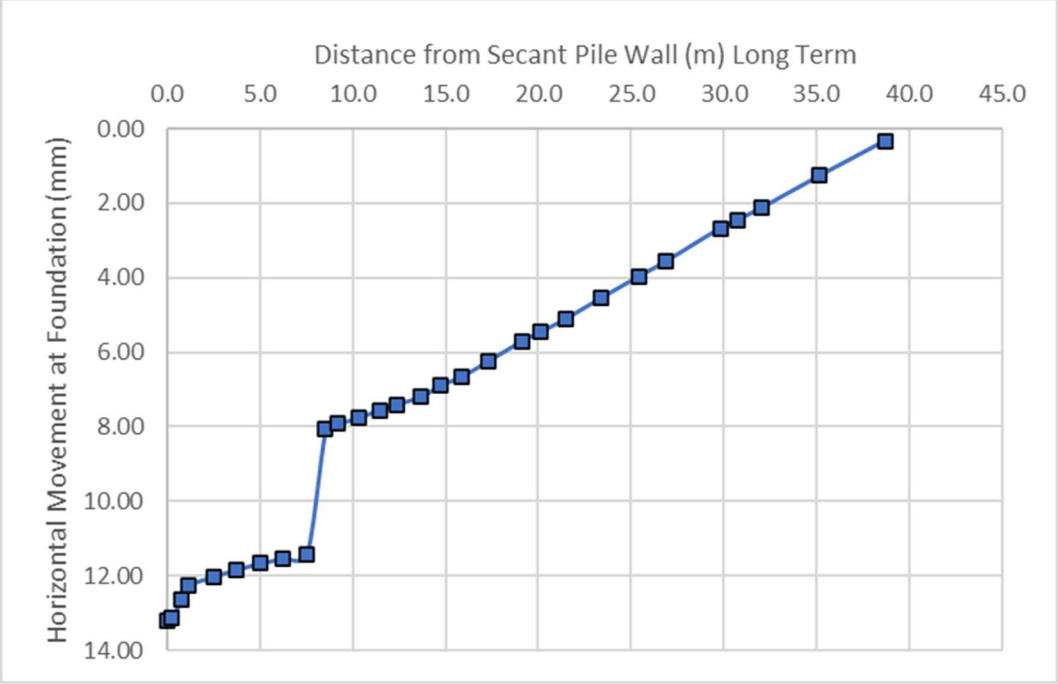

Figure 8.4: Western Boundary Horizontal Movement

8.2.3 Northern Elevation

The predicted ground movements along the northern elevation were determined using empirical charts as detailed in Section 7.

8.3 Damage Impact Assessment

ByrneLooby have carried out a Damage Impact Assessment of the neighbouring structures based on the ground movements outlined above and the classifications given in Table 6.4 of CIRIA C760 (formally C580). These classifications, which have been extracted from and shown in the table below are based on the method of damage assessment outlined by Burland et al (1977), Boscardin and Cording (1989) and Burland (2001).

The assessment has been completed using the XDisp software.

Table 8.1: Table 6.4 of CIRIA C760: Classification of visible damage to walls (after Burland et al, 1977, Boscardin and Cording, 1989, and 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	

8.3.1 Southern Elevation

The nearest properties to the southern elevation secant pile wall are 21 and 22 Asgard Park houses, located approximately 40m south of the secant pile wall.

Based on the predicted ground movements, a **Category 0 (Negligible category)** has been determined for the garage of 22 Asgard Park, while 21 and 22 Asgard Park lie outside the zone of sensitivity, as shown in Figure 8.5.

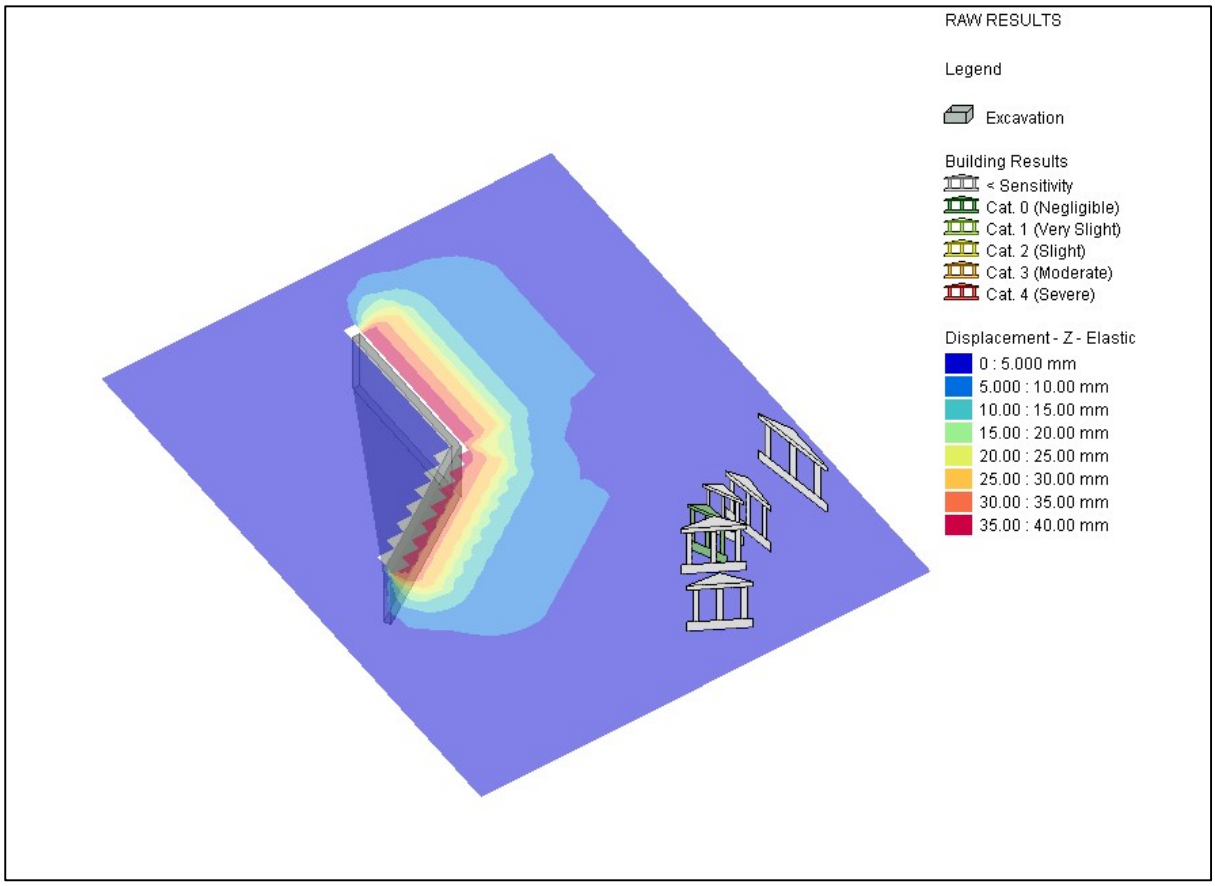

Figure 8.5: Building Damage Assessment – Southern Elevation Secant Pile Wall

8.3.2 Western Elevation

The nearest property to the western elevation secant pile wall is the single level property to the rear of 25 Abbey Street. Based on the proposed alignment of the secant pile wall, the property is located approximately 2m from the secant pile wall.

Based on the predicted movements and proximity of the adjacent building, a **Category 2 (Slight category)** has been determined for the single storey property to the rear of 25 Abbey Street, as shown in Figure 8.6. Category 2 is considered an aesthetic damage category as outlined in Table 8.1.

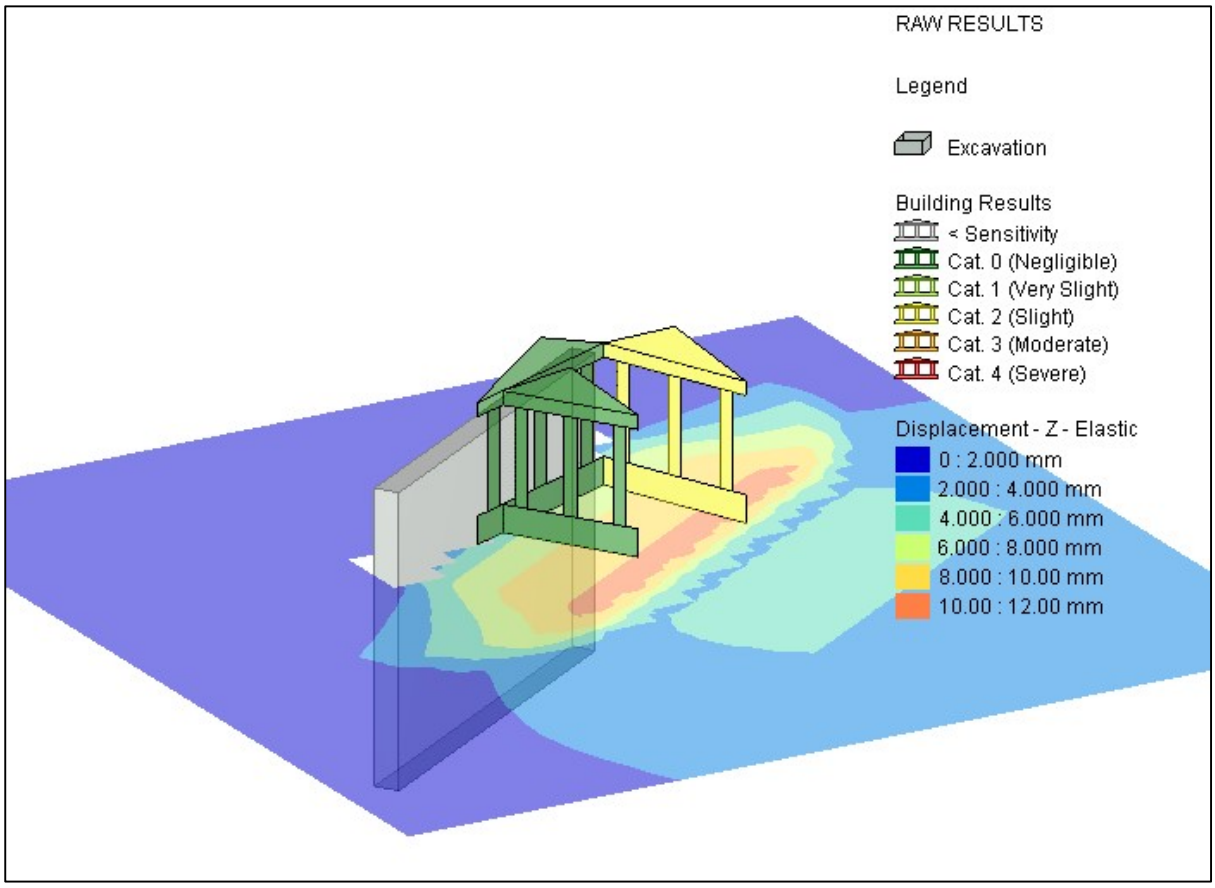

Figure 8.6: Building Damage Assessment – Southern Elevation Secant Pile Wall

8.3.3 Northern Elevation

Martello Tower is located approximately 45m from the basement excavation.

Based on the predicted ground movements and offset to Martello Tower, Martello Tower falls **outside the zone of sensitivity** caused by the basement excavation works.

9 Eastern Elevation Stabilisation Works

9.1 Background

Evidence of local slippages such as scarp and displaced fenceposts are observed to the south-east of the site, adjacent to Martello Tower, as shown in Figure 9.1. This is outside the site boundary and a vibration monitoring regime will be established along this boundary to ensure the proposed works do not cause slippages. All ground works will involve low-vibration methods of construction.

Figure 9.1: Balscadden Road adjacent to Martello Tower (ref. Google Maps) South East of the Site

It is recommended that remedial works are carried out on the eastern elevation adjacent to the site, to prevent any potential future slips occurring. The eastern elevation is shown as Figure 9.2.

The recommended remedial works involve the use of soil nailing and a flexible mesh. Soil nailing is a technique which reinforces the slope by the insertion of tendons. The nails address the global slope stability, which are connected in turn to a facing system which provides surficial stability. A suitable mesh would be selected in the construction which would encourage the growth of vegetation following its construction. It is recommended that the remedial works be completed in advance of the main piling and excavation works in the site.

Figure 9.2: Balscadden Road adjacent to the site

Figure 9.3 Soil Nailing Example, prior to vegetation re-growth

9.2 Basis of Design

ByrneLooby have completed an analysis to assess the suitability of soil nails as a remedial measure along the eastern elevation.

The assessment was completed using the GeoStudio 2021 slope stability software package SLOPE/W. SLOPE/W uses the limit equilibrium method of analysis by dissecting a potential sliding mass into vertical slices. It assesses the factor of safety for both moment and force equilibrium based on various methods, including Janbu (1954), Bishop (1955) and Morgenstern and Price (1965). The Morgenstern-Price method has been used in this instance as it satisfys all equilibrium conditions and can deal with any shape of failure surface.

I.S. EN 1997-1:2004 Eurocode 7 outlines that the practice for the design and execution of reinforced fill structures and soil nailing should utilise the limit equilibrium method and partial factors recommended in 'BS 8006-2:2011: Code of Practice for Strengthened/Reinforced Soils and Other Fills'. Best practice guidance set out in CIRIA C637 (2005) has also been used where suitable. Table 5 from BS 8006-2:2011 is reproduced below as a summary of the appropriate partial factors.

Table 9.1: Summary of Partial Factors as per BS 8006-2:2011

Table 5 **Partial factors for soil nail design**

Design values are to be obtained by multiplying the representative values of the actions, and dividing the characteristic values of the material properties and soil nail resistances, by the following partial factors.[A)]

				Set 1	Set 2
Actions	Self-weight of soil, W		dst[B)]	$\gamma_g = 1.35$	$\gamma_g = 1.0$
			stb[B)]	$\gamma_g = 1.0$	$\gamma_g = 1.0$
	Permanent surcharge, q_p		dst	$\gamma_{qp} = 1.35$	$\gamma_{qp} = 1.0$
			stb	$\gamma_{qp} = 1.0$	$\gamma_{qp} = 1.0$
	Variable surcharge, q_v		dst	$\gamma_{qv} = 1.5$	$\gamma_{qv} = 1.3$
			stb	$\gamma_{qv} = 0$	$\gamma_{qv} = 0$
	Ground-water pressure, u		dst	$\gamma_u = 1.0$	$\gamma_u = 1.0$
			stb	$\gamma_u = 1.0$	$\gamma_u = 1.0$
Material properties	$\tan \varphi'_k$			$\gamma_{\tan\varphi'} = 1.0$	$\gamma_{\tan\varphi'} = 1.3$
	c'_k			$\gamma_{c'} = 1.0$	$\gamma_{c'} = 1.3$
	cu_k			$\gamma_{cu} = 1.0$	$\gamma_{cu} = 1.4$
	γ_k			$\gamma_\gamma = 1.0$	$\gamma_\gamma = 1.0$
Soil nail resistances [C)]	Bond stress[D)], τ_{bk}	Empirical		$\gamma_{rb} = 1.1$	$\gamma_{rb} = 1.5$
		Effective stress[E)]		$\gamma_{rb} = 1.1$	$\gamma_{rb} = 1.5$
		Total stress[E)]		$\gamma_{rb} = 1.1$	$\gamma_{rb} = 1.5$
		Pull-out tests[F)]		$\gamma_{rb} = 1.1 - 1.7$	$\gamma_{rb} = 1.5 - 2.25$
	Tendon strength, T_k			$\gamma_s = 1.0$	$\gamma_s = 1.15$ for steel
Model factor	Applied to the effect of unfavourable actions[F),G)] (e.g. to $M_{driving}$ in the case of Bishop's slip circles)			γ_{Sd}	γ_{Sd}

In order to obtain caharacterisitc bond stress parameters, the partial factors as outlined in Table 6 of BS 8006-2:2011 have been accounted for. Table 6 has been shown below for information.

Table 9.2: Summary of Partial Factors Recommended in BS 8006-2:2011

Table 6 — *Ultimate limit state approach to deriving design values*

Method of determining ultimate bond stress, τ_{bu}	**Factors for determining characteristic bond stress from ultimate values** $\tau_{bk} = \tau_{bu} / \gamma_k$	**Factors for determining design bond stress from characteristic values for set 1,** $\tau_{bd} = \tau_{bk} / \gamma_{\tau b}$	**Factors for determining design bond stress from characteristic values for set 2,** $\tau_{bd} = \tau_{bk} / \gamma_{\tau b}$
Empirical pullout test data	γ_k = 1.35 to 2.0 Selected value to be based on degree of confidence relative to proposed structure, soils, construction method, etc.	$\gamma_{\tau b} = 1.11$	$\gamma_{\tau b} = 1.50$
Effective stress *NOTE* τ_{bu} derived from characteristic φ'	γ_k = 1.0 to 1.35 Selected value to account for potential for dilation and degree slope deformation in active zone	$\gamma_{\tau b} = 1.11$	$\gamma_{\tau b} = 1.50$
Total stress *NOTE* τ_{bu} derived from characteristic c_u.	γ_k = 1.35 to 2.0 selected value to account for potential for strain softening, plasticity and shrink swell effects	$\gamma_{\tau b} = 1.11$	$\gamma_{\tau b} = 1.50$
Pullout tests	See BS EN 14490:2010 *Characteristic selected as a cautious estimate of the test data, taking into account the number of test results, location and consistency.*	$\gamma_{\tau b}$ = 1.1 to 1.3 for coarse grained soils $\gamma_{\tau b}$ = 1.5 to 1.7 for medium and high plasticity soils	$\gamma_{\tau b}$ = 1.5 to 1.7 for coarse grained soils $\gamma_{\tau b}$ = 2.0 to 2.25 for medium and high plasticity soils

9.3 Surcharge

A surcharge of 10kPa has been applied to the analysis, which is representative of plant up to 30 tonne loaded weight as per recommendations in Ciria C760.

9.4 Design Sections

Based on the topographical survey a single design section has been taken. The design section taken is summarised in the table below. Please note the assessment is subject to detailed construction design which may lead to a refinement change in the number and spacing of soil nails.

Table 9.3: Design Sections for Soil Nail Design

Design Section	Slope Height (m)	Slope Angle (deg)	Row of Nails (No.)	Angle of Nails (deg)	Horizontal Spacing (m)	Vertical Spacing (m)
1	10	40	6	15	1.5	1.5

9.5 Soil Nail Parameters

9.5.1 Tensile Strength of Nails

The maximum value of the design tensile strength has been calculated using Section 4.5.1 of BS 8006-2:2011:

$$R_{td} = \frac{R_{tk}}{\gamma_s} = \frac{A_{s,nom}\, f_{yk}}{\gamma_s}$$

Where:

- R_{td} is the design tensile strength
- γ_s is the partial factor on steel strength, taken as 1.15
- $A_{s,nom}$ is the nominal cross-sectional area of the reinforcement taking account of corrosion
- f_{yk} is the characteristic yield strengths of the tendon

ByrneLooby have carried out the analysis based on Dywidag R32-250 DYWI Drill Hollow Bar Type Soil Nail. Based on this, the design strength has been calculated as:

Design Strength, R_{td} = (302 × 510) / 1.15 = 164,086N = 134kN

9.5.2 Borehole Diameter

ByrneLooby have carried out the analysis based on a drill bit of 115mm.

9.5.3 Bond Stress of Soil Nails

Recommendations outlined in CIRIA C637 in relation to ultimate bond stress between the grouted soil nail and the surrounding ground have been used to estimate the bond stress for design purposes. Table 8.4 of CIRIA C637 summarises typical soil nail test results and bond stress values observed for various British and Irish soils – extracts from this table have been shown below.

Based on the below and the ground conditions encountered on site an ultimate bond stress of 50kPa has been used in the analysis.

Table 9.4: Typical Values of Ultimate Bond Stress (ref. CIRIA C637)

Soil type and description	Nail type	Nail diameter (mm)	Ultimate unit bond (kN/m)	Ultimate bond stress (kN/m²)
Sands, silty sands and clayey sands				
Dense Woburn Sand Formation sand	Rough driven bar	25.4	4–15	81–190
Weakly cemented fine to medium sand (Bracklesham Group)	Bored and grouted	140	60, 116	130, 265
Dense silty clayey sand	Not available	120	n/a	110–130
Weakly cemented silty sand (Tunbridge Wells Sand Formation)	Drilled and grouted	114	17	49
Firm sandy clay and silty fine sand (Hythe Formation)	Self-drilled with 75 mm-diameter clay bit	100	18–30	58–98
Boulder clays and glacial tills				
Black Boulder Clay (Eire)	Drilled and grouted	114	63–84	177–235
Glacial till (South Yorkshire)	Drilled and grouted	Not available	Not available	65
Firm to stiff slightly sandy clay with some gravel (glacial till – Midlands)	Self-drilled with sacrificial bit	75	16–37	68–155
Firm sandy clay (till)	Auger and grouted	187	20, 54	34, 92

Construction method	Soil type	Ultimate bond stress (kN/m²)
Augered	Loess	25–75
	Soft clay	20–30
	Stiff to hard clay	40–60
	Clayey silt	40–100
	Calcareous sandy clay	90–140
	Silty sand fill	15–20
Open hole	Non-plastic silt	20–30
	Medium-dense sand and silty sand/sandy silt	50–75
	Dense silty sand and gravel	80–100
	Very dense silty sand and gravel	120–240
	Stiff clay	40–60
	Stiff clayey silt	40–100
	Stiff sandy clay	50–100
Rotary-drilled	Marl/limestone	300–400
	Soft dolomite	400–600
	Weathered sandstone	200–300
	Weathered shale	100–150
	Weathered schist	100–175
	Basalt	500–600
	Silty sand	100–150
	Silt	60–75
Driven casing	Dense sand/gravel	180–210
	Sandy colluvium	70–150
	Clayey colluvium	40–75
Jet-grouted	Sand	380
	Sand/gravel	700

9.6 Analysis Results

The results of the SLOPE/W analysis of the soil nailed slope are shown in the table below, with the graphical outputs included in the figures below.

Table 9.5: Slope/W Soil Nail Slope Analysis Results

Section	Vertical Spacing (m)	Horiz. Spacing (m)	Total No. of Rows	FoS / ODF		
				SLS	ULS Set 1	ULS Set 2
1	1.5	1.5	6	1.509	1.410	1.130

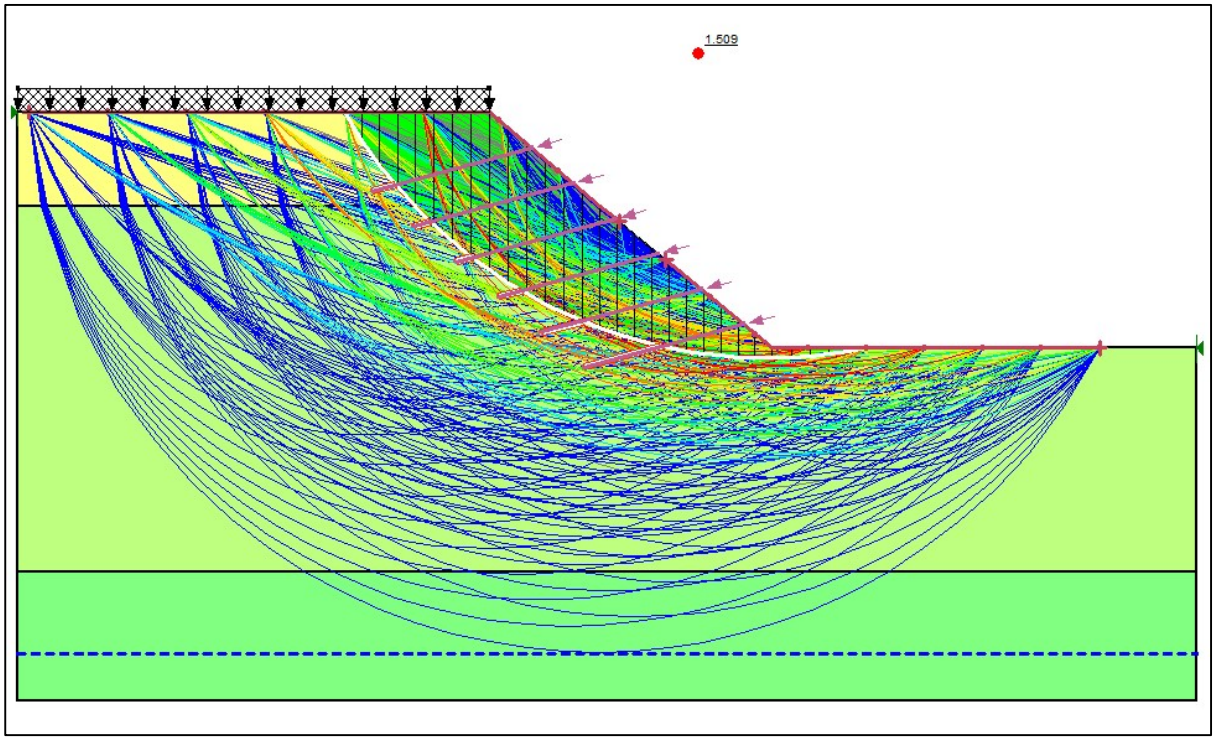

Figure 9.4: Slope/W SLS Analysis Results

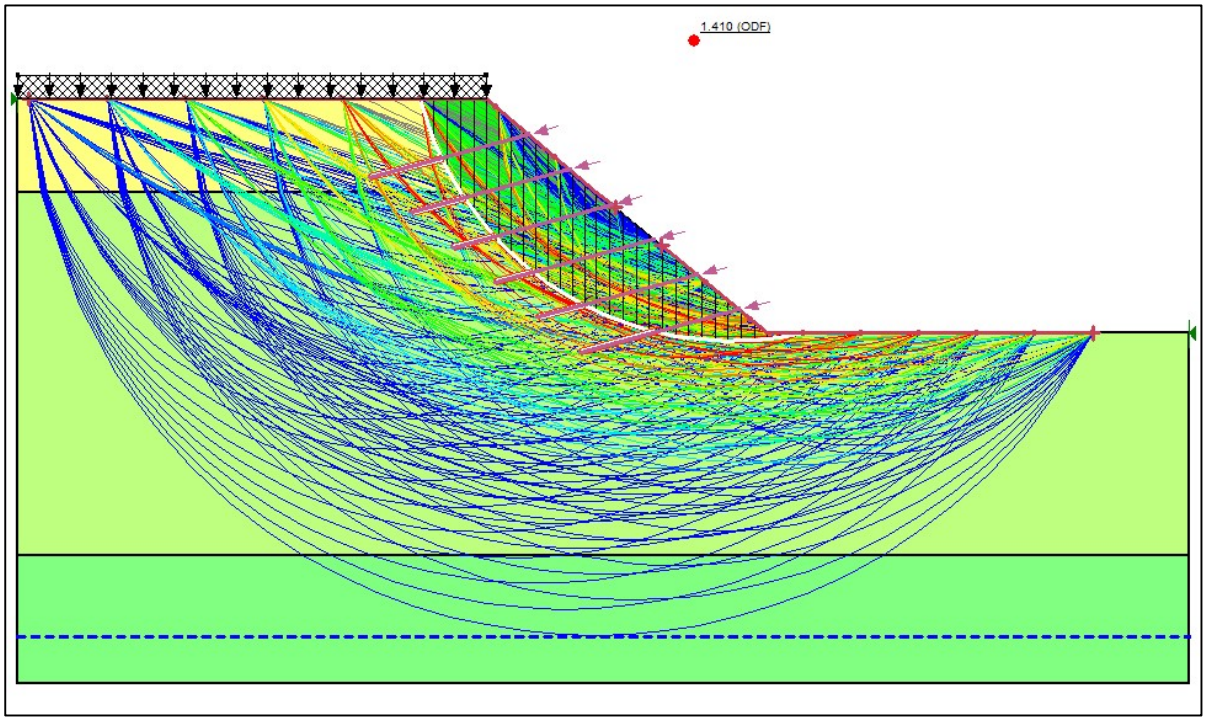

Figure 9.5: Slope/W ULS Set 1 Analysis Results

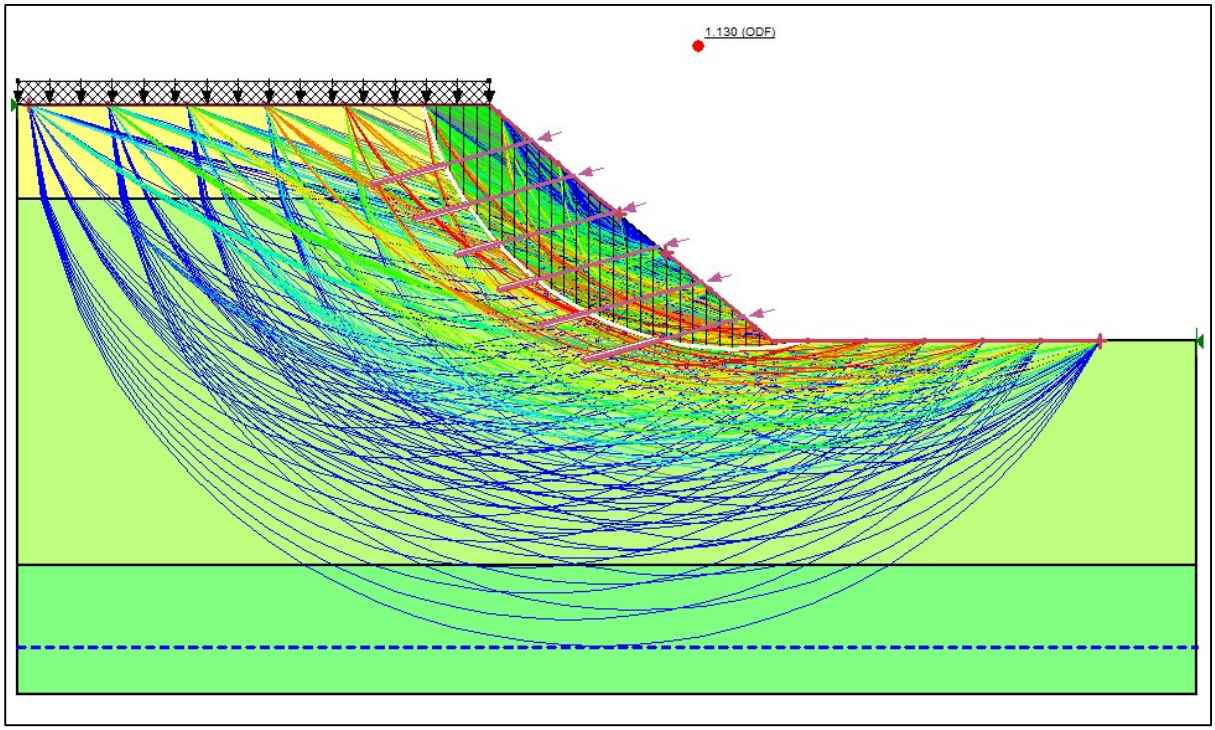

Figure 9.6: Slope/W ULS Set 2 Analysis Results

10 Howth Sewer Tunnel Assessment

10.1 Howth Sewer Description

As part of the North Dublin Drainage Scheme, a tunnel was constructed through the site in the 1950s. The location of the tunnel is shown as Figure 10.1. The approximate site location has been imposed onto the drawing and is shown as Figure 10.2. The tunnel is understood to be 6ft in diameter and consists of a high and low level tunnel. The depth to the tunnel invert is believed to range from 20m to 35m below the site's ground level.

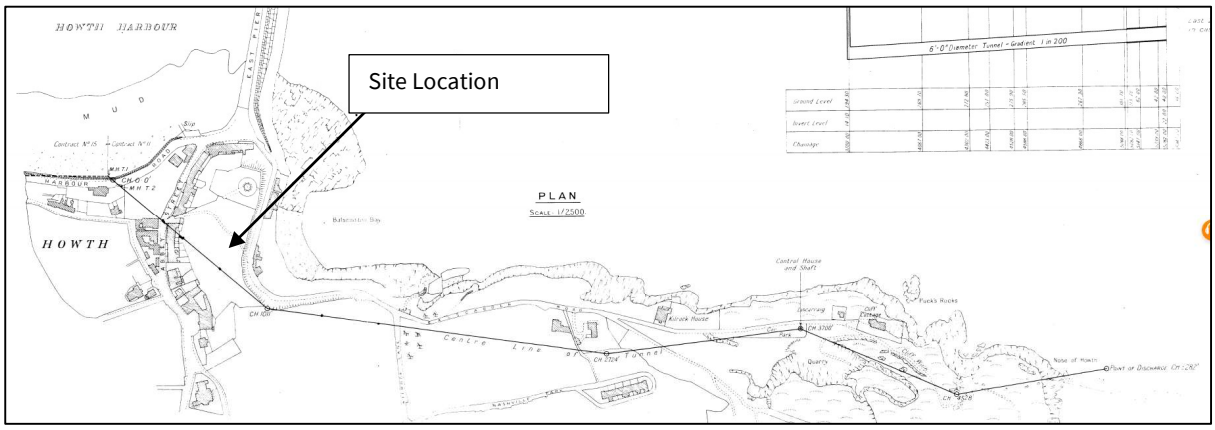

Figure 10.1: North Dublin Drainage Scheme – Howth Tunnel

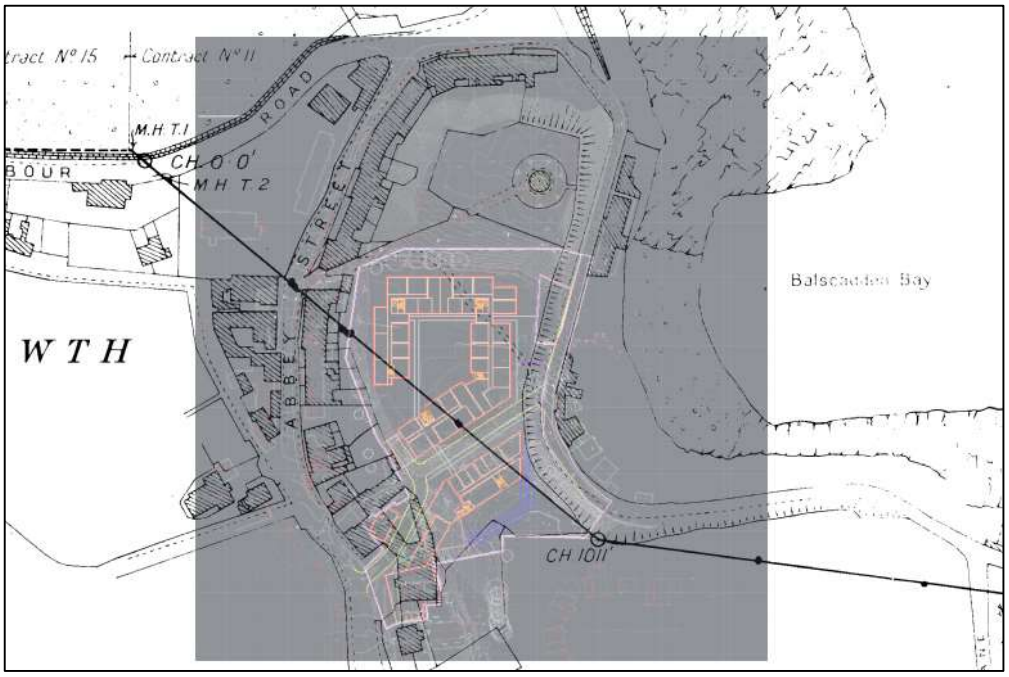

Figure 10.2: North Dublin Drainage Scheme – Howth Tunnel

10.2 Raft Foundations

The foundations proposed for this development are raft foundations. The raft area of the deepest, Block B, is approximately 5,300m^2 in area and 69m in width (based on latest Architectural plans). The basement proposed formation level is approximately +17.5m OD (which is approximately 3m below existing ground level) and the raft foundation will have a bearing pressure of 80kN/m^2 as confirmed by Waterman Moylan.

10.3 Stress Induced by Applied Loads

ByrneLooby have carried out an assessment to assess the change in stress applied to the sewer tunnel using Plaxis 2D. The analysis has been carried out for Block B, where the excavation shall be least. In areas north of Block B, where excavation depths are greater there will be a net reduction on stress on the tunnel, despite the raft foundation loadings.

The assessment has modelled the initial stresses on the tunnel and modelled the construction sequence through bulk excavation works and construction of raft slab and building loading.

Based on the above information, the stress on the tunnel prior to any construction works has been calculated as 373kN/m^2. Following bulk excavation works, construction of the basement raft slab and the building, the stress on the tunnel has been calculated as 387kN/m^2, resulting in an increase in stress of 14kN/m^2 (4% increase in stress), with the results shown in Figure 10.3 and Figure 10.4. It is noted that the tunnel sewer has been presented as a line indicating the assumed level of the tunnel invert. Based on the limited stress increase on the tunnel, and that the initial tunnel stresses being greater north of this section (where the overburden over the tunnel is significantly greater) than the net stresses under Block B, the above increase in stress is considered acceptable.

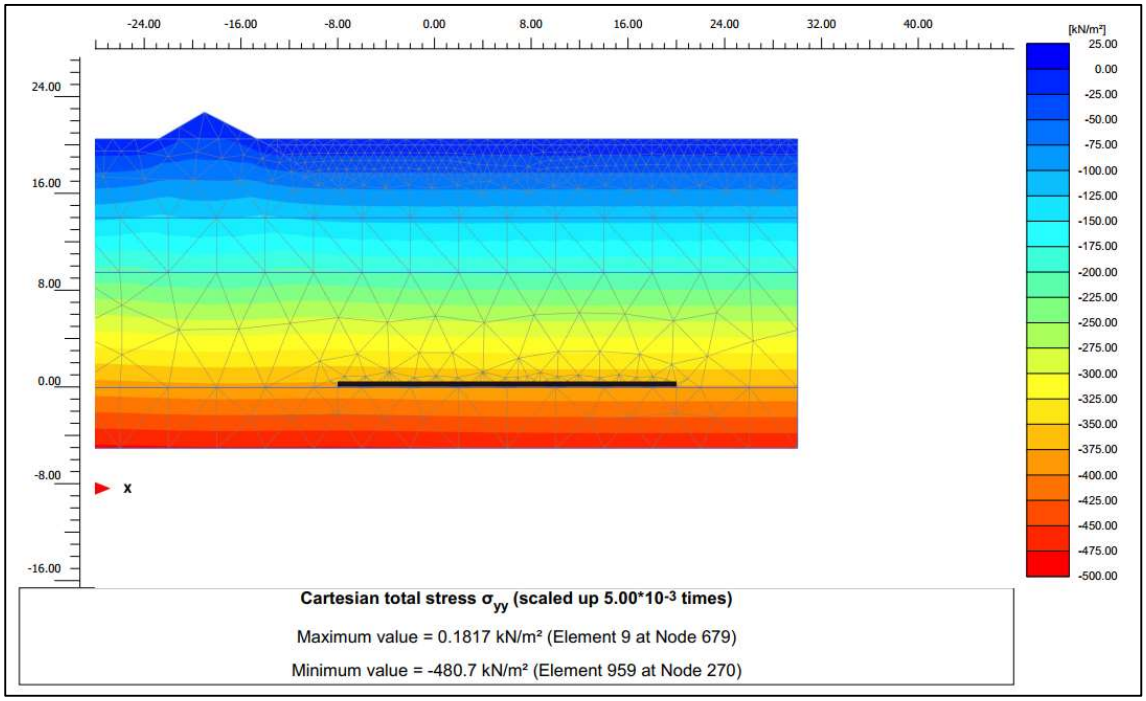

Figure 10.3: Sewer Assessment – Short Term

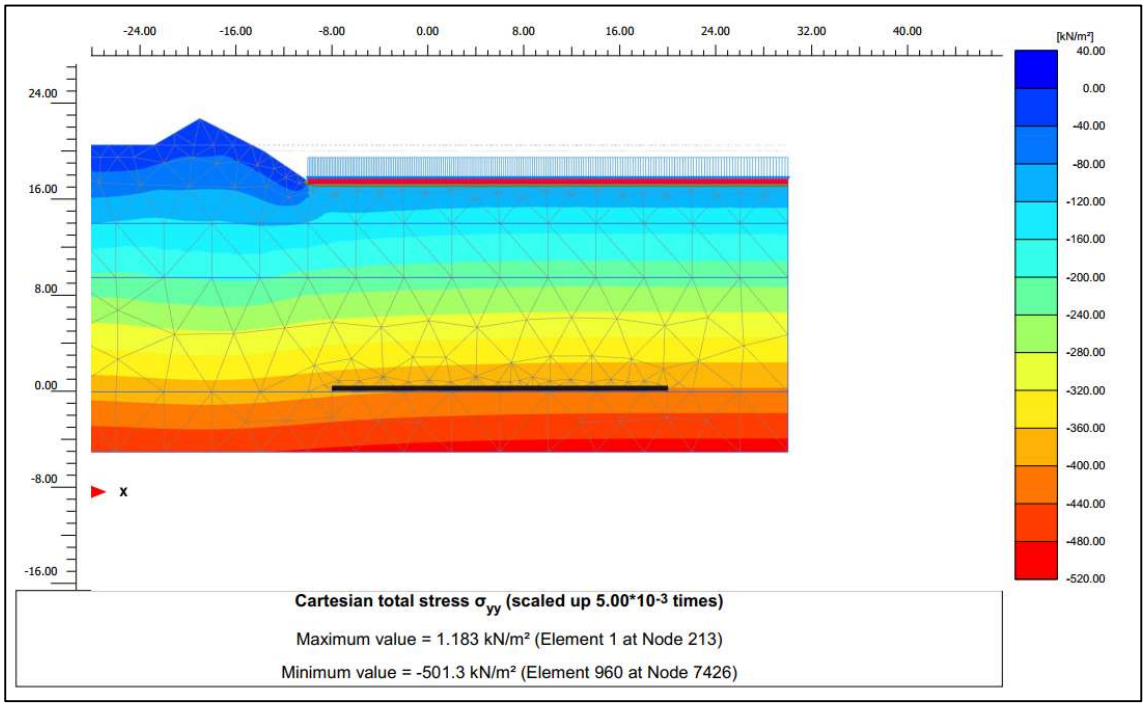

Figure 10.4: Sewer Assessment– Long Term

11 Conclusion

ByrneLooby have been requested by Balscadden GP3 to provide geotechnical design services for the proposed development at Balscadden Road, Howth. The engineer for the scheme is Waterman Moylan Consulting Engineers.

This report has been produced to detail the various geotechnical aspects covered in ByrneLooby's assessment. These include:

- Design of a secant pile wall with buttress piles along the southern elevation and building damage assessment based on predicted ground movements. Arising from the Damage Impact Assessment of neighbouring structures based on ground movements along this elevation, a Category 0 (Negligible Category) has been determined for the garage of 22 Asgard Park, while 21 and 22 Asgard Park lie outside the zone of sensitivity;

- Design of secant pile wall along the western elevation and building damage assessment based on predicted ground movements. Arising from the Damage Impact Assessment of neighbouring structures based on ground movements along this elevation, a Category 2 (Slight Category) has been determined for the for the single storey property to the rear of 25 Abbey Street. As outlined, Category 2 is considered an aesthetic damage category;

- Assessment of ground movements along northern elevation for open cut basement excavation. Arising from the Damage Impact Assessment of neighbouring structures based on ground movements along this elevation, it has been determined that the Martello Tower falls out of the zone of sensitivity caused by the basement excavation works;

- Proposed remedial works along eastern elevation. These proposed remedial works have been outlined as a soil nailing solution; and

- Assessment of raft slab foundation pressures on Howth Sewer Tunnel. The assessment has calculated an increase in stress on the sewer of 4%. As areas to the south of the assessed area are currently applying greater stresses than the calculated increased value, this increase in stress is considered acceptable.

Full details of the assessments are found within this report.

Appendix A – Designers Risk Assessment

Form 0066Q
Rev: 00
Effective Date: 18/04/2018

Project Risk Assessment of Safety and Health Hazards / Risks

Engineers Ireland

Designer's Assessment of Safety and Health Hazards / Risks

Project: Balscadden	**Designer: Nick Peters**	**Date:**	04/02/2022
Ref No: B1800-GEO-DRA01	**Checker: Maurice Ryan**	**Date:**	04/02/2022

Design Phase (Concept; Preliminary; Detailed or Redesign): Piling platform design

Note: review previous phase b/f items

No.	Key construction hazards (or risks) identified	Evaluations. Design decisions made (or alternative actions)
1	Unsuitable Wall Design for southern and western elevations	Secant Pile retaining walls designed in accordance with EC7 with recommendations from CIRIA C760. Walls have been designed based on recent site specific ground investigations and groundwater monitoring.
2	Formation Levels	Formation levels have been provided by the Engineer/Architect. Strict control over formation levels are to be implemented by the contractor. Formation levels are not to be exceeded.
3	Unforseen Ground Conditions	Secant Pile retaining wall has been designed in accordance with relevant SI data. Any variations in ground conditions should be communicated to the detailed pile designer.
4	Ground and adjacent building movement	ByrneLooby have outlined predicted movements based on the specimen design and the impact of these movements on adjacent structures/infrastructure.
5	Groundwater Levels	Minerex have completed a Hydrogeological Assessment Report which has outlined groundwater levels. The secant pile walls have been designed such that the female piles shall terminate at shallow depths than the male piles to allow flow of water beneath the slab level.
6	Martello Tower	A ground movement assessment has been carried out adjacent to the northern elevation. The assessment is considered conservative and shows that the movements will not impact on the Martello Tower.
7	Monitoring	Vibration monitoring is to be completed through the piling works to ensure no impact on the adjacent structures and infrastructure. Movement monitoring is to be carried out throughout the bulk excavation works based on the trigger limits outlined in the report.
8	Howth Sewer	ByrneLooby have carried out an assessment on the impact on the development on the underlying Sewer which shows there will only be a minor increase in stress on the sewer. As areas to the south of the site currently apply greater stress to the sewer, the above increase in stress at the location of the development is considered appropriate.
9		
10		

Notes re providing info.	Item Nos. (from above)	Remarks
a) For client's designer	All	
b) Hazards particular risks	-	
c) Other particular risks	-	
d) Re assumed construction methods	All	
e) For safety file	All	
f) In-house: b/f to future stages	-	

Other parties please take note: These are designer's risk evaluations of design options carried out in-house for the purpose of our complying with designer' duties under the Safety, Health and Welfare at Work (Construction) Regulations 2006 -2013, CDM2015 CDM2016 N.I. or other legislative EHS requirements. The evaluations relate only to those aspects / elements of the project which we are responsible for designing under the terms of our appointment by our client. Other Parties should not rely on these evaluations for their own purposes; in particular, contractors, who must deal with and control risk arising during construction, must carry out their own definitive risk assessment ab initio for that purpose

Appendix B – Minerex Hydrogeological Assessment Report

Hydrogeological Assessment Report for proposed development at Balscadden Road, Howth, Co. Dublin

Minerex Doc. Ref.: 3330-031 (Hydrogeological Assessment Report) (Rev 1)

Date: 21/02/2022

Report by:

Minerex Environmental Limited
Hydrogeological, Environmental and
Geophysical Services
Taney Hall, Dundrum, Dublin 14, Ireland
Dublin 14, Ireland
Tel.: +353-(0)1-2964435
Fax.: +353-(0)1-2964436
Email: enquiries@minerex.ie
Website: www.minerex.ie

Report To:

Shaun Thorpe
Heritage House,
23 St. Stephen's Green
Dublin 2
D02 AR55
Ireland

Prepared by:	**Reviewed by:**
	
Chris Fennell Ph.D	**Cecil Shine** B.Sc., M.Sc., PGeo, EurGeol
Hydrogeologist	Project Director Dewatering & Contaminated land

Minerex Environmental

Contents

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Executive Summary

1. The site for the proposed development is underlain by a thick layer of glacial sands, gravels and clays. A wide mapped fault is located along the southern end of the site dividing Carboniferous limestones (North) from older Cambrian Bedrock (South) with fault Breccia visible on the southern end of Balscadden Bay.
2. Continuous water level monitoring, site surveys, water sampling and hydrochemical analysis have been used to develop a conceptual hydrogeological site model.
3. The conceptual site model indicates groundwater flow towards Grays Brook to the west of the site, northwards towards the Martello tower and eastwards towards Balscadden Bay as evidenced by the mapped and sampled springs.
4. The conceptual site model indicates that the proposed development, which includes 2no. secant piled walls (south and west), is unlikely to impede groundwater flow or create any significant barrier effect. The southern piled wall does not extend to the water table. While the male piles of the western piled wall do extend to the water table the likelihood of any impedance of groundwater flow is mitigated due to the groundwater flow direction and the raised levels of the female piles.

1. Introduction

Minerex Environmental Limited (MEL) was commissioned by Marlet to carry out a hydrogeological assessment for a proposed development at Balscadden Road, Howth. Co. Dublin.

The scope of this report and the specific deliverables of the assessment, as requested, are as follows:

"A Hydrological Assessment of the site is required including an assessment of the groundwater levels and natural ground water flows and/or water courses adjacent to and within the site. The Hydrological Assessment shall address the proposed development in relation to the existing hydrology both within and adjacent to the site and shall include:

1. *Groundwater monitoring of the 2 no. borehole standpipe piezometers (via diver data logger or similar) over a 3-month period.*
2. *Logs for the monitoring of groundwater including a rainfall event.*
3. *Mapping of hydrological water courses both within and adjacent to the site.*
4. *Hydrological testing of existing water courses to determine source (saline testing).*
5. *Recommendations for the management of groundwater hydrology within the proposed development.*
6. *Impact of the proposed development on local groundwater hydrology.*
7. *Interpretive report."*

2. Site Description

2.1 Geology

The site is predominantly underlain by the Ballysteen Formation. The lithology of the Ballysteen Formation is described as irregularly bedded with nodular bedded argillaceous bioclastic limestones (wackestones and packstones), interbedded with fossiliferous calcareous shales (Appendix A). A mapped fault is shown towards the southern edge of the site separating the Ballysteen formation from the Elsinore Formation. The Elsinore Formation is described as a polymict melange of quartzite, greywacke, siltstone, mudstone, and calcareous sandstone in a chaotic mudstone-sandstone matrix. Components in this formation can vary in size from pebbles to blocks hundreds of metres across.

A description of the local geology of Balscadden Bay including the fault located at the southern end of the site is included in Ref. 1 (see Figures 2.1 and 2.2). The southern side of Balscadden Bay is comprised of Cambrian aged 500-million-year-old bedrock that is more typical of the rest of the Howth peninsula. A wide fault zone spans the entire back of Balscadden Bay with fault Breccias evident on the southern end of the beach (Figures 2.3 and 2.4). Further north, The Martello Tower is underlain by glacial sediments which are in turn underlain by the aforementioned Carboniferous Limestone that is visible gently dipping along the beach (Figure 2.5).

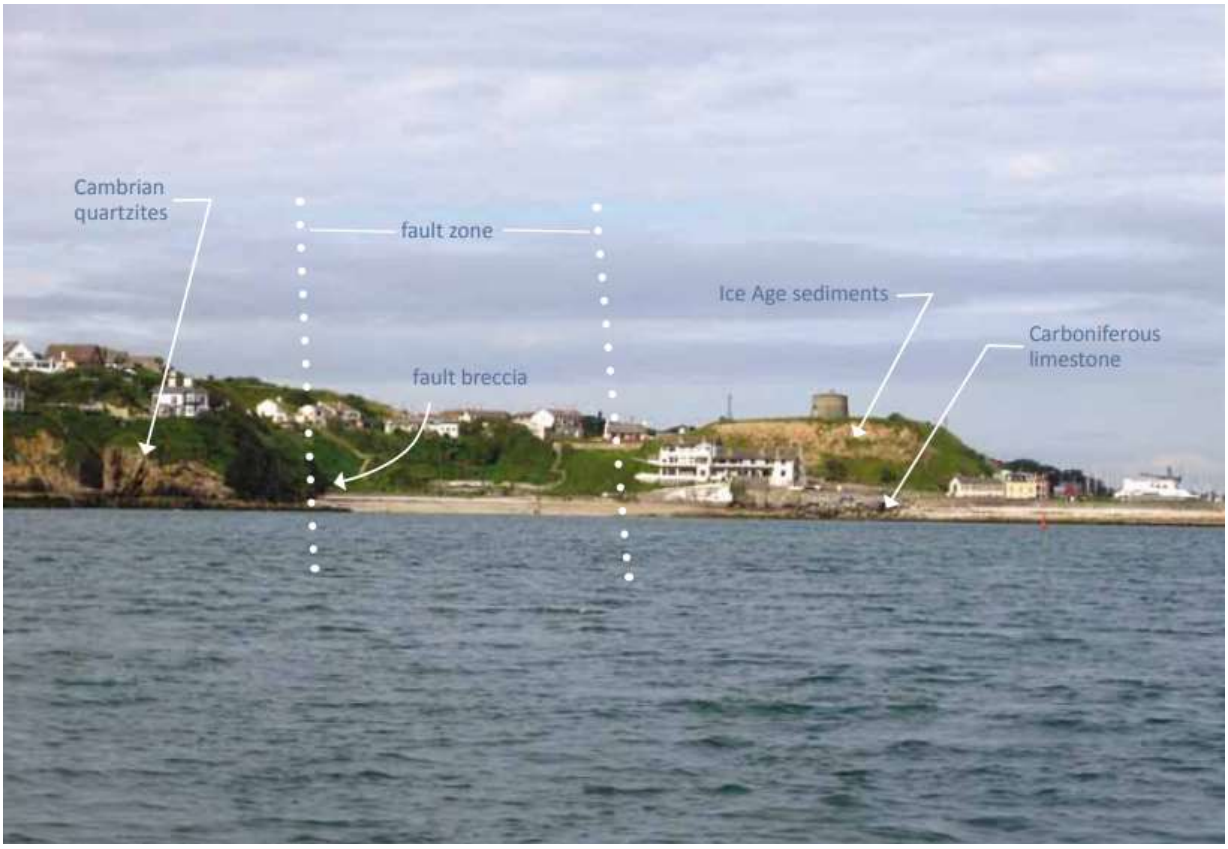


Figure 2.1 Eastward view of Balscadden Bay showing bedrock lithology and fault (Ref.1)

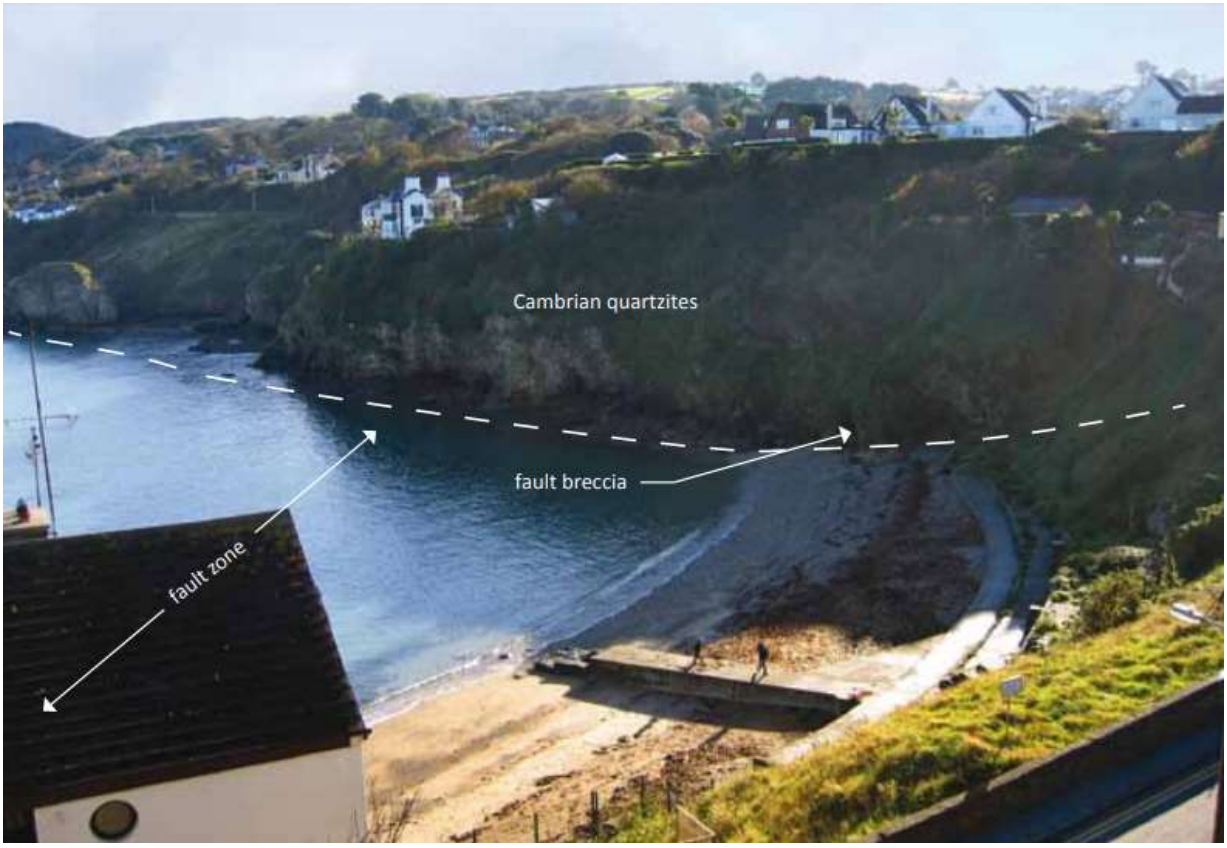


Figure 2.2 Southward view of Balscadden Bay showing bedrock lithology and fault (Ref.1).

Figure 2.3 Fault Breccia visible at the southern end of Balscadden Bay.

Figure 2.4 Fault Breccia visible at the southern end of Balscadden Bay.

Figure 2.5 Carboniferous limestone on Balscadden Beach.

2.2 Quaternary Sediment / Overburden

The Quaternary sediment overburden of the site is described as gravels from Lower Palaeozoic sandstones and shales. As described in Ref.1, the steep slopes surrounding the site and the Martello Tower to the north are exposures of thick sands and gravels deposited by glacial meltwaters. There is a layer of till on top of these that indicate an ice sheet advanced over the sands as a last episode of glaciation. Much of the subsoil is mapped as having low permeability (Appendix A).

2.3 Aquifer Classification

The classification of the aquifer underlying the site reflects the bedrock lithology described in Section 2.1. The portion of the site to the north of the fault underlain by the Ballysteen formation is classed as locally important aquifer with bedrock that is moderately productive only in local zones. To the south of the mapped fault the aquifer is classed as poor which is generally unproductive except for local zones (Appendix A).

2.4 Groundwater Recharge

The volume of effective rainfall likely to reach groundwater, i.e. recharge, can be estimated from recharge coefficients compiled by the Working Group on Groundwater, which are based on soil drainage, subsoil permeability, vulnerability and aquifer type (Ref. 2).

Areas classified as “made ground” are assigned a recharge coefficient of 20% (see Appendix A) due to likely restrictions in recharge as a result of paving, building etc. (Ref. 2). This recharge coefficient provides an average recharge value of 53mm/yr for the site and surrounding areas. While this likely represents the developed areas surrounding the site, as much of this site itself is undeveloped, this likely underestimates the recharge.

While groundwater recharge is indicated by the combination of soils and subsoils, a natural recharge capacity limit is applied to poorly productive aquifers to simulate ‘rejected recharge’. This reflects the limited ability of these aquifers to accept and transmit recharging waters.

The natural recharge capacity of locally important ‘Ll’ bedrock aquifers is taken as 200 mm/yr, and 100 mm/yr for poor ‘Pl’ and ‘Pu’ bedrock aquifers. Hence, the maximum recharge capacity for the proposed site is likely between 100 - 200 mm/yr.

2.5 Groundwater Vulnerability

Groundwater vulnerability at the site is mapped as ranging from High (H) at the east of the site to Extreme (E and X) towards the western edge of the site (Appendix A). High groundwater vulnerability represents

an area where the depth to rock or extent of subsoil overburden ranges between 3 – 10m. The Extreme (E) and (X) vulnerability categories represent areas where the subsoil thickness ranges from 0 – 3 m and where rock is at or near the surface respectively.

While much of the western half of the site is mapped as E/X, the site investigation boreholes (BH01 and BH02) indicate at least 17m of overburden is present at these locations. While the eastern half of the site is regarded as having High vulnerability, the log from BH03 shows there to be at least 12.8 m of overburden.

The discrepancy between the vulnerability map and the site investigation is likely attributable to limitations in the vulnerability mapping data and its resolution. Given the findings of the site investigation the vulnerability of the site is likely to be moderate or low.

2.6 Protected Areas

The area to the east of the site, including Balscadden Bay and extending south around Howth Head and north along the East Pier, is designated under the Howth Head Special Area of Conservation (SAC) (Appendix A).

2.7 Surface Water Features

The EPA rivers database (Ref. 3) show two streams, one to the east and one to the west of the site (Appendix A). Gray's Brook flows northwards along Main Street onto Abbey Street where it flows along the west side of the site. It passes under Harbour Road and enters the sea to the east of the Yacht Club. Coolcur Brook, to the west of the site, flows northwards along Kilrock Road and enters the sea at the southern end of Balscadden Bay.

A more comprehensive and historical description of both rivers and their tributaries is presented in Ref. 4 (Figure 2.6). The Coolcur Brook has a catchment area of 47 hectares and is bounded by the Gray's Brook catchment on the west and the Kilrock and Canon Rock area on the east and north-east of the hill. Gray's Brook has a catchment area of 96 hectares and is bounded on the west by the Offington Stream catchment.

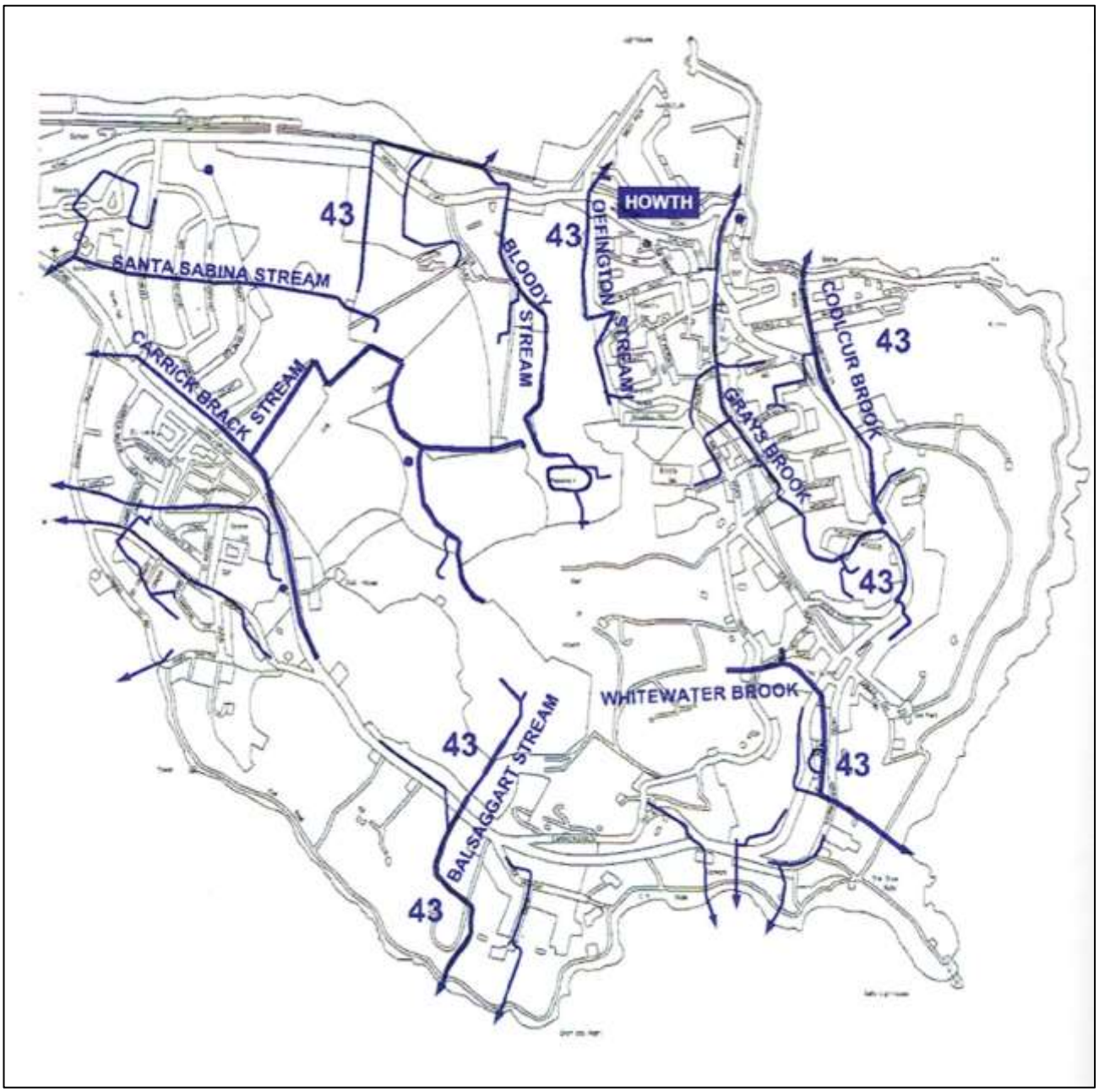


Figure 2.6 Rivers of Howth Head and Balscadden Bay (Ref. 4).

2.8 Howth Tunnel

The Howth Tunnel was constructed between 1955 and 1956 as the last section of a Main Trunk Sewer. It consists of a high and low level tunnel, which together are one-mile long (Ref. 5). The internal diameter of the sewer is 6.0 feet (1.83m) throughout the tunnel. The first 300m (1,000 feet) of the tunnel (from the Harbour Road Shaft), had to be supported with the primary lining RC segment rings. In that area material was not self – supporting or sound, and it predominantly consisted of boulder clay, limestone rock, dense clays of various colours, and loose brecciated quartzite rock. The tunnel passes under the site as shown in Figure 3.3.

3. Sampling & Assessment

3.1 Site Investigations

An initial site investigation was carried out in September 2017. Cable percussion boring was undertaken at 1 no. location (BH-GDG-01 – see Figure 3.1) using a Dando 150 rig to construct a 200mm diameter borehole. The borehole terminated at the scheduled depth of 20mbgl.

The groundwater standpipe installation incorporated a bentonite seal from 13.00mbgl to 14.50mbgl with a gravel response zone below this to 18.00mbgl and a second bentonite seal at the base of the response zone. The standpipe was installed to 18.00mbgl with a 3m slotted section back to 15.00mbgl to allow for any groundwater in this zone to ingress. A geosock was placed around the pipe at the slotted section. The borehole log is presented in Appendix B.

Following completion, a period of groundwater monitoring was undertaken. The well was found to be dry on four separate occasions throughout October 2017. This borehole was found to dry during all Minerex site visits in 2021.

In accordance with a Specification for Site Investigation Requirements Report issued by Waterman Moylan, two further S.I boreholes were scheduled for construction. In June 2021 cable percussion boring was undertaken at 3 no. locations (see Figure 3.1) using a Dando 150 rig to construct 200mm diameter boreholes. The boreholes terminated at depths ranging from 13.00mbgl (BH03) to 17.20mbgl (BH02) when obstructions were encountered. Groundwater monitoring standpipes were installed consisting of slotted pipe surrounded by a gravel response zone with bentonite seals (see Appendix C).

3.2 Monitoring & Sampling

3.2.1 Borehole Monitoring

Continuous groundwater level loggers or “divers” were installed in 2 no. boreholes (BH01 and BH02) for a nine-week period from August to October 2021. Groundwater levels were manually measured using a Solinst Dip meter during this period.

Boreholes BH01 and BH02 were sampled twice during the monitoring period (10/09/2021 and 06/10/2011). Prior to sampling the water level and total borehole depth of each monitoring point was recorded using a Solinst dip meter. Static water level was recorded with respect to a fixed point on the top of the well casing (noted on field sheet) with the height of this fixed above ground level also recorded. Sampling was conducted using a 12V submersible WASP five stage pump with dedicated tubing for each borehole. Prior to sampling each borehole was purged in accordance to BS ISO 5667:11. Samples were only taken once the stabilisation of field hydrochemical parameters was achieved. All field hydrochemical

parameters (pH, electrical conductivity and temperature) were recorded using a HANNA INSTRUMENTS™ Probe calibrated using respective standard solutions.

3.2.2 Surface Water Monitoring

Three samples were taken from surface water streams in proximity to the site on the 10/09/2021. The locations and photos of each sampling points is presented in Figure 3.2. One sample (SW3) was taken upgradient of the site from Gray's Brook after is passes through a culvert under Dungriffin Road.

Note, there are discrepancies between the published Ref. 3 and Ref. 4 maps as to where Gray's Brook enters the sea. A sample (SW2) was taken from a visible surface discharge into the sea just east of the Yacht club. This is in proximity to where it is mapped by Ref. 3 and is likely Gray's Brook. A sample (SW01) was also taken from where Ref. 4 states it enters the sea at the base of East Pier.

No samples could be obtained from Coolcur Brook to the east of the site due to restricted access.

3.2.3 Spring Monitoring

A site survey and coastal assessment was carried out during low tide on the 10/09/2021. Groundwater springs were mapped and recorded. Several springs and seepages were observed along the western edge of the site, both on Balscadden Road and Balscadden Beach. Several seepages are evident on the retaining wall running along Balscadden Road at the base and to the west of the Martello Tower. These seepages are also apparent where they run onto the road itself.

Several spring discharges are apparent along the length of the beach. These are visible through a combination of pipe drains cast into the retaining wall at the top of the beach as well as through several weakness/pathways in the concrete. At low tide, spring discharge can be seen flowing over the beach and outcropping limestone on the northern part of the bay.

Three springs were sampled where sufficient water volume could be obtained. The locations and photos of each sampling point is presented in Figure 3.3. Sample SP1 was obtained from a concrete trough on Balscadden Road. The trough is fed from a drainage pipe cast into the retaining wall below the Martello Tower. Sample SP2 was obtained from a spring seepage apparent underneath the buildings at the northern end of Balscadden Bay. Sample SP3 was obtained from a spring flow through the concrete wall and pathway at the top of Balscadden Beach. This spring was located below the pedestrian steps to the beach. Several springs are also visible in the breccia exposed on the southern end of Balscadden Bay (Figure 2.4) however, flows were not sufficient to obtain a sample.

The western and northern bounds of the site (along Abbey Street) was also examined for the presence of springs. None were observed; however, the built-up nature of this area means observations are limited.

Figure 3.1
S.I Boreholes

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

Site Outline

2021 S.I Boreholes

2017 S.I Borehole

BAld

BH01
2021 S.I

BH02
2021 S.I

BH03
2021 S.I

BH-GDG-01
2017 S.I

Howth Harbour
H o w t h H a r b o u r
West Pier
Church St
Dunro Hill
Harbour Rd
Abbey St
Balscadden Bay
Evora Pk
View
Harbour
Saint
Lawrence Rd
Grace O'Malley Rd
Main St
Tucketts Ln
Balkill Pk
Saint
Nessan
Nashville Rd
Kilrock Rd
Nashville Pk
100 m

Minerex Environmental

Figure 3.2
Surface Water Sampling Points

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

Site Outline

Surface water sampling location

Grays Brook

N

100 m

Howth
East Pier
Abbey Street
Church Street
Balscadden Road
Leinster
County Dublin
Howth ED
Fingal
Balscadden Road
Grace O'Malley Road
Grace O'Malley Drive
St Lawrence Terrace
Tuckett's Lane
Howth Primary School, Scoil Mhuire
Main Street
Asgard Park
Kilrock Road
Kilrock House
Nashville Park
Nashville Road
St Nasan's Close
St Peter's Terrace
Balkill Park
Howth Allotments
Thormanby Road
Cowbooter Lane
Thormanby Lawns
Upper Cliff Road
Dungriffin Road
Woodcliff Heights
Balkill Road
Hill of Howth Tramline Path

Minerex Environmental

Figure 3.3
Sampling Locations

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.Rev.1
Drawn by: CF 22/10/2021

Common Legend

- Site Outline
- Borehole (2021 S.I)
- Borehole BH-GDG-01 (2017 S.I)
- Spring (Sampled)
- Spring (Not sampled)
- Surface water sample
- Proposed secant pile wall (approximate)

Minerex Environmental

N

Coastline

Gray's Brook

Approx. line of Howth Tunnel

A'

A

BH1 Static WL: 7.63 mOD (MEL 21/10/21)

BH2 Static WL: 10.77 mOD (MEL 21/10/21)

BH3 Static WL: 14.91 mOD (MEL 21/10/21)

west

south

Fault

100 m

SP3

SP1

SP2

4. Results & Assessments

4.1 Hydrochemistry

Hydrochemistry results are presented in Table 4.1. Corresponding laboratory certificates of analysis are included in Appendix D.

The hydrochemical signatures associated with the surface water, groundwater and spring samples taken at the site are illustrated using a trilinear Piper diagram in Figure 4.1. The ultimate source of most dissolved ions in groundwater is the mineral assemblages in rocks near the land surface. Consequently, a general relationship between the mineral composition (or the hydrochemical signature) of natural water and that of the solid minerals with which the water has been in contact is to be expected. The term “hydrochemical facies” is used to describe the different types of groundwater hydrochemical signatures brought about by these interactions.

The hydrochemical signature associated with both BH1 and BH2 are similar and are consistent across the two separate sampling events. The hydrochemical results are consistent with a calcium/magnesium/bicarbonate signature. This is consistent with the carbonate nature of limestone bedrock.

The signatures from samples SW1 and SW2 are likely skewed towards a high sodium signature due to saline coastal influences. Both sampling points are submerged during high tide. While the samples were taken at low tide the saline signature was still evident. This is consistent with the electrical conductivity recorded at the time of sample (37,800 and 23,000 μS/cm). Comparisons between the upgradient and downgradient sample from Grays Brook are therefore challenging.

Sample SW3, taken upgradient of the site, is notably similar to the signature recorded at BH1 and BH2 (calcium/magnesium/bicarbonate). The sample was, however, significantly less mineralised, with lower concentrations of the major ions as would be expected from a surface water system.

The hydrochemical signature associated with samples SP1 and SP2 is notability consistent with BH1, BH2 and SW3. While SP1 has a similar signature, it is less mineralized compared to BH1, BH2 and SP2, with the conductivity less than half. This is consistent with mixing occurring between the natural groundwater and a less mineralized surface water. As this spring sample was taken from underneath the buildings on Balscadden Road, the mixing could be a result of a mains water leak.

The signature from SP3 has higher concentrations of sodium and potassium compared to SP1 and SP2. However, remaining hydrochemical parameters are consistent with the S.I boreholes and SP2. Note, sample SP3 was taken directly from the concrete trough on Balscadden Road due to insufficient flow from the spring. Hence, the water would have been stagnant. The elevated sodium and potassium concentrations would be consistent with increased exposure to the coastal environment.

Table 4.1 Hydrochemistry result for borehole, spring and surface water monitoring.

Minerex Environmental		BH1	BH2	BH1	BH2	SP1	SP2	SP3	SW1	SW2	SW3
Parameter	**Unit**	**13/09/2021**		**06/10/2021**		**13/09/2021**			**13/09/2021**		
Alkalinity, Total as CaCO3	mg/l	355	300	348	390	115	305	315	155	180	150
Ammoniacal Nitrogen as N	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ammoniacal Nitrogen as NH4	mg/l	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chloride	mg/l	74.1	77.9	80	81	33.5	110	115	16300	9290	40.1
Conductivity	uS/cm	887	856	897	847	446	980	977	37800	23000	483
pH	pH	7.39	7.27	7.3	7.16	8.13	7.57	7.69	7.81	7.71	8.04
Nitrate as NO3	mg/l	35.3	30.2	37.1	29.4	7.61	30.7	<0.35	4.27	9.27	6.88
Phosphate (Ortho as P)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.0281	0.079	0.0826	0.03
Sulphate	mg/l	113	66.3	113	66.5	43	58.6	51.7	2240	1210	50.5
Calcium (Dis.Filt)	mg/l	123	116	126	122	52	122	81.4	343	228	66.8
Iron (Dis.Filt)	mg/l	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	0.0433	<0.114	<0.019	0.109
Magnesium (Dis.Filt)	mg/l	20.5	18.9	20	19	5.86	20.5	19.5	1020	624	8.85
Manganese (diss.filt)	µg/l	43.7	6.9	5.78	<3	<3	<3	9.69	<18	<3	44.4
Phosphorus (diss.filt)	µg/l	<10	<10	<10	<10	<10	<10	23.9	78.6	91.9	54.5
Potassium (Dis.Filt)	mg/l	8.36	5.71	9.71	5.5	2.94	7.27	11.9	299	175	2.44
Sodium (Dis.Filt)	mg/l	42.3	44.3	42.5	42.4	22.1	56.4	93.7	8940	5050	26

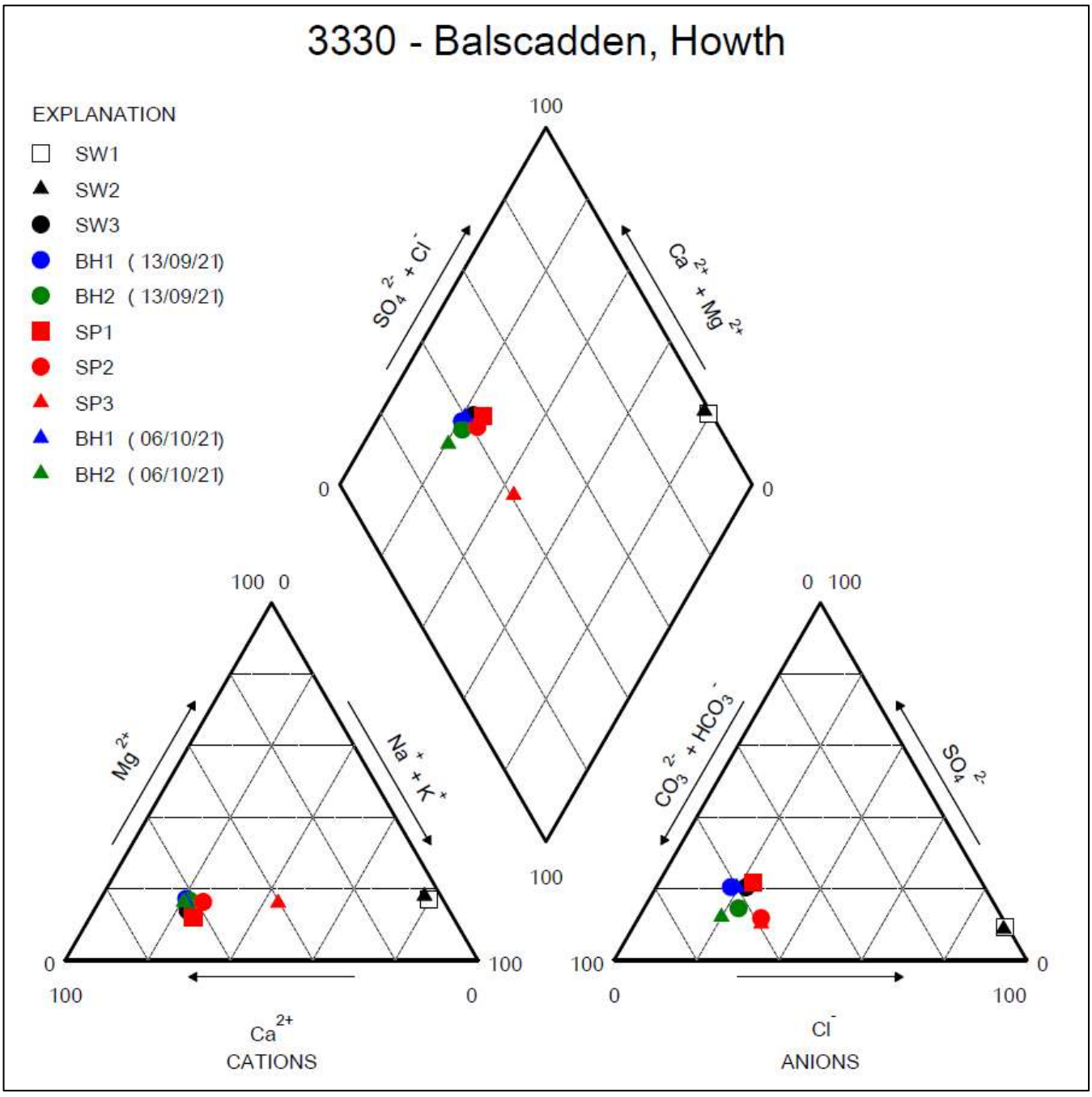


Figure 4.1 Hydrochemical signatures associated with the samples obtained (Ref. 6).

4.2 Water Level Monitoring

Continuous water level data and antecedent rainfall taken from Met Eireann (Dublin Airport) is presented in Figures 4.2 – 4.4. The water level was consistently deeper (approx. 3m) in BH01 compared to BH02. Borehole BH-GDG-01 was dry during initial monitoring in 2017. It was dry throughout the course of this investigation in 2021.

Figure 4.2 Continuous water level data from BH01 and BH02.

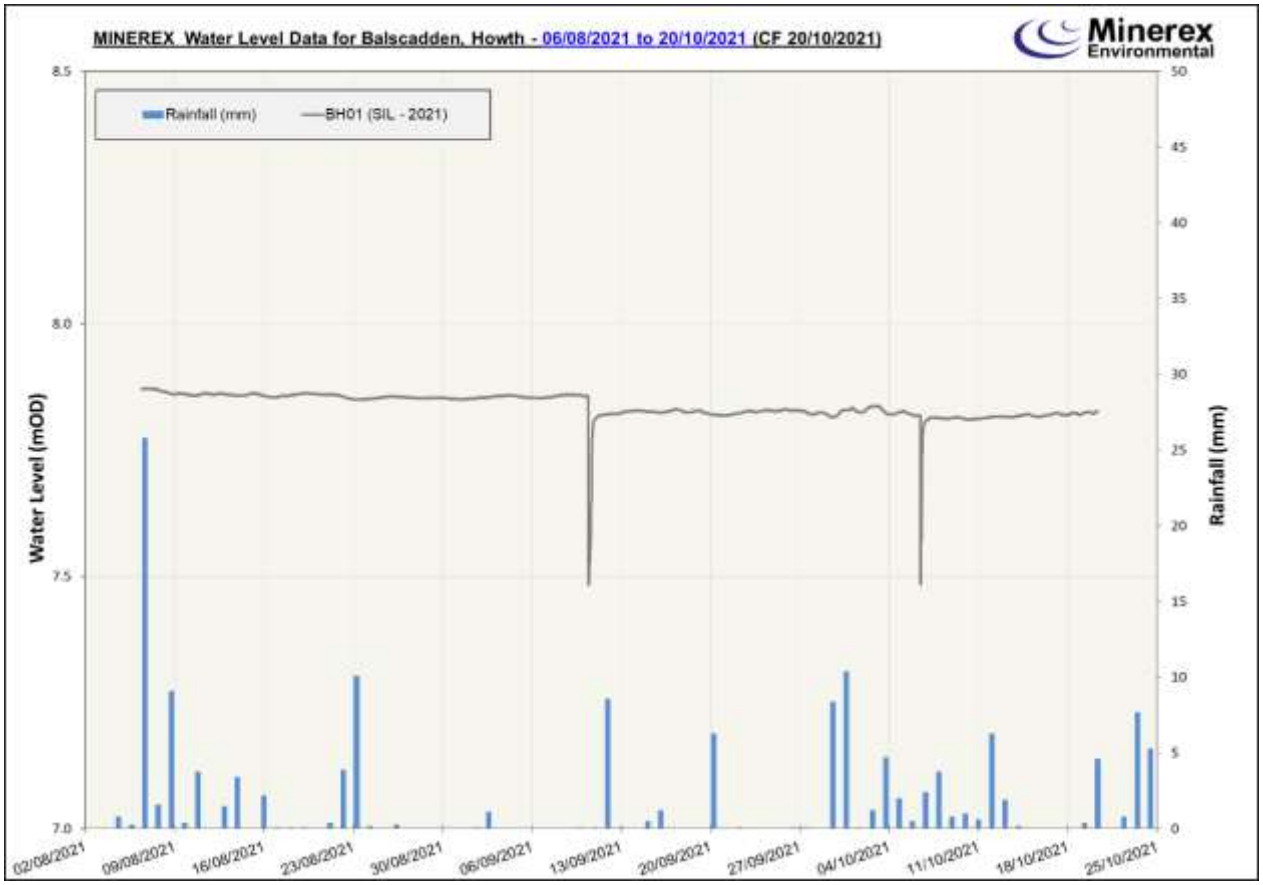


Figure 4.3 Continuous water level data from BH01 and antecedent rainfall.

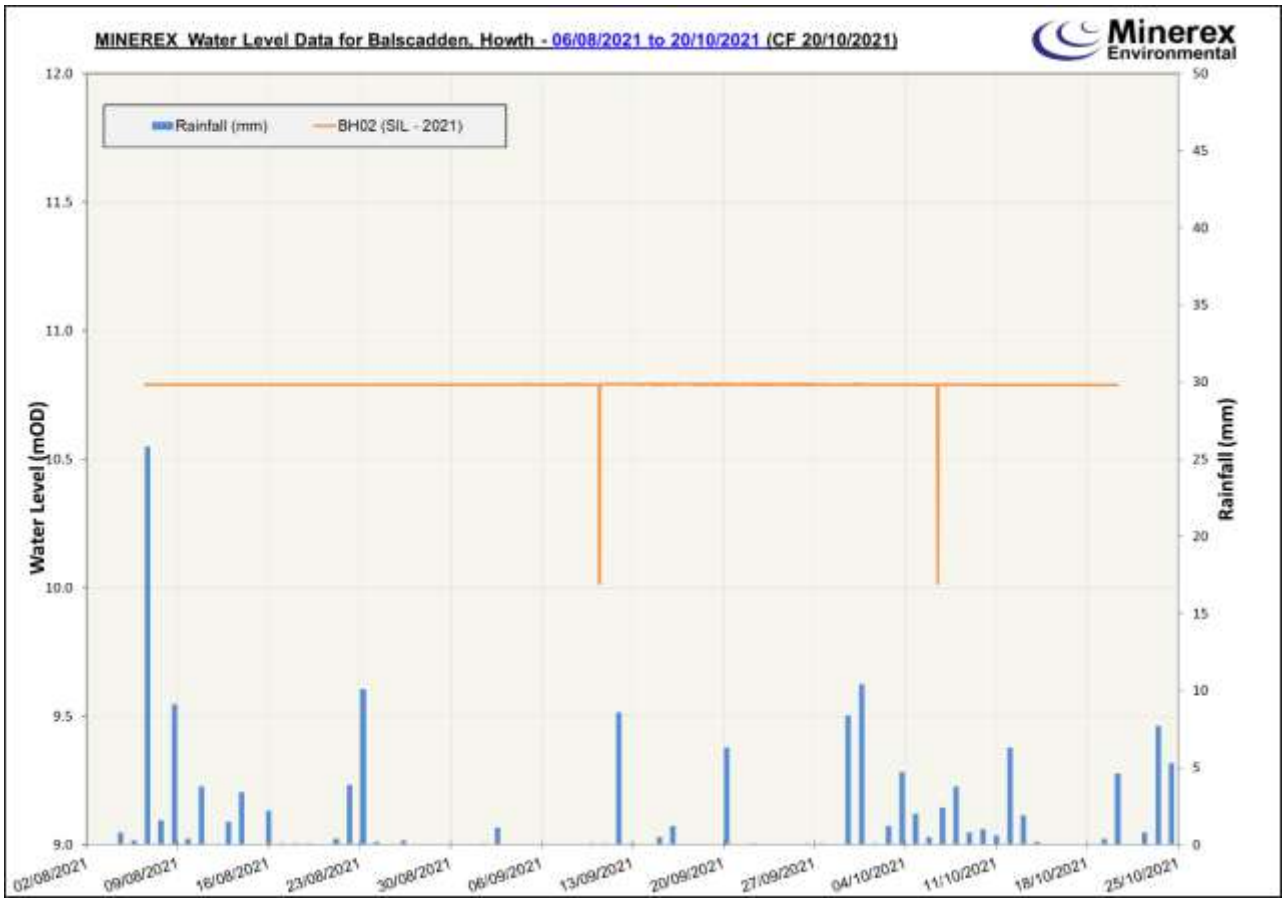


Figure 4.4 Continuous water level data from BH02 and antecedent rainfall.

5. Proposed Development & Local Hydrogeology

5.1 Conceptual Hydrogeological Site Model

A conceptual hydrogeological site model including conceptual groundwater contours and flow directions is presented in Figure 5.1.

As shown, groundwater flow is likely bound to the west of the site by Gray's Brook, with baseflow contributions likely from the western boundary of the site towards the Brook. A steep groundwater gradient from BH3 to BH1 is consistent with a northwards flow direction. Groundwater flow to the east is also apparent as evidenced by the presence of springs along Balscadden Road and Balscadden Bay. This is consistent with the hydrochemical signatures presented in Section 4.1. Bedrock groundwater flow is likely bounded to the south by the mapped fault. Seepages apparent in the Breccia located on the southern end of Balscadden Bay is consistent with groundwater flow along this fault.

The influence of the Howth Tunnel on the hydrogeological regime of the site is uncertain and would depend on the integrity of the lined section of the tunnel.

The groundwater hydrograph for BH01 and BN02 suggests little correlation with rainfall, at least on a short to medium timescale. This is consistent with depth and nature of the overburden. Further monitoring would be required to identify temporal variability of hydrographs in the long term. However, significant variation in the water level would not be expected seasonally.

5.2 Proposed Development Structures

Plans and section for the proposed development were provided to Minerex by Waterman Moylan and Byrne Looby. Two secant piled walls are planned as part of the development. One is located on the southern boundary of the site with the second located along a short section of the western boundary.

It is proposed that the male and female piles on the southern piled wall will extend to 17mOD and 23.5mOD, respectively. It is proposed that the male and female piles on the western piled wall will extend 11.5mOD and 16mOD, respectively. An 850mm RC raft slab will be constructed with an SSL of 18 mOD under a portion of the proposed development.

5.3 Proposed Development Influence on Hydrogeology

A conceptual cross section of the site, including the S.I boreholes, water level data and proposed piled walls is presented in Figure 5.2. The male piles of the southern piled wall do not extend to the water table (male pile toe level 17mOD). The likelihood of any disruption of groundwater flow and the creation of any barrier effect is low. This is further mitigated by the raised female pile toe level as the subsequent

gaps (conservative estimate of 15% open area) between the male and female piles will facilitate any flow from the unsaturated zone.

The base of the male piles in the western piled wall do potentially extend to the water table. However, any disruption to groundwater flow is mitigated by the level of the female piles. Furthermore, as shown in Figure 5.1, the inferred groundwater flow direction at this location is not perpendicular to the wall and rather is closer to parallel, further reducing the likelihood of any barrier effect.

Given a formation level of approximately 17mOD for the basements of the proposed development the likelihood of any disruption to groundwater flow is low. The nature of the bedrock and overburden give rise to a low recharge coefficient for the site. The development and the construction of any paved surfaces will likely further reduce the natural recharge capacity of the site. This should be mitigated against using permeable paving and adequately designed soakaways to manage surface water where possible.

Figure 5.1
Conceptual Site Model

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.Rev.1
Drawn by: CF 22/10/2021

Common Legend

- Site Outline
- Borehole (2021 S.I)
- Borehole BH-GDG-01 (2017 S.I)
- Spring (Sampled)
- Spring (Not sampled)
- Surface water sample
- Proposed secant pile wall (approximate)
- Groundwater equipotentials
- Conceptual GW flow direction

Minerex Environmental

Figure 5.2 Hydrogeological Cross-Section

Minerex Environmental

Drawing Ref: 3330-008.
Drawn by: CF 21/10/2021

A (South)

A' (North)

Looking West

mOD

36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2

BH-GDG-01
SIL
04/10/2017
Level
34.67m

BH consistently dry

EOH @
14.67mOD

Southern
Pile Wall
1200mm

Base of female
piles 23.5mOD

Base of male
piles 17mOD

BH03
SIL
28/06/2021
Level
19.42m

This well is located to the west of the site where the ground slopes from the level represented by the black line (shown above) towards towards Abbey Street (West)

Static WL:
4.51 mbGL
(MEL 21/10/21)

EOH @
6.42mOD

Ground level

Western Pile
Wall
900mm

Base of female
piles 16mOD

Base of male piles
11.50mOD

Water level

BH02
SIL
18/06/2021
Level
19.58m

Static WL:
8.81 mbGL
(MEL 21/10/21)

EOH @
2.38mOD

BH01
SIL
23/06/2021
Level
19.98m

Static WL:
12.35 mbGL
(MEL 21/10/21)

EOH @
2.98mOD

Howth Tunnel
(invert level 5mOD)

LEGEND

MADE GROUND	NATURAL GROUND
1	2 Clay, 3 Sand, 4 Gravel, 5 Obstruction – possible boulder

6. Summary & Conclusions

1. The site for the proposed development is underlain by a thick layer of glacial sands, gravels and clays. A wide mapped fault is located along the southern end of the site dividing Carboniferous limestones (North) from older Cambrian Bedrock (South) with fault Breccia visible on the southern end of Balscadden Bay.

2. Continuous water level monitoring, site surveys, water sampling and hydrochemical analysis have been used to develop a conceptual hydrogeological site model.

3. The conceptual site model indicates groundwater flow towards Grays Brook to the west of the site, northwards towards the Martello tower and eastwards towards Balscadden Bay as evidenced by the mapped and sampled springs.

4. The conceptual site model indicates that the proposed development, which includes 2no. secant piled walls (south and west), is unlikely to impede groundwater flow or create any significant barrier effect. The southern piled wall does not extend to the water table. While the male piles of the western piled wall do extend to the water table the likelihood of any impedance of groundwater flow is mitigated due to the groundwater flow direction and the raised levels of the female piles.

7. References

No.	Description
1	Parkes, M (2012) Islands, Coasts and Quarries. The Geological Heritage of Fingal. Fingal County Council
2.	Hunter Williams, N.H., Misstear, B.D., Daly, D and Lee, M (2013) Development of a national groundwater recharge map for the Republic of Ireland. *Journal of Engineering Geology and Hydrogeology*, **46**, 493-506.
3	EPA Geoportal Map Viewer (2021) Environmental Protection Agency
4	Sweeney, C.L., O'Connell, G and Curtis, M (2017) The Rivers of Dublin. Irish Academic Press: Kildare.
5	O'Connor Sutton Cronin (2019) Rennie Place Strategic Housing Development, Balscadden Road, Howth, Co. Dublin. Structural and Geotechnical Engineering Report for CREKAV TRADING GP LTD.
6	Winston, R.B., 2020, GW Chart version 1.30: U.S. Geological Survey Software Release.
7	Public Data Viewer Series (2021) Geological Survey of Ireland

8. Appendices

Appendix A

Drawing Title
Bedrock Geology

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

Site Outline

WA Waulsortian Limestone
- Massive unbedded lime-mudstone

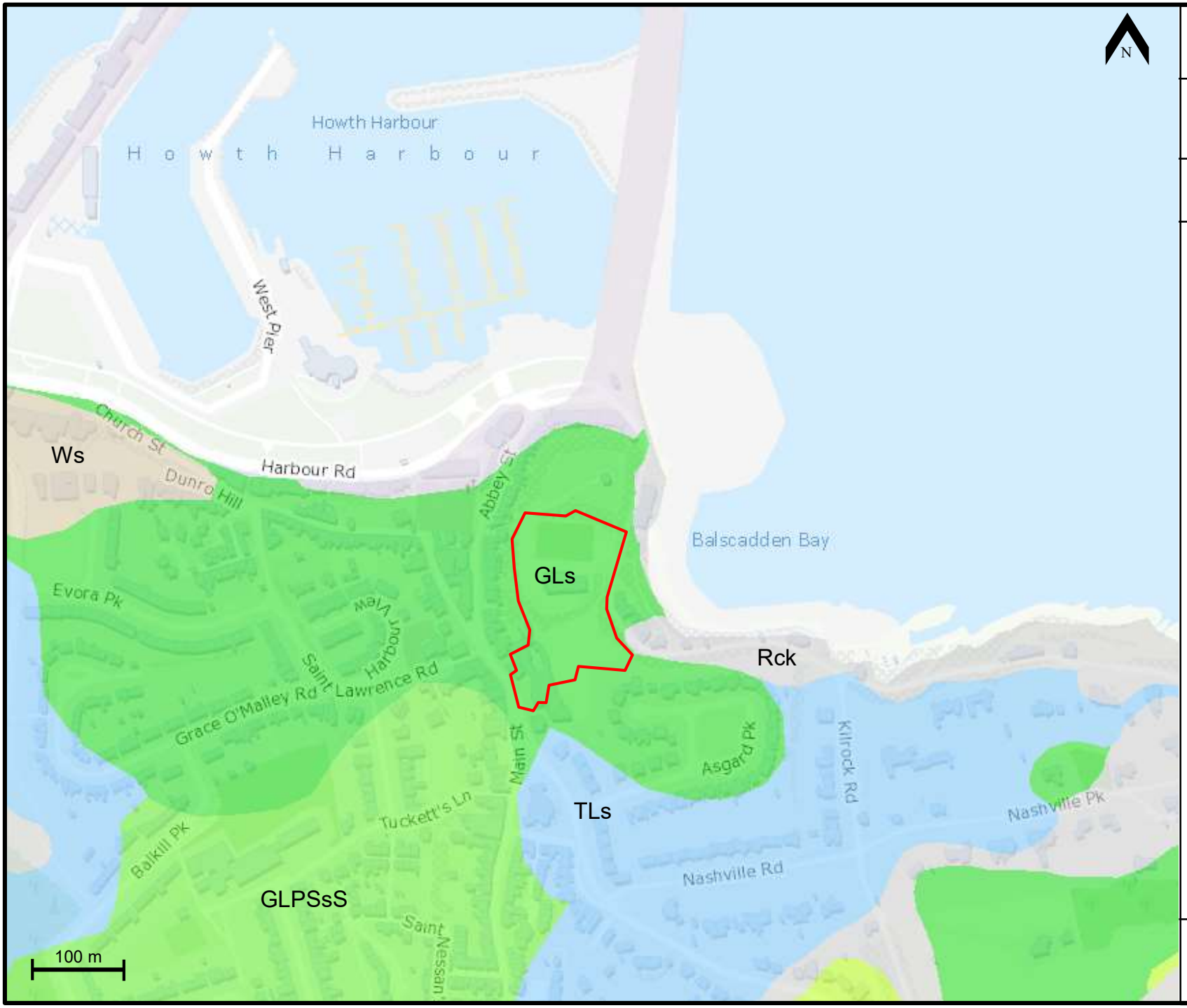
BA Ballysteen Formation
- Dark muddy limestone, shale

EL Elsinore Formation
- Polymict melange

DK Drumleck Formation
- Quartzite & mudstone melange

Ref.7

Minerex Environmental



Drawing Title
Quaternary Sediments

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

- Site Outline
- *GLs* Gravels derived from Limestones
- *TLs* Till derived from Limestones
- *GLP SsS* Gravels derived from Lower Palaeozoic sandstones and shales
- *Ws* Windblown sands
- *Rck* Bedrock outcrop of subcrop

Ref.7

Minerex Environmental

Drawing Title
Subsoil Permeability

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

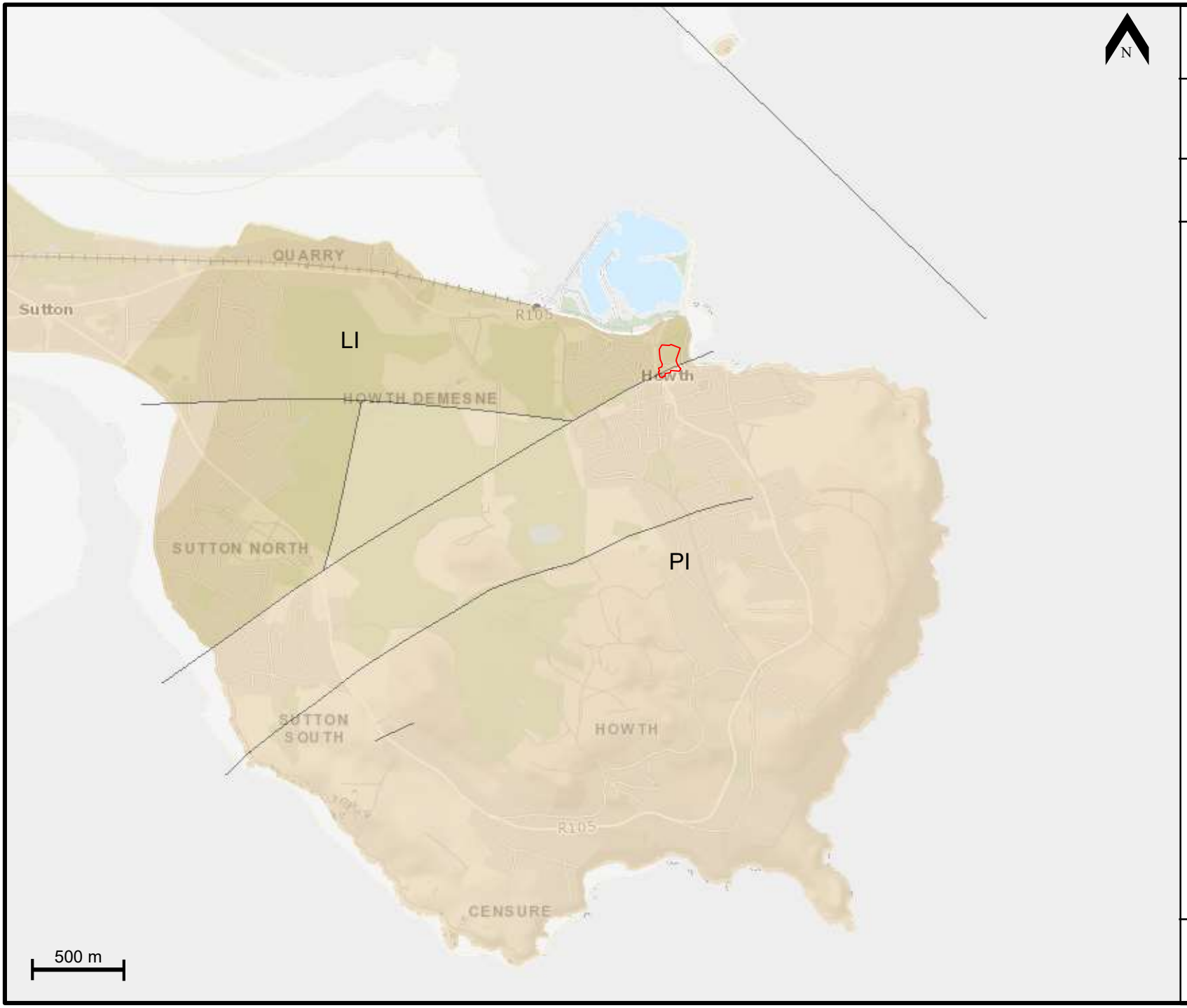
Common Legend

Site Outline

L Low permeability

Ref.7

Minerex Environmental



Drawing Title
Aquifer Classification

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

Site outline

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

Ref.7

Minerex Environmental

Drawing Title
Groundwater Recharge

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

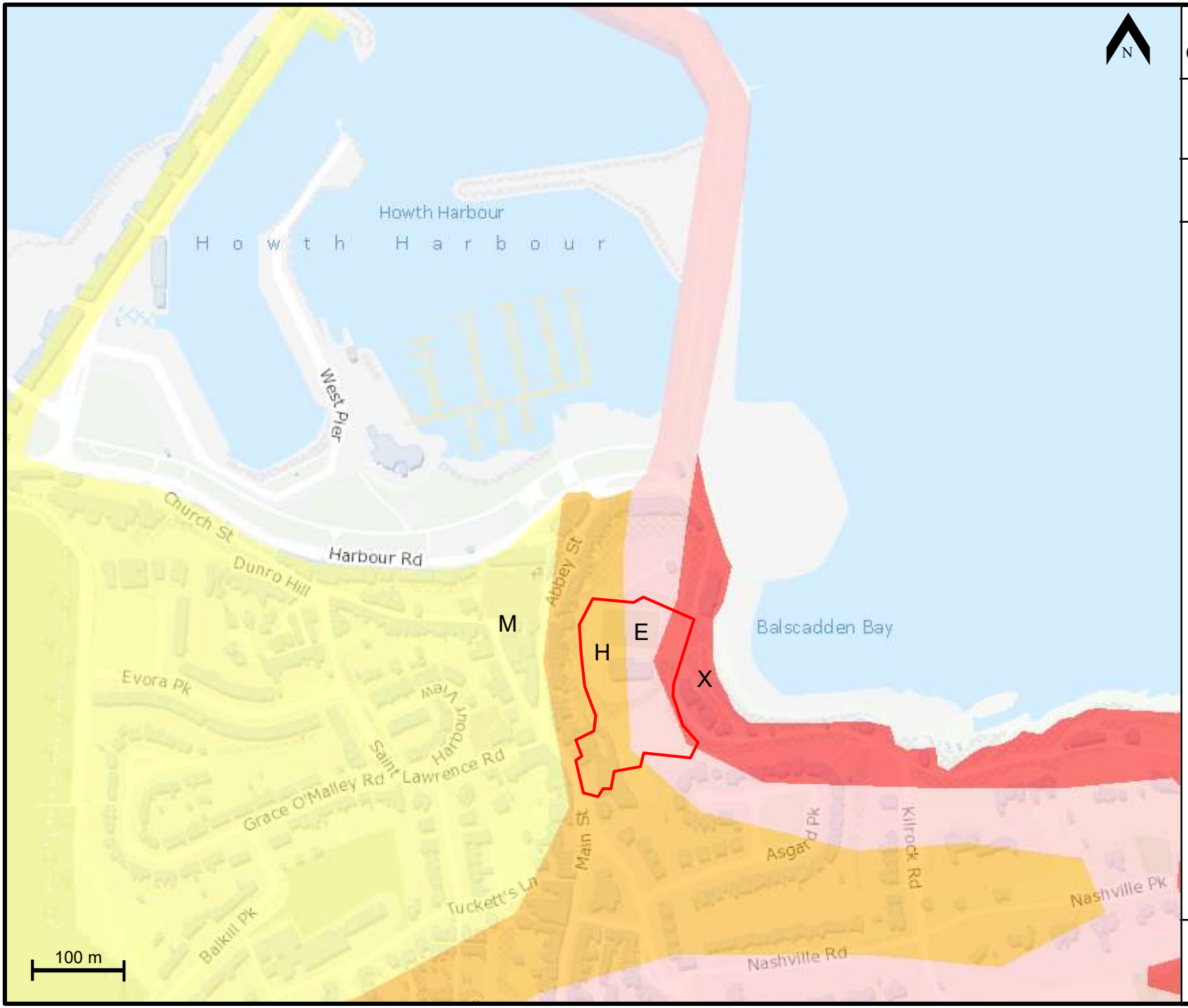
Site Outline

1 Recharge Coefficient = 20%
Average Recharge = 53 mm/yr

2 Recharge Coefficient = 40%
Average Recharge = 40 mm/yr

Ref.7

Minerex Environmental



Drawing Title
Groundwater Vulnerability

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

- Site Outline
- *M* Moderate
- *H* High
- *E* Extreme
- *X* Rock near surface or karst

Ref.7

Minerex Environmental

Drawing Title
Protected Areas

Client: Marlet - Balscadden
Project: 3330

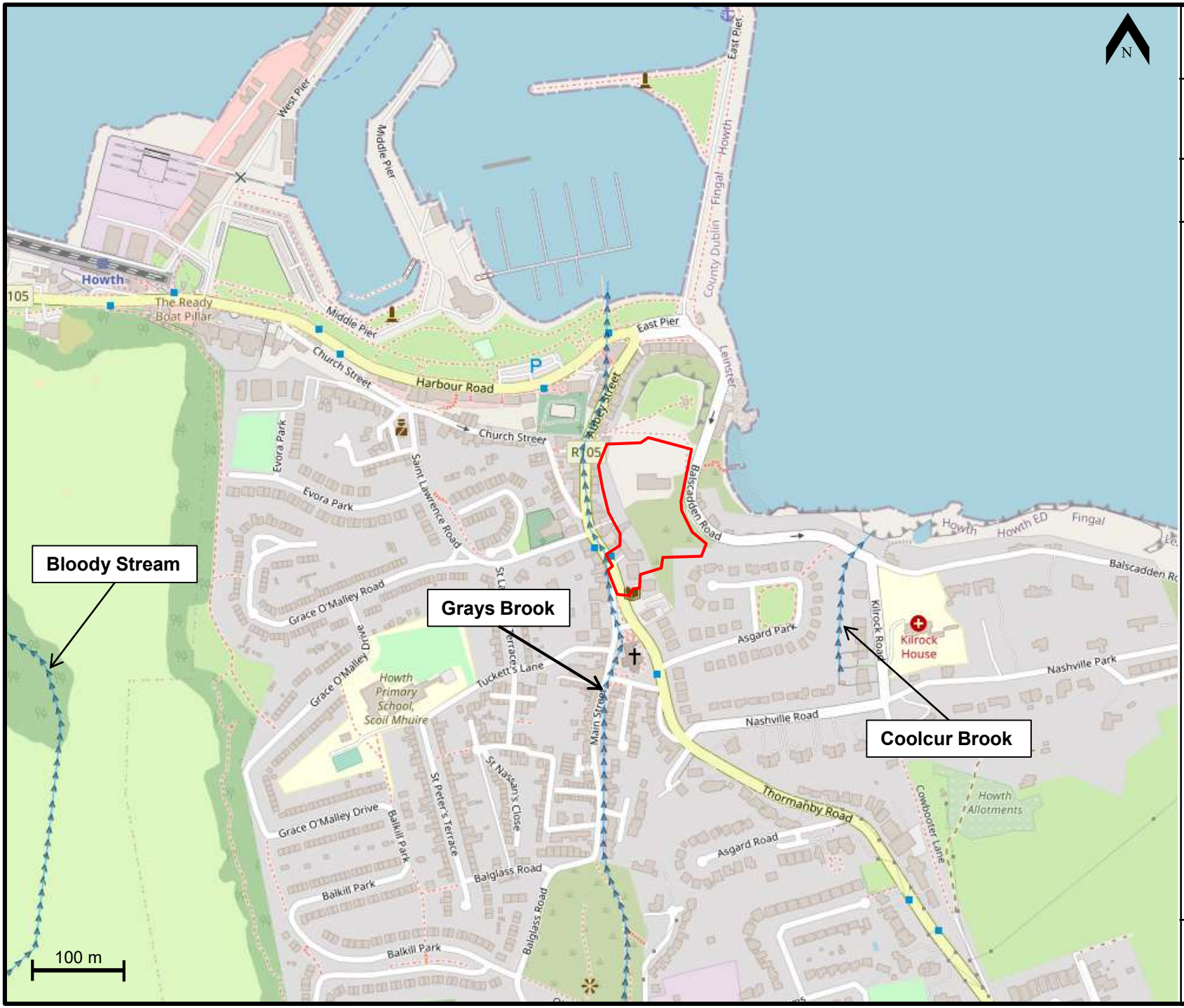
Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

Site Outline

Ref.3

Minerex Environmental



Drawing Title
Stream Network

Client: Marlet - Balscadden
Project: 3330

Drawing Ref: 3330-008.ppt
Drawn by: CF 12/10/2021

Common Legend

Site Outline

Ref.3

Minerex Environmental

Appendix B

Contract No: 5417	**Cable Percussion Borehole Log**		Borehole No: **BH-GDG-01**

Contract:	Balscadden	Easting:	728800.001	Date Started:	29/09/2017
Location:	Howth, Dublin 13	Northing:	739083.441	Date Completed:	04/10/2017
Client:	Crekav Ltd Partnership	Elevation:	34.67	Logged By:	S. Letch
Engineer:	Gavin & Doherty Geosolutions	Rig Type:	Dando 150	Drilled By:	T. Tindall

Depth (m)		Stratum Description	Legend	Level (mOD)		Samples and Insitu Tests			Water Strike	Backfill
Scale	Depth			Scale	Depth	Depth	Type	Result		
	0.20	TOPSOIL.		34.5	34.47					
		Stiff brown sandy slightly gravelly silty CLAY.				0.50	B	TT01		
0.5				34.0						
1.0						1.00	C	N=17 (4,3/4,4,4,5)		
				33.5						
	1.40				33.27	1.50	B	TT02		
1.5		Medium dense light brown silty gravelly fine to coarse SAND with lenses of silty very sandy GRAVEL.		33.0						
2.0						2.00	C	N=30 (4,4/7,9,7,7)		
				32.5						
2.5						2.50	B	TT03		
				32.0						
3.0						3.00	C	N=42 (5,10/10,11,10,11)		
				31.5						
3.5						3.50	B	TT04		
				31.0						
4.0						4.00	C	N=34 (2,3/4,6,8,16)		
				30.5						
4.5						4.50	B	TT05		
				30.0						
5.0						5.00	C	N=25 (3,3/5,6,6,8)		
				29.5						
5.5						5.50	B	TT06		
				29.0						
6.0						6.00	C	N=28 (4,5/7,6,6,9)		
				28.5						
6.5						6.50	B	TT07		
				28.0						
7.0						7.00	C	N=27 (3,4/4,7,8,8)		
				27.5						
7.5						7.50	B	TT08		
				27.0						
8.0						8.00	C	N=34 (3,5/6,8,11,9)		
				26.5						
8.5						8.50	B	TT09		
				26.0						
9.0						9.00	C	N=23 (4,5/4,4,7,8)		
				25.5						
9.5						9.50	B	TT10		
				25.0						
10.0						10.00	C	N=22 (5,4/4,6,6,6)		

Chiselling:

From:	To:	Time:

Water Strikes:

Strike:	Rose:	Depth Sealed:

Water Details:

Date:	Hole Depth:	Water Depth:
29/09	2.00	Dry
02/10	2.00	Dry
02/10	8.50	Dry
03/10	8.50	Dry

Installation:

From:	To:	Pipe:
0.00	15.00	Solid
15.00	18.00	Slotted

Backfill:

From:	To:	Type:
0.00	13.00	Gravel
13.00	14.50	Bentonite
14.50	18.00	Gravel
18.00	19.00	Bentonite
19.00	20.00	Gravel

Remarks:

Water added to assist drilling - approx 165l/m.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
C: Cone SPT
S: Split spoon SPT

Contract No: 5417	**Cable Percussion Borehole Log**				Borehole No: **BH-GDG-01**
Contract:	Balscadden	Easting:	728800.001	Date Started:	29/09/2017
Location:	Howth, Dublin 13	Northing:	739083.441	Date Completed:	04/10/2017
Client:	Crekav Ltd Partnership	Elevation:	34.67	Logged By:	S. Letch
Engineer:	Gavin & Doherty Geosolutions	Rig Type:	Dando 150	Drilled By:	T. Tindall

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
10.5		Medium dense light brown silty gravelly fine to coarse SAND with lenses of silty very sandy GRAVEL.		24.0		10.50	B	TT11		
11.0				23.5		11.00	C	N=22 (8,5/5,4,6,7)		
11.5				23.0		11.50	B	TT12		
12.0				22.5		12.00	C	N=21 (4,5/4,6,5,6)		
12.5				22.0		12.50	B	TT13		
13.0				21.5		13.00	C	N=26 (4,4/4,7,8,7)		
13.5				21.0		13.50	B	TT14		
14.0				20.5		14.00	C	N=24 (4,5/5,8,5,6)		
14.5				20.0		14.50	B	TT15		
15.0				19.5		15.00	C	N=29 (6,8/5,5,8,11)		
15.5				19.0		15.50	B	TT16		
16.0				18.5		16.00	C	N=23 (5,5/4,6,7,6)		
16.5				18.0		16.50	B	TT17		
17.0				17.5		17.00	C	N=32 (6,7/9,6,6,11)		
17.5				17.0		17.50	B	TT18		
18.0				16.5		18.00	C	N=15 (3,3/4,3,4,4)		
18.5				16.0		18.50	B	TT19		
19.0				15.5		19.00	C	N=40 (5,8/7,11,12,10)		
	19.20	Very stiff brown slightly sandy slightly gravelly silty CLAY with low cobble content.			15.47					
19.5				15.0		19.50	B	TT20		
20.0	20.00	End of Borehole at 20.00m		14.5	14.67					

Chiselling:

From:	To:	Time:

Water Strikes:

Strike:	Rose:	Depth Sealed:

Water Details:

Date:	Hole Depth:	Water Depth:
29/09	2.00	Dry
02/10	2.00	Dry
02/10	8.50	Dry
03/10	8.50	Dry

Installation:

From:	To:	Pipe:
0.00	15.00	Solid
15.00	18.00	Slotted

Backfill:

From:	To:	Type:
0.00	13.00	Gravel
13.00	14.50	Bentonite
14.50	18.00	Gravel
18.00	19.00	Bentonite
19.00	20.00	Gravel

Remarks:

Water added to assist drilling - approx 165l/m.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
C: Cone SPT
S: Split spoon SPT

Appendix C

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH01**

Contract:	Balscadden	Easting:	728766.929	Date Started:	16/06/2021
Location:	Howth, Co. Dublin	Northing:	739199.986	Date Completed:	18/06/2021
Client:	Marlet	Elevation:	19.98	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
	0.20	MADE GROUND: tarmacadam.			19.78					
		MADE GROUND: grey silty sandy gravel.								
0.5	0.50	Medium dense brown silty sandy GRAVEL with low cobble content.		19.5	19.48					
1.0				19.0		1.00	B	JOT01		
						1.00	C	N=17 (2,4/4,5,4,4)		
1.5				18.5						
2.0				18.0		2.00	B	JOT02		
						2.00	C	N=12 (1,2/2,3,3,4)		
2.5				17.5						
	2.80	Loose becoming medium dense light brown silty gravelly SAND.			17.18					
3.0				17.0		3.00	B	JOT03		
						3.00	C	N=7 (1,1/1,2,2,2)		
3.5				16.5						
4.0				16.0		4.00	B	JOT04		
						4.00	C	N=15 (1,2/3,3,4,5)		
4.5				15.5						
5.0				15.0		5.00	B	JOT05		
						5.00	C	N=20 (2,2/3,4,6,7)		
5.5	5.50	Light brown slightly silty gravelly SAND.		14.5	14.48					
6.0	6.00	Medium dense becoming dense light brown slightly silty gravelly SAND.		14.0	13.98	6.00	B	JOT06		
						6.00	C	N=21 (2,2/4,5,6,6)		
6.5				13.5						
7.0				13.0		7.00	B	JOT07		
						7.00	C	N=28 (2,4/5,7,7,9)		
7.5				12.5						
8.0				12.0		8.00	B	JOT08		
						8.00	C	N=30 (1,3/6,7,7,10)		
8.5				11.5						
9.0				11.0		9.00	B	JOT09		
						9.00	C	N=36 (2,4/7,9,9,11)		
9.5				10.5						
						10.00	B	JOT10		

Chiselling:

From:	To:	Time:
15.00	15.20	00:45
16.40	16.50	00:45
16.80	17.00	01:00

Water Strikes:

Strike:	Rose:	Depth Sealed

Water Details:

Date:	Hole Depth:	Water Depth:
16/06	9.30	Dry
17/06	12.30	Dry
18/06	17.00	Dry

Installation:

From:	To:	Pipe:
0.00	14.00	Solid
14.00	17.00	Slotted

Backfill:

From:	To:	Type:
0.00	0.70	Bentonite
0.70	12.00	Gravel
12.00	13.00	Bentonite
13.00	17.00	Gravel

Remarks:

Borehole terminated due to obstruction.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**			Borehole No: **BH01**
Contract:	Balscadden	Easting:	728766.929	Date Started: 16/06/2021
Location:	Howth, Co. Dublin	Northing:	739199.986	Date Completed: 18/06/2021
Client:	Marlet	Elevation:	19.98	Drilled By: J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status: FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
10.5	10.50	Medium dense becoming dense light brown slightly silty gravelly SAND.		9.5	9.48	10.00	C	N=18 (2,3/4,4,5,5)		
		Very stiff brown slightly sandy gravelly silty CLAY with low cobble content and bands of gravelly sand.				11.00	B	JOT11		
11.0				9.0		11.00	C	N=24 (3,4/5,6,6,7)		
11.5				8.5						
12.0				8.0		12.00	B	JOT12		
						12.00	C	N=35 (4,5/7,9,9,10)		
12.5				7.5						
13.0				7.0		13.00	B	JOT13		
						13.00	C	50 (25 for 125mm/50 for 90mm)		
13.5				6.5						
14.0				6.0		14.00	B	JOT14		
						14.00	C	N=50 (4,9/50 for 235mm)		
14.5				5.5						
15.0				5.0		15.00	B	JOT15		
						15.00	C	50 (10,15/50 for 125mm)		
15.5				4.5						
16.0				4.0		16.00	B	JOT16		
						16.00	C	50 (11,14/50 for 100mm)		
16.5				3.5						
	16.80	Obstruction - possible boulders.			3.18					
17.0	17.00	End of Borehole at 17.00m		3.0	2.98	17.00	C	50 (25 for 5mm/50 for 5mm)		
17.5				2.5						
18.0				2.0						
18.5				1.5						
19.0				1.0						
19.5				0.5						

Chiselling:

From:	To:	Time:
15.00	15.20	00:45
16.40	16.50	00:45
16.80	17.00	01:00

Water Strikes:

Strike:	Rose:	Depth Sealed

Water Details:

Date:	Hole Depth:	Water Depth:

Installation:

From:	To:	Pipe:
0.00	14.00	Solid
14.00	17.00	Slotted

Backfill:

From:	To:	Type:
0.00	0.70	Bentonite
0.70	12.00	Gravel
12.00	13.00	Bentonite
13.00	17.00	Gravel

Remarks:

Borehole terminated due to obstruction.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH02**

Contract:	Balscadden	Easting:	728791.582	Date Started:	21/06/2021
Location:	Howth, Co. Dublin	Northing:	739163.531	Date Completed:	23/06/2021
Client:	Marlet	Elevation:	19.58	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
	0.20	MADE GROUND: tarmacadam.		19.5	19.38					
		Grey slightly silty very sandy GRAVEL.		19.0						
				18.5		1.00	B	JOT17		
						1.00	C	N=12 (1,2/2,3,3,4)		
				18.0						
				17.5		2.00	B	JOT18		
						2.00	C	N=15 (2,3/3,4,4,4)		
				17.0						
	3.00	Loose becoming medium dense brown silty very gravelly SAND.		16.5	16.58	3.00	B	JOT19		
						3.00	C	N=10 (1,1/2,2,3,3)		
				16.0						
				15.5		4.00	B	JOT20		
						4.00	C	N=8 (2,2/2,2,2,2)		
				15.0						
				14.5		5.00	B	JOT21		
						5.00	C	N=11 (2,2/3,3,2,3)		
				14.0						
				13.5		6.00	B	JOT22		
						6.00	C	N=8 (2,1/2,2,2,2)		
				13.0						
				12.5		7.00	B	JOT23		
						7.00	C	N=11 (3,3/2,3,3,3)		
				12.0						
				11.5		8.00	B	JOT24		
						8.00	C	N=15 (3,3/4,4,3,4)		
	8.50	Medium dense becoming dense light brown silty gravelly SAND.		11.0	11.08					
				10.5		9.00	B	JOT25		
						9.00	C	N=13 (2,2/3,3,3,4)		
	9.70	Very stiff brown slightly sandy gravelly silty CLAY with		10.0	9.88					
						10.00	B	JOT26		

Chiselling: From:	To:	Time:	Water Strikes: Strike:	Rose:	Depth Sealed	Water Details: Date:	Hole Depth:	Water Depth:	Installation: From:	To:	Pipe:	Backfill: From:	To:	Type:	Remarks:
17.10	17.20	01:00				21/06	3.00	Dry	0.00	9.00	Solid	0.00	1.00	Bentonite	Borehole terminated due to obstruction.
						22/06	12.00	Dry	9.00	17.20	Slotted	1.00	7.00	Gravel	
						23/06	17.20	Dry				7.00	8.00	Bentonite	
												8.00	17.20	Gravel	

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH02**

Contract:	Balscadden	Easting:	728791.582	Date Started:	21/06/2021
Location:	Howth, Co. Dublin	Northing:	739163.531	Date Completed:	23/06/2021
Client:	Marlet	Elevation:	19.58	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
		low cobble content.		9.5		10.00	C	N=38 (6,7/7,9,11,11)		
10.5	10.50	Very stiff brown slightly sandy slightly gravelly silty CLAY.		9.0	9.08					
11.0				8.5		11.00 11.00	B C	JOT27 N=40 (7,8/9,9,10,12)		
11.5				8.0						
12.0				7.5		12.00 12.00	B C	JOT28 N=37 (5,7/9,9,9,10)		
12.5				7.0						
13.0				6.5		13.00 13.00	B C	JOT29 N=44 (4,6/10,11,11,12)		
13.5				6.0						
14.0				5.5		14.00 14.00	B C	JOT30 N=39 (3,5/7,11,10,11)		
14.5	14.60	Very stiff brown slightly sandy gravelly silty CLAY with low cobble content and bands of gravelly sand.		5.0	4.98					
15.0				4.5		15.00 15.00	B C	JOT31 50 (5,11/50 for 60mm)		
15.5				4.0						
16.0				3.5		16.00 16.00	B C	JOT32 50 (6,12/50 for 115mm)		
16.5				3.0						
17.0	17.10			2.5	2.48	17.00	C	50 (23 for 95mm/50 for 5mm) JOT33		
	17.20	Obstruction - possible boulders. End of Borehole at 17.20m			2.38	17.10	B			
17.5				2.0						
18.0				1.5						
18.5				1.0						
19.0				0.5						
19.5				0.0						

Chiselling:

From:	To:	Time:
17.10	17.20	01:00

Water Strikes:

Strike:	Rose:	Depth Sealed

Water Details:

Date:	Hole Depth:	Water Depth:

Installation:

From:	To:	Pipe:
0.00	9.00	Solid
9.00	17.20	Slotted

Backfill:

From:	To:	Type:
0.00	1.00	Bentonite
1.00	7.00	Gravel
7.00	8.00	Bentonite
8.00	17.20	Gravel

Remarks:

Borehole terminated due to obstruction.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH03**

Contract:	Balscadden	Easting:	728739.243	Date Started:	24/06/2021
Location:	Howth, Co. Dublin	Northing:	739069.592	Date Completed:	28/06/2021
Client:	Marlet	Elevation:	19.42	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
	0.10	MADE GROUND: tarmacadam.			19.32					
0.5	0.60	MADE GROUND: grey sandy gravel with medium cobble content and some red brick and concrete fragments.		19.0	18.82					
		Medium dense light brown silty gravelly SAND.		18.5		1.00	B	JOT34		
1.0						1.00	C	N=18 (2,3/4,4,5,5)		
1.5				18.0						
2.0				17.5		2.00	B	JOT35		
						2.00	C	N=21 (2,4/5,5,5,6)		
2.5				17.0						
	2.80	Medium dense yellow slightly silty SAND.			16.62					
3.0				16.5		3.00	B	JOT36		
						3.00	C	N=23 (4,5/5,6,6,6)		
3.5				16.0						
4.0				15.5		4.00	B	JOT37		
						4.00	C	N=19 (2,4/4,5,5,5)		
4.5				15.0						
	4.90	Medium dense light brown silty gravelly SAND.		14.5	14.52	5.00	B	JOT38		
5.0						5.00	C	N=15 (2,2/3,4,4,4)		
5.5				14.0						
6.0				13.5		6.00	B	JOT39		
						6.00	C	N=24 (2,4/5,6,6,7)		
6.5	6.40	Stiff brown slightly sandy gravelly silty CLAY with low cobble content.		13.0	13.02					
7.0				12.5		7.00	B	JOT40		
						7.00	C	N=30 (2,5/7,7,7,9)		
7.5	7.50	Very stiff black slightly sandy gravelly silty CLAY with low cobble content.		12.0	11.92					
8.0				11.5		8.00	B	JOT41		
						8.00	C	50 (25 for 135mm/50 for 10mm)		
8.5				11.0						
9.0				10.5		9.00	B	JOT42		
						9.00	C	50 (5,7/50 for 100mm)		
9.5				10.0						
				9.5		10.00	B	JOT43		

Chiselling: From:	To:	Time:	Water Strikes: Strike:	Rose:	Depth Sealed	Water Details: Date:	Hole Depth:	Water Depth:	Installation: From:	To:	Pipe:	Backfill: From:	To:	Type:	Remarks:
12.80	13.00	01:00	4.80	4.50	6.80	24/06	3.50	Dry	0.00	4.00	Solid	0.00	3.00	Bentonite	Borehole terminated due to obstruction.
						25/06	10.50	10.20	4.00	13.00	Slotted	3.00	13.00	Gravel	
						28/06	13.00	3.80							

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH03**

Contract:	Balscadden	Easting:	728739.243	Date Started:	24/06/2021
Location:	Howth, Co. Dublin	Northing:	739069.592	Date Completed:	28/06/2021
Client:	Marlet	Elevation:	19.42	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m)		Stratum Description	Legend	Level (mOD)		Samples and Insitu Tests			Water Strike	Backfill
Scale	Depth			Scale	Depth	Depth	Type	Result		
10.5		Very stiff black slightly sandy gravelly silty CLAY with low cobble content.		9.0		10.00	C	50 (25 for 125mm/50 for 110mm)		
11.0				8.5		11.00	B	JOT44		
						11.00	C	50 (25 for 125mm/50 for 100mm)		
11.5				8.0						
12.0				7.5		12.00	B	JOT45		
						12.00	C	50 (25 for 115mm/50 for 25mm)		
12.5				7.0						
	12.80	Obstruction - possible boulders.			6.62	12.80	B	JOT46		
13.0	13.00	End of Borehole at 13.00m		6.5	6.42	13.00	C	50 (25 for 5mm/50 for 5mm)		
13.5				6.0						
14.0				5.5						
14.5				5.0						
15.0				4.5						
15.5				4.0						
16.0				3.5						
16.5				3.0						
17.0				2.5						
17.5				2.0						
18.0				1.5						
18.5				1.0						
19.0				0.5						
19.5				0.0						
				-0.5						

Chiselling:			Water Strikes:			Water Details:			Installation:			Backfill:			Remarks:
From:	To:	Time:	Strike:	Rose:	Depth Sealed	Date:	Hole Depth:	Water Depth:	From:	To:	Pipe:	From:	To:	Type:	
12.80	13.00	01:00	4.80	4.50	6.80				0.00	4.00	Solid	0.00	3.00	Bentonite	Borehole terminated due to obstruction.
									4.00	13.00	Slotted	3.00	13.00	Gravel	

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Appendix D

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

Minerex Environmental
Taney hall
Eglinton Terrace
Dundrum
Dublin
Dublin 14

Attention: Chris Fennell

CERTIFICATE OF ANALYSIS

Date of report Generation:	23 September 2021
Customer:	Minerex Environmental
Sample Delivery Group (SDG):	210914-80
Your Reference:	3330-COC1
Location:	Marlet - Balscadden
Report No:	614351
Order Number:	

This report has been revised and directly supersedes 613762 in its entirety.

We received 8 samples on Tuesday September 14, 2021 and 8 of these samples were scheduled for analysis which was completed on Thursday September 23, 2021. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden.

All sample data is provided by the customer. The reported results relate to the sample supplied, and on the basis that this data is correct.
Incorrect sampling dates and/or sample information will affect the validity of results.
The customer is not permitted to reproduce this report except in full without the approval of the laboratory.

Approved By:

Sonia McWhan

Operations Manager

CERTIFICATE OF ANALYSIS

SDG: 210914-80 **Report Number:** 614351 **Superseded Report:** 613762
Client Ref.: 3330-COC1 **Location:** Marlet - Balscadden

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
24972424	BH1		0.00 - 0.00	13/09/2021
24972431	BH2		0.00 - 0.00	13/09/2021
24972467	SP1		0.00 - 0.00	13/09/2021
24972476	SP2		0.00 - 0.00	13/09/2021
24972482	SP3		0.00 - 0.00	13/09/2021
24972439	SW1		0.00 - 0.00	13/09/2021
24972453	SW2		0.00 - 0.00	13/09/2021
24972460	SW3		0.00 - 0.00	13/09/2021

Only received samples which have had analysis scheduled will be shown on the following pages.

Validated

CERTIFICATE OF ANALYSIS

SDG: 210914-80 **Report Number:** 614351 **Superseded Report:** 613762
Client Ref.: 3330-COC1 **Location:** Marlet - Balscadden

Results Legend

X Test

N No Determination Possible

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
DW - Drinking Water Non-regulatory
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

			Lab Sample No(s)	Customer Sample Reference	AGS Reference	Depth (m)	Container	Sample Type
			24972424	BH1		0.00 - 0.00	1lplastic (ALE221)	GW
							H2SO4 (ALE244)	GW
							HNO3 Filtered (ALE204)	GW
			24972431	BH2		0.00 - 0.00	1lplastic (ALE221)	GW
							H2SO4 (ALE244)	GW
							HNO3 Filtered (ALE204)	GW
			24972467	SP1		0.00 - 0.00	1lplastic (ALE221)	GW
							H2SO4 (ALE244)	GW
							HNO3 Filtered (ALE204)	GW
			24972476	SP2		0.00 - 0.00	500ml Plastic (ALE208)	GW
							H2SO4 (ALE244)	GW
							HNO3 Filtered (ALE204)	GW
			24972482	SP3		0.00 - 0.00	1lplastic (ALE221)	GW
							H2SO4 (ALE244)	GW
							HNO3 Filtered (ALE204)	GW
			24972439	SW1		0.00 - 0.00	1lplastic (ALE221)	SW
							H2SO4 (ALE244)	SW
							HNO3 Filtered (ALE204)	SW
			24972453	SW2		0.00 - 0.00	1lplastic (ALE221)	SW
Alkalinity as CaCO3	All	NDPs: 0 Tests: 8	X	X			X			X			X			X			X
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 8		X			X			X			X			X			X	
Anions by ion Chromatography	All	NDPs: 0 Tests: 8	X	X			X			X			X			X			X	
Anions by Kone (w)	All	NDPs: 0 Tests: 8	X	X			X			X			X			X			X	
Conductivity (at 20 deg.C)	All	NDPs: 0 Tests: 8	X	X			X			X			X			X			X	
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 8			X			X			X			X			X			X	
Phosphate by Kone (w)	All	NDPs: 0 Tests: 8	X	X			X			X			X			X			X	

24972460	SW3		0.00 - 0.00	HNO3 Filtered (ALE204)	SW											X			
				H2SO4 (ALE244)	SW				X										
				1lplastic (ALE221)	SW		X				X		X		X				X
24972453	SW2		0.00 - 0.00	HNO3 Filtered (ALE204)	SW											X			
				H2SO4 (ALE244)	SW				X										

Validated

CERTIFICATE OF ANALYSIS

SDG: 210914-80 **Report Number:** 614351 **Superseded Report:** 613762

Client Ref.: 3330-COC1 **Location:** Marlet - Balscadden

Results Legend	
#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted - refer to subcontractor report for accreditation status.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2	SP1	SP2	SP3	SW1
			Depth (m)	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00
			Sample Type	Ground Water (GW)	Ground Water (GW)	Ground Water (GW)	Ground Water (GW)	Ground Water (GW)	Surface Water (SW)
			Date Sampled	13/09/2021	13/09/2021	13/09/2021	13/09/2021	13/09/2021	13/09/2021
			Sample Time	00:00	00:00	00:00	00:00	00:00	00:00
			Date Received	14/09/2021	14/09/2021	14/09/2021	14/09/2021	14/09/2021	14/09/2021
			SDG Ref	210914-80	210914-80	210914-80	210914-80	210914-80	210914-80
			Lab Sample No.(s)	24972424	24972431	24972467	24972476	24972482	24972439
			AGS Reference						
Alkalinity, Total as CaCO3	<2 mg/l	TM043		355 #	300 #	115 #	305 #	315 #	155 #
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099		<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099		<0.3 #	<0.3 #	<0.3 #	<0.3 #	<0.3 #	<0.3 #
Conductivity @ 20 deg.C	<0.02 mS/cm	TM120		0.86 #	0.803 #	0.39 #	0.936 #	0.89 #	37.8 #
Manganese (diss.filt)	<3 µg/l	TM152		43.7 #	6.9 #	<3 #	<3 #	9.69 #	<18 #
Phosphorus (diss.filt)	<10 µg/l	TM152		<10 #	<10 #	<10 #	<10 #	23.9 #	78.6 #
Sodium (Dis.Filt)	<0.076 mg/l	TM152		42.3 #	44.3 #	22.1 #	56.4 #	93.7 #	8940 #
Magnesium (Dis.Filt)	<0.036 mg/l	TM152		20.5 #	18.9 #	5.86 #	20.5 #	19.5 #	1020 #
Potassium (Dis.Filt)	<0.2 mg/l	TM152		8.36 #	5.71 #	2.94 #	7.27 #	11.9 #	299 #
Calcium (Dis.Filt)	<0.2 mg/l	TM152		123 #	116 #	52 #	122 #	81.4 #	343 #
Iron (Dis.Filt)	<0.019 mg/l	TM152		<0.019 #	<0.019 #	<0.019 #	<0.019 #	0.0433 #	<0.114 #
Sulphate	<2 mg/l	TM184		113 #	66.3 #	43 #	58.6 #	51.7 #	2240 #
Chloride	<2 mg/l	TM184		74.1 #	77.9 #	33.5 #	110 #	115 #	16300 #
Phosphate (Ortho as P)	<0.02 mg/l	TM184		<0.02 #	<0.02 #	<0.02 #	<0.02 #	0.0281 #	0.079 #
Nitrate as NO3	<0.07 mg/l	TM226		35.3 #	30.2 #	7.61 #	30.7 #	<0.35 #	4.27 #

CERTIFICATE OF ANALYSIS

SDG: 210914-80 **Report Number:** 614351 **Superseded Report:** 613762
Client Ref.: 3330-COC1 **Location:** Marlet - Balscadden

Results Legend

#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted - refer to subcontractor report for accreditation status.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	SW2	SW3				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Surface Water (SW)	Surface Water (SW)				
			Date Sampled	13/09/2021	13/09/2021				
			Sample Time	00:00	00:00				
			Date Received	14/09/2021	14/09/2021				
			SDG Ref	210914-80	210914-80				
			Lab Sample No.(s)	24972453	24972460				
			AGS Reference						
Alkalinity, Total as CaCO3	<2 mg/l	TM043		180 #	150 #				
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099		<0.2 #	<0.2 #				
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099		<0.3 #	<0.3 #				
Conductivity @ 20 deg.C	<0.02 mS/cm	TM120		23 #	0.457 #				
Manganese (diss.filt)	<3 µg/l	TM152		<3 #	44.4 #				
Phosphorus (diss.filt)	<10 µg/l	TM152		91.9 #	54.5 #				
Sodium (Dis.Filt)	<0.076 mg/l	TM152		5050 #	26 #				
Magnesium (Dis.Filt)	<0.036 mg/l	TM152		624 #	8.85 #				
Potassium (Dis.Filt)	<0.2 mg/l	TM152		175 #	2.44 #				
Calcium (Dis.Filt)	<0.2 mg/l	TM152		228 #	66.8 #				
Iron (Dis.Filt)	<0.019 mg/l	TM152		<0.019 #	0.109 #				
Sulphate	<2 mg/l	TM184		1210 #	50.5 #				
Chloride	<2 mg/l	TM184		9290 #	40.1 #				
Phosphate (Ortho as P)	<0.02 mg/l	TM184		0.0826 #	0.03 #				
Nitrate as NO3	<0.07 mg/l	TM226		9.27 #	6.88 #				

Table of Results - Appendix

Method No	Reference	Description
TM043	Method 2320B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part109 1984	Determination of alkalinity in aqueous samples
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser
TM120	Method 2510B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part 9:1970	Determination of Electrical Conductivity using a Conductivity Meter
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers
TM226	In-House Method	Determination of Anions in Waters using Ion Chromatography

NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden.

CERTIFICATE OF ANALYSIS

SDG: 210914-80 **Report Number:** 614351 **Superseded Report:** 613762
Client Ref.: 3330-COC1 **Location:** Marlet - Balscadden

Test Completion Dates

Lab Sample No(s)	24972424	24972431	24972467	24972476	24972482	24972439	24972453	24972460
Customer Sample Ref.	BH1	BH2	SP1	SP2	SP3	SW1	SW2	SW3
AGS Ref.								
Depth	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00
Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Surface Water	Surface Water	Surface Water
Alkalinity as CaCO3	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021
Ammoniacal Nitrogen	17-Sep-2021	20-Sep-2021	17-Sep-2021	17-Sep-2021	17-Sep-2021	20-Sep-2021	20-Sep-2021	20-Sep-2021
Anions by ion Chromatography	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021	16-Sep-2021
Anions by Kone (w)	18-Sep-2021	18-Sep-2021	18-Sep-2021	18-Sep-2021	18-Sep-2021	18-Sep-2021	18-Sep-2021	18-Sep-2021
Conductivity (at 20 deg.C)	23-Sep-2021	23-Sep-2021	23-Sep-2021	23-Sep-2021	23-Sep-2021	23-Sep-2021	23-Sep-2021	23-Sep-2021
Dissolved Metals by ICP-MS	17-Sep-2021	17-Sep-2021	17-Sep-2021	17-Sep-2021	17-Sep-2021	18-Sep-2021	18-Sep-2021	17-Sep-2021
Phosphate by Kone (w)	15-Sep-2021	15-Sep-2021	15-Sep-2021	15-Sep-2021	15-Sep-2021	15-Sep-2021	15-Sep-2021	15-Sep-2021

Appendix General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

3. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

4. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

5. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

6. NDP - No determination possible due to insufficient/unsuitable sample.

7. Results relate only to the items tested.

8. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

9. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

10. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

11. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

12. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

13. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

14. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

15. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

16. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

17 Data retention. All records, communications and reports pertaining to the analysis are archived for seven years from the date of issue of the final report.

18. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as "mixed hydrocarbons". Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

19. **Sample Deviations**

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Matrix interference**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to late arrival of instructions or samples**
§	**Sampled on date not provided**

20. **Asbestos**

When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining.

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Respirable Fibres

Respirable fibres are defined as fibres of <3 µm diameter, longer than 5 µm and with aspect ratios of at least 3:1 that can be inhaled into the lower regions of the lung and are generally acknowledged to be most important predictor of hazard and risk for cancers of the lung.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

Minerex Environmental
Taney hall
Eglinton Terrace
Dundrum
Dublin
Dublin 14

Attention: Chris Fennell

CERTIFICATE OF ANALYSIS

Date of report Generation:	14 October 2021
Customer:	Minerex Environmental
Sample Delivery Group (SDG):	211007-123
Your Reference:	3330-COC2
Location:	Marlet - Balscadden
Report No:	617204
Order Number:	

We received 2 samples on Thursday October 07, 2021 and 2 of these samples were scheduled for analysis which was completed on Thursday October 14, 2021. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden.

All sample data is provided by the customer. The reported results relate to the sample supplied, and on the basis that this data is correct.
Incorrect sampling dates and/or sample information will affect the validity of results.
The customer is not permitted to reproduce this report except in full without the approval of the laboratory.

Approved By:

Sonia McWhan

Operations Manager

CERTIFICATE OF ANALYSIS

SDG: 211007-123 **Report Number:** 617204 **Superseded Report:**
Client Ref.: 3330-COC2 **Location:** Marlet - Balscadden

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
25113801	BH1		0.00 - 0.00	06/10/2021
25113808	BH2		0.00 - 0.00	06/10/2021

Only received samples which have had analysis scheduled will be shown on the following pages.

Validated

CERTIFICATE OF ANALYSIS

SDG: 211007-123 **Report Number:** 617204 **Superseded Report:**
Client Ref.: 3330-COC2 **Location:** Marlet - Balscadden

Results Legend

X Test

N No Determination Possible

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
DW - Drinking Water Non-regulatory
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

			Lab Sample No(s)					
			25113801			25113808		
			Customer Sample Reference					
			BH1			BH2		
			AGS Reference					
			Depth (m)					
			0.00 - 0.00			0.00 - 0.00		
			Container					
			1lplastic (ALE221)	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	1lplastic (ALE221)	H2SO4 (ALE244)	HNO3 Filtered (ALE204)
			Sample Type					
			GW	GW	GW	GW	GW	GW
Alkalinity as CaCO3	All	NDPs: 0 Tests: 2	X			X		
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 2		X			X	
Anions by ion Chromatography	All	NDPs: 0 Tests: 2	X			X		
Anions by Kone (w)	All	NDPs: 0 Tests: 2	X			X		
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 2			X			X
Phosphate by Kone (w)	All	NDPs: 0 Tests: 2	X			X		

Validated

CERTIFICATE OF ANALYSIS

SDG: 211007-123 **Report Number:** 617204 **Superseded Report:**
Client Ref.: 3330-COC2 **Location:** Marlet - Balscadden

Results Legend

#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted - refer to subcontractor report for accreditation status.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Ground Water (GW)	Ground Water (GW)				
			Date Sampled	06/10/2021	06/10/2021				
			Sample Time	00:00	00:00				
			Date Received	07/10/2021	07/10/2021				
			SDG Ref	211007-123	211007-123				
			Lab Sample No.(s)	25113801	25113808				
			AGS Reference						
Alkalinity, Total as CaCO3	<2 mg/l	TM043		348 #	390 #				
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099		<0.2 #	<0.2 #				
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099		<0.3 #	<0.3 #				
Manganese (diss.filt)	<3 µg/l	TM152		5.78 #	<3 #				
Phosphorus (diss.filt)	<10 µg/l	TM152		<10 #	<10 #				
Sodium (Dis.Filt)	<0.076 mg/l	TM152		42.5 #	42.4 #				
Magnesium (Dis.Filt)	<0.036 mg/l	TM152		20 #	19 #				
Potassium (Dis.Filt)	<0.2 mg/l	TM152		9.71 #	5.5 #				
Calcium (Dis.Filt)	<0.2 mg/l	TM152		126 #	122 #				
Iron (Dis.Filt)	<0.019 mg/l	TM152		<0.019 #	<0.019 #				
Sulphate	<2 mg/l	TM184		113 #	66.5 #				
Chloride	<2 mg/l	TM184		80 #	81 #				
Phosphate (Ortho as P)	<0.02 mg/l	TM184		<0.02 #	<0.02 #				
Nitrate as NO3	<0.07 mg/l	TM226		37.1 #	29.4 #				

CERTIFICATE OF ANALYSIS

SDG: 211007-123 **Report Number:** 617204 **Superseded Report:**
Client Ref.: 3330-COC2 **Location:** Marlet - Balscadden

Table of Results - Appendix

Method No	Reference	Description
TM043	Method 2320B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part109 1984	Determination of alkalinity in aqueous samples
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers
TM226	In-House Method	Determination of Anions in Waters using Ion Chromatography

NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden.

CERTIFICATE OF ANALYSIS

SDG: 211007-123 **Report Number:** 617204 **Superseded Report:**
Client Ref.: 3330-COC2 **Location:** Marlet - Balscadden

Test Completion Dates

Lab Sample No(s)	25113801	25113808
Customer Sample Ref.	BH1	BH2
AGS Ref.		
Depth	0.00 - 0.00	0.00 - 0.00
Type	Ground Water	Ground Water
Alkalinity as CaCO3	11-Oct-2021	11-Oct-2021
Ammoniacal Nitrogen	12-Oct-2021	12-Oct-2021
Anions by ion Chromatography	12-Oct-2021	12-Oct-2021
Anions by Kone (w)	11-Oct-2021	11-Oct-2021
Dissolved Metals by ICP-MS	14-Oct-2021	14-Oct-2021
Phosphate by Kone (w)	11-Oct-2021	11-Oct-2021

Appendix General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

3. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

4. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

5. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

6. NDP - No determination possible due to insufficient/unsuitable sample.

7. Results relate only to the items tested.

8. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

9. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

10. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

11. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

12. For dried and crushed preparations of soils volatile loss may occur e.g volatile mercury.

13. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

14. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

15. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

16. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

17 Data retention. All records, communications and reports pertaining to the analysis are archived for seven years from the date of issue of the final report.

18. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as "mixed hydrocarbons". Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

19. **Sample Deviations**

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Matrix interference**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to late arrival of instructions or samples**
§	**Sampled on date not provided**

20. **Asbestos**

When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining.

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Respirable Fibres

Respirable fibres are defined as fibres of <3 µm diameter, longer than 5 µm and with aspect ratios of at least 3:1 that can be inhaled into the lower regions of the lung and are generally acknowledged to be most important predictor of hazard and risk for cancers of the lung.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Appendix C – 2021 Ground Investigation

S.I. Ltd Contract No: 5836

Client: Marlet
Engineer: Waterman Moylan
Contractor: Site Investigations Ltd

Balscadden,
Howth, Co. Dublin
Site Investigation Report

Prepared by:

.....
Stephen Letch

Issue Date:	13/07/2021
Status	Final
Revision	2

Contents:

Appendices:

1. Introduction

On the instructions of Waterman Moylan, Site Investigations Ltd (SIL) was appointed to complete a ground investigation at Balscadden, Howth, Co. Dublin. The investigation was completed for a residential development on the site and was completed on behalf of the Client, Marlet. The investigation was completed in June 2021.

2. Site Location

The site is located on the Balscadden Road, Howth, Co. Dublin, on the Howth peninsula to the east of Dublin city. The map of the Dublin (below left) shows the location of Howth and the second map shows the boundary of the site in Howth.

3. Fieldwork

The fieldworks comprised a programme of cable percussive boreholes and trial pits. All fieldwork was carried out in accordance with BS 5930:2015, Engineers Ireland GI Specification and Related Document 2nd Edition 2016 and Eurocode 7: Geotechnical Design.

The fieldworks comprised the following:

- 3 No. cable percussive boreholes
- 3 No. trial pits

3.1. Cable Percussion Boreholes with Rotary Coreholes

Cable percussion boring was undertaken at 3 No. locations using a Dando 150 rig and constructed 200mm diameter boreholes. The boreholes terminated at depths ranging from 13.00mbgl (BH03) to 17.20mbgl (BH02) when obstructions were encountered. It was not possible to collect undisturbed samples due to the granular soils encountered so bulk disturbed samples were recovered at regular intervals.

To test the strength of the stratum, Standard Penetration Tests (SPT's) were performed at 1.00m intervals in accordance with BS 1377 (1990). In soils with high gravel and cobble content it is appropriate to use a solid cone (60°) (CPT) instead of the split spoon and this was used throughout the testing. The test is completed over 450mm and the cone is driven 150mm into the stratum to ensure that the test is conducted over an undisturbed zone. The cone is then driven the remaining 300mm and the blows recorded to report the N-Value. The report shows the N-Value with the 75mm incremental blows listed in brackets (e.g., BH01 at 1.00mbgl where N=17(2,4/4,5,4,4). Where refusal of 50 blows across the test zone was encountered was achieved during testing, the penetration depth is also reported (e.g., BH01 at 13.00mbgl where N=50-(25 for 125mm/50 for 90mm)).

Groundwater monitoring standpipes were installed, upon instruction from Minerex Ltd, and consisted of slotted pipe surrounded by a gravel response zone with bentonite seals.

The cable percussive borehole logs are presented in Appendix 1.

3.2. Trial Pits

3 No. trial pits were excavated using a wheeled excavator. The strata were logged and photographed by SIL geotechnical engineer and groundwater ingresses and pit wall stability was also recorded. Representative disturbed bulk samples were recovered as the pits were excavated, which were returned to the laboratory for geotechnical testing.

The trial pit logs and photographs are presented in Appendix 2.

3.3. Surveying

Following completion of all the fieldworks, a survey of the exploratory hole locations was completed using a GeoMax GPS Rover. The data is supplied on each individual log and along with a site plan in Appendix 4.

4. Laboratory Testing

Laboratory testing has been performed on representative soil samples, as scheduled by ByrneLooby,and these were completed in accordance of BS1377: 1990 or the relevant specification. Testing included:

- 2 No. Moisture contents
- 2 No. Atterberg limits
- 8 No. Particle size gradings
- 5 No. pH
- 5 No. Water soluble sulphate

Specialist geotechnical testing was completed on the samples by NMTL Ltd and consisted of the following:

- 1 No. Shear box

The soil laboratory test results are presented in Appendix 3.

Appendix 1

Cable Percussive Borehole Logs

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH01**

Contract:	Balscadden	Easting:	728766.929	Date Started:	16/06/2021
Location:	Howth, Co. Dublin	Northing:	739199.986	Date Completed:	18/06/2021
Client:	Marlet	Elevation:	19.98	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
	0.20	MADE GROUND: tarmacadam.			19.78					
		MADE GROUND: grey silty sandy gravel.								
0.5	0.50	Medium dense brown silty sandy GRAVEL with low cobble content.		19.5	19.48					
1.0				19.0		1.00	B	JOT01		
						1.00	C	N=17 (2,4/4,5,4,4)		
1.5				18.5						
2.0				18.0		2.00	B	JOT02		
						2.00	C	N=12 (1,2/2,3,3,4)		
2.5				17.5						
	2.80	Loose becoming medium dense light brown silty gravelly SAND.			17.18					
3.0				17.0		3.00	B	JOT03		
						3.00	C	N=7 (1,1/1,2,2,2)		
3.5				16.5						
4.0				16.0		4.00	B	JOT04		
						4.00	C	N=15 (1,2/3,3,4,5)		
4.5				15.5						
5.0				15.0		5.00	B	JOT05		
						5.00	C	N=20 (2,2/3,4,6,7)		
5.5	5.50	Light brown slightly silty gravelly SAND.		14.5	14.48					
6.0	6.00	Medium dense becoming dense light brown slightly silty gravelly SAND.		14.0	13.98	6.00	B	JOT06		
						6.00	C	N=21 (2,2/4,5,6,6)		
6.5				13.5						
7.0				13.0		7.00	B	JOT07		
						7.00	C	N=28 (2,4/5,7,7,9)		
7.5				12.5						
8.0				12.0		8.00	B	JOT08		
						8.00	C	N=30 (1,3/6,7,7,10)		
8.5				11.5						
9.0				11.0		9.00	B	JOT09		
						9.00	C	N=36 (2,4/7,9,9,11)		
9.5				10.5						
						10.00	B	JOT10		

Chiselling:

From:	To:	Time:
15.00	15.20	00:45
16.40	16.50	00:45
16.80	17.00	01:00

Water Strikes:

Strike:	Rose:	Depth Sealed

Water Details:

Date:	Hole Depth:	Water Depth:
16/06	9.30	Dry
17/06	12.30	Dry
18/06	17.00	Dry

Installation:

From:	To:	Pipe:
0.00	14.00	Solid
14.00	17.00	Slotted

Backfill:

From:	To:	Type:
0.00	0.70	Bentonite
0.70	12.00	Gravel
12.00	13.00	Bentonite
13.00	17.00	Gravel

Remarks:

Borehole terminated due to obstruction.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**			Borehole No: **BH01**
Contract:	Balscadden	Easting:	728766.929	Date Started: 16/06/2021
Location:	Howth, Co. Dublin	Northing:	739199.986	Date Completed: 18/06/2021
Client:	Marlet	Elevation:	19.98	Drilled By: J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status: FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
10.5	10.50	Medium dense becoming dense light brown slightly silty gravelly SAND.		9.5	9.48	10.00	C	N=18 (2,3/4,4,5,5)		
		Very stiff brown slightly sandy gravelly silty CLAY with low cobble content and bands of gravelly sand.				11.00	B	JOT11		
11.0				9.0		11.00	C	N=24 (3,4/5,6,6,7)		
11.5				8.5						
12.0				8.0		12.00	B	JOT12		
						12.00	C	N=35 (4,5/7,9,9,10)		
12.5				7.5						
13.0				7.0		13.00	B	JOT13		
						13.00	C	50 (25 for 125mm/50 for 90mm)		
13.5				6.5						
14.0				6.0		14.00	B	JOT14		
						14.00	C	N=50 (4,9/50 for 235mm)		
14.5				5.5						
15.0				5.0		15.00	B	JOT15		
						15.00	C	50 (10,15/50 for 125mm)		
15.5				4.5						
16.0				4.0		16.00	B	JOT16		
						16.00	C	50 (11,14/50 for 100mm)		
16.5				3.5						
	16.80	Obstruction - possible boulders.			3.18					
17.0	17.00	End of Borehole at 17.00m		3.0	2.98	17.00	C	50 (25 for 5mm/50 for 5mm)		
17.5				2.5						
18.0				2.0						
18.5				1.5						
19.0				1.0						
19.5				0.5						

Chiselling:

From:	To:	Time:
15.00	15.20	00:45
16.40	16.50	00:45
16.80	17.00	01:00

Water Strikes:

Strike:	Rose:	Depth Sealed

Water Details:

Date:	Hole Depth:	Water Depth:

Installation:

From:	To:	Pipe:
0.00	14.00	Solid
14.00	17.00	Slotted

Backfill:

From:	To:	Type:
0.00	0.70	Bentonite
0.70	12.00	Gravel
12.00	13.00	Bentonite
13.00	17.00	Gravel

Remarks:

Borehole terminated due to obstruction.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH02**

Contract:	Balscadden	Easting:	728791.582	Date Started:	21/06/2021
Location:	Howth, Co. Dublin	Northing:	739163.531	Date Completed:	23/06/2021
Client:	Marlet	Elevation:	19.58	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
	0.20	MADE GROUND: tarmacadam.		19.5	19.38					
		Grey slightly silty very sandy GRAVEL.		19.0						
				18.5		1.00	B	JOT17		
						1.00	C	N=12 (1,2/2,3,3,4)		
				18.0						
				17.5		2.00	B	JOT18		
						2.00	C	N=15 (2,3/3,4,4,4)		
				17.0						
	3.00	Loose becoming medium dense brown silty very gravelly SAND.		16.5	16.58	3.00	B	JOT19		
						3.00	C	N=10 (1,1/2,2,3,3)		
				16.0						
				15.5		4.00	B	JOT20		
						4.00	C	N=8 (2,2/2,2,2,2)		
				15.0						
				14.5		5.00	B	JOT21		
						5.00	C	N=11 (2,2/3,3,2,3)		
				14.0						
				13.5		6.00	B	JOT22		
						6.00	C	N=8 (2,1/2,2,2,2)		
				13.0						
				12.5		7.00	B	JOT23		
						7.00	C	N=11 (3,3/2,3,3,3)		
				12.0						
				11.5		8.00	B	JOT24		
						8.00	C	N=15 (3,3/4,4,3,4)		
	8.50	Medium dense becoming dense light brown silty gravelly SAND.		11.0	11.08					
				10.5		9.00	B	JOT25		
						9.00	C	N=13 (2,2/3,3,3,4)		
	9.70	Very stiff brown slightly sandy gravelly silty CLAY with		10.0	9.88					
						10.00	B	JOT26		

Chiselling: From:	To:	Time:	Water Strikes: Strike:	Rose:	Depth Sealed	Water Details: Date:	Hole Depth:	Water Depth:	Installation: From:	To:	Pipe:	Backfill: From:	To:	Type:	Remarks:
17.10	17.20	01:00				21/06	3.00	Dry	0.00	9.00	Solid	0.00	1.00	Bentonite	Borehole terminated due to obstruction.
						22/06	12.00	Dry	9.00	17.20	Slotted	1.00	7.00	Gravel	
						23/06	17.20	Dry				7.00	8.00	Bentonite	
												8.00	17.20	Gravel	

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH02**

Contract:	Balscadden	Easting:	728791.582	Date Started:	21/06/2021
Location:	Howth, Co. Dublin	Northing:	739163.531	Date Completed:	23/06/2021
Client:	Marlet	Elevation:	19.58	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
		low cobble content.		9.5		10.00	C	N=38 (6,7/7,9,11,11)		
10.5	10.50	Very stiff brown slightly sandy slightly gravelly silty CLAY.		9.0	9.08					
11.0				8.5		11.00 11.00	B C	JOT27 N=40 (7,8/9,9,10,12)		
11.5				8.0						
12.0				7.5		12.00 12.00	B C	JOT28 N=37 (5,7/9,9,9,10)		
12.5				7.0						
13.0				6.5		13.00 13.00	B C	JOT29 N=44 (4,6/10,11,11,12)		
13.5				6.0						
14.0				5.5		14.00 14.00	B C	JOT30 N=39 (3,5/7,11,10,11)		
14.5	14.60	Very stiff brown slightly sandy gravelly silty CLAY with low cobble content and bands of gravelly sand.		5.0	4.98					
15.0				4.5		15.00 15.00	B C	JOT31 50 (5,11/50 for 60mm)		
15.5				4.0						
16.0				3.5		16.00 16.00	B C	JOT32 50 (6,12/50 for 115mm)		
16.5				3.0						
17.0	17.10			2.5	2.48	17.00	C	50 (23 for 95mm/50 for 5mm) JOT33		
	17.20	Obstruction - possible boulders. End of Borehole at 17.20m			2.38	17.10	B			
17.5				2.0						
18.0				1.5						
18.5				1.0						
19.0				0.5						
19.5				0.0						

Chiselling:

From:	To:	Time:
17.10	17.20	01:00

Water Strikes:

Strike:	Rose:	Depth Sealed

Water Details:

Date:	Hole Depth:	Water Depth:

Installation:

From:	To:	Pipe:
0.00	9.00	Solid
9.00	17.20	Slotted

Backfill:

From:	To:	Type:
0.00	1.00	Bentonite
1.00	7.00	Gravel
7.00	8.00	Bentonite
8.00	17.20	Gravel

Remarks:

Borehole terminated due to obstruction.

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH03**

Contract:	Balscadden	Easting:	728739.243	Date Started:	24/06/2021
Location:	Howth, Co. Dublin	Northing:	739069.592	Date Completed:	28/06/2021
Client:	Marlet	Elevation:	19.42	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m) Scale	Depth	Stratum Description	Legend	Level (mOD) Scale	Depth	Samples and Insitu Tests Depth	Type	Result	Water Strike	Backfill
	0.10	MADE GROUND: tarmacadam.			19.32					
0.5	0.60	MADE GROUND: grey sandy gravel with medium cobble content and some red brick and concrete fragments.		19.0	18.82					
		Medium dense light brown silty gravelly SAND.		18.5		1.00	B	JOT34		
1.0						1.00	C	N=18 (2,3/4,4,5,5)		
1.5				18.0						
2.0				17.5		2.00	B	JOT35		
						2.00	C	N=21 (2,4/5,5,5,6)		
2.5				17.0						
	2.80	Medium dense yellow slightly silty SAND.			16.62					
3.0				16.5		3.00	B	JOT36		
						3.00	C	N=23 (4,5/5,6,6,6)		
3.5				16.0						
4.0				15.5		4.00	B	JOT37		
						4.00	C	N=19 (2,4/4,5,5,5)		
4.5				15.0						
	4.90	Medium dense light brown silty gravelly SAND.		14.5	14.52	5.00	B	JOT38		
5.0						5.00	C	N=15 (2,2/3,4,4,4)		
5.5				14.0						
6.0				13.5		6.00	B	JOT39		
						6.00	C	N=24 (2,4/5,6,6,7)		
6.5	6.40	Stiff brown slightly sandy gravelly silty CLAY with low cobble content.		13.0	13.02					
7.0				12.5		7.00	B	JOT40		
						7.00	C	N=30 (2,5/7,7,7,9)		
7.5	7.50	Very stiff black slightly sandy gravelly silty CLAY with low cobble content.		12.0	11.92					
8.0				11.5		8.00	B	JOT41		
						8.00	C	50 (25 for 135mm/50 for 10mm)		
8.5				11.0						
9.0				10.5		9.00	B	JOT42		
						9.00	C	50 (5,7/50 for 100mm)		
9.5				10.0						
				9.5		10.00	B	JOT43		

Chiselling: From:	To:	Time:	Water Strikes: Strike:	Rose:	Depth Sealed	Water Details: Date:	Hole Depth:	Water Depth:	Installation: From:	To:	Pipe:	Backfill: From:	To:	Type:	Remarks:
12.80	13.00	01:00	4.80	4.50	6.80	24/06	3.50	Dry	0.00	4.00	Solid	0.00	3.00	Bentonite	Borehole terminated due to obstruction.
						25/06	10.50	10.20	4.00	13.00	Slotted	3.00	13.00	Gravel	
						28/06	13.00	3.80							

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Contract No: 5836	**Cable Percussion Borehole Log**	Borehole No: **BH03**

Contract:	Balscadden	Easting:	728739.243	Date Started:	24/06/2021
Location:	Howth, Co. Dublin	Northing:	739069.592	Date Completed:	28/06/2021
Client:	Marlet	Elevation:	19.42	Drilled By:	J. O'Toole
Engineer:	Waterman Moylan	Borehole Diameter:	200mm	Status:	FINAL

Depth (m)		Stratum Description	Legend	Level (mOD)		Samples and Insitu Tests			Water Strike	Backfill
Scale	Depth			Scale	Depth	Depth	Type	Result		
10.5		Very stiff black slightly sandy gravelly silty CLAY with low cobble content.		9.0		10.00	C	50 (25 for 125mm/50 for 110mm)		
11.0				8.5		11.00	B	JOT44		
						11.00	C	50 (25 for 125mm/50 for 100mm)		
11.5				8.0						
12.0				7.5		12.00	B	JOT45		
						12.00	C	50 (25 for 115mm/50 for 25mm)		
12.5				7.0						
	12.80	Obstruction - possible boulders.			6.62	12.80	B	JOT46		
13.0	13.00	End of Borehole at 13.00m		6.5	6.42	13.00	C	50 (25 for 5mm/50 for 5mm)		
13.5				6.0						
14.0				5.5						
14.5				5.0						
15.0				4.5						
15.5				4.0						
16.0				3.5						
16.5				3.0						
17.0				2.5						
17.5				2.0						
18.0				1.5						
18.5				1.0						
19.0				0.5						
19.5				0.0						
				-0.5						

Chiselling:			Water Strikes:			Water Details:			Installation:			Backfill:			Remarks:
From:	To:	Time:	Strike:	Rose:	Depth Sealed	Date:	Hole Depth:	Water Depth:	From:	To:	Pipe:	From:	To:	Type:	
12.80	13.00	01:00	4.80	4.50	6.80				0.00	4.00	Solid	0.00	3.00	Bentonite	Borehole terminated due to obstruction.
									4.00	13.00	Slotted	3.00	13.00	Gravel	

Legend:
B: Bulk
D: Disturbed
U: Undisturbed
ES: Environmental
W: Water
C: Cone SPT
S: Split spoon SPT

Appendix 2

Trial Pit Logs and Photographs

Contract No: 5836	**Trial Pit Log**				Trial Pit No: **TP01**
Contract:	Balscadden	Easting:	728786.136	Date:	15/06/2021
Location:	Howth, Co. Dublin	Northing:	739106.863	Excavator:	JCB 3CX
Client:	Marlet	Elevation:	29.92	Logged By:	M. Kaliski
Engineer:	Waterman Moylan	Dimensions (LxWxD) (m):	2.50 x 1.10 x 2.50	Status:	FINAL

Level (mbgl) Scale:	Depth	Stratum Description	Legend	Level (mOD) Scale:	Depth:	Samples / Field Tests Depth	Type	Result	Water Strike
	0.05	TOPSOIL.			29.87				
		Brown silty slightly gravelly fine to coarse SAND with low cobble content and some gravel laminas. Gravel is fine to coarse, subrounded to rounded of various lithologies. Cobbles are subrounded to rounded of various lithologies.		29.5					
0.5									
				29.0					
1.0						1.00	B	MK01	
				28.5					
1.5									
				28.0					
2.0									
				27.5					
2.5	2.50	**Pit terminated at 2.50m**			27.42	2.50	B	MK02	
				27.0					
3.0									

Termination:	Pit Wall Stability:	Groundwater Rate:	Remarks:	Key:
Scheduled depth.	Pit walls stable.	Dry	-	B = Bulk disturbed D = Small disturbed CBR = Undisturbed CBR ES = Environmental

Contract No: 5836	**Trial Pit Log**				Trial Pit No: **TP02**
Contract:	Balscadden	Easting:	728754.368	Date:	15/06/2021
Location:	Howth, Co. Dublin	Northing:	739110.303	Excavator:	JCB 3CX
Client:	Marlet	Elevation:	23.98	Logged By:	M. Kaliski
Engineer:	Waterman Moylan	Dimensions (LxWxD) (m):	2.90 x 1.10 x 2.70	Status:	FINAL

Level (mbgl) Scale:	Depth	Stratum Description	Legend	Level (mOD) Scale:	Depth:	Samples / Field Tests Depth	Type	Result	Water Strike
		TOPSOIL.							
	0.20	Brown silty very gravelly fine to coarse SAND with low cobble content and some gravel laminas. Gravel is fine to coarse, subrounded to rounded of various lithologies. Cobbles are subrounded to rounded of various lithologies. (Possible MADE GROUND: traces of plastic identified in pit).			23.78				
0.5				23.5					
1.0				23.0		1.00	B	MK05	
1.5				22.5					
2.0				22.0		2.00	B	MK06	
2.5				21.5					
	2.70	**Pit terminated at 2.70m**			21.28				
3.0				21.0					

Termination:	Pit Wall Stability:	Groundwater Rate:	Remarks:	Key:
Scheduled depth.	Pit walls stable.	Dry	-	B = Bulk disturbed D = Small disturbed CBR = Undisturbed CBR ES = Environmental

Contract No: 5836	**Trial Pit Log**				Trial Pit No: **TP03**
Contract:	Balscadden	Easting:	728736.781	Date:	15/06/2021
Location:	Howth, Co. Dublin	Northing:	739134.128	Excavator:	JCB 3CX
Client:	Marlet	Elevation:	20.47	Logged By:	M. Kaliski
Engineer:	Waterman Moylan	Dimensions (LxWxD) (m):	2.50 x 1.10 x 3.00	Status:	FINAL

Level (mbgl) Scale:	Depth	Stratum Description	Legend	Level (mOD) Scale:	Depth:	Samples / Field Tests Depth	Type	Result	Water Strike
	0.05	TOPSOIL.			20.42				
		MADE GROUND: grey brown silty very gravelly sand with low cobble content and some plastic fragments.							
	0.20	Brown silty gravelly fine to coarse SAND with some gravel laminas. Gravel is fine to coarse, subrounded to rounded of various lithologies.			20.27				
0.5				20.0					
	0.90	Grey brown silty very gravelly fine to coarse SAND with medium cobble content. Gravel is fine to coarse, subrounded to rounded of various lithologies. Cobbles are subrounded to rounded of various lithologies.			19.57				
1.0				19.5		1.00	B	MK03	
1.5				19.0					
2.0				18.5		2.00	B	MK04	
2.5				18.0					
3.0	3.00	**Pit terminated at 3.00m**		17.5	17.47				

Termination:	Pit Wall Stability:	Groundwater Rate:	Remarks:	Key:
Scheduled depth.	Pit walls stable.	Dry	-	B = Bulk disturbed D = Small disturbed CBR = Undisturbed CBR ES = Environmental

TP01 Sidewall

TP01 Spoil

TP02 Sidewall

TP02 Spoil

TP03 Sidewall

TP03 Spoil

Appendix 3

Geotechnical Laboratory Test Results

Classification Tests in accordance with BS1377: Part 4

Client	Marlet
Site	Balscadden, Howth
S.I. File No	5836 / 21
Test Lab	Site Investigations Ltd., Carhugar The Grange, 12th Lock Rd., Lucan Co. Dublin. Tel (01) 6108768 Email info@siteinvestigations.ie
Report Date	6th July 2021

Hole ID	Depth	Sample No	Lab Ref No.	Sample Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plastic Index %	Min. Dry Density Mg/m^3	Particle Density Mg/m^3	% passing 425um	Comments	**Remarks** **C**=Clay; **M**=Silt **Plasticity**: **L**=Low; **I**=Intermediate; **H**=High; **V**=Very High; **E**=Extremely High
BH01	12.00	JOT12	21/838	B	12.1	34	20	14			63.2		CL
BH02	16.00	JOT32	21/842	B	18.5	38	24	14			50.9		CI

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BS 1377 Particle Size Analysis

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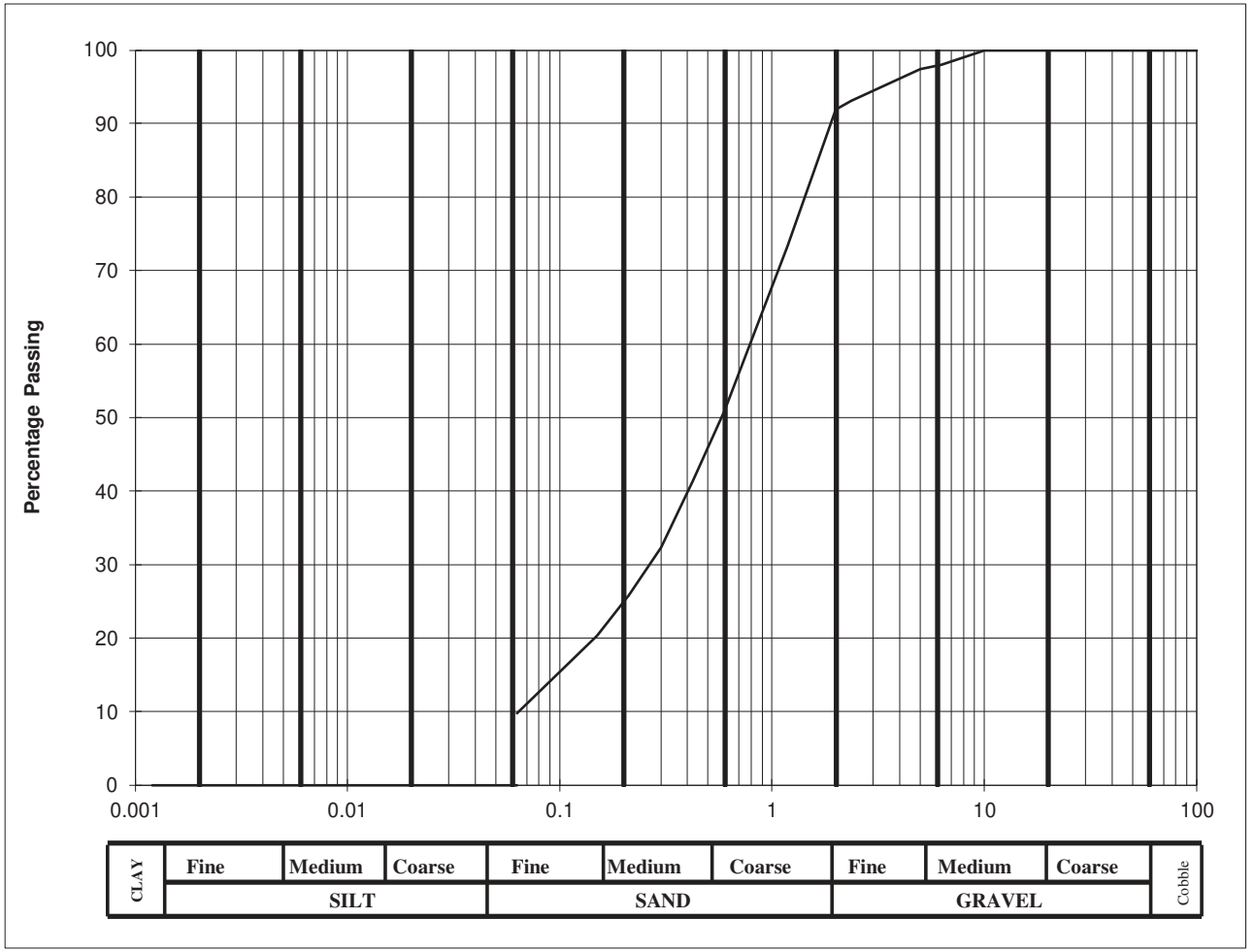
BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	98		
5.0	97.4		
2.36	93.1		
2.00	91.9		
1.18	73.2		
0.600	50.9		
0.425	41.4		
0.300	32.3		
0.212	25.8		
0.150	20.3		
0.063	10		

Cobbles, %	0
Gravel, %	8
Sand, %	82
Clay / Silt, %	10



Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/836
Sample No :	JOT04

Hole ID :	BH 01
Depth, m :	4.00

Material description :	silty gravelly SAND
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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BS 1377 Particle Size Analysis

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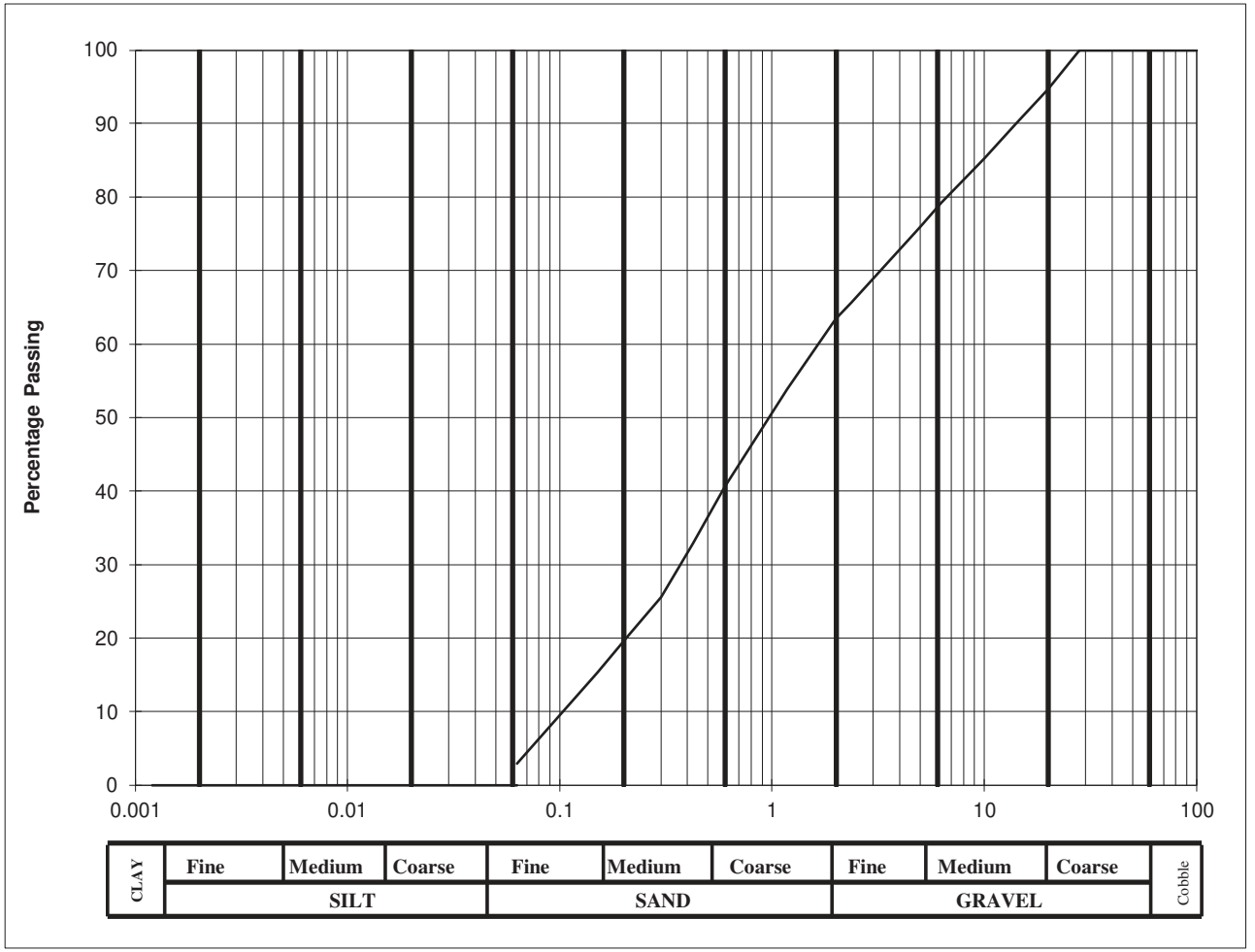
BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	100		
20	94.7		
14	89.9		
10	85.2		
6.3	79.2		
5.0	75.9		
2.36	65.6		
2.00	63.4		
1.18	53.9		
0.600	40.5		
0.425	32.8		
0.300	25.6		
0.212	20.4		
0.150	15.3		
0.063	3		

Cobbles, %	0
Gravel, %	37
Sand, %	60
Clay / Silt, %	3



Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/837
Sample No :	JOT08

Hole ID :	BH 01
Depth, m :	8.00

Material description :	slightly silty gravelly SAND
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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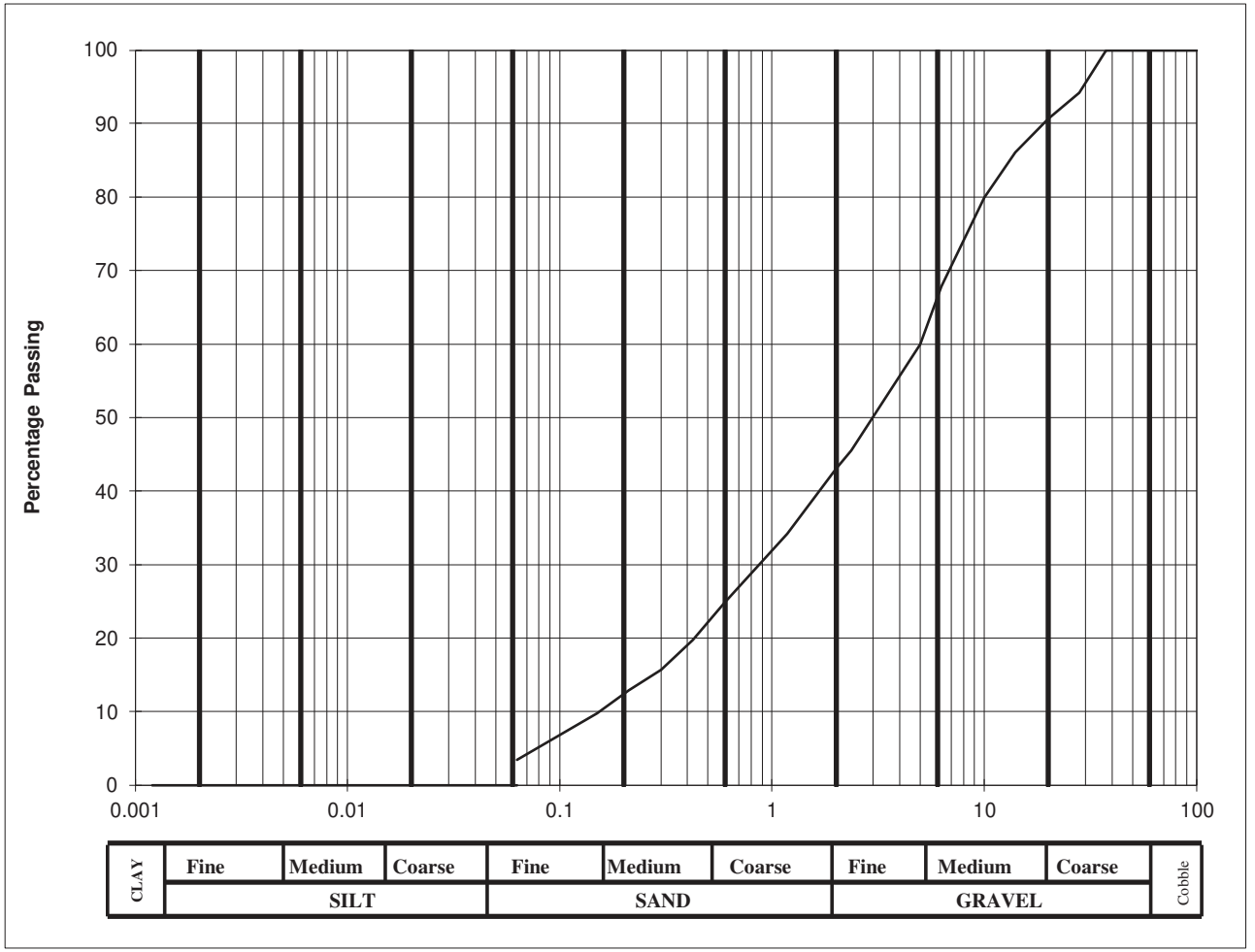
BS 1377 Particle Size Analysis

Site Investigations Limited

BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	94.2		
20	90.6		
14	86.1		
10	79.9		
6.3	67.8		
5.0	60		
2.36	45.5		
2.00	43		
1.18	34.2		
0.600	24.8		
0.425	19.7		
0.300	15.7		
0.212	12.9		
0.150	9.8		
0.063	4		

Cobbles, %	0
Gravel, %	57
Sand, %	39
Clay / Silt, %	4



Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/839
Sample No :	JOT18

Hole ID :	BH 02
Depth, m :	2.00

Material description :	slightly silty very sandy GRAVEL
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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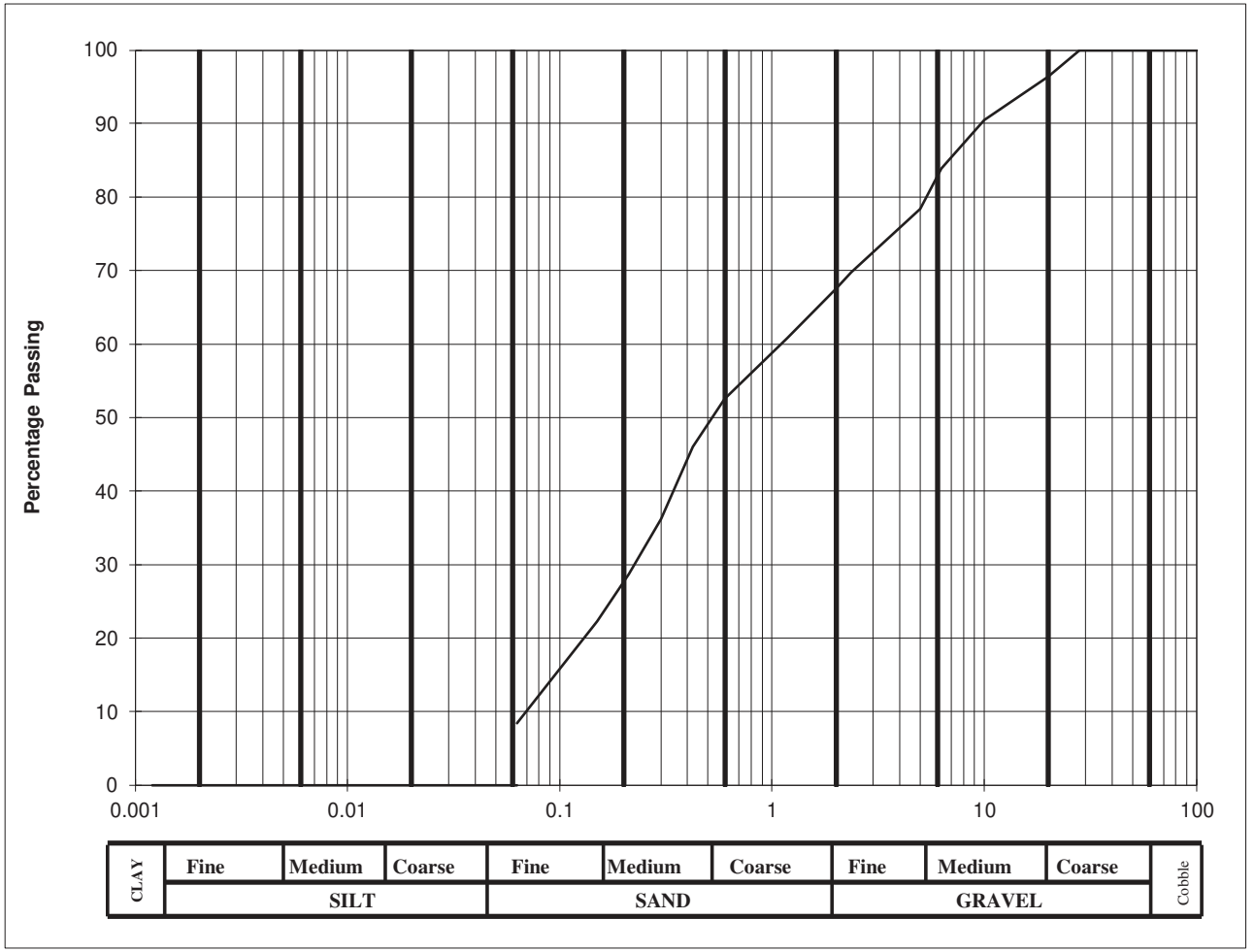
BS 1377 Particle Size Analysis

Site Investigations Limited

BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	100		
20	96.4		
14	93.3		
10	90.5		
6.3	83.9		
5.0	78.4		
2.36	69.8		
2.00	67.5		
1.18	60.8		
0.600	52.5		
0.425	46		
0.300	36.2		
0.212	28.7		
0.150	22.3		
0.063	9		

Cobbles, %	0
Gravel, %	33
Sand, %	59
Clay / Silt, %	9



Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/840
Sample No :	JOT21

Hole ID :	BH 02
Depth, m :	5.00

Material description :	silty very gravelly SAND
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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BS 1377 Particle Size Analysis

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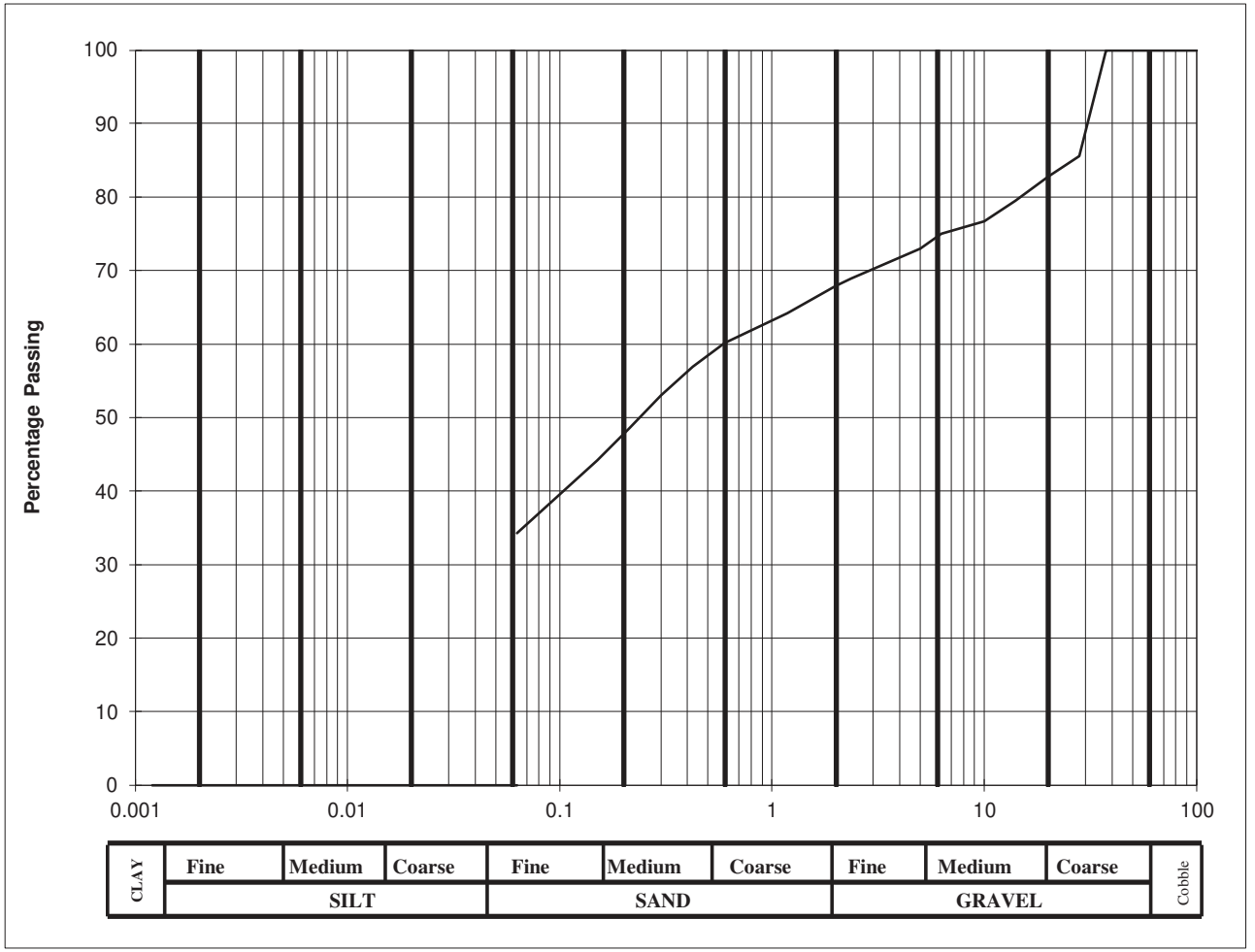
BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	85.6		
20	82.8		
14	79.5		
10	76.7		
6.3	75		
5.0	73		
2.36	68.9		
2.00	67.9		
1.18	64.2		
0.600	60.1		
0.425	56.9		
0.300	53		
0.212	48.5		
0.150	44.2		
0.063	34		

Cobbles, %	0
Gravel, %	32
Sand, %	34
Clay / Silt, %	34



Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/841
Sample No :	JOT29

Hole ID :	BH 02
Depth, m :	13.00

Material description :	slightly sandy slightly gravelly silty CLAY
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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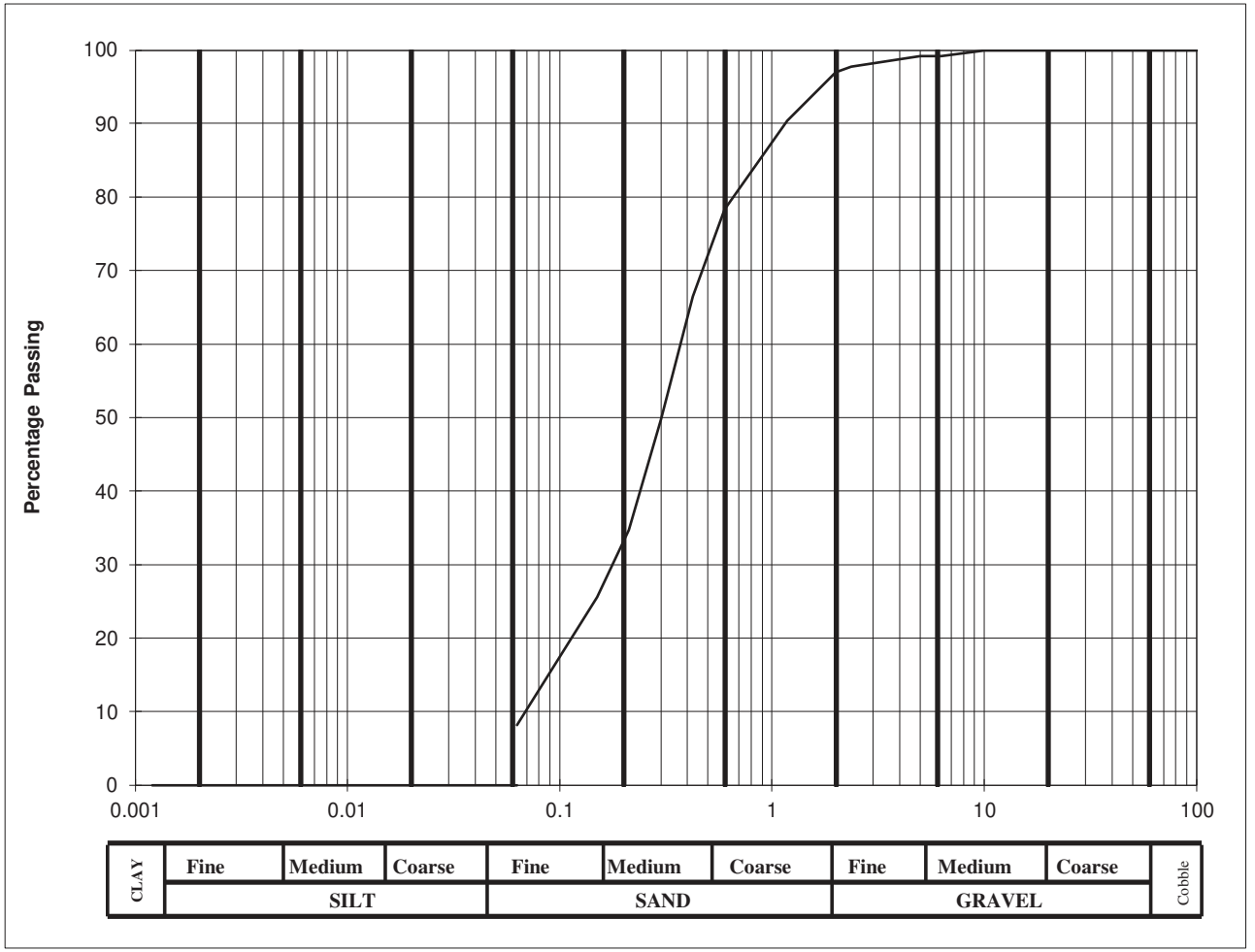
BS 1377 Particle Size Analysis

Site Investigations Limited

BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	99.2		
5.0	99.2		
2.36	97.7		
2.00	97		
1.18	90.4		
0.600	78.3		
0.425	66.5		
0.300	49.8		
0.212	34.7		
0.150	25.6		
0.063	8		

Cobbles, %	0
Gravel, %	3
Sand, %	89
Clay / Silt, %	8



Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/833
Sample No :	MK01

Hole ID :	TP 01
Depth, m :	1.00

Material description :	silty slightly gravelly SAND
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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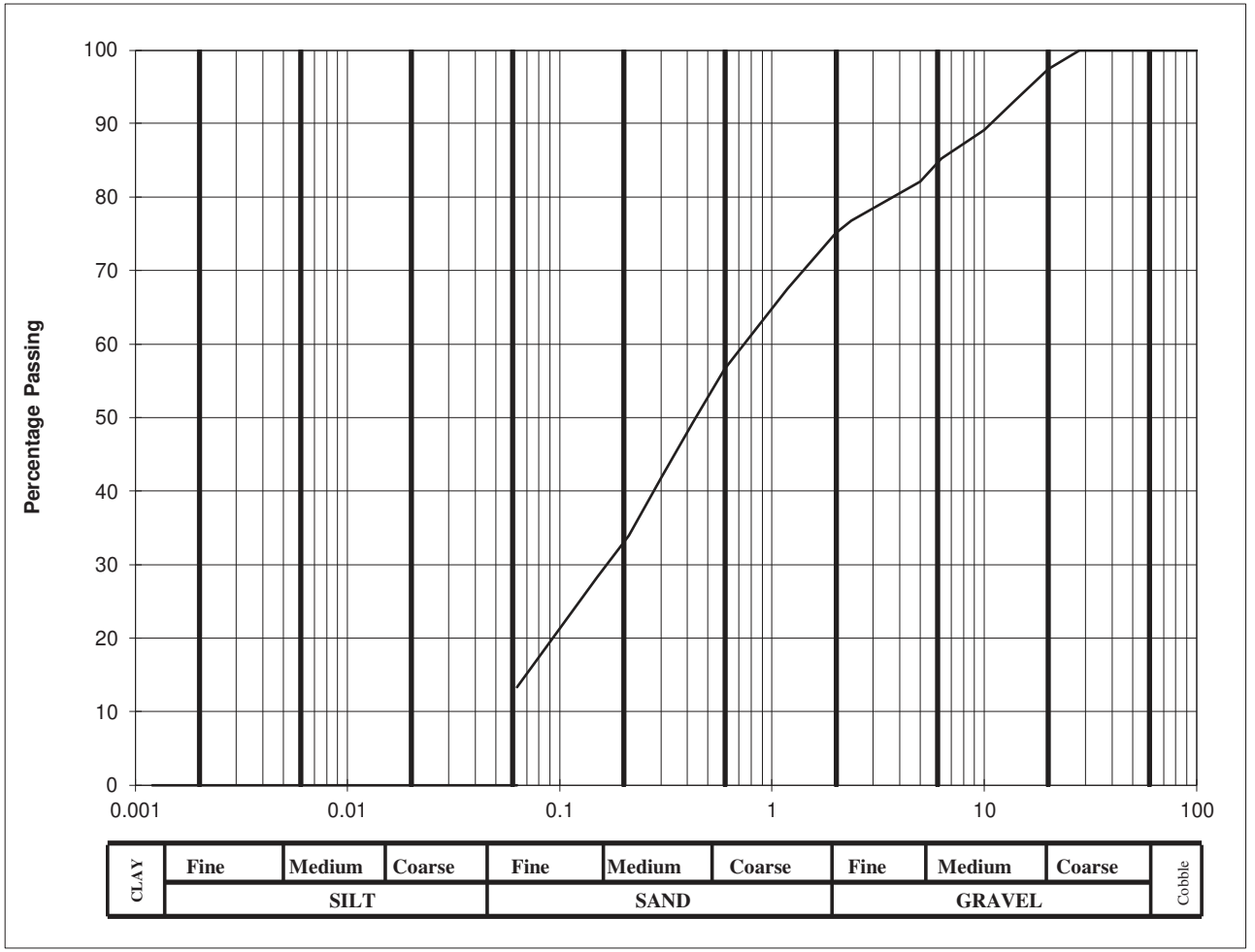
_____Paddy McGonagle
Site Investigations Ltd

BS 1377 Particle Size Analysis

Site Investigations Limited

BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	100		
20	97.4		
14	93.2		
10	89.1		
6.3	85.2		
5.0	82.1		
2.36	76.8		
2.00	75.1		
1.18	67.5		
0.600	56.6		
0.425	49.3		
0.300	41.8		
0.212	33.9		
0.150	28.3		
0.063	13		



Cobbles, %	0
Gravel, %	25
Sand, %	62
Clay / Silt, %	13

Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/834
Sample No :	MK06

Hole ID :	TP 02
Depth, m :	2.00

Material description :	silty very gravelly SAND
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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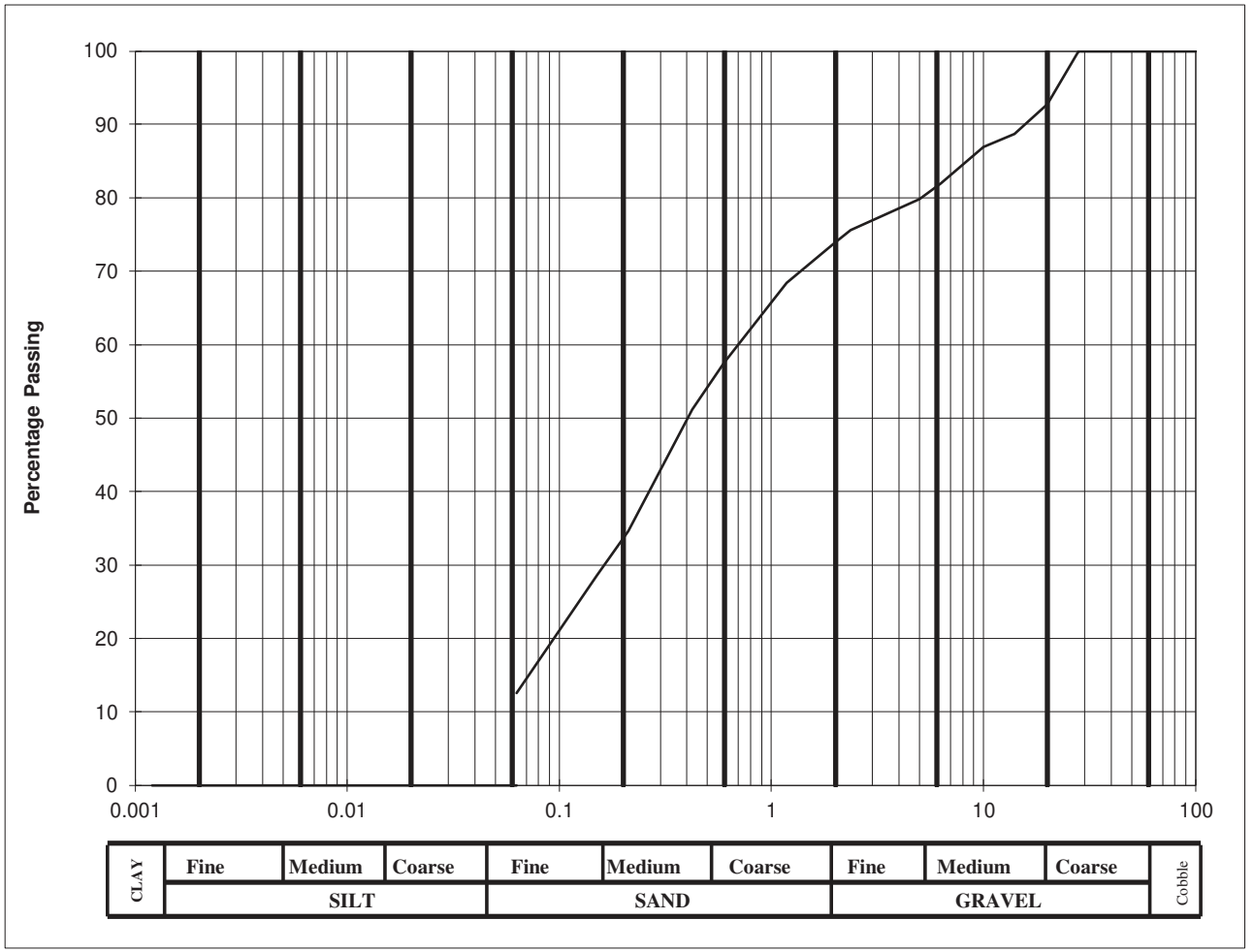
Site Investigations Ltd

BS 1377 Particle Size Analysis

Site Investigations Limited

BS Sieve size, mm	Percent passing	Hydrometer analysis	
		Diameter, mm	% passing
100	100	**0.0630**	
90	100	**0.0200**	
75	100	**0.0060**	
63	100	**0.0020**	
50	100		
37.5	100		
28	100		
20	92.7		
14	88.7		
10	86.9		
6.3	81.9		
5.0	79.8		
2.36	75.6		
2.00	73.9		
1.18	68.4		
0.600	57.5		
0.425	51.2		
0.300	43		
0.212	34.6		
0.150	28.5		
0.063	13		

Cobbles, %	0
Gravel, %	26
Sand, %	61
Clay / Silt, %	13



Client :	Marlet
Project :	Balscadden, Howth

Lab. No :	21/835
Sample No :	MK04

Hole ID :	TP 03
Depth, m :	2.00

Material description :	silty very gravelly SAND
Remarks :	Soils with clay or silt content between 15% - 35% can be classified as clay or silt depending on the field Engineers assessment of in-situ behaviour. Where material is for re-use and therefore disturbed, only soils with clay or silt >35% are classified as clay or silt

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Site Investigations Ltd

Chemical Testing
In accordance with BS 1377: Part 3

Client	Marlet
Site	Balscadden, Howth
S.I. File No	5836 / 21
Test Lab	Site Investigations Ltd., Carhugar The Grange, 12th Lock Rd., Lucan Co. Dublin. Tel (01) 6108768 Email:info@siteinvestigations.ie
Report Date	6th July 2021

Hole Id	Depth (mBGL)	Sample No	Lab Ref	pH Value	Water Soluble Sulphate Content (2:1 Water-soil extract) (SO_3) g/L	Water Soluble Sulphate Content (2:1 Water-soil extract) (SO_3) %	Loss on Ignition (Organic Content) %	Chloride ion Content (water:soil ratio 2:1) %	% passing 2mm	Remarks
BH01	4.00	JOT04	21/836	8.57	0.119	0.109			91.9	
BH02	5.00	JOT21	21/840	8.57	0.120	0.081			67.5	
TP01	1.00	MK01	21/833	8.56	0.122	0.118			97.0	
TP02	2.00	MK06	21/834	8.49	0.117	0.088			75.1	
TP03	2.00	MK04	21/835	8.50	0.117	0.087			73.9	

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SHEAR BOX TEST

Test Method **BS 1377 : Part 7 : 1990 : Method 4**

Preparation procedure **Remoulded with 2.5 kg rammer at natural moisture content.**
Material screened on 2mm sieve

Description **Reb/brown slightly silty slightly gravelly fine to coarse SAND.**

Weighings		**Stage 1**	**Stage 2**	**Stage 3**
Wet soil	gms	345.2	344.5	344.9
Dry soil	gms	160.9	160.5	160.7
Wet soil	gms	190.5	189.9	190.4
Dry soil	gms	160.9	160.5	160.7
Water	gms	29.7	29.4	29.7
Moisture Content (%)		18.4	18.3	18.5
Bulk Density (Mg/m3)		2.12	2.11	2.12
Dry density (Mg/m3)		1.79	1.78	1.79
Voids ratio e		0.5104	0.5140	0.5121
Degree of saturation (%)		97.5	96.2	97.3

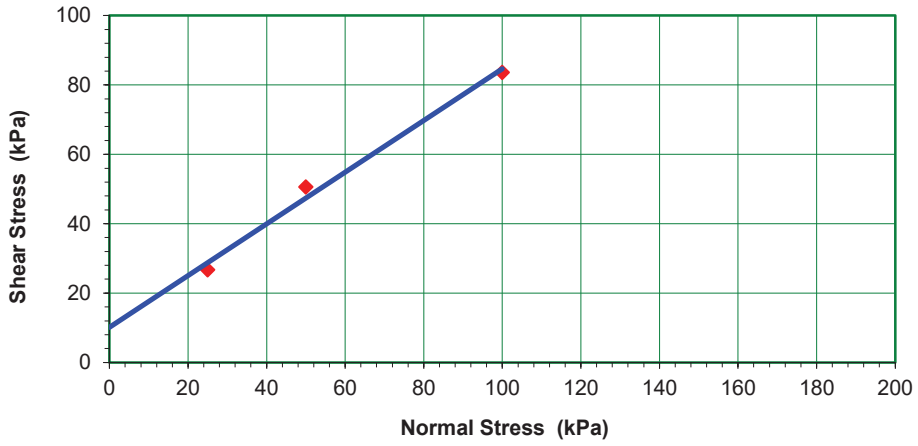
Nominal Dimensions		
Length	L1 mm	60
	L2 mm	60
Area	A mm2	3600
Height	H mm	25
Volume	V cm3	90
Particle density	Mg/m3	2.70

Final Details

	Stage 1	**Stage 2**	**Stage 3**
Normal Loads(kPa)	25	50	100
Shear stress (kPa)	26.7	50.6	83.6
Horizontal Displacement (mm)	1.743	2.227	2.039
Vertical displacement (mm)	-0.169	0.015	-0.040
Rate of displacement (mm/min)		0.5000	

			Peak
Date sampled	n/a		
Date received	25/06/2021	Cohesion c' (kPa)	10.2
Date tested	08/07/2021	Friction angle phi'	36.1°

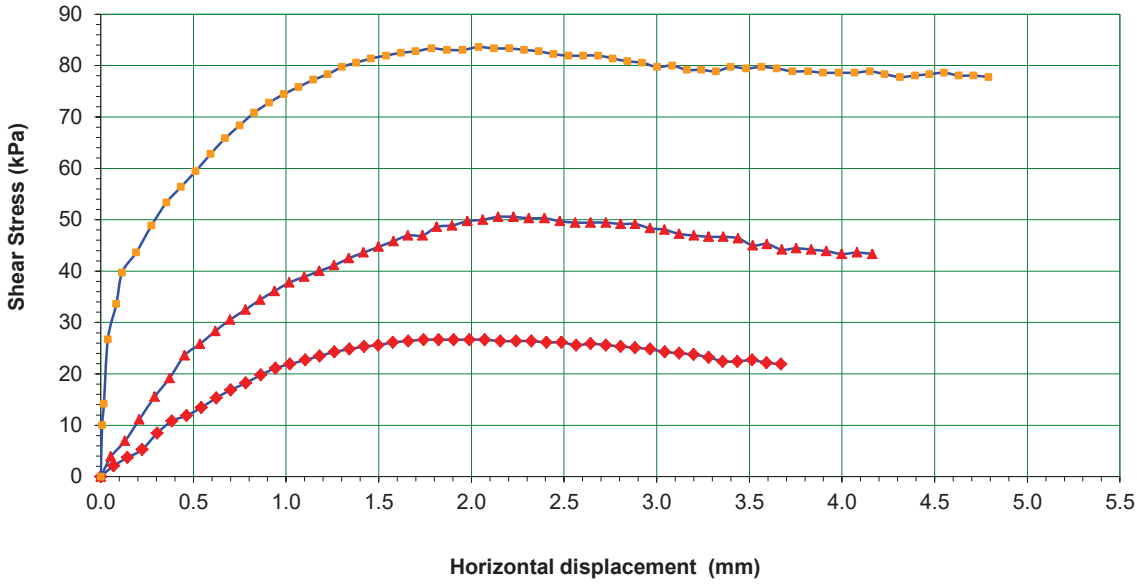
Mohr Envelope

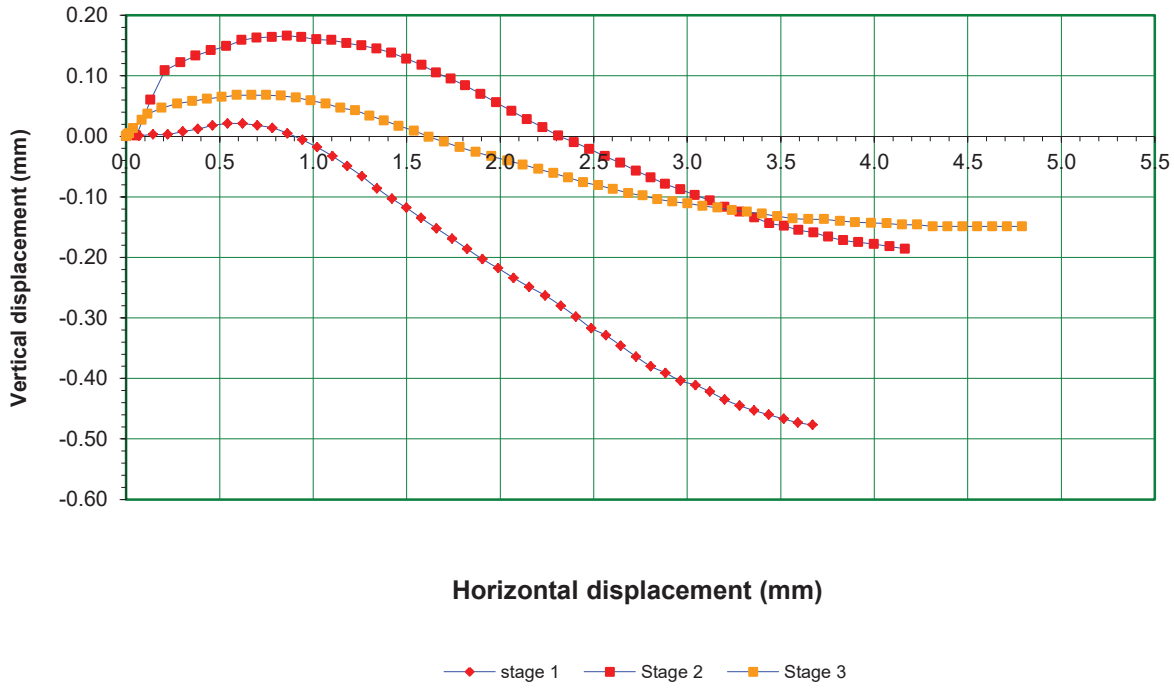


SIL PROJECT ID: 5836-21

NM T L Ltd	**Quick drained shear box in 60mm square shear box**		Job No.	NMTL_3403
			Borehole No.	TP01
	Project	Balscadden, Howth	Sample No.	MK02
Operator Sb	Checked Nc	Approved Bc	Depth.	2.50m

SHEAR STAGE





SIL PROJECT ID: 5836-21

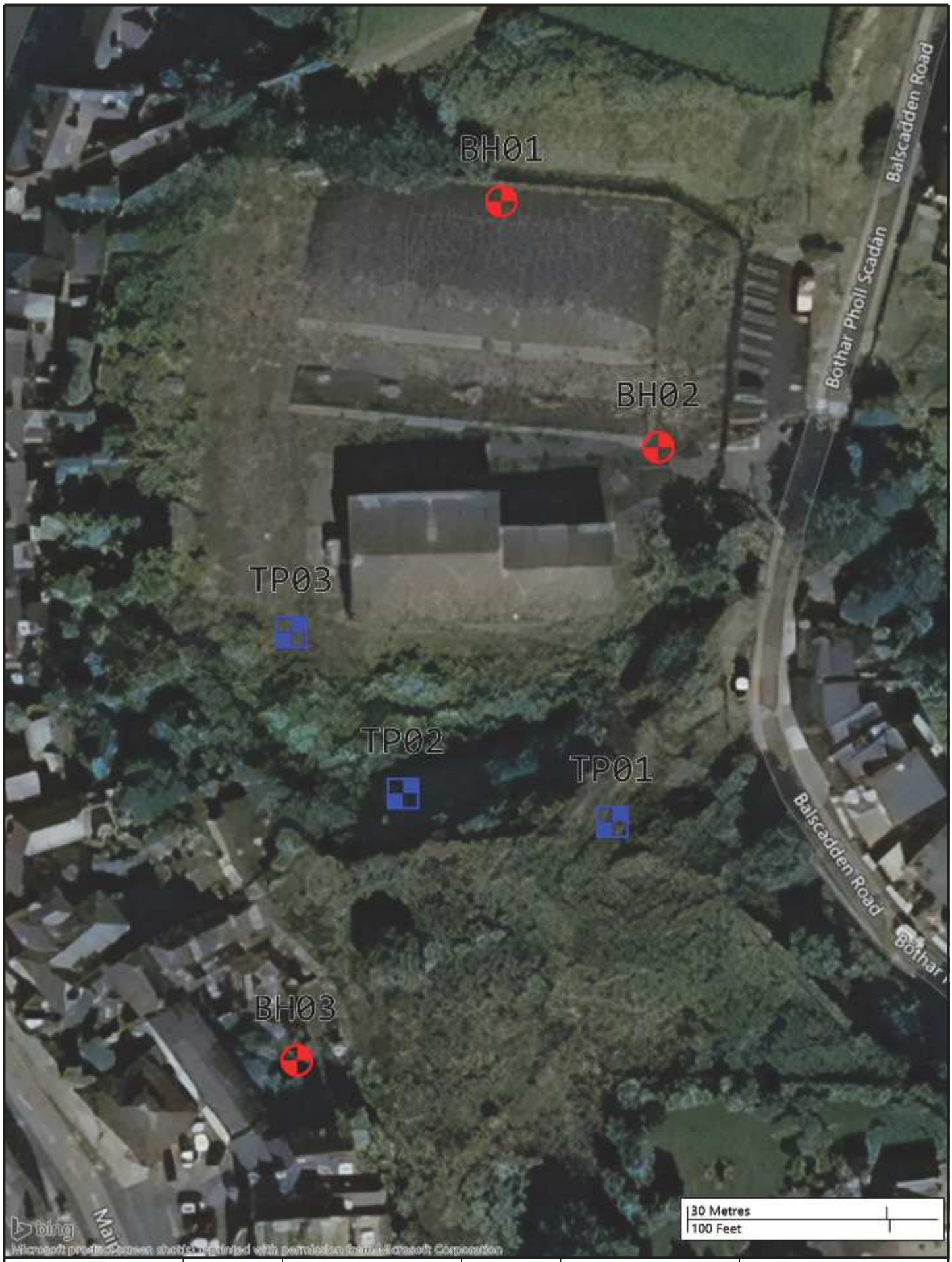
NM T L Ltd	Quick drained shear box in 60mm square shear box			Job No.	NMTL_3403
				Borehole No.	TP01
	Project	Balscadden, Howth		Sample No.	MK02
Operator Sb	Checked	Nc	Approved Bc	Depth.	2.50m

Appendix 4

Survey Data

Survey Data

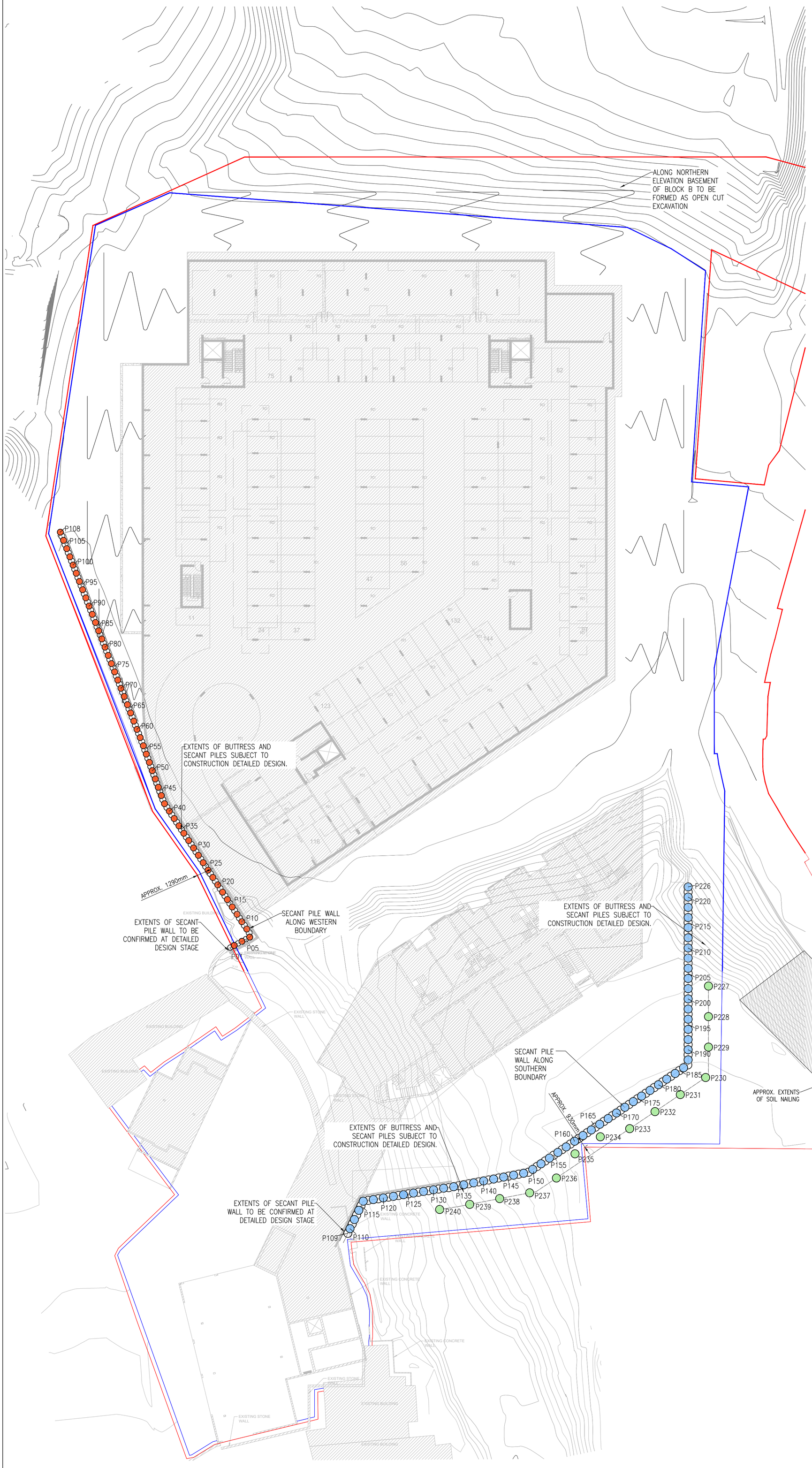
Location	Irish Transverse Mercator		Elevation	Irish National Grid	
	Easting	Northing		Easting	Northing
Boreholes					
BH01	728766.929	739199.986	19.98	328844.016	239174.894
BH02	728791.582	739163.531	19.58	328868.675	239138.431
BH03	728739.243	739069.592	19.42	328816.326	239044.471
Trial Pits					
TP01	728786.136	739106.863	29.92	328863.228	239081.751
TP02	728754.368	739110.303	23.98	328831.454	239085.191
TP03	728736.781	739134.128	20.47	328813.863	239109.021



Contract No:	5836	Client:	Marlet	Legend Key
Contract:	Balscadden	Engineer:	Waterman Moylan	Locations By Type - CP
Location:	Howth, Co. Dublin	Scale:	1:750	Locations By Type - TP
Title:	Site Plan	Drawn By:	SL	

Appendix D – Drawings

A1



PLAN 1:300 **PILE LAYOUT**
SCALE 1:300

GENERAL NOTES

1. DO NOT SCALE OFF DRAWING.
2. ALL DIMENSIONS IN MILLIMETERS UNLESS NOTED OTHERWISE.
3. ALL LEVELS IN METERS (MALIN HEAD) UNLESS NOTED OTHERWISE.
4. DESIGN IS SUBJECT TO DETAILED CONSTRUCTION DESIGN.
5. DRAWINGS TO BE READ IN CONJUCTION WITH BYRNELOOBY REPORT B1800–GEO–R001.
6. PILES TO BE DESIGNED IN ACCORDANCE WITH I.S. EN 1997–1:2004 EUROCODE 7 GEOTECHNICAL DESIGN – PART 1 AND THE IRISH NATIONAL ANNEX TO I.S. EN 1997–1:2004.
7. DESIGN IS BASED ON 1200mm DIAMETER HARD AND FIRM PILES FOR SECANT PILE WALL TYPE 01 AND BUTTRESS PILES – PILE TYPE 03. DESIGN IS BASED ON 900mm DIAMETER HARD AND FIRM PILES FOR SECANT PILE WALL FOR SECANT PILE WALL TYPE 02.
8. FIRM PILES FOR SECANT PILE WALLS TO EXTEND TO A MINIMUM OF 1m BELOW FORMATION LEVEL.
9. BYRNELOOBY LAYOUT DRAWINGS ARE INDICATIVE ONLY. PILE SETTING OUT DETAILS SUBJECT TO ENGINEERS DETAILING.

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PROJECT
BALSCADDEN ROAD

DRAWING TITLE
OVERALL SITE PLAN

STATUS
DRAFT

Date: 26/11/21	Scale: 1:300	Drawn: MON	Chk: NP	App: MR

Project No:	Drg. No:	Rev:
B1800	B1800–1000	01

A1

PLAN 1:200 PILE LAYOUT
SCALE 1:200

TYP 1:25 SECANT PILE WALL TYPICAL SETOUT
SCALE 1:25

TYP 1:25 SECANT PILE WALL TYPICAL SETOUT
SCALE 1:25

LEGEND:

- WALL TYPE 01 (WT01)
- WALL TYPE 02 (WT02)
- WALL TYPE 03 (WT03)
- DEVELOPMENT BOUNDARY (TBC BY WM)
- SITE BOUNDARY (TBC BY WM)

TYP 1:25 CONTIGUOUS BUTTRESS PILE WALL TYPICAL SETOUT
SCALE 1:25

GENERAL NOTES

1. DO NOT SCALE OFF DRAWING.
2. ALL DIMENSIONS IN MILLIMETERS UNLESS NOTED OTHERWISE.
3. ALL LEVELS IN METERS (MALIN HEAD) UNLESS NOTED OTHERWISE.
4. DESIGN IS SUBJECT TO DETAILED CONSTRUCTION DESIGN.
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7. DESIGN IS BASED ON 1200mm DIAMETER HARD AND FIRM PILES FOR SECANT PILE WALL TYPE 01 AND BUTTRESS PILES – PILE TYPE 03. DESIGN IS BASED ON 900mm DIAMETER HARD AND FIRM PILES FOR SECANT PILE WALL FOR SECANT PILE WALL TYPE 02.
8. FIRM PILES FOR SECANT PILE WALLS TO EXTEND TO A MINIMUM OF 1m BELOW FORMATION LEVEL.
9. BYRNELOOBY LAYOUT DRAWINGS ARE INDICATIVE ONLY. PILE SETTING OUT DETAILS SUBJECT TO ENGINEERS DETAILING.

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RETAINING WALL PILE LAYOUT

STATUS
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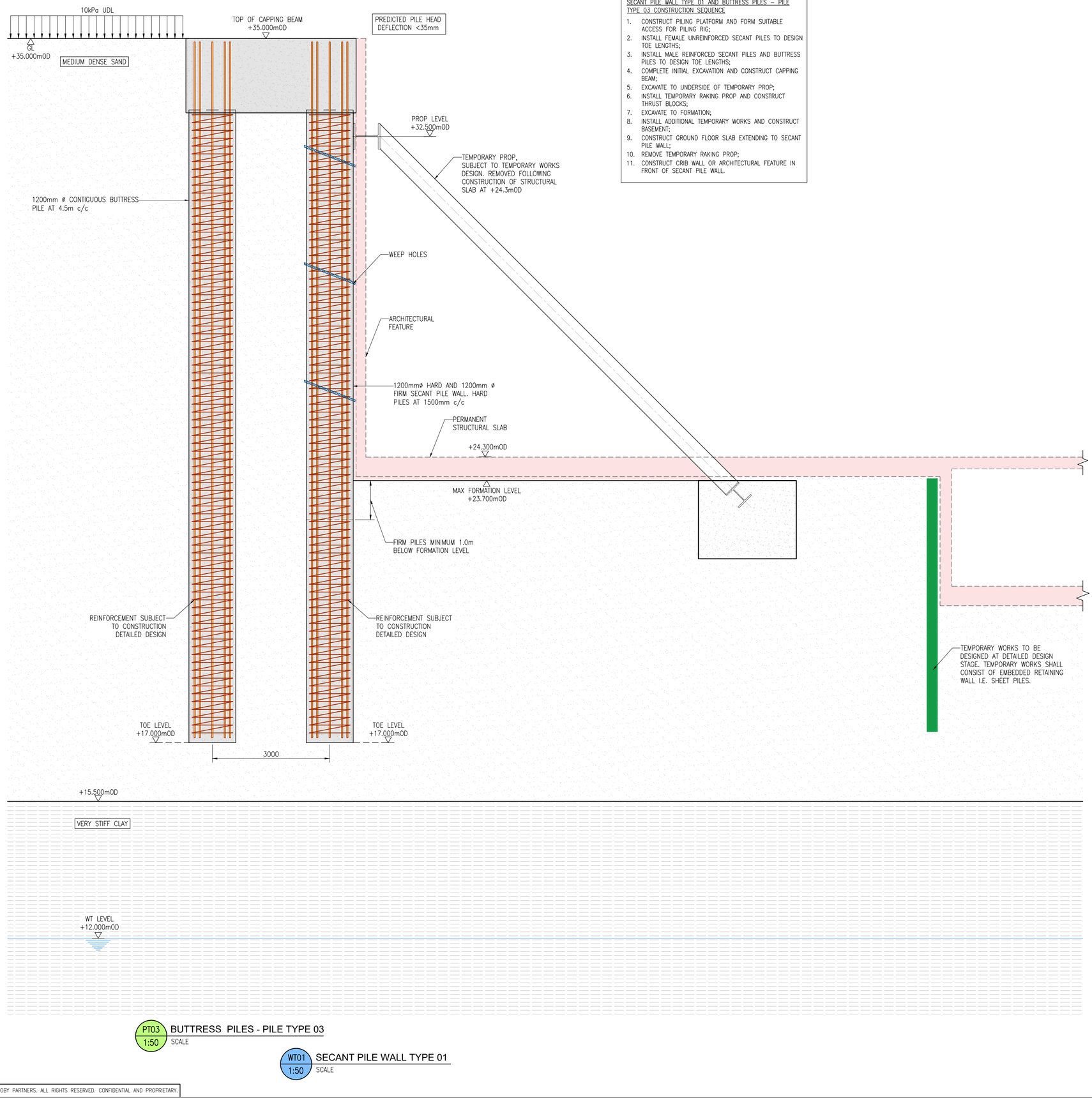
Project No:	Drg. No:	Rev:
B1800	B1800-1001	01

A1



SECANT PILE WALL TYPE 01 AND BUTTRESS PILES – PILE TYPE 03 CONSTRUCTION SEQUENCE

1. CONSTRUCT PILING PLATFORM AND FORM SUITABLE ACCESS FOR PILING RIG;
2. INSTALL FEMALE UNREINFORCED SECANT PILES TO DESIGN TOE LENGTHS;
3. INSTALL MALE REINFORCED SECANT PILES AND BUTTRESS PILES TO DESIGN TOE LENGTHS;
4. COMPLETE INITIAL EXCAVATION AND CONSTRUCT CAPPING BEAM;
5. EXCAVATE TO UNDERSIDE OF TEMPORARY PROP;
6. INSTALL TEMPORARY RAKING PROP AND CONSTRUCT THRUST BLOCKS;
7. EXCAVATE TO FORMATION;
8. INSTALL ADDITIONAL TEMPORARY WORKS AND CONSTRUCT BASEMENT;
9. CONSTRUCT GROUND FLOOR SLAB EXTENDING TO SECANT PILE WALL;
10. REMOVE TEMPORARY RAKING PROP;
11. CONSTRUCT CRIB WALL OR ARCHITECTURAL FEATURE IN FRONT OF SECANT PILE WALL.

PT03 1:50 BUTTRESS PILES - PILE TYPE 03 SCALE

WT01 1:50 SECANT PILE WALL TYPE 01 SCALE

GENERAL NOTES

1. DO NOT SCALE OFF DRAWING.
2. ALL DIMENSIONS IN MILLIMETERS UNLESS NOTED OTHERWISE.
3. ALL LEVELS IN METERS (MALIN HEAD) UNLESS NOTED OTHERWISE.
4. DESIGN IS SUBJECT TO DETAILED CONSTRUCTION DESIGN.
5. DRAWINGS TO BE READ IN CONJUCTION WITH BYRNELOOBY REPORT B1800-GEO-R001.
6. PILES TO BE DESIGNED IN ACCORDANCE WITH I.S. EN 1997-1:2004 EUROCODE 7 GEOTECHNICAL DESIGN – PART 1 AND THE IRISH NATIONAL ANNEX TO I.S. EN 1997-1:2004.
7. DESIGN IS BASED ON 1200mm DIAMETER HARD AND FIRM PILES FOR SECANT PILE WALL TYPE 01 AND BUTTRESS PILES – PILE TYPE 03. DESIGN IS BASED ON 900mm DIAMETER HARD AND FIRM PILES FOR SECANT PILE WALL FOR SECANT PILE WALL TYPE 02.
8. FIRM PILES FOR SECANT PILE WALLS TO EXTEND TO A MINIMUM OF 1m BELOW FORMATION LEVEL.
9. BYRNELOOBY LAYOUT DRAWINGS ARE INDICATIVE ONLY. PILE SETTING OUT DETAILS SUBJECT TO ENGINEERS DETAILING.

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DRAWING TITLE
RETAINING WALL PILES
SECTIONS AND DETAILS
SHEET 01 OF 02

STATUS
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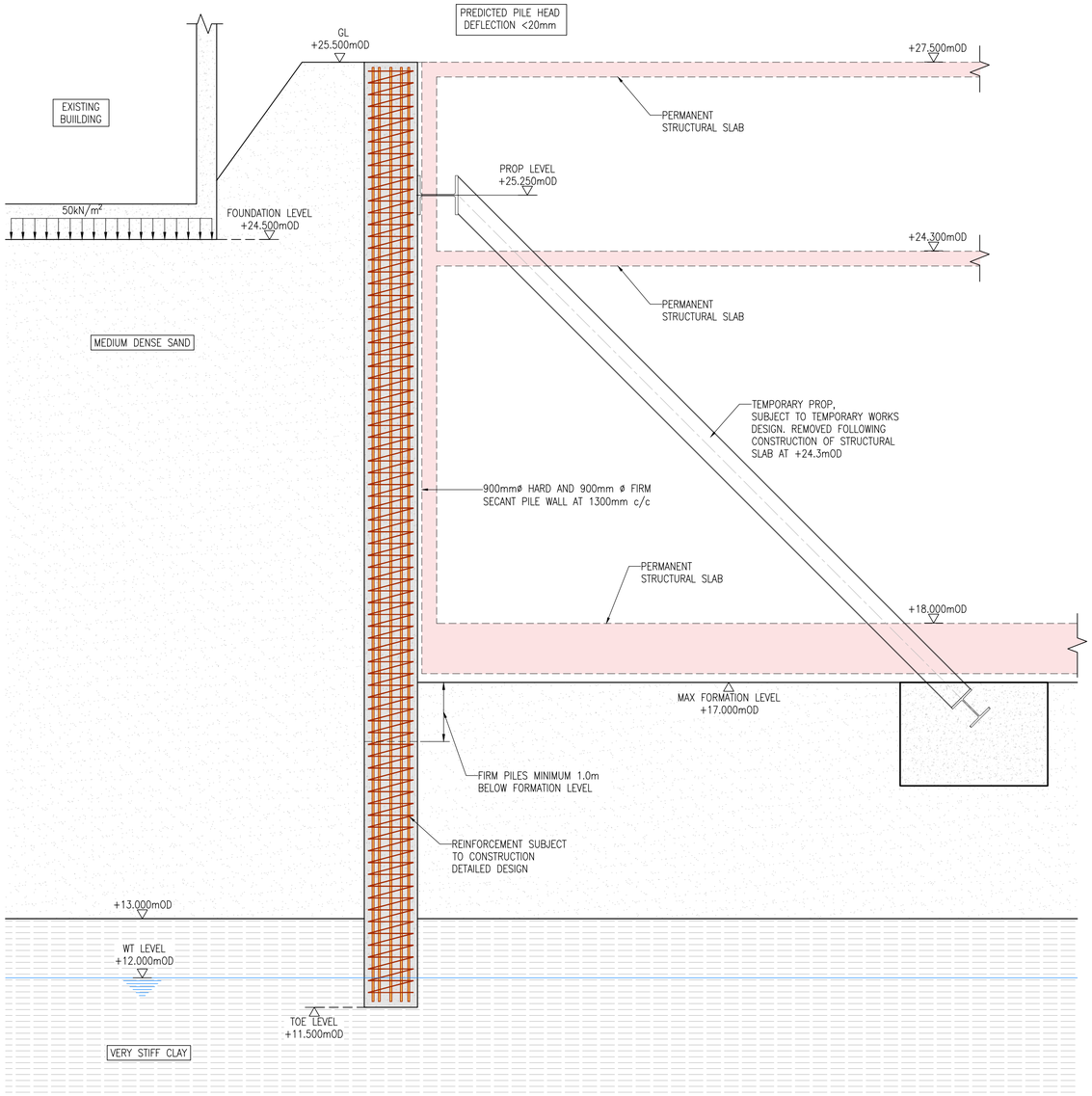
Date: 26/10/21	Scale: AS NOTED	Drawn: AI	Chk: NP	App: MR

Project No:	Drg. No:	Rev:
B1800	B1800-1002	01

A1

SECANT PILE WALL TYPE 02

1. CONSTRUCT PILING PLATFORM AND FORM SUITABLE ACCESS FOR PILING RIG;
2. INSTALL FEMALE UNREINFORCED SECANT PILES TO DESIGN TOE LENGTHS;
3. INSTALL MALE REINFORCED SECANT PILES TO DESIGN TOE LENGTHS;
4. COMPLETE INITIAL EXCAVATION;
5. EXCAVATE TO UNDERSIDE OF TEMPORARY PROP;
6. INSTALL TEMPORARY RAKING PROP AND CONSTRUCT THRUST BLOCKS;
7. EXCAVATE TO FORMATION;
8. CONSTRUCT BASEMENT FLOOR SLAB, GROUND FLOOR SLAB AND FIRST FLOOR SLAB;
9. REMOVE TEMPORARY RAKING PROP;
10. CONSTRUCT CRIB WALL OR ARCHITECTURAL FEATURE IN FRONT OF SECANT PILE WALL.



WT02 1:50 SECANT PILE WALL TYPE 02
SCALE

GENERAL NOTES

1. DO NOT SCALE OFF DRAWING.
2. ALL DIMENSIONS IN MILLIMETERS UNLESS NOTED OTHERWISE.
3. ALL LEVELS IN METERS (MALIN HEAD) UNLESS NOTED OTHERWISE.
4. DESIGN IS SUBJECT TO DETAILED CONSTRUCTION DESIGN.
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8. FIRM PILES FOR SECANT PILE WALLS TO EXTEND TO A MINIMUM OF 1m BELOW FORMATION LEVEL.
9. BYRNELOOBY LAYOUT DRAWINGS ARE INDICATIVE ONLY. PILE SETTING OUT DETAILS SUBJECT TO ENGINEERS DETAILING.

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RETAINING WALL PILES
SECTIONS AND DETAILS
SHEET 02 OF 02

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