NOTE TO FILE

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Dún Laoghaire - Rathdown
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Tufa Catchment Study

1 Introduction

This interim note summarises the updated assessment of a catchment study to spatially assess areas that may be important in supporting a sensitive groundwater fed tufa spring bounding the Cherrywood Strategic Development Zone. An initial catchment study was presented in 2018 on behalf of the County Council. This update is based on additional intrusive site investigations carried out by developers and by JBA in the catchment.

This note summarises provides an update of our understanding of the functioning of the spring, which was presented in three previous reports prepared by JBA Consulting. It has the following structure:

- Presentation of most recent additional site investigation data (completed in early Spring 2019) involving excavation of trial pits and advancing groundwater monitoring boreholes,
- An update of the existing hydrogeological Conceptual Model of the Tufa Spring,
- Identification of potential impact mechanisms that could affect the future integrity of the tufa spring,
- Further baseline assessment of the catchment supporting the tufa spring,
- Spatial zoning of the catchment to identify:
    - The hydrogeological role of catchment zones in supporting the spring,
    - Potential impact mechanisms that might affect the spring in each zone,
    - The broad nature of mitigation measures required in each zone.

2 Data Sets

The following datasets were available for review for this report.

Table 2-1: Data Sources

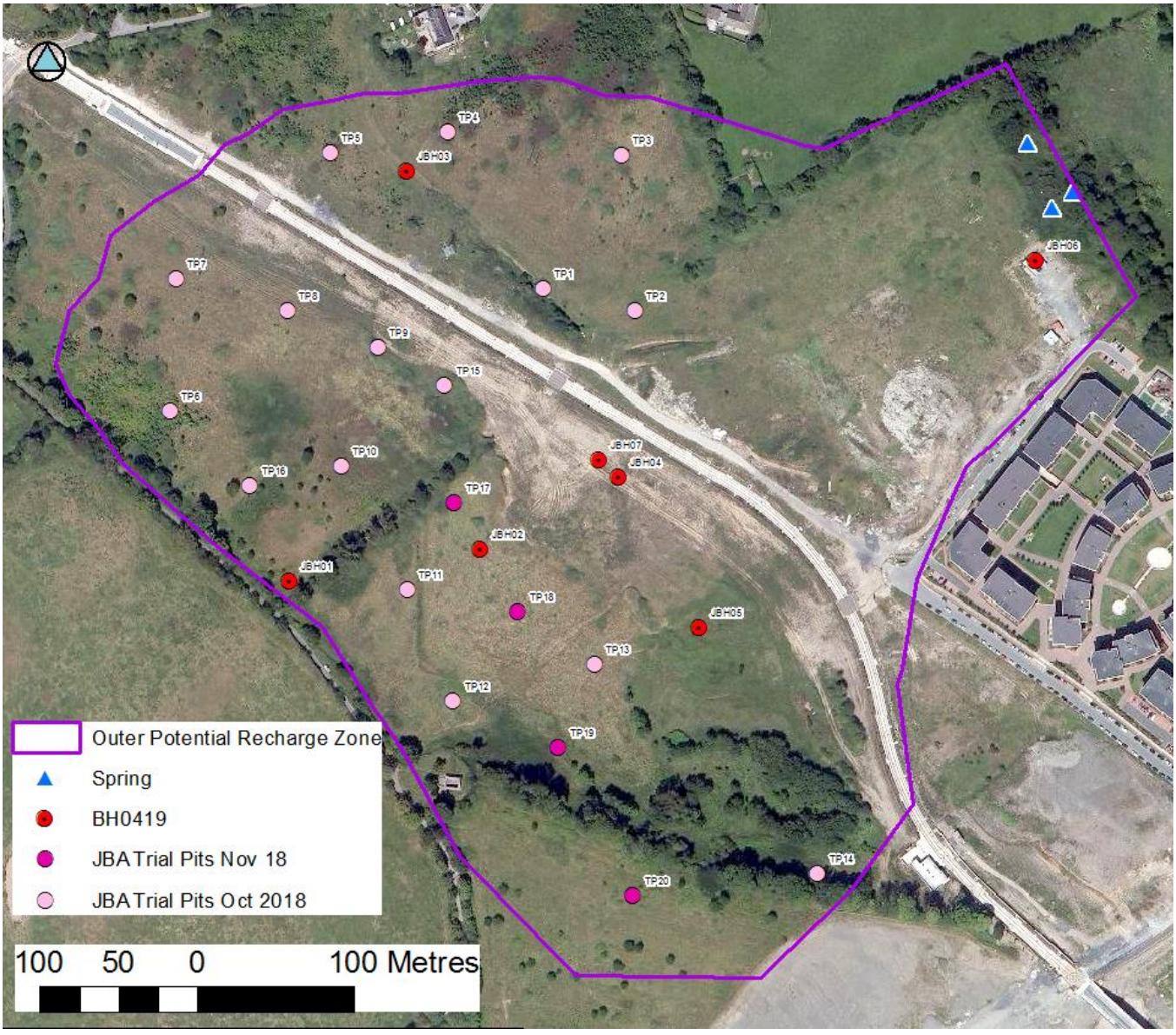
Area	Source
Topo-graphy	LIDAR
Historic Maps	25 inch 1888-1913 6 inch 1837- 1842 Available at http://map.geohive.ie/mapviewer.html
Site Investigation	GSI National Geotechnical Borehole Database – Report Numbers 1461, 2589, and 6043 Available at http://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228 Site Investigation Ltd – 2001 – Four Borehole logs covering development to the south. Ground Investigation Ireland Ltd – 2017 – 9 boreholes, 14 Trial Pits on land immediately uphill of Tufa Spring. Ground Investigation Ireland Ltd – 2017 – Site at Domville, Cherrywood, Dublin 18 – Site Investigation Report. JBA Trial Pitting 2018– See Appendix A. Causeway Geotech, April 2019, Cherrywood Ground Investigation – See Appendix B.
Aerial Photograp	Geohive 2000, 2005 and Latest Aerial Photographs available at http://map.geohive.ie/mapviewer.html

hy	Google Earth
Reports	Stephen Buss Environmental Consulting, September 2016, Hydrological Monitoring of Tufa Spring at Cherrywood. RPS, September 2011, Phase 1 Hydrogeological Assessment of the Cherrywood SDZ. Engineering Planning Report for a Proposed Residential Development at Domville, Cherrywood, Dublin 18 for William Neville & Sons – Muir Associates Ltd. JBA Consulting, July 2018, Review of Response to CFI (Planning Reference DZ17A/0714)
Thesis	MD Lyons (2015), The Flora and Conservation Status of Petrifying Springs in Ireland.

3 New Intrusive Site Investigation Information

Additional site investigations has been conducted in 2019 under the supervision of JBA to provide additional characterisation of ground and groundwater conditions within the spring catchment (See Trial Pit logs in Appendix A and Causeway Geotech 2019 in Appendix B). The locations of new investigation points are shown in the figure below and the supporting documents are provided in the appendices of this note.

Figure 3-1: Exploratory Locations



The site investigation identified three significant findings that have been used to update the conceptual model. These are discussed below.

3.1 Hilltop Till

Trial Pitting has identified a distinct type of deposit on the top of the hill, across the south and western area of the spring catchment (see Figure 3-3). The trial pits in this area identified a relatively thick sequence of

superficial deposits which included deposits sands and gravels from 1 to 5m thick. These deposits are not seen elsewhere in the catchment and are likely to be a source of the carbonate and much of the recharge that the tufa is dependent upon. The nature of these deposits is collaborated by RPS 2011 observations (see Figure 3 3) which also identified limestone rich till and tufa formations on a cut slope on the same hill to the south east of the study area. Additional water chemistry data for groundwater found within these deposits is discussed in Section 3.3

Figure 3-2: Detail from RPS 2011

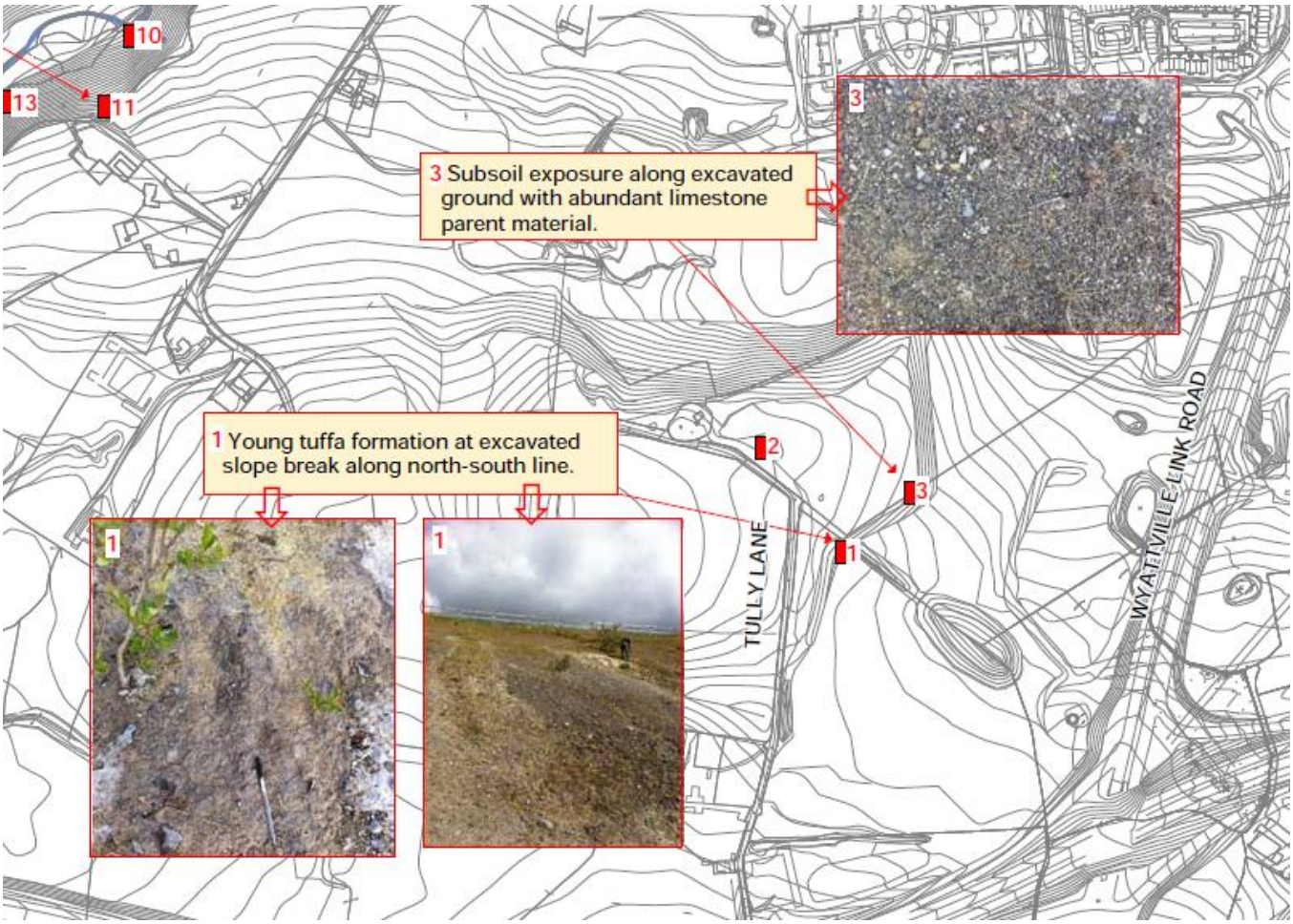
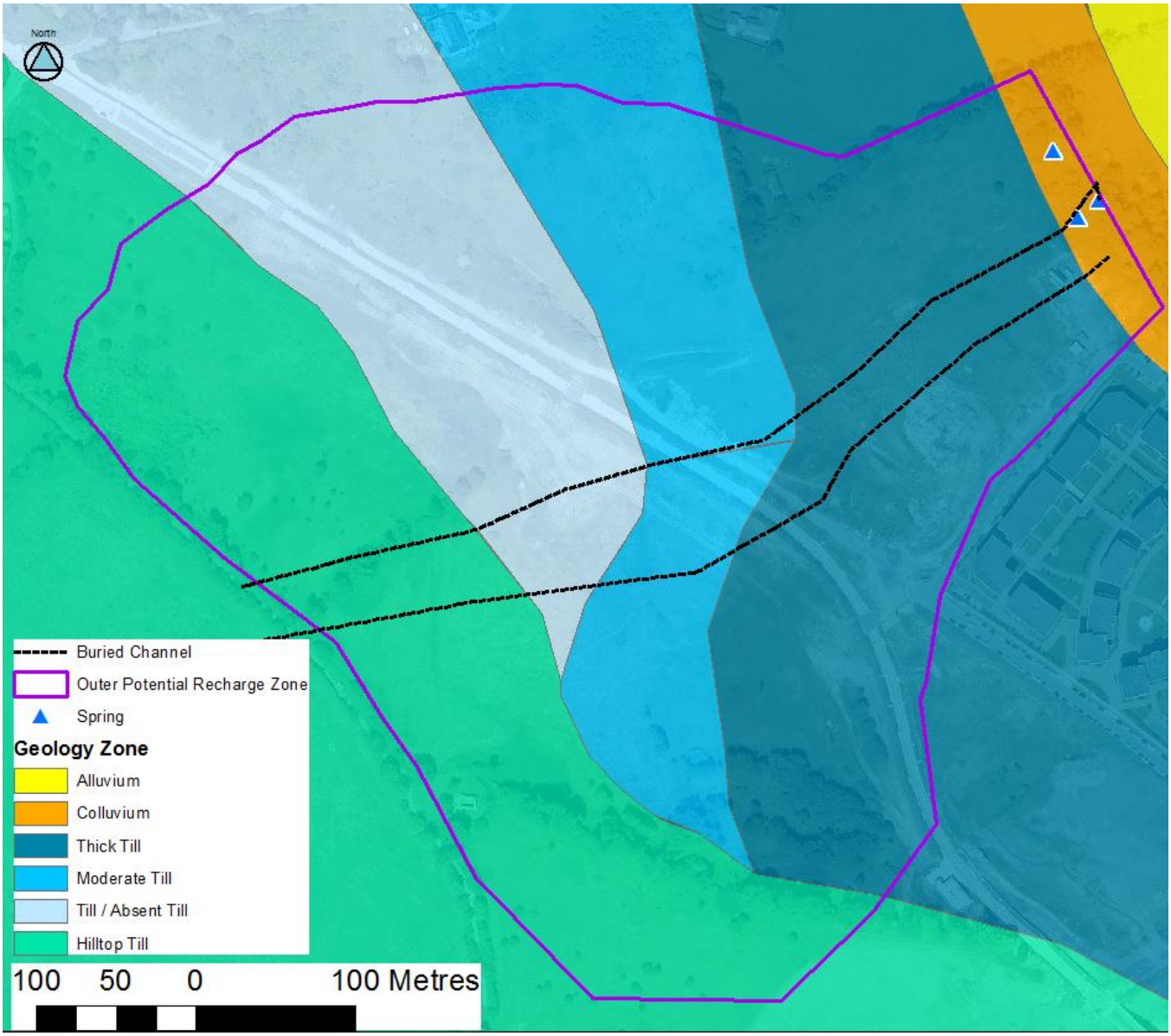


Figure 3-3: Broad Geological Classification Zones



3.2 Buried Valley

Four of the new boreholes identified a thick layer of greyish white silty sand at their base. Similar deposits at depth had not been identified in previous site investigations.

Table 3-1: Identified Buried Valley Deposits Summary

Borehole	Thickness of Silty Sand Deposits
JBH01	10m+
JBH02	6m+
JBH04	14m+
JBH06	10m+

Review of the surround site investigation information suggests that these deposits fill a steep sided buried valley cut into the granite bedrock surface. The approximate line of the buried valley is shown in Figure 3-3. For example, JBH07 and 04 are approximately 16 metres apart, bedrock at JBH07 is found at 3.2mbgl, whereas the base of JBH04 at 16mgl does not find the bedrock. This indicates the this buried valley has steep sides with at least a 1 in 1 slope. It may be a relatively narrow feature, which would explain why previous site investigations did not identify it.

Identifying the buried valley is important for updating our understanding of the location of the tufa spring. In effect, the buried valley may act as a conduit for groundwater flow focusing discharge at the spring. This may also explain why the neighbouring slopes have no groundwater discharge. However, there is a 200m gap between identify the buried valley deposits at JBH4 and at JBH6 (above the spring). Further site investigation would be recommended to try to identify the line of it through this area, possibly with the aid of non-intrusive investigation techniques such as geophysics.

3.3 Water Chemistry Results

Groundwater chemistry results suggest that that the soils found at hill top till act as a key source of calcium carbonate. Analysis indicates that, using field and laboratory measurements of pH, to calculate the Calcium Carbonate Saturation Index leads to varying results. Depending on the method of calculation, the results show groundwater lies at or close to supersaturated with respect to Calcium Carbonate in the majority of samples (see Table 3-2). This includes JBH01 showing Calcium Carbonate is present in the groundwater system in high concentrations from the top of the catchment.

Table 3-2: CaCO3 Saturation Index[1]

Sample ID		JBH - 1	JBH - 2	JBH - 3	JBH - 4	JBH - 5	JBH - 6	JBH - 7	Spring
17/04/2019	Field	0.37	0.17	0.12	0.11	0.51	0.48	0.43	N/A
	Lab	0.15	-0.48	-0.31	-0.31	0.13	0.08	-0.11	
14/04/2019	Field	0.12	-0.72	-0.53	-0.47	-0.26	-0.18	-0.53	-0.088
	Lab	0.14	0.08	-0.06	0.24	0.23	0.08	0.16	0.35

Table 3-3 presents water quality measurements at Cherrywood and the range of water quality results presented in Lyon (2015). Lyon (2015) sampled 115 tufa springs across Ireland and presents the mean, medium, minimum and maximum concentrations of a range of parameters. The table shows the parameters at Cherrywood are within the range of the Lyon samples, notably with generally high Calcium and Alkalinity

[1] The Saturation Index (SI) is a method of determining whether water will deposit calcium carbonate or maintain it in solution. Values greater than 0 are supersaturated.

levels and lower nitrate levels.

Table 3-3: Water Quality Parameters at Domville vs Parameters at other Tufa Springs (mg/l)

Sample ID	JBH - 1	JBH - 2	JBH - 3	JBH - 4	JBH - 5	JBH - 6	JBH - 7	Spring	JBA Mean	Lyon Mean	Lyon Median	Lyon Min	Lyon Max
Dissolved Calcium	108.5	133.7	124.6	100	125.2	133.2	138.3		123.4	87.8	84.5	19.08	181.22
	113	91.8	126.2	104.3	133.4	138.4	136.6	168.9	129.8				
Dissolved Magnesium #	10.3	15.4	6.3	17.6	8.7	12.3	14.7		12.2	10.11	8.15	0.22	30.56
	11.1	7.5	6	14.9	6.7	11.7	13.7	9.6	10.35				
Dissolved Potassium #	3.6	1.9	0.9	1.5	3.2	1.5	1.3		2.0	1.75	0.91	0.14	10.4
	3.3	1.4	0.9	1	0.9	1.4	1.1	1.1	1.1				
Dissolved Sodium #	26.5	15.1	12.8	13.7	14.8	16.7	15.3		16.4	15.52	8.97	5.1	82.31
	26.7	13.5	12.3	10.9	12	15.9	14.2	14.7	13.85				
Sulphate as SO4 #	22.1	34	36.3	29.2	38.7	62.7	40.6		37.7	14.27	8.28	0.06	96.25
	23.4	29.3	32.8	22.7	46.4	59.2	39.5	104.3	36.15				
Chloride #	50.5	23.5	25.6	17.1	21.8	28.3	15.4		26.0	24.16	14.61	6.98	131.89
	23.4	29.3	32.8	22.7	46.4	59.2	39.5	104.3	36.15				
Nitrate as N #	5.39	2.55	1.62	0.37	0.65	0.94	1.35		1.8	5.09	1.56	<0.07	44.05
	5.26	2.72	1.31	0.8	0.97	0.6	1.45	1.54	1.38				
Total Alkalinity as CaCO3	420	258	328	317	361	455	391		361.4	293.7	292.8	109.1	609.2
	600	335	333	330	624	431	414	353	383.5				
pH	7.62	7.43	7.36	7.47	7.51	7.54	7.5		7.5	7.88	7.97	7	8.47
	7.37	7.61	7.36	7.78	7.37	7.36	7.5	7.63	7.435				

Note
1) Two results are presents for each location on site. The upper is from the 17/04/2019 monitoring round and the lower is from the 14/04/2019.
2) No sample was taken from the spring in the first round.

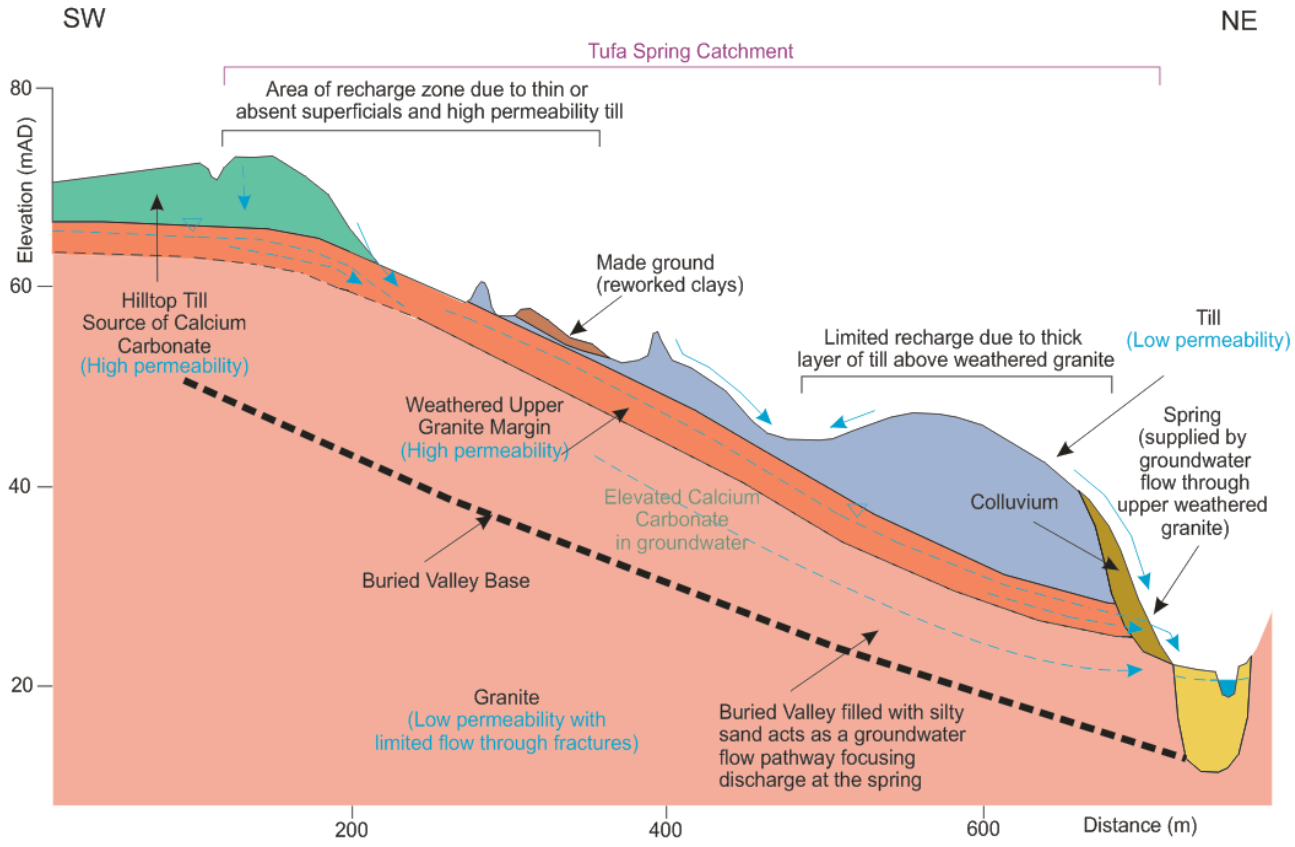
4 Updated Hydrogeological Conceptual Model

The current hydrogeological conceptual model of the tufa spring has been developed from two reports previously produced by JBA Consulting and the additional site investigation data summarised in the section above. It has the following features:

- The tufa springs form and discharge where a buried valley filled with silty sand intersects with the valley side.
- The upper weathered margin of the granite bedrock which is observed in previous site investigations acts as a relatively high permeability layer which discharges groundwater to the buried valley from the surrounding area.
- The recharge is likely to be derived from an area of thinner/absent till which overlies the bedrock and higher permeability till deposits in the upper catchment. These high permeability tills are also likely to also be a key source of calcium carbonate for the spring.
- Recharge in the area immediately uphill of the spring is limited by a thick layer of low permeability till.

The updated conceptual site model is shown in Figure 4-1.

Figure 4-1: Conceptual Model



4.1 Potential Impact Mechanisms

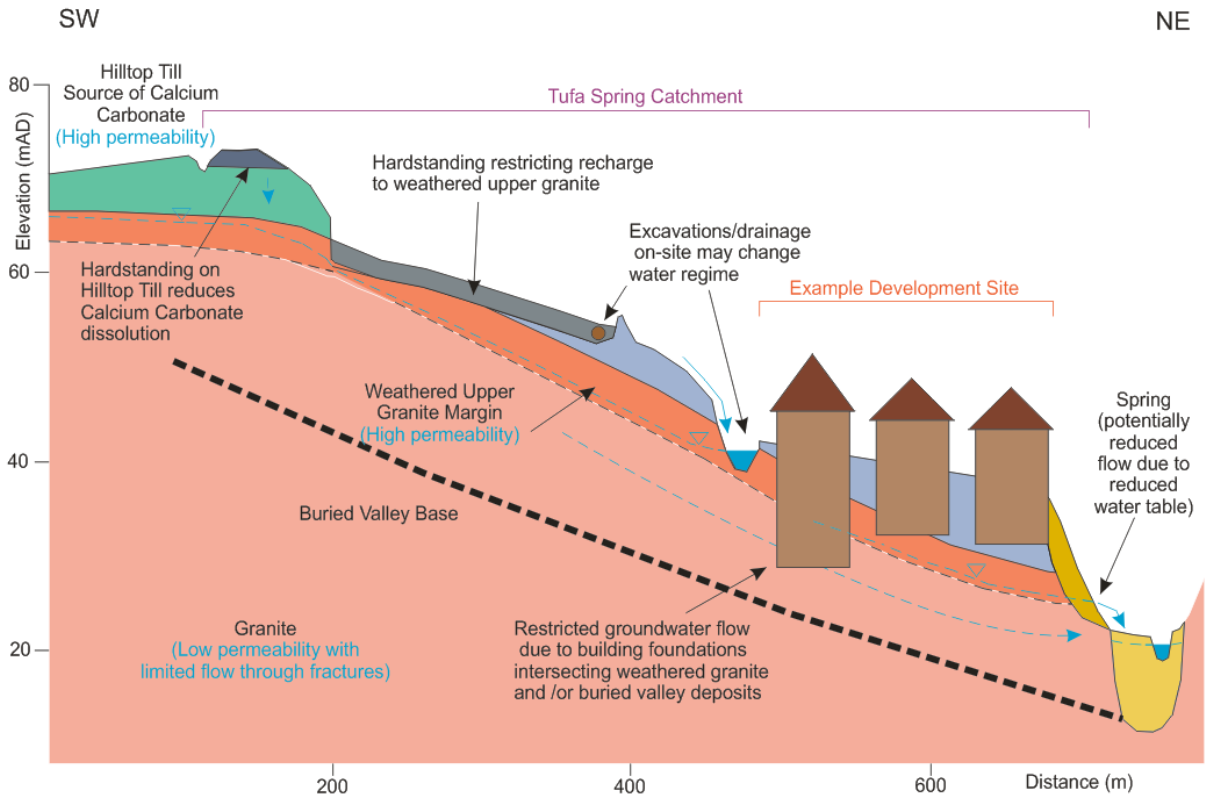
The potential impact mechanisms caused by future development can be divided into three broad categories (see table below). These are based on three key elements of the groundwater conceptual model which explains the functioning of the tufa spring.

Table 4-1: Potential Impact Mechanisms

Tufa Spring Support Element	Impact Mechanism
The water recharge zone	Reducing the permeability of the ground e.g. through construction of hardstanding over recharge area. Installation of drainage systems which divert surface water and alter the spring catchment.
Flow of water through the relatively high permeability tills, buried valley deposits and weathered upper margin of the granite bedrock.	Physical barriers to impede or divert groundwater flow (e.g. contiguous piling, foundations etc.) . Excavation below the local water table leading to a change inflow patterns, or installation of services below the water table which act as conduits for groundwater flow.
Direct Damage	Direct physical damage could occur to the tufa formation. This could lead to a change in the flow across the tufa, and the distribution of habitats on the formation.

These impact mechanisms are shown in the impact conceptual model in Figure 4-2.

Figure 4-2: Impact Conceptual Model



5 Catchment Baseline Analysis

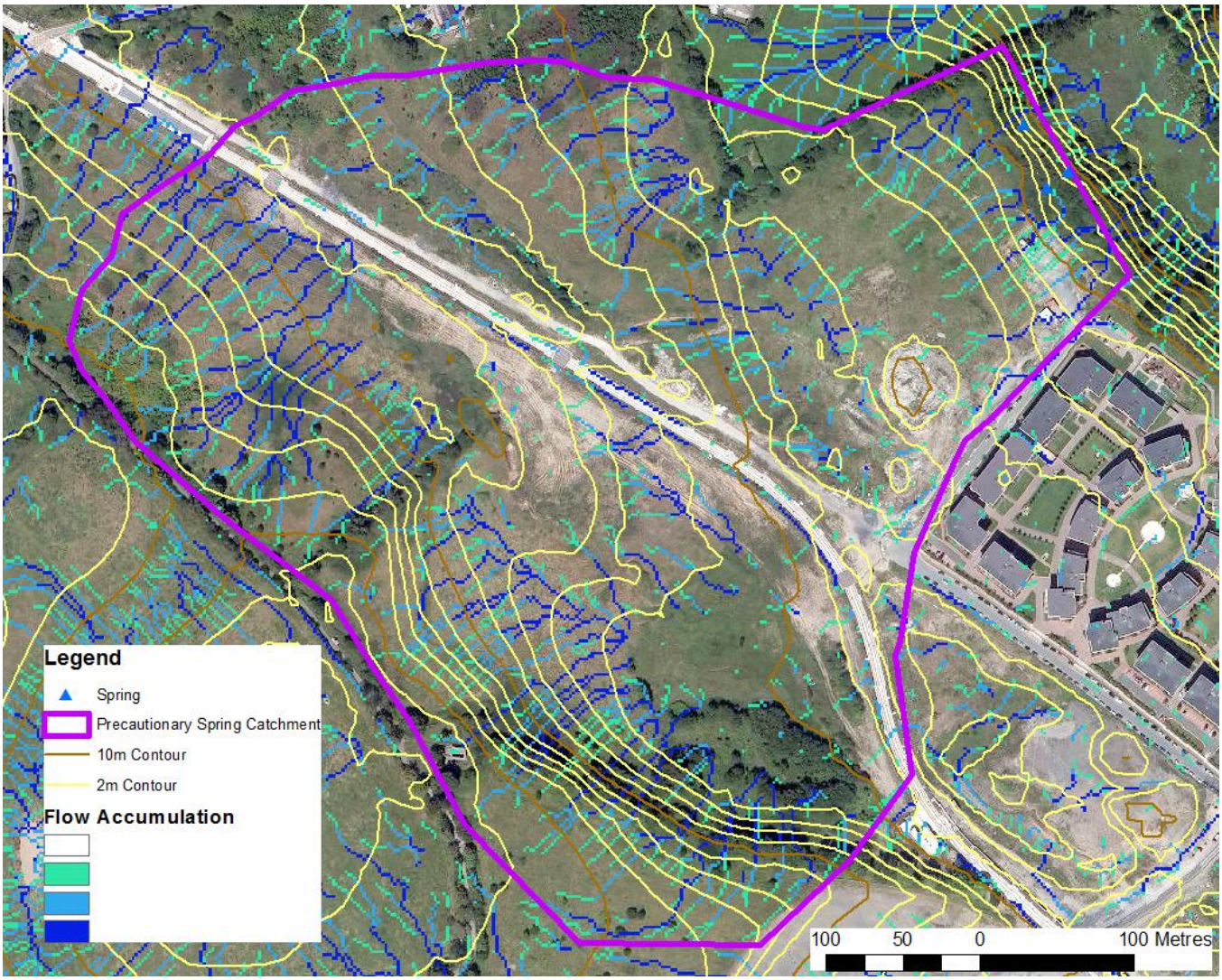
This section outlines several key elements of the analysis undertaken on the tufa catchment to identify areas which may potentially be sensitive to future development.

5.1 Precautionary Catchment Area

A Precautionary Catchment Area is shown in Figure 5-1. It is likely to be slightly larger than the true spring groundwater catchment and its extent has been defined based on the following:

- ArcGIS flow accumulation analysis to identify watersheds and main overland flow paths.
- Recharge calculations (in SBEC 2016), which suggest the catchment should be circa 28ha to account for the flow at the spring.
- The catchment excludes the existing development immediately to the south, which appears not to have affected the spring.

Figure 5-1: Precautionary Catchment Area



5.2 Intrusive Investigation Review

Data from six intrusive site investigation reports (see Table 2-1) were available for review. Appendix A presents a summary of the exploratory locations, identifying the nature and thickness of the superficial and bedrock geology. Two summary figures are presented below showing the estimated base of the superficial soils and depth to granite bedrock. Figure 5-2 shows a general slope to the top of the granite in line within general topography from west to east. The contours show the line of the buried valley west of the Luas Line and near the spring. Between those area, the site investigation locations have not identified the buried valley.

Figure 5-2: Base of Till/ Top of Granite mAD

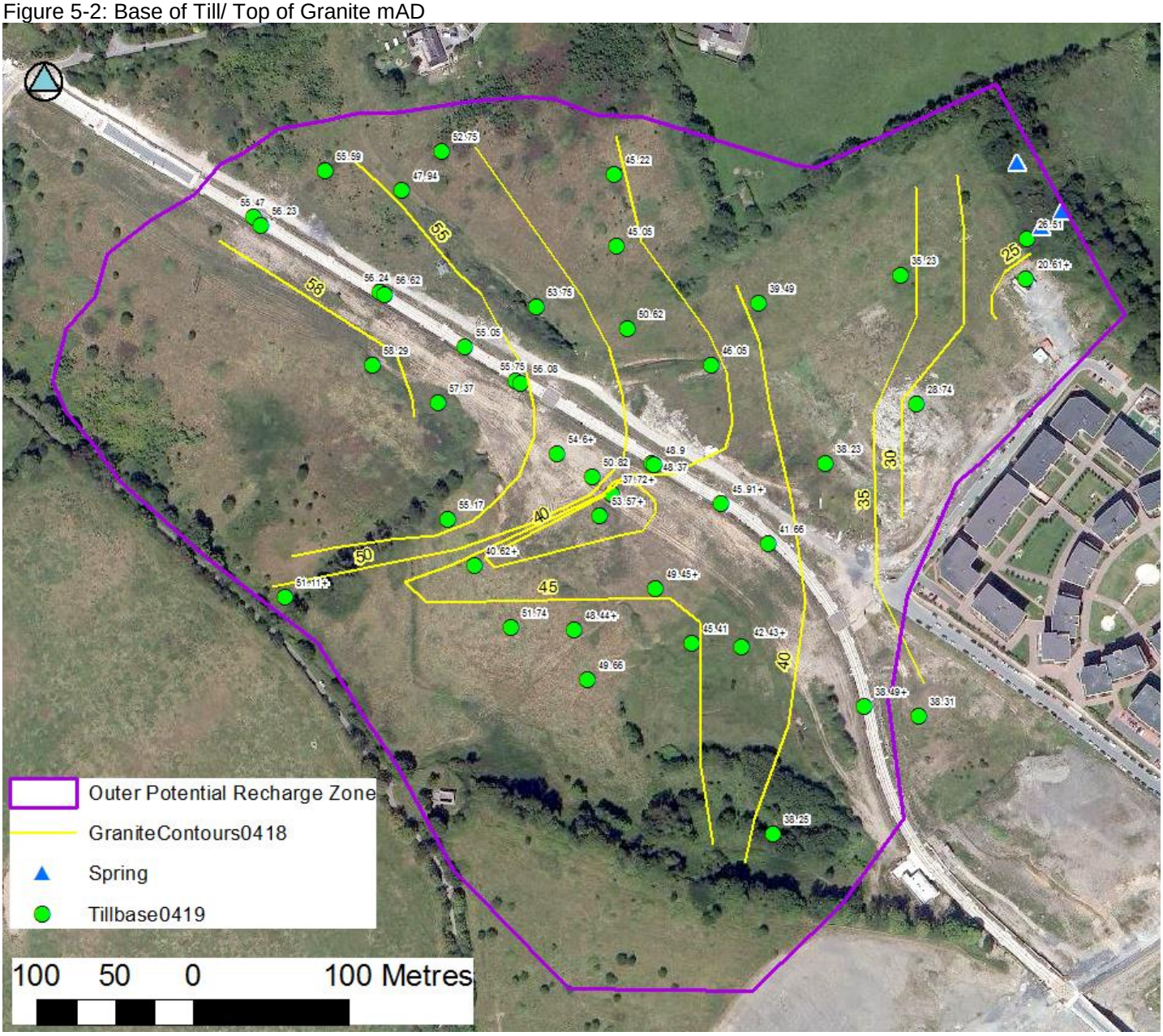


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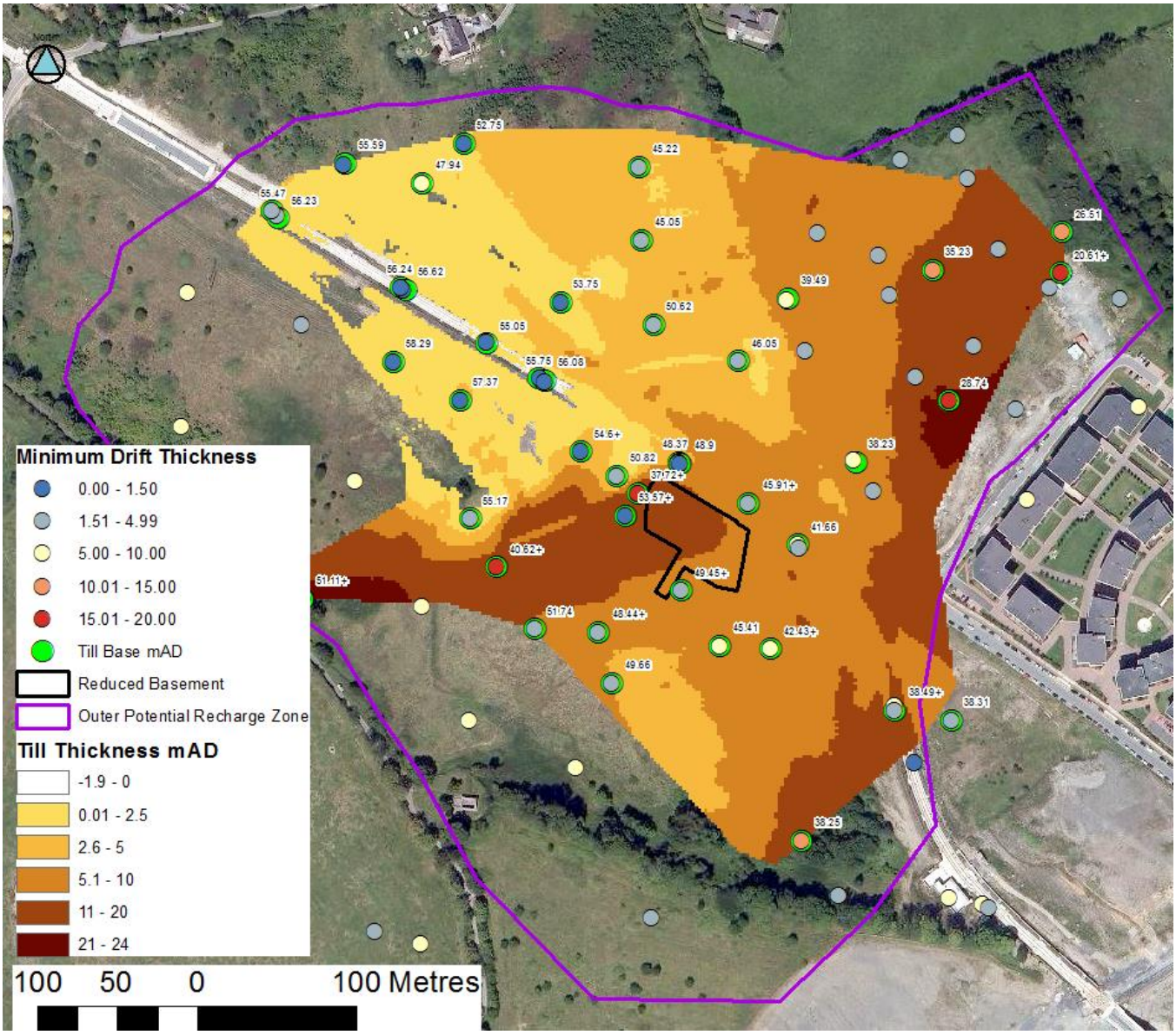
Figure 5-3: Depth to Weathered Bedrock



5.3 General Geological Classification

A review of available SI data (including that recently collected in 2018/2019), published geological mapping and topography data has been used to produce a broad classification of the geology of the catchment. This is shown in Figure 5-4 and a stratigraphic cross section is shown in Figure 5-5. There are the following classes:

- Alluvium – occupying the valley floor below the spring,
- Colluvium – till material that has migrated down the steep hill through gravity,
- Thick Till – an area of thick till (up to 17m thick) which forms a plateau above the tufa spring,
- Moderate Till – an area of moderately (approximately 2.5-5m) thick till which represents a wedging

out of the thick till in the central area of the conjectured spring catchment area,

- Thin/absent Till – above the thick till plateau as the surrounding ground slopes upwards in the west of the catchment area. The overlying till wedges out on this slope so the bedrock lies close to the surface..This is classified as till less that circa 2.5m thick
- Hilltop Till – at the top of the catchment in the west is a plateau area underlain with till with a relatively high sand and gravel content.
- The approximate line of the buried valley identified during the most recent investigations is indicated with by dashed lines. This buried valley is filled with silty and sand rich deposits.

The entire area is underlain by granite bedrock with a weathered upper surface.

Figure 5-4: Broad Geological Classification Zones

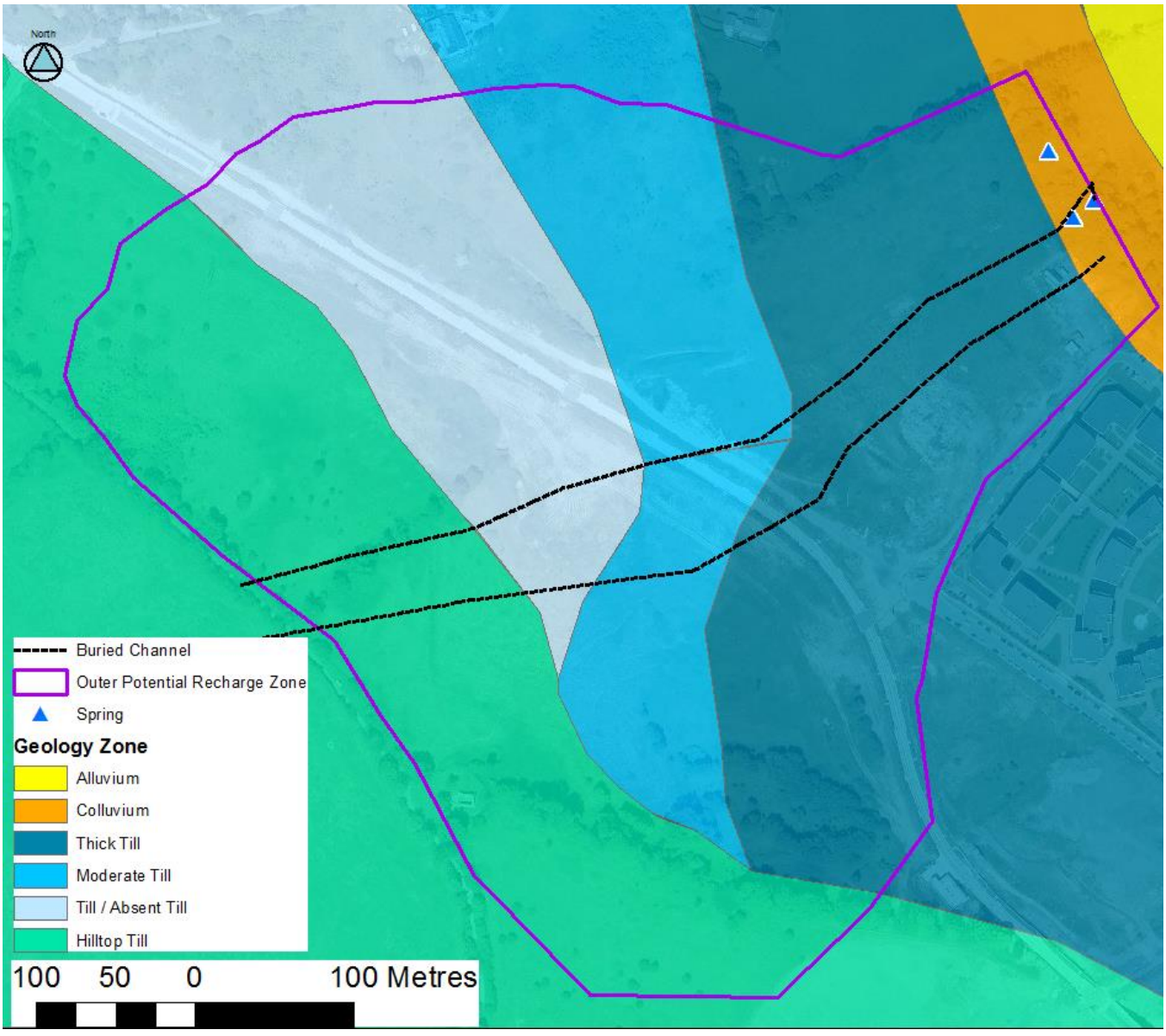
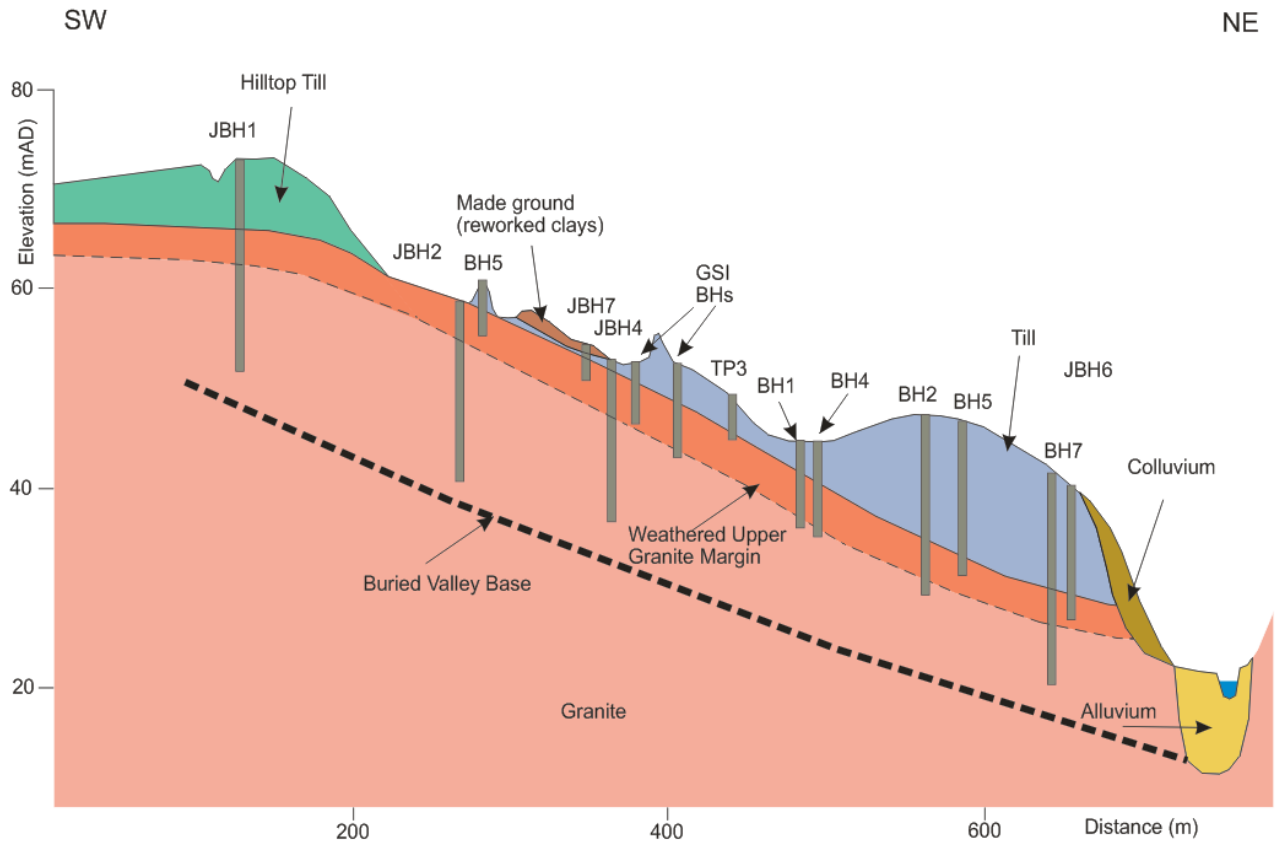


Figure 5-5: Stratigraphic Cross Section



5.4 Identifying Reworked Ground

An analysis of the SI information, LIDAR, Historic Mapping and Aerial photographs have been used to identify areas of reworked, or made ground. This includes areas of cutting and stockpiling. They are shown in Figure 5-6 and described in Table 5-1.

Figure 5-6: Reworked Ground

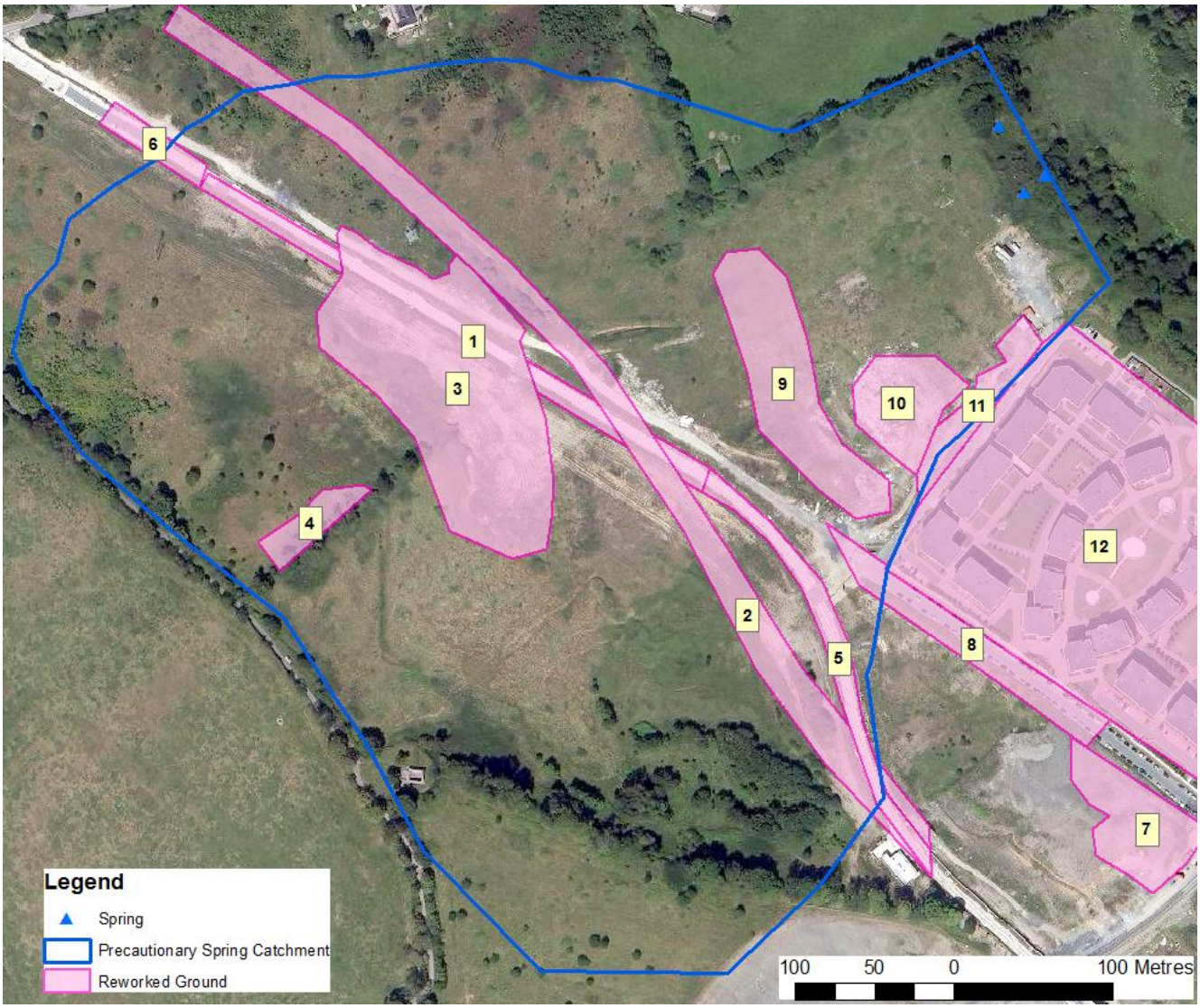


Table 5-1: Reworked Ground Descriptions

Number	Description
1	Railway line – cut section
2	Historic line of railway line
3	Area of earth stockpile (Domville SI, LIDAR and aerial photographs)
4	Historic gravel pit – 1837-42 map
5	Railway line – raised section
6	Railway line – limited cut
7	Earth stockpile
8	Road

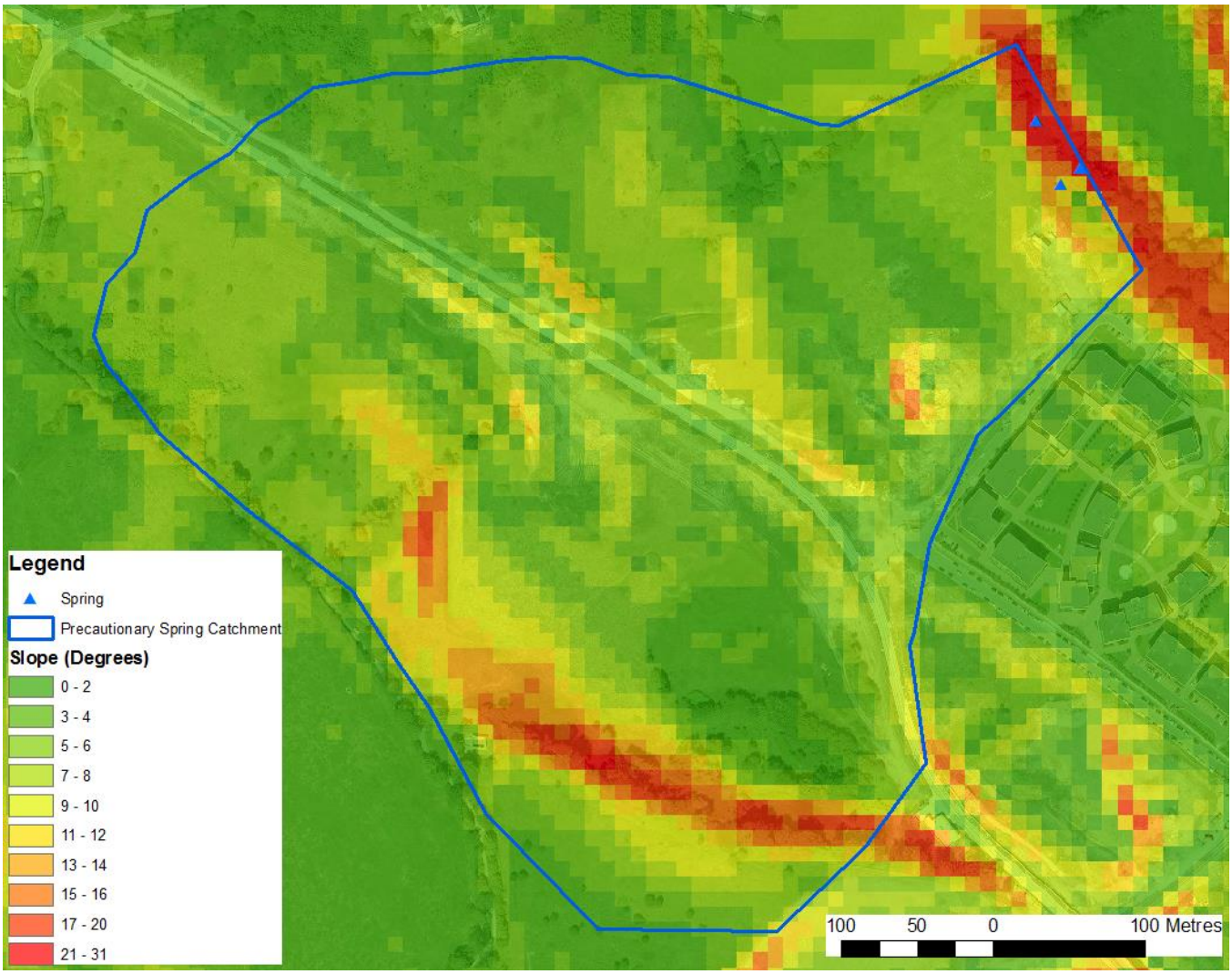
9	Thin area of made ground (SI)
10	Earth Stockpile (LIDAR and aerial photograph)
11	Section cut and levelled (LIDAR)
12	Flats

5.5 Slope and Topography Analysis

Figure 5-7 presents an analysis of slope angle across the catchment using ArcGIS analysis (of 10m aggregated version of the LIDAR data to remove "noise" of microtopographical features). It shows the following:

- The floodplain below the springs,
- The steep slope on which the springs lie,
- The plateau above the spring,
- The gentle slope further up the hill,
- The steep slope at the top of the catchment in the south, and,
- The hill top plateau.

Figure 5-7: Slope Analysis



6 Catchment Sensitivity Zone Classification

This section presents an updated catchment sensitivity zone classification scheme. The zones into which the catchment have previously been sub-divided are shown in Figure 6-1. Table 6-2 provides a description of the potential development related impacts that could arise within each zone, and the outline recommended mitigation actions. These are based on an assessment of the superficial geology coverage proven by site investigation and shown in Figure 5-4, the slope analysis provided in Figure 5-7 and the relative distances from the spring..

The following provides a short summary of development impact classes. However, it does not take into account large scale development works such as extensive and deep excavations (more that 2.5m deep) which could fundamentally alter the groundwater system and therefore the future status of the springs. **Such work, anywhere within the Precautionary Spring Catchment as defined above, should be supported by a hydrogeological risk assessment and an appropriate level of site investigation**. In certain zones, excavations less than 2.5m could be undertaken without further excavations, as they would occur entirely in low permeability till deposits. For each area, there are two Potential Impact Classes described in Table 6-1. Any proposed development should not significantly change the nature or area of the catchment of the spring, through divergence of surface or groundwater away from the catchment.

Table 6-1:Potential Impact Classes

Potential Impact Classes	Possible Mechanism	Spatial Locations Where Impact is Most Likely to Occur
Alteration of Recharge Characteristics	Reducing the permeability of the ground and infiltration of surface water through construction of extensive areas of hardstanding. Installation of drainage systems which change the spring catchment, or lead to reduced recharge within the catchment.	Where groundwater recharge rates are likely to be higher, i.e. areas where till is relatively thin (or absent), or of relatively high permeability.
Alteration of Groundwater Flow Paths	Physical barriers to groundwater flow (secant piled walls, deep foundations for undercroft parking etc.) could be built through the upper weathered margin or buried valley. Deep permanent excavation below the local water table, or installation of deep service conduits.	In the lower part of the spring catchment, where till is thick, this impact mechanism is only likely to only occur with deeper excavations. Where till is thin or absent or higher permeability development works could have the potential to alter flow paths. It has been assumed that groundwater flow paths in the lower catchment will not be significantly affected by excavations and physical barriers in the upper catchment, i.e. all except very large excavations in the upper catchment will not change the groundwater catchment of the spring

Table 4-1 identifies a third impact mechanism relating to changing groundwater chemistry (close to the spring. This impact mechanism is more likely to occur only in the vicinity of the springs in Zone 1.

Figure 6-1: Catchment Sensitivity Classification

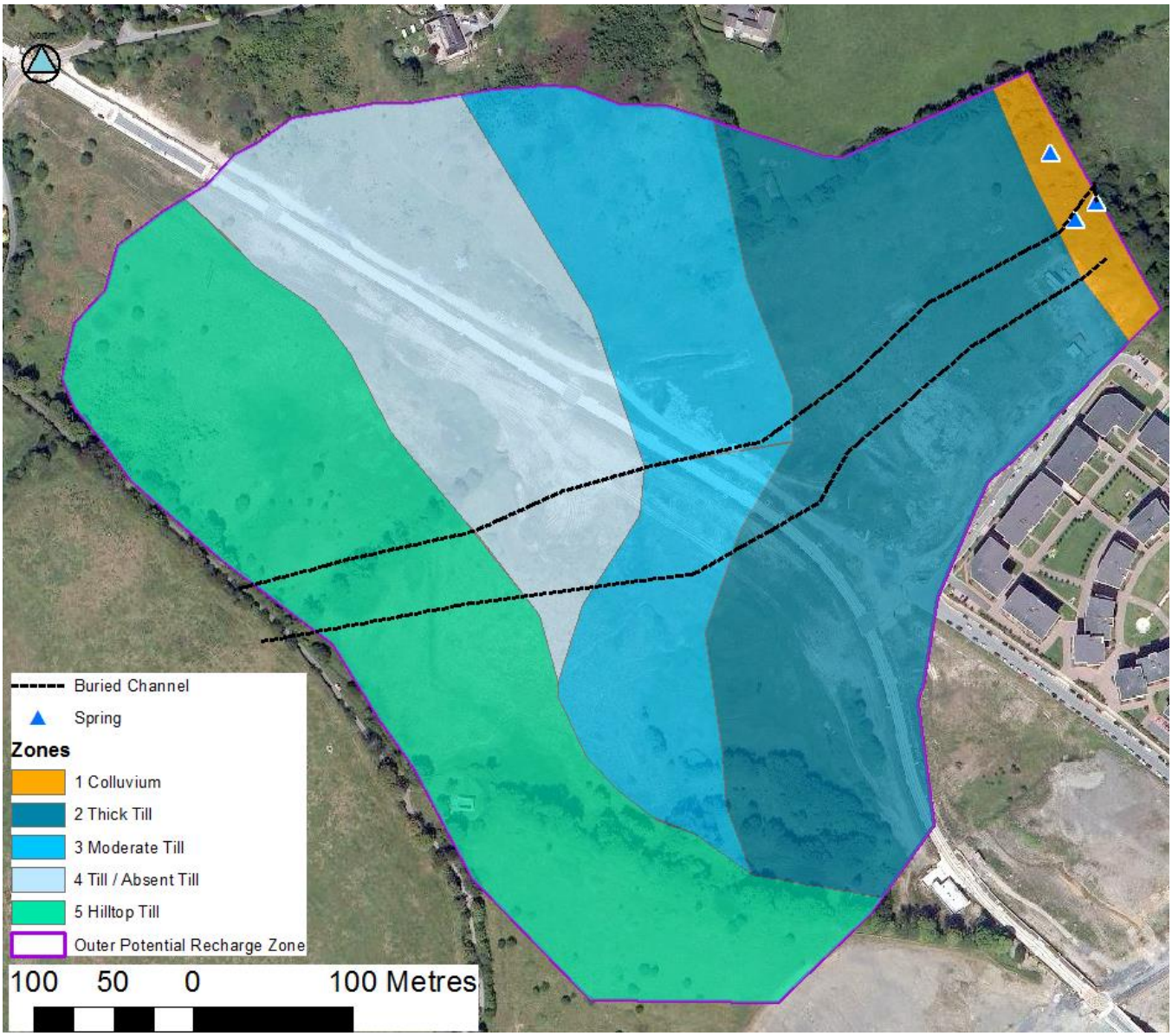


Table 6-2: Sensitivity Zone Classification

Zone	Recharge Impact Potential	Flow Impact Potential
1 - Colluvium	Zone 1 represents the slope where spring flow occurs and should be avoided in all cases	
2 – Thick Till	Unlikely – No further analysis is likely to be required.	Unlikely - No further analysis is likely to be required. Note area may be more suitable for deeper excavations further analysis would be required.

3 – Moderate Till	Unlikely – No further analysis is likely to be required	Unlikely - No further analysis is likely to be required
4 Till / Absent	Likely – Areas of proposed hardstanding and other low permeability cover will require further analysis to establish the extent of impact on recharge to the spring. Where areas can be shown to have a significant layer of low permeability till no further analysis would be required.	Likely – Excavations that are expected to reach the gravel (weathered bedrock) and bedrock layers would require further analysis to establish the extent of impact on the groundwater flow to the spring.
5 Hilltop Till	Likely – Areas of proposed hardstanding and other low permeability cover will require further analysis to establish the extent of impact on recharge to the spring.	Likely – Excavations that are expected to reach saturated deposits would require further analysis to establish the extent of impact on the groundwater flow to the spring.

7 Domville Review

This section provides an interim summary on the proposals for basement areas below Blocks C, D and F as part of planning reference DZ17A/0714 in the light of the recent GI findings.

7.1 Updated Hydrogeological Conceptual Model

Figure 7-1 presents the location of the basement with regards to the Sensitivity Zones (from Figure 6-1) and Figure 7-2 presents a cross section through the basement. The following should be noted:

- The basement lies within the footprint of the buried valley which has been identified during the most recent round of ground investigation.
    - The GI has shown that this buried valley feature is infilled with deposits containing silty sands, which are likely to acts as a key groundwater flow path to the tufa spring,
    - The thickness of these deposits were shown to be at least 16m deep at JBH04,
    - The lateral extent of the buried valley is not well constrained, especially its southern boundary, though it appears that it is relatively steep sided.
- Recent monitoring of static groundwater levels (see Table 7-1 and Figure 7-2) indicates that groundwater levels in the north of the basement are slightly higher than the basement floor which lies at a proposed elevation of 49.37mAD. This is within the footprint of the buried valley. In the south, groundwater levels fall below the base of the basement.

Figure 7-1: Sensitivity Zones and the Basement

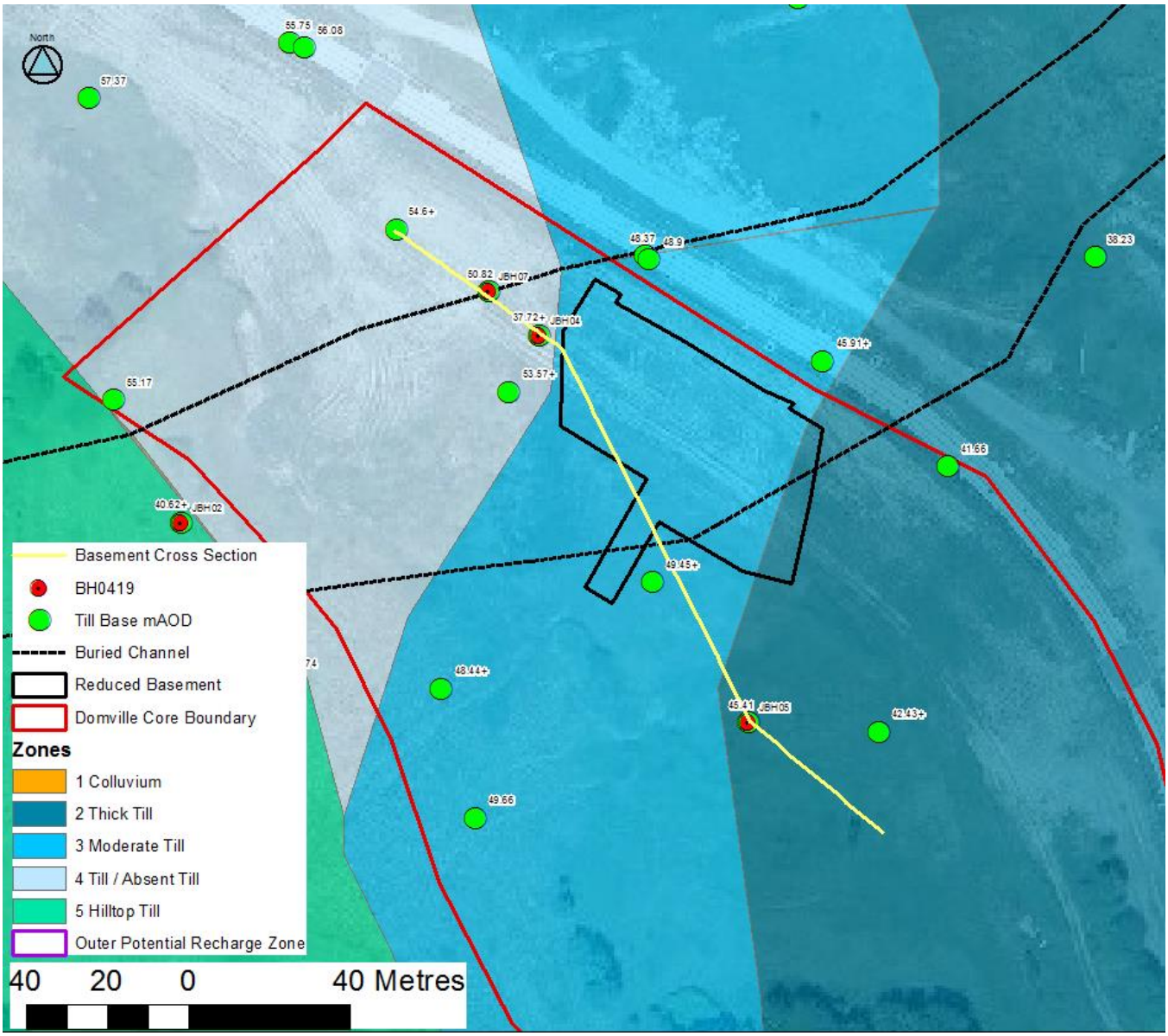


Figure 7-2: Hydrogeological Cross Section of the Basement

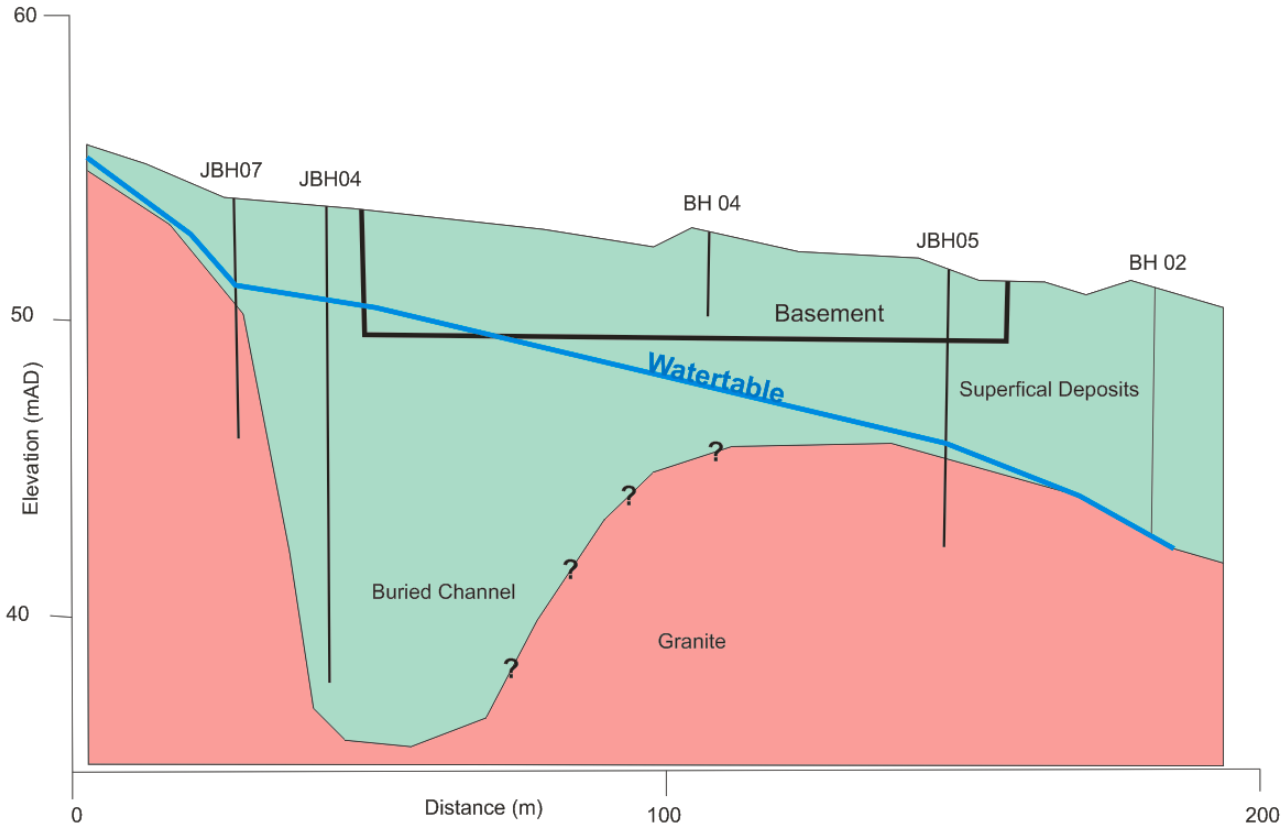


Table 7-1: Groundwater Water Level Monitoring

Sample ID	JBH - 2	JBH - 4	JBH - 5	JBH - 7
Water Level mbgl	4.2	2.98	5.75	2.44
	4.82	3.14	5.91	2.84
Water level mAD	52.22	50.74	45.16	51.58
	51.6	50.58	45	7.47
Note 1) Two results are presents for each location on site. The upper is from the 17/04/2019 monitoring round and the lower is from the 14/04/2019.				

7.2 Impact Assessment Update

The table below presents the impact assessment that was competed prior to the most recent round of ground investigation (JBA July 2018) presented in Appendix A. It presents a series of potential outcomes based on what further site investigation might identify. The text highlighted in yellow are our opinion on the most likely outcomes based upon a review of existing and recent GI data.

Table 7-2: Previous Impact Assessment (JBA July 2018)

Area	Technical Conclusion
Reduced Basement during operation	The proposed new basement is all at one level – 49.37mAD. In the previous design the eastern half of the basement dropped to 45.83mAD. This reduced basement probably removes the potential for the artesian excavation impact to occur, however aquifer interaction impact is still a potential risk. There is only one borehole in the footprint of the new basement, and it shows the basement floor would be close to the top of the weather upper margin of the granite. The decision tree (Appendix B) shows the potential results of an SI, but this can be summarised as: 1. No interaction with the aquifer – no impact. 2. Interaction with the aquifer (the basement cuts into the aquifer supplying the spring) – but the aquifer is shown to be thick below the basement, so groundwater can travel underneath the basement and won't be significantly affected – no impact. 3. Interaction with the aquifer – the basement blocks groundwater flow – but water flows around the basement to the north and the south and so the supply to the spring won't change – no impact. 4. Interaction with the aquifer – the basement blocks groundwater flow and it diverts groundwater in a new direction, so the catchment of the spring is reduced – significant impact. There is only one potential outcome with a pre-mitigation significant impact, however the chance of this occurring is low, and there should be design mitigation options available (e.g. underlying the basement with a high permeability gravel layer.
Reduced Basement during construction	Construction impacts have the potential to be more significant than the long-term effects of the basement, as it could include moderate periods of dewatering activity which could reduce flows to spring. There are ways to mitigate the impact to an acceptable level which may include: - Constructing during a dry period (i.e. outside of winter/early spring) when dewatering of the groundwater body may not be required. - Constructing during extremely wet periods when flows at the spring a strong, and dewatering is unlikely to dry the spring out. - Inject pumped water back into the aquifer at a suitable downgradient location.

Groundwater monitoring data suggests that the local water table is at a similar level to the basement along its western edge. There therefore may be localised modification of groundwater flow paths around this section of the basement. However, recent GI data also indicates the presence of a deep buried valley which is likely to provide significant recharge to the spring and there is in effect a significant thickness of aquifer below the basement which will continue to provide recharge.

During construction water level monitoring indicates that part of the excavation could require dewatering. This is based on one monitoring round in April, where groundwater levels are normally expected to be somewhere nearest to their seasonal highpoint. Options to avoid possible dewatering impacts during construction are presented in Table 7-2.

APPENDIX A – TRIAL PITS

SITE INVESTIGATION LOGS

JBA Project Code	2018s1298
Contract	Domville Catchment Site Investigation
Client	Dun Laoghaire Rathdown County Council
Day, Date and Time	09/10/18
Author	D Casey
Reviewer / Sign-off	A Jones
Subject	Tufa Spring Catchment Trial Pits

Equipment & Methods JCB Backhoe	Pit No TP1		Ground level (mAOD) N/A		Date 09/10/18
Logged by: D Casey	GRID REFERENCE				

Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown Sandy SILT Sub round gravels	0-0.3					
Brown Silty CLAY Dry, Fine	0.3-0.4					
Weathered Granite Bedrock	0.4-05					
Bedrock	0.5+					
END AT	0.5					

Notes

SITE INVESTIGATION LOGS

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Equipment & Methods JCB Backhoe	Pit No TP2		Ground level (mAOD) N/A		Date 09/10/18
Logged by: D Casey	GRID REFERENCE				

Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown Topsoil Sandy Silty CLAY Dry Loose	0-0.2					
Brown Silty CLAY Dry, sticky,Some sub-round gravels	0.2 – 2.3					
Weathered Granite Bedrock						
Granite Bedrock	+2.35					
END AT	2.35					
Notes						

SITE INVESTIGATION LOGS

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Author	D Casey
Reviewer / Sign-off	A Jones
Subject	Tufa Spring Catchment Trial Pits

Equipment & Methods JCB Backhoe	Pit No TP3		Ground level (mAOD) N/A		Date 09/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Light Brown Clayey Silt Topsoil Loose, soft	0-0.3					
Very Light Brown Clayey Silt Dry, Loose Sub-round gravels	0.3 - 0.5					
Brown Silty CLAY Dry Some subangular gravels	0.5-1.5					
Dark Brown silty CLAY Sticky, slightly moist Sub-angular gravels	1.5-2.8					
Weathered Bedrock	2.8-2.9					
END AT	2.9					
Notes						

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Equipment & Methods JCB Backhoe	Pit No TP4		Ground level (mAOD) N/A		Date 09/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Light Brown Clayey Silt Topsoil	0-0.1					
Brown Silty CLAY Sub-angular Gravels Dry, crumbly Texture	0.1 – 1.25 Becoming dark brown after 0.6					
Broken Bedrock Dry	1.25 – 1.7					
Bedrock	1.7					
END AT	1.7					
Notes						

SITE INVESTIGATION LOGS

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Equipment & Methods JCB Backhoe	Pit No TP5		Ground level (mAOD) N/A			Date 09/10/18
\	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Brown Sandy Silt Topsoil	0 - 0.25					
Brown Silty CLAY Dry, loose Sub-angular Gravels Sub-round gravels	0.25 – 1.2					
Broken Bedrock Silty clay Sub-round /angular cobbles	1.2-2.8					
Fracture Bedrock Sandy Silty CLAY Sub-round cobbles, Gravels Dry	2.8-3.5					
Bedrock	3.5					
END AT						
Notes Groundwater encountered at 3.5mbgl, slow seepage.						

SITE INVESTIGATION LOGS

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Equipment & Methods JCB Backhoe	Pit No TP6		Ground level (mAOD) N/A		Date 09/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown Silty Clay SAND topsoil Dry, Loose	0-0.1					
Dark Brown Sandy Clayey Silt Dry, Round gravels	0.1-0.6					
Dark Brown Silty Sand Loose, dry Sub-round gravels	0.6-1.3					
Brown SAND Dry, loose, round/sub round gravels	1.3-2.4					
Dark Brown Sandy SILT Dry, Loose Round – sub-round gravels	2.4-2.6					
Dark Brown Silty Clay Fine Sticky, dry Sub round gravels	2.6-2.9					
Reddish Sandy CLAY	2.9-4.3					
Light Brown CLAY Sticky, dry, Firm	4.3-5					
END AT	5					
Notes						

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Equipment & Methods JCB Backhoe	Pit No TP7		Ground level (mAOD) N/A			Date 09/10/18
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown SILT	0-0.1					
Dark Brown Sandy SILT Dry, loose cobbly Sub angular Gravels	0.1-0.8					
Becoming Dark Brown very Silty CLAY Dry, Sticky Sub-angular Gravels	0.8-2					
Brown / Light Grey Very Silty CLAY Dry, loose Sub-angular gravels	2-5					
END AT						
Notes						

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Subject	Tufa Spring Catchment Trial Pits

Equipment & Methods JCB Backhoe	Pit No TP8		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Sandy SILT Topsoil	0-0.2					
Brown Sandy Clay SILT Dry, Loose Some sub-angular Gravels	0.2-1.7					
Dark Brown Silty CLAY Dry, sticky Sub angular gravels	1.7-2.0					
Dark Brown Silty Clayey GRAVELs Round – subround gravels Round- subround cobbles	2.0-2.9					
END AT	2.9					
Notes						

SITE INVESTIGATION LOGS

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Equipment & Methods JCB Backhoe	Pit No TP9		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown Sandy Silt Topsoil	0-0.2					
Brown Clayey SLIT Dry, loose Course Sub-angular gravels	0.2-1.4					
Weather Bedrock	1.3-1.4					
Bedrock	1.4					
END AT	1.4					
Notes						

SITE INVESTIGATION LOGS

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Equipment & Methods JCB Backhoe	Pit No TP10		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Brown Sandy Silt Topsoil	0-0.2					
Brown-sandy Silty CLAY Dry Sub-round gravel	0.2-1.2					
Brown Silty Clayey GRAVELS Sub-round and sub-angular gravels	1.2-2.1					
Pale Yellow SANDS Round cobbles	2.1-2.4					
Brown Very Silty CLAY Firm, sticky, dry Sub-round gravels	2.4-3.1					
Silty CLAY	3.1-4.8					
Light Brown CLAY Fine Dry No gravel	4.8-5					
END AT	5					
Notes: Bedrock not met, no groundwater strikes						

Equipment & Methods JCB Backhoe	Pit No TP11		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown Sandy SILT Topsoil	0 - 0.2					
Dark Brown Sandy Silty CLAY Dry Loose Sub-round gravels	0.2 – 0.8					
Light Brown CLAY Moist, loose No Gravels	0.8-2.3					
Dark Brown Silty clay GRAVELS Sub angular gravel Firm, moist, sticky Course	2.3-3.8					
Brown Silty Sand Course Sub-round / round gravels	3.8-5.3					
Large Cobbles and Boulders	5.3-5.7					
END AT	5.7					
Notes Bedrock not met, no groundwater strikes						

Equipment & Methods JCB Backhoe	Pit No TP12		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown Sandy Silt Topsoil Dry Loose	0-0.2					
Dark Brown Clayey SILT Dry, course, loose, subangular gravels	0.2-0.8					
Light Brown Silty CLAY Dry, loose, subangular gravel	0.8-1					
Light Brown Silty Sand Dry soft Waterstrike at 3.5	1-4.9					
Dark Brown Silty clayey GRAVEL Sub-round gravels/cobble Angular gravel (shale)	4.9-5					
END AT	5					
Notes						

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Equipment & Methods JCB Backhoe	Pit No TP13		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Brown Sandy Silt Topsoil Dry, loose, course	0-0.2					
Brown Clayey SILT Dry, loose, course, subround, sub-angular gravels	0.2-2.2					
Sandy Clayey GRAVEL Dry Loose, course subround gravels	2.2-2.4					
Broken Bedrock, large cobbles and boulders	2.4-2.5					
Bedrock	2.5					
END AT	2.5					
Notes						

SITE INVESTIGATION LOGS

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Equipment & Methods JCB Backhoe	Pit No TP14		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Dark Brown Sandy SILT Topsoil Dry, loose	0-0.2					
Brown Sandy SILT Dry loose, Course sub-angular – sub-round gravels	0.2-1.2					
Brown Sandy Silty GRAVELS Dry, loose Course sub angular, sub round gravels and cobbles	1.2-2.4					
Brown Clayey Silty, GRAVELS Dry, loose Course sub-round cobbles Sub-angular gravels	2.4-4.6					
END AT	4.6					
Notes						

Equipment & Methods JCB Backhoe	Pit No TP15		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Brown Sandy SILT Topsoil Loose, Dry, Course	0-0.2					
MADE GROUND - Brown Silty clayey GRAVEL Sub-round, sub angular stones and cobble	0.2 – 1.1					
MADE GROUND - Brown, Silty CLAY with some brown black colouration and pieces of wooden branches	1.1-2.8					
Bedrock	2.8					
END AT	2.8					
Notes						

Equipment & Methods JCB Backhoe	Pit No TP16		Ground level (mAOD) N/A		Date 10/10/18	
Logged by: D Casey	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Brown Sandy Silt Topsoil Course Dry	0-0.2					
Brown, Clayey SILT Dry, loose, course Sub-angular gravels	0.2-0.8					
Light Yellow Silty SAND Dry, course, loose No gravel	0.8-1.4					
Grey Sandy CLAY Dry sticky soft No Gravels	1.4-3.4					
Light Brown / reddish Silty Sand, course, loose, dry	3.4-4.8					
Grey Course SANDS Dry	4.8-5.1					
Cobble and Boulders	5.1					
END AT						
Notes						

SITE INVESTIGATION LOGS

JBA Project Code	2018s1298
Contract	Domville Catchment Site Investigation
Client	Dun Laoghaire Rathdown County Council
Day, Date and Time	09/10/18
Author	D Casey
Reviewer / Sign-off	A Jones
Subject	Tufa Spring Catchment Trial Pits

Equipment & Methods JCB Backhoe	Pit No TP17		Ground level (mAOD) N/A		Date 8/11/2018	
Logged by: H Moore	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
TOPSOIL	0-0.4					
Brown Gravelly Silty SAND Increasing gravel /boulder content with depth	0.4-2.7					
Granite Bedrock	2.7					
END AT						
Notes						

Equipment & Methods JCB Backhoe	Pit No TP18		Ground level (mAOD) N/A		Date 8/11/2018	
Logged by: H Moore	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
Fine Sandy TOPSOIL	0-0.5					
Red Brown Slightly Gravelly, Slightly cobbly SILT	0.5-1.3					
Reb Brown Slightly Gravelly, Slightly Cobbly, Silty SAND	1.3-3.5					
Cobbly Sandy GRAVEL (weathered bedrock)	3.5-5					
END AT	5.5					
Notes						

Equipment & Methods JCB Backhoe	Pit No TP19		Ground level (mAOD) N/A		Date 8/11/2018	
Logged by: H Moore	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
TOPSOIL	0-0.4					
Light Brown Gravelly Sandy CLAY	0.4-2.3					
Clayey Cobbly Gravelly SAND	2.3-4.2					
Clayey Gravelly SAND	4.2-5					
END AT	5					
Notes – gravels granitic in nature						

SITE INVESTIGATION LOGS

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Equipment & Methods JCB Backhoe	Pit No TP20		Ground level (mAOD) N/A		Date 8/11/2018	
Logged by: H Moore	GRID REFERENCE					
Description	Level BGL	Reduced level	Lithology	Samples/tests		Notes
				Depth	No	
TOPSOIL	0-0.4					
Brown Gravelly CLAY	0.4-0.6					
Slightly Gravelly Slightly Cobbly SILTY CLAY	0.6-1.3					
Clayey Sandy Cobbly GRAVEL	1.3-2					
Silty Clayey Gravelly COBBLES	2-2.5					
Clayey Boulders GRAVEL	2.5-4.6					
END AT	4.6					
Notes – high proportion of limestone material						

APPENDIX B - SITE INVESTIGATION

Cherrywood – Ground Investigation

Client:	Dún Laoghaire – Rathdown County Council
Client's Representative:	JBA Consulting
Report No.:	19-0148
Date:	April 2019
Status:	Final for Issue

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Approved: ISO 9001 • ISO 14001 • OHSAS 18001

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APPENDICES

Document Control Sheet

Report No.:		19-0148			
Project Title:		Cherrywood			
Client:		Dún Laoghaire – Rathdown County Council			
Client's Representative:		JBA Consulting			
Revision:	A00	**Status:**	Final for issue	**Issue Date:**	15 April 2019
Prepared by:		**Reviewed by:**		**Approved by:**	
 Sean Ross BSc MSc		 Matthew Gilbert MEarthSci FGS		 Darren O'Mahony BSc MSc MIEI	

The works were conducted in accordance with:

British Standards Institute (2015) BS 5930:2015, Code of practice for site investigations.

BS EN 1997-2: 2007: Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing.

Geotechnical Society of Ireland (2016), Specification & Related Documents for Ground Investigation in Ireland

METHODS OF DESCRIBING SOILS AND ROCKS

Soil and rock descriptions are based on the guidance in BS5930:2015, The Code of Practice for Site Investigation.

Abbreviations used on exploratory hole logs	
U	Nominal 100mm diameter undisturbed open tube sample (thick walled sampler)
UT	Nominal 100mm diameter undisturbed open tube sample (thin walled sampler)
P	Nominal 100mm diameter undisturbed piston sample
B	Bulk disturbed sample
LB	Large bulk disturbed sample
D	Small disturbed sample
C	Core sub-sample (displayed in the Field Records column on the logs)
L	Liner sample from dynamic sampled borehole
W	Water sample
ES / EW	Soil sample for environmental testing / Water sample for environmental testing
SPT (s)	Standard penetration test using a split spoon sampler (small disturbed sample obtained)
SPT (c)	Standard penetration test using 60 degree solid cone
x,x/x,x,x,x	Blows per increment during the standard penetration test. The initial two values relate to the seating drive (150mm) and the remaining four to the 75mm increments of the test length. The length achieved is stated (mm) for any test increment less than 75mm
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300mm)
N=X/Z	Incomplete standard penetration test where the full test length was not achieved. The blows 'X' represent the total blows for the given test length 'Z' (mm)
V VR	Shear vane test (borehole) Hand vane test (trial pit) Shear strength stated in kPa V: undisturbed vane shear strength VR: remoulded vane shear strength
dd/mm/yy: 1.0 dd/mm/yy: dry	Date & water level at the borehole depth at the end of shift and the start of the following shift
▽	Water strike: initial depth of strike
▼	Water strike: depth water rose to
Abbreviations relating to rock core – reference Clause 36.4.4 of BS 5930: 2015	
TCR (%)	Total Core Recovery: Ratio of rock/soil core recovered (both solid and non-intact) to the total length of core run.
SCR (%)	Solid Core Recovery: Ratio of solid core to the total length of core run. Solid core has a full diameter, uninterrupted by natural discontinuities, but not necessarily a full circumference and is measured along the core axis between natural fractures.
RQD (%)	Rock Quality Designation: Ratio of total length of solid core pieces greater than 100mm to the total length of core run.
FI	Fracture Index: Number of natural discontinuities per metre over an indicated length of core of similar intensity of fracturing.
NI	Non Intact: Used where the rock material was recovered fragmented, for example as fine to coarse gravel size particles.
AZCL	Assessed zone of core loss: The estimated depth range where core was not recovered.
DIF	Drilling induced fracture: A fracture of non-geological origin brought about by the rock coring.
(xxx/xxx/xxx)	Spacing between discontinuities (minimum/average/maximum).

Cherrywood

1 AUTHORITY

On the instructions of JBA Consulting Engineers, ("the Client's Representative"), acting on the behalf of Dún Laoghaire – Rathdown County Council ("the Client"), a ground investigation was undertaken at the above location to provide geotechnical information for input to the development of the site, as part of the larger Cherrywood development.

This report details the work carried out on site; it contains a description of the site, the works undertaken and the exploratory hole logs.

All information given in this report is based upon the ground conditions encountered during the site investigation works, and on the results of the laboratory and field tests performed. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata, contaminant concentrations, and water conditions between or below exploratory holes. It should be noted that groundwater levels usually vary due to seasonal and/or other effects and may at times differ to those recorded during the investigation. No responsibility can be taken for conditions not encountered through the scope of work commissioned, for example between exploratory hole points, or beneath the termination depths achieved.

This report was prepared by Causeway Geotech Ltd for the use of the Client and the Client's Representative in response to a particular set of instructions. Any other parties using the information contained in this report do so at their own risk and any duty of care to those parties is excluded.

2 SCOPE

The extent of the investigation, as instructed by the Client's Representative, included boreholes, soil sampling, and the preparation of a factual report on the findings.

3 DESCRIPTION OF SITE

As shown on the site location plan in Appendix A, the works were conducted on a currently undeveloped site in Cherrywood, south Dublin. The site is located either side of the Luas tracks in between the Laughanstown and Cherrywood stations. The site is currently agricultural fields on the south of the Luas tracks, while the north section of the site is unused and contains a large amount of construction and demolition waste. The site varies in topography with a c.20m fall across the site from south to north.

4 SITE OPERATIONS

4.1 Summary of site works

Site operations, which were conducted between 12th March and the 3rd April 2019, comprised:

- three light cable percussion boreholes,
- seven boreholes by rotary drilling methods, four of which were conducted as follow-ons to the cable percussion holes; and
- a standpipe installation in seven boreholes.

The exploratory holes and in-situ tests were located as instructed by the Client's Representative, as shown on the exploratory hole location plan in Appendix A.

4.2 Boreholes

A total of seven boreholes were put down in a minimum diameter of 150mm through soils and rock strata to their completion depths by a combination of methods, including light cable percussion boring by a Dando 2500 rig, and rotary drilling by a Hanjin 8D tracked rotary drilling rig.

The borehole logs state the methodology and plant used for each location, as well as the appropriate depth ranges.

A summary of the boreholes, subdivided by category in accordance with the methods employed for their completion, is presented in the following sub-sections.

Appendix B presents the borehole logs.

4.2.1 Boreholes by combined percussion boring and rotary follow-on drilling

Four boreholes (JBH01, JBH02, JBH05 and JBH06) were put down by a combination of light cable percussion boring and rotary follow-on drilling techniques. Cable percussion boreholes were advanced to their scheduled depths, after which rotary percussive methods were employed to advance the borehole to their scheduled completion depths, or to bedrock, where rotary coring was undertaken. Symmetrix cased full-hole drilling was used during the rotary percussion sections.

Hand dug inspection pits were carried out between ground level and 1.20m depth to ensure boreholes were put down at locations clear of services or subsurface obstructions.

Disturbed (bulk bag) samples were taken within the strata encountered by the cable percussion rig.

Any water strikes encountered during boring were recorded along with any changes in their levels as the borehole proceeded.

Where water was added to assist with boring, a note has been added to the log to account for same.

Where coring was carried out within bedrock strata, conventional coring methods were used with a metric T2-101 core barrel, which produced core of nominal 84mm diameter, and was placed in triple channel wooden core boxes.

The core was subsequently photographed and examined by a qualified and experienced Engineering Geologist, thus enabling the production of an engineering log in accordance with *BS 5930: 2015: Code of practice for ground investigations*.

Appendix B presents the borehole logs, with core photographs presented in Appendix C.

4.2.2 Rotary drilled boreholes

Three boreholes (JBH03, JBH04 and JBH07) were put to their completion by rotary drilling techniques only. The boreholes were completed using a Hanjin 8D tracked rotary drilling rig

Symmetrix-cased full hole rotary percussive drilling techniques were employed to advance the boreholes to bedrock, after which rotary coring was employed to recover core samples of the bedrock. JBH04 did not encounter bedrock, and rotary percussive drilling was used to put the borehole to completion.

Any water strikes encountered during boring were recorded along with any changes in their levels as the borehole proceeded.

Where water was added to assist with boring, a note has been added to the log to account for same.

Where coring was carried out within bedrock strata, the core was extracted in up to 1.5m lengths using a metric T2-101 core barrel, which produced core of nominal 84mm diameter, and was placed in triple channel wooden core boxes.

The core was subsequently photographed and examined by a qualified and experienced Engineering Geologist, thus enabling the production of an engineering log in accordance with *BS 5930: 2015: Code of practice for ground investigations*.

Appendix B presents the borehole logs, with core photographs presented in Appendix C.

4.3 Standpipe installations

A groundwater monitoring standpipe was installed in JBH01 – JBH07.

Details of the installations, including the depth range of the response zone, are provided in Appendix B on the individual borehole logs.

4.4 Surveying

The as-built exploratory hole positions were surveyed following completion of site operations by a Site Engineer from Causeway Geotech. Surveying was carried out using a Trimble R6 GPS system employing VRS and real time kinetic (RTK) techniques.

The plan coordinates (Irish National Grid) and ground elevation (mOD Malin) at each location are recorded on the individual exploratory hole logs. The exploratory hole plan presented in Appendix A shows these as-built positions.

4.5 Groundwater and ground gas monitoring

Following completion of site works, groundwater was conducted on one round. Ground water monitoring was carried out using a water interface probe.

5 GROUND CONDITIONS

5.1 General geology of the area

Published geological mapping indicate the superficial deposits underlying the site comprise Glacial Till. These deposits are underlain by Type 2e and 2p Leinster Granite.

5.2 Ground types encountered during investigation of the site

A summary of the ground types encountered in the exploratory holes is listed below, in approximate stratigraphic order:

- **Topsoil:** encountered in JBH01 – JBH03 and JBH05 with a thickness of 100 – 300mm.
- **Made Ground (fill):** reworked sandy gravelly clay/silty sand encountered in JBH06 and JBH07 ranging in thickness from 100 – 500mm.
- **Glacial Till:** sandy gravelly clay, frequently with low cobble content, typically firm or stiff in upper horizons, becoming very stiff with increasing depth.

- **Fluvioglacial deposits/weathered granite:** typically, grey/brown silty sands and gravels with cobbles of granite encountered across all holes down to 20mbgl in JBH01 and JBH06.

- **Bedrock (Granite):** Rockhead was encountered at depths ranging from 5.50m in JBH05 to 6.80m in JBH03.

5.3 Groundwater

Groundwater was encountered during percussion boring and rotary drilling through soil and rock as water strikes as shown in Table 1 below.

Table 1: Groundwater strikes encountered during the ground investigation

GI Ref.	Water level (mbgl)	Comments
BH02	11.20	Rose to 10.00mbgl after 5mins
BH02	14.00	No rise after 5 mins
BH03	1.50	Seepage
BH04	11.00	Seepage
BH06	2.70	Rose to 2.00m after 20mins
BH06	9.20	Rose to 6.00m after 10mins

Details of the individual groundwater strikes, along with any relative changes in levels as works proceeded, are presented on the exploratory hole logs for each location.

Groundwater was not noted during drilling at any of the other borehole locations. However, it should be noted that the casing used in supporting the borehole walls during drilling may have sealed out any/additional groundwater strikes and the possibility of encountering groundwater during excavation works should not be ruled out.

It should be noted that any groundwater strikes within bedrock may have been masked by the fluid used as the drilling flush medium.

Subsequent groundwater monitoring of the standpipe installations recorded water levels as shown in Table 2.

Table 2: Groundwater monitoring

GI Ref	Water level (mbgl)
	12/04/2019
JBH01	11.78
JBH02	10.02
JBH03	1.13
JBH04	2.88
JBH05	5.37
JBH06	4.50
JBH07	2.00

Seasonal variation in groundwater levels should also be factored into design considerations, and continued monitoring of the seven installed standpipes will give an indication of the seasonal variation in groundwater level.

6 REFERENCES

Geotechnical Society of Ireland (2016), Specification & Related Documents for Ground Investigation in Ireland

BS 1377: 1990: Methods of test for soils for civil engineering purposes. British Standards Institution.

BS 5930: 2015: Code of practice for ground investigations. British Standards Institution.

BS EN 1997-2: 2007: Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing. British Standards Institution.

BS EN ISO 14688-1:2018: Geotechnical investigation and testing. Identification and classification of soil. Part 1 Identification and description.

BS EN ISO 14688-2:2018: Geotechnical investigation and testing. Identification and classification of soil. Part 2 Principles for a classification.

BS EN ISO 14689-1:2018: Geotechnical investigation and testing. Identification and classification of rock. Identification and description.

CAUSEWAY GEOTECH

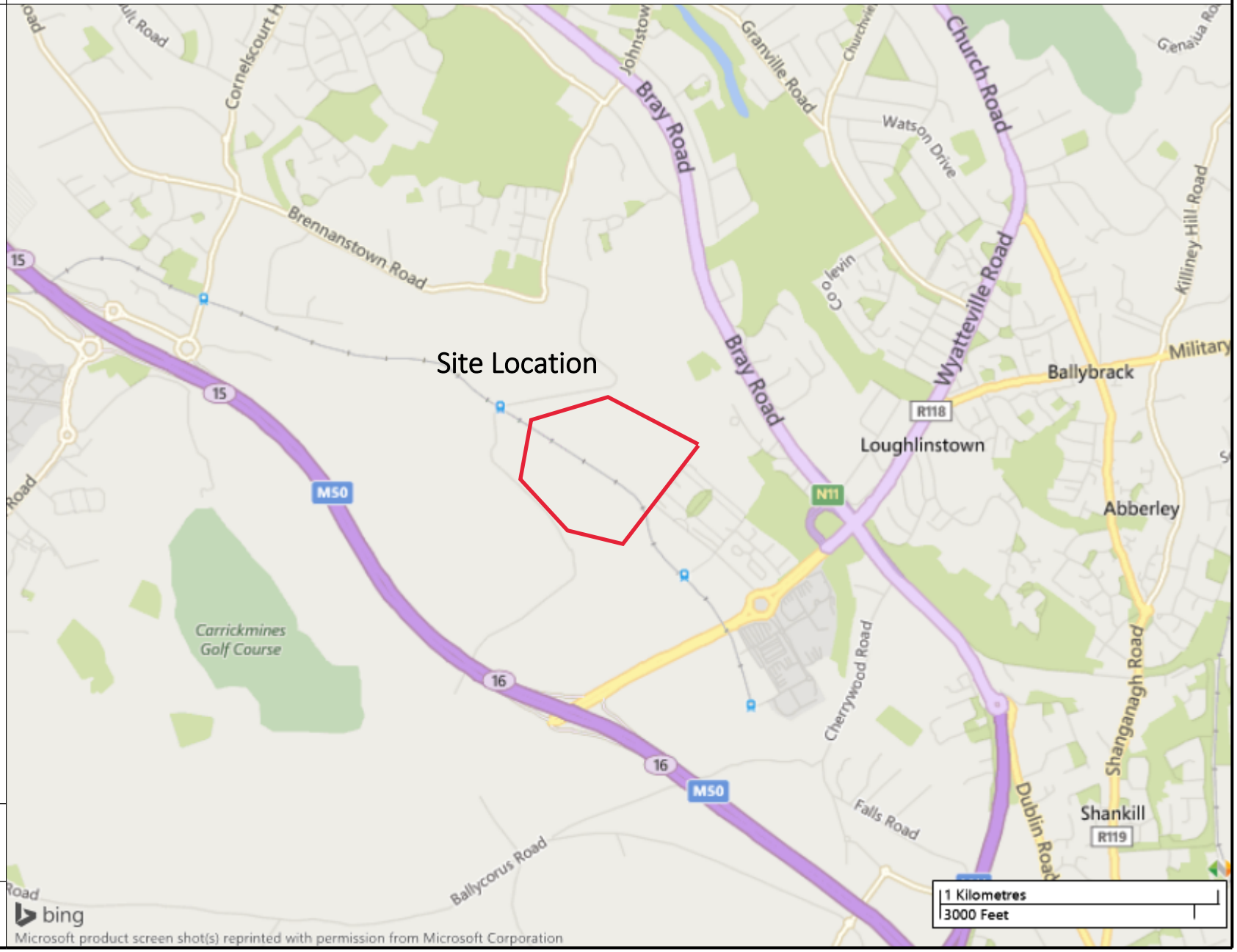
APPENDIX A

SITE AND EXPLORATORY HOLE LOCATION PLANS

CAUSEWAY GEOTECH

Project No.:	19-0148	**Client:**	Dun Laoghaire - Rathdown County Council
Project Name:	Cherrywood, Co. Dublin	**Client's Representative:**	JBA Consulting

Legend Key



Title:
Site Location Plan

Last Revised:	**Scale:**
08/04/2019	1:20000

CAUSEWAY GEOTECH

Project No.:	19-0148	**Client:**	Dun Laoghaire - Rathdown County Council
Project Name:	Cherrywood, Co. Dublin	**Client's Representative:**	JBA Consulting

Legend Key

- Locations By Type - CP+RC
- Locations By Type - RO
- Locations By Type - RO + RC

Title:

Site Location Plan

Last Revised:	**Scale:**
09/04/2019	1:5000

CAUSEWAY GEOTECH

APPENDIX B

BOREHOLE LOGS

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion Rotary Drilling	Dando 2500 Hanjin 8D	0.00 7.50	7.50 20.00

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH01

Coordinates: 323288.68 E 223523.89 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 1 of 2

Client's Representative: JBA Consulting

Scale: 1:50

Driller: RN+KW

Ground Level: 71.11 mOD

Dates: 12/03/2019 - 26/03/2019

Logger: SR+

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
						(0.20)		TOPSOIL
0.20 - 1.00	B1				70.91	0.20		Soft brown sandy CLAY. Sand is fine.
1.00 - 2.00	B2							
						(2.80)		
2.00 - 3.50	B3							
					68.11	3.00		Brown clayey fine to coarse SAND.
						(0.50)		
3.50 - 4.50	B4				67.61	3.50		Grey gravelly silty fine to coarse SAND. Gravel is subrounded fine to coarse of mixed lithologies.
4.50 - 5.50	B5					(2.00)		
5.50 - 7.00	B6				65.61	5.50		Greyish brown fine to coarse SAND and subangular to subrounded fine to coarse GRAVEL of mixed lithologies with occasional cobbles. Cobbles are subrounded of mixed lithologies predominantly granite.
						(1.50)		
7.00 - 7.50	B7				64.11	7.00		Firm brown sandy gravelly CLAY with occasional cobble content. Sand is fine to coarse. Gravel is subangular fine to coarse of mixed lithologies.
						(0.50)		
					63.61	7.50		Brown sandy gravelly CLAY with occasional cobbles. (Driller's description).
						(2.50)		
					61.11	10.00		Light brown gravelly fine to coarse SAND. (Driller's description).
						(0.50)		

Water

Backfill

Remarks

Hand dug inspection pit excavated to 1.20m.

No noticeable groundwater strikes encountered.

Terminated at scheduled depth.

Core Barrel

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Chiselling Details

From (m)	To (m)	Time (hh:mm)
7.50	7.50	01:00

Flush Type

Water

Water Added

From (m)	To (m)
3.50	7.50
11.50	20.00

Casing Details

To (m)	Diam (mm)
20.00	200

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion Rotary Drilling	Dando 2500 Hanjin 8D	0.00 7.50	7.50 20.00

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH01

Coordinates: 323288.68 E 223523.89 N

Client: Dun Laoghaire - Rathdown County Council

Client's Representative: JBA Consulting

Ground Level: 71.11 mOD

Dates: 12/03/2019 - 26/03/2019

Sheet 2 of 2

Scale: 1:50

Driller: RN+KW

Logger: SR+

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
					60.61	10.50		Light brown gravelly fine to coarse SAND. (Driller's description).
								Light grey gravelly silty fine to coarse SAND. (Driller's description).
								At 11.50m: Coring attempted but no recovery.
13.00						(9.50)		
								At 16.50m: Coring attempted but no recovery.
18.00								
		20.00	Dry	26-03-2019	51.11	20.00		End of Borehole at 20.00m

Water

Backfill

10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0 16.5 17.0 17.5 18.0 18.5 19.0 19.5 20.0 20.5

Remarks

Hand dug inspection pit excavated to 1.20m.

No noticeable groundwater strikes encountered.

Terminated at scheduled depth.

Core Barrel

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Chiselling Details

From (m)	To (m)	Time (hh:mm)
7.50	7.50	01:00

Flush Type

Water

Water Added

From (m)	To (m)
3.50	7.50
11.50	20.00

Casing Details

To (m)	Diam (mm)
20.00	200

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion Rotary Drilling	Dando 2500 Hanjin 8D	0.00 10.00	10.00 16.00

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH02

Coordinates: 323410.41 E 223544.13 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 1 of 2

Client's Representative: JBA Consulting

Scale: 1:50

Driller: RN+KW

Ground Level: 56.42 mOD

Dates: 13/03/2019 - 03/04/2019

Logger: SR+

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
0.20 - 1.00	B1				56.22	(0.20) 0.20		TOPSOIL
								Soft brown sandy gravelly CLAY with occasional cobbles. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.
1.00 - 2.00	B2					(1.80)		
2.00 - 3.00	B3				54.42	2.00		Brown sandy clayey subangular to subrounded fine to medium GRAVEL of mixed lithologies. Sand is fine to coarse.
3.00 - 4.00	B4					(2.00)		
4.00 - 5.00	B5				52.42	4.00		Brown gravelly clayey fine to coarse SAND. Gravel is subangular to subrounded fine to coarse of mixed lithologies.
5.00 - 6.00	B6					(3.00)		
6.00 - 7.00	B7							
7.00 - 8.00	B8	7.00 7.00	6.00 6.10	13-03-2019 14-03-2019	49.42	7.00		Firm brown sandy gravelly CLAY with occasional cobbles. Sand is fine to coarse. Gravels are subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies predominantly granite.
8.00 - 9.00	B9					(3.00)		
9.00 - 10.00	B10							
				14-03-2019	46.42	10.00		Brown sandy gravelly CLAY. (Drillers' description).
	TCR	SCR	RQD	FI				

Water

Backfill

Remarks

Hand dug inspection pit excavated to 1.20m.

Terminated at scheduled depth.

Core Barrel

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
11.20		5	10.00
14.00		2	14.00

Chiselling Details

From (m)	To (m)	Time (hh:mm)
10.00	10.00	01:00

Flush Type

Water

Water Added

From (m)	To (m)
2.00	10.00

Casing Details

To (m)	Diam (mm)
20.00	200

CAUSEWAY GEOTECH

Project No.:	Project Name:	Borehole No.:
19-0148	Cherrywood, Co. Dublin	JBH02
Coordinates:	**Client:**	Sheet 2 of 2
323410.41 E	Dun Laoghaire - Rathdown County Council	
223544.13 N	**Client's Representative:** JBA Consulting	**Scale:** 1:50
Ground Level:	**Dates:**	**Driller:** RN +KW
56.42 mOD	13/03/2019 - 03/04/2019	**Logger:** SR+

Method	Plant Used	Top	Base
Cable Percussion Rotary Drilling	Dando 2500 Hanjin 8D	0.00 10.00	10.00 16.00

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
							(1.20)		Brown sandy gravelly CLAY. (Drillers' description).
					Water strike at 11.20	45.22	11.20		Brown gravelly clayey fine to coarse SAND. (Driller's description).
							(2.80)		
					Water strike at 14.00	42.42	14.00		Light brownish grey gravelly fine to coarse SAND. (Driller's description)
							(2.00)		
						40.42	16.00		End of Borehole at 16.00m
	TCR	SCR	RQD	FI					

Water

Backfill

10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0 16.5 17.0 17.5 18.0 18.5 19.0 19.5 20.0 20.5

Remarks
Hand dug inspection pit excavated to 1.20m.

Terminated at scheduled depth.

Core Barrel

Flush Type
Water

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
11.20		5	10.00
14.00		2	14.00

Water Added

From (m)	To (m)
2.00	10.00

Casing Details

To (m)	Diam (mm)
20.00	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
10.00	10.00	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Rotary Drilling	Hanjin 8D	0.00	6.80
Rotary Coring	Hanjin 8D	6.80	9.80

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH03

Coordinates: 323363.69 E 223785.37 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 1 of 1

Client's Representative: JBA Consulting

Scale: 1:50

Driller: KW

Ground Level: 54.74 mOD

Dates: 22/03/2019 - 25/03/2019

Logger: RS

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
					54.44	(0.30) 0.30		TOPSOIL
						(1.20)		Firm brown sandy gravelly CLAY with cobbles. (Driller's description).
				Water Strike at 1.50m	53.24	1.50		Light greyish brown fine to coarse SAND with cobbles of granite. (Driller's description)
		5.50	3.00	22-03-2019				
		5.50	3.00	25-03-2019				
						(5.30)		
					47.94	6.80		Medium strong white phaneritic GRANITE. Partially to moderately weathered. Discontinuities: 1. 60 degree fracture closely spaced (45/85/350) planar, rough, open, orange staining present on surface. 2. 80 - 90 degree joint, probably medium spaced, planar, rough, open, orange staining present on most surfaces.
7.80	100 71 56							
	100 56 40		6			(3.00)		
8.80				25-03-2019				
	100 65 48							
9.80					44.94	9.80		End of Borehole at 9.80m
	TCR SCR RQD		FI					

Water: Backfill

Remarks

Hand dug inspection pit excavated to 1.20m.

Terminated at scheduled depth.

Core Barrel

T2-101

Flush Type

Water

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
1.50	1.50	10	1.50

Water Added

From (m)	To (m)
6.80	9.80

Casing Details

To (m)	Diam (mm)
6.80	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Rotary Drilling	Hanjin 8D	0.00	16.00

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH04

Coordinates: 323498.90 E 223590.29 N

Client: Dun Laoghaire - Rathdown County Council

Client's Representative: JBA Consulting

Ground Level: 53.72 mOD

Dates: 27/03/2019 - 02/04/2019

Sheet 1 of 2

Scale: 1:50

Driller: KW

Logger: KW

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
						(0.50)		MADE GROUND: Stiff brown sandy gravelly CLAY. (Driller's description).
					53.22	0.50		Brown sandy gravelly CLAY with occasional cobbles. (Driller's description).
						(1.60)		
					51.62	2.10		Light greyish white very silty fine to coarse SAND. (Driller's description).
								At 4.0m: Coring attempted but no recovery
						(13.90)		

Water

Backfill

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5

Remarks

Hand dug inspection pit excavated to 1.20m.

Terminated at scheduled depth.

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
11.00		10	11.00

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
16.00	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Rotary Drilling	Hanjin 8D	0.00	16.00

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH04

Coordinates: 323498.90 E 223590.29 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 2 of 2

Client's Representative: JBA Consulting

Scale: 1:50

Ground Level: 53.72 mOD

Dates: 27/03/2019 - 02/04/2019

Driller: KW

Logger: KW

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
				Water strike at 11.0				Light greyish white very silty fine to coarse SAND. (Driller's description).
								At 14.5m: Coring attempted but no recovery
					37.72	16.00		End of Borehole at 16.00m

Water

Backfill

10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0 16.5 17.0 17.5 18.0 18.5 19.0 19.5

Remarks

Hand dug inspection pit excavated to 1.20m.

Terminated at scheduled depth.

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
16.00	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 2500	0.00	5.50
Rotary Coring	Hanjin 8D	5.50	8.50

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH05

Coordinates: 323550.72 E, 223494.60 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 1 of 1

Client's Representative: JBA Consulting

Scale: 1:50

Driller: RN+KW

Ground Level: 50.91 mOD

Dates: 19/03/2019 - 02/04/2019

Logger: SR+RS

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
0.20 - 1.20	B1				50.71	(0.20) 0.20		TOPSOIL
								Soft dark brown sandy gravelly CLAY with occasional cobbles. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.
1.20 - 2.00	B2					(1.80)		
2.00 - 2.50	B3				48.91	2.00		Soft grey sandy slightly gravelly CLAY with occasional cobbles. Sand is fine to coarse. Gravel is subrounded and of mixed lithologies. Cobbles are subrounded of mixed lithologies predominantly granite.
2.50 - 4.00	B4				48.41	(0.50) 2.50		Light brown gravelly fine to coarse SAND with occasional cobbles. Gravel is subangular to subrounded fine to coarse of mixed lithologies.
						(1.50)		
4.00 - 5.00	B5				46.91	4.00		Firm dark brown sandy gravelly CLAY with occasional cobbles. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies predominantly granite.
						(1.00)		
5.00 - 6.50	B6				45.91	5.00		Firm brownish grey sandy very gravelly CLAY with occasional cobbles. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of granite. Cobbles are subrounded of granite.
						(0.50)		
					45.41	5.50		Medium strong white phaneritic GRANITE. Partially to moderately weathered.
	100 57 53							Discontinuities:
6.50								1. 0 to 30 degree, horizontal to sub-horizontal fractures, medium spaced (60/300/680) undulating, rough, open (2-3mm) with an orange/brown staining present on surfaces.
	100 67 20					(3.00)		*6.00m to 7.40m: 80 degree sub-vertical joint, undulating, rough, open with an orange staining penetrating up to 25mm.*
7.50								
	100 80 80							
8.50					42.41	8.50		End of Borehole at 8.50m
	TCR SCR RQD FI							

Water: 9

Backfill

Remarks

Hand dug inspection pit excavated to 1.20m.

No noticeable groundwater strikes encountered.

Terminated at scheduled depth.

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)
5.50	8.50

Casing Details

To (m)	Diam (mm)
6.50	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
6.50	6.50	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion Rotary Drilling	Dando 2500 Hanjin 8D	0.00 5.50	5.50 20.00

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH06

Coordinates: 323765.35 E 223728.71 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 1 of 2

Client's Representative: JBA Consulting

Scale: 1:50

Driller: RN+KW

Ground Level: 40.61 mOD

Dates: 20/03/2019 - 21/03/2019

Logger: SR+

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
0.10 - 1.20	B1				40.51	(0.10) 0.10		MADE GROUND: Brownish grey sandy gravelly CLAY with fragments of red brock and concrete. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies.
						(1.90)		Soft brown gravelly CLAY with occasional cobbles. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies. .
1.20 - 2.00	B2							
2.00 - 2.50	B3				38.61	2.00		
						(0.50)		Soft grey slightly gravelly silty CLAY with occasional cobbles. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies. .
2.50 - 3.50	B4			Water strike at 2.70m	38.11	2.50		Firm brown sandy gravelly CLAY with rare cobbles. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse. Cobbles are subrounded of mixed lithologies predominantly granite.
3.50 - 4.50	B5					(2.00)		
					36.11	4.50		No recovery, pushing boulder
						(1.00)		
					35.11	5.50		Grey very sandy subangular fine to coarse GRAVEL with some cobbles. (Driller's description).
						(1.80)		
					33.31	7.30		Brown very silty fine to coarse SAND. (Driller's description).
						(0.70)		
					32.61	8.00		Brownish grey sandy gravelly CLAY with some cobbles. (Driller's description).
						(1.20)		
				Water strike at 9.20m	31.41	9.20		Light grey fine to coarse SAND. (Driller's description).
						(0.60)		
					30.81	9.80		Light brown fine to medium SAND. (Driller's description)
	TCR	SCR	RQD	FI				

Water: Backfill

Remarks

Hand dug inspection pit excavated to 1.20m.

Terminated at scheduled depth.

Core Barrel

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
2.70	2.70	20	2.00
9.20	9.20	10	6.00

Chiselling Details

From (m)	To (m)	Time (hh:mm)
4.50	5.50	01:00

Flush Type

Water

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
17.50	200

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion Rotary Drilling	Dando 2500 Hanjin 8D	0.00 5.50	5.50 20.00

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH06

Coordinates: 323765.35 E 223728.71 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 2 of 2

Client's Representative: JBA Consulting

Scale: 1:50

Driller: RN +KW

Ground Level: 40.61 mOD

Dates: 20/03/2019 - 21/03/2019

Logger: SR+

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
							(4.00)		Light brown fine to medium SAND. (Driller's description)		
						26.81	13.80		Yellowish brown fine to coarse SAND. (Drillers description).		
						20.61	20.00		End of Borehole at 20.00m		

10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0 16.5 17.0 17.5 18.0 18.5 19.0 19.5 20.0 20.5

Remarks

Hand dug inspection pit excavated to 1.20m.

Terminated at scheduled depth.

Core Barrel

Flush Type Water

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
2.70	2.70	20	2.00
9.20	9.20	10	6.00

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
17.50	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
4.50	5.50	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Rotary Drilling	Hanjin 8D	0.00	1.00
Rotary Coring	Hanjin 8D	1.00	7.70

Project No.: 19-0148

Project Name: Cherrywood, Co. Dublin

Borehole No.: JBH07

Coordinates: 323486.26 E 223601.09 N

Client: Dun Laoghaire - Rathdown County Council

Sheet 1 of 1

Client's Representative: JBA Consulting

Scale: 1:50

Driller: KW

Ground Level: 54.02 mOD

Dates: 27/03/2019 - 27/03/2019

Logger: RS

Depth (m)	Sample / Tests		Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description
							(0.50)		MADE GROUND: Brown silty SAND with cobbles. (Driller's description).
						53.52	0.50		
							(0.30)		Brown sandy gravelly CLAY with occasional cobbles. (Driller's description)
						53.22	0.80		
	45	0	0				(1.00)		White slightly gravelly COBBLES of granite. Gravel is subangular coarse of granite (Weathered bedrock).
1.80						52.22	1.80		
	0	0	0	NI			(1.40)		Greyish white silty fine to medium SAND. (Driller's description).
3.20						50.82	3.20		
	33	9	9				(1.70)		Weak white phaneritic GRANITE. Distinctly weathered to destructured. No discernable discontinuity sets
4.70						49.12	4.90		
	88	64	44						Weak cream phaneritic GRANITE. Moderately weathered. Discontinuities: 1. 45 degree joints, probably medium spaced, planar, rough open with a slight orange staining on surface.
6.20				8			(2.80)		
	67	31	18						
7.70						46.32	7.70		End of Borehole at 7.70m
	TCR	SCR	RQD	FI					

Water

Backfill

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0

Remarks

Hand dug inspection pit excavated to 1.20m.

No noticeable groundwater strikes encountered.

Terminated at scheduled depth.

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)
1.00	7.70

Casing Details

To (m)	Diam (mm)
1.00	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)

CAUSEWAY GEOTECH

APPENDIX C

CORE PHOTOGRAPHS

BH03 Box 1 6.80 – 9.80m

BH05 Box 1 5.5 – 8.50m

BH07 Box 1 1.00 – 6.20m

BH07 Box 2 6.20 – 7.70m

APPENDIX C – WATER QUALITY DATA

Appendix C1 – Lab Results

Exova Jones Environmental

Registered Office: Exova Environmental UK Limited, 10 Lower Grosvenor Place, London, SW1W 0EN. Reg No. 11371415

Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

Tel: +44 (0) 1244 833780
Fax: +44 (0) 1244 833781

JBA Consulting
17 Laureston Crescent
Tower
Co. Cork
Ireland

Attention :	Declan Egan
Date :	26th April, 2019
Your reference :	Cherrywood
Our reference :	Test Report 19/6410 Batch 1
Location :	
Date samples received :	18th April, 2019
Status :	Final report
Issue :	1

Seven samples were received for analysis on 18th April, 2019 of which seven were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

Paul Boden BSc
Senior Project Manager

Client Name: JBA Consulting
Reference: Cherrywood
Location:
Contact: Declan Egan
JE Job No.: 19/6410

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

J E Sample No.	1-9	10-18	19-27	28-36	37-45	46-54	55-63				LOD/LOR	Units	Method No.
Sample ID	JBH - 1	JBH - 2	JBH - 3	JBH - 4	JBH - 5	JBH - 6	JBH - 7						
Depth													
COC No / misc													
Containers	V H HN HCL N Z P	V H HN HCL N Z P	V H HN HCL N Z P	V H HN HCL N Z P	V H HN HCL N Z P	V H HN HCL N Z P	V H HN HCL N Z P						
Sample Date	17/04/2019	17/04/2019	17/04/2019	17/04/2019	17/04/2019	17/04/2019	17/04/2019						
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water						
Batch Number	1	1	1	1	1	1	1						
Date of Receipt	18/04/2019	18/04/2019	18/04/2019	18/04/2019	18/04/2019	18/04/2019	18/04/2019						
Dissolved Calcium #	108.5	133.7	124.6	100.0	125.2	133.2	138.3				<0.2	mg/l	TM30/PM14
Dissolved Magnesium #	10.3	15.4	6.3	17.6	8.7	12.3	14.7				<0.1	mg/l	TM30/PM14
Dissolved Potassium #	3.6	1.9	0.9	1.5	3.2	1.5	1.3				<0.1	mg/l	TM30/PM14
Dissolved Sodium #	26.5	15.1	12.8	13.7	14.8	16.7	15.3				<0.1	mg/l	TM30/PM14
Total Hardness Dissolved (as CaCO3)	315	399	338	324	350	385	407				<1	mg/l	TM30/PM14
Sulphate as SO4 #	22.1	34.0	36.3	29.2	38.7	62.7	40.6				<0.5	mg/l	TM38/PM0
Chloride #	50.5	23.5	25.6	17.1	21.8	28.3	15.4				<0.3	mg/l	TM38/PM0
Nitrate as N #	5.39	2.55	1.62	0.37	0.65	0.94	1.35				<0.05	mg/l	TM38/PM0
Nitrite as N #	0.097	<0.006	<0.006	0.023	<0.006	<0.006	<0.006				<0.006	mg/l	TM38/PM0
Ortho Phosphate as P #	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03				<0.03	mg/l	TM38/PM0
Ammoniacal Nitrogen as N #	0.20	0.03	<0.03	<0.03	0.04	0.05	0.10				<0.03	mg/l	TM38/PM0
Dissolved Carbon Dioxide	62415	88306	105841 ++	88583	61581	86680	142139 ++				<1	ug/l	TM25/PM0
Total Alkalinity as CaCO3 #	420	258	328	317	361	455	391				<1	mg/l	TM75/PM0
Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1				<1	mg/l	TM75/PM0
Electrical Conductivity @25C #	718	314	388	548	732	543	383				<2	uS/cm	TM76/PM0
pH #	7.62	7.43	7.36	7.47	7.51	7.54	7.50				<0.01	pH units	TM73/PM0

Please see attached notes for all abbreviations and acronyms

Client Name: JBA Consulting
Reference: Cherrywood
Location:
Contact: Declan Egan

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Analysis	Reason
No deviating sample report results for job 19/6410						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.
Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

JE Job No.: 19/6410

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. The temperature of sample receipt is recorded on the confirmation schedules in order that the client can make an informed decision as to whether testing should still be undertaken.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to an Exova Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

JE Job No: 19/6410

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM25	Determintaion of Dissolved Methane, Ethane and Ethene by Headspace GC-FID	PM0	No preparation is required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.	Yes			
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods 325.2 (Chloride), 375.4 (Sulphate), 365.2 (o-Phosphate), 353.1 (TON), 354.1 (Nitrite), 350.1 (NH4+) comparable to BS ISO 15923-1, 7196A (Hex Cr)	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 and 9045D and BS1377:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.				
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			
TM76	Modified US EPA method 120.1. Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			

Exova Jones Environmental

Registered Office: Exova Environmental UK Limited, 10 Lower Grosvenor Place, London, SW1W 0EN. Reg No. 11371415

Unit 3 Deeside Point
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Tel: +44 (0) 1244 833780
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JBA Consulting
17 Laureston Crescent
Tower
Co. Cork
Ireland

Attention :	David Casey
Date :	24th May, 2019
Your reference :	2018s1298
Our reference :	Test Report 19/7960 Batch 1
Location :	Cherrywood
Date samples received :	16th May, 2019
Status :	Final report
Issue :	1

Eight samples were received for analysis on 16th May, 2019 of which eight were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

Paul Boden BSc
Senior Project Manager

Client Name: JBA Consulting
Reference: 2018s1298
Location: Cherrywood
Contact: David Casey
JE Job No.: 19/7960

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

J E Sample No.	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24			LOD/LOR	Units	Method No.
Sample ID	JBH-1	JBH-2	JBH-3	JBH-4	JBH-5	JBH-6	JBH-7	Spring					
Depth													
COC No / misc													
Containers	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P	H HN P					
Sample Date	14/05/2019	14/05/2019	14/05/2019	14/05/2019	14/05/2019	14/05/2019	14/05/2019	14/05/2019					
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Surface Water					
Batch Number	1	1	1	1	1	1	1	1					
Date of Receipt	16/05/2019	16/05/2019	16/05/2019	16/05/2019	16/05/2019	16/05/2019	16/05/2019	16/05/2019					
Dissolved Calcium #	113.0	91.8	126.2	104.3	133.4	138.4	136.6	168.9			<0.2	mg/l	TM30/PM14
Dissolved Magnesium #	11.1	7.5	6.0	14.9	6.7	11.7	13.7	9.6			<0.1	mg/l	TM30/PM14
Dissolved Potassium #	3.3	1.4	0.9	1.0	0.9	1.4	1.1	1.1			<0.1	mg/l	TM30/PM14
Dissolved Sodium #	26.7	13.5	12.3	10.9	12.0	15.9	14.2	14.7			<0.1	mg/l	TM30/PM14
Total Hardness Dissolved (as CaCO3)	329	261	341	323	362	395	399	463			<1	mg/l	TM30/PM14
Sulphate as SO4 #	23.4	29.3	32.8	22.7	46.4	59.2	39.5	104.3			<0.5	mg/l	TM38/PM0
Chloride #	53.1	22.5	25.4	15.6	21.0	30.4	15.7	23.1			<0.3	mg/l	TM38/PM0
Nitrate as N #	5.26	2.72	1.31	0.80	0.97	0.60	1.45	1.54			<0.05	mg/l	TM38/PM0
Nitrite as N #	0.050	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			<0.006	mg/l	TM38/PM0
Ortho Phosphate as P #	<0.03	<0.03	<0.03	<0.03	0.05	<0.03	<0.03	<0.03			<0.03	mg/l	TM38/PM0
Ammoniacal Nitrogen as N #	0.16	<0.03	<0.03	<0.03	<0.03	0.04	<0.03	<0.03			<0.03	mg/l	TM38/PM0
Dissolved Carbon Dioxide	62852	71578	111272++	74812	121192++	110303++	153596++	94046			<1	ug/l	TM25/PM0
Total Alkalinity as CaCO3 #	600	335	333	330	624	431	414	353			<1	mg/l	TM75/PM0
Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1			<1	mg/l	TM75/PM0
Electrical Conductivity @25C #	731	630	719	654	743	788	837	930			<2	uS/cm	TM76/PM0
pH #	7.37	7.61	7.36	7.78	7.37	7.36	7.50	7.63			<0.01	pH units	TM73/PM0

Please see attached notes for all abbreviations and acronyms

Client Name: JBA Consulting
Reference: 2018s1298
Location: Cherrywood
Contact: David Casey

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Analysis	Reason
No deviating sample report results for job 19/7960						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.
Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

JE Job No.: 19/7960

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. The temperature of sample receipt is recorded on the confirmation schedules in order that the client can make an informed decision as to whether testing should still be undertaken.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to an Exova Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

JE Job No: 19/7960

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM25	Determintaion of Dissolved Methane, Ethane and Ethene by Headspace GC-FID	PM0	No preparation is required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.	Yes			
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods 325.2 (Chloride), 375.4 (Sulphate), 365.2 (o-Phosphate), 353.1 (TON), 354.1 (Nitrite), 350.1 (NH4+) comparable to BS ISO 15923-1, 7196A (Hex Cr)	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 and 9045D and BS1377:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.				
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			
TM76	Modified US EPA method 120.1. Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			

Appendix C2 – Field and Calculated Results

Field Measurements 17/04/2019

Sample ID	JBH - 1	JBH - 2	JBH - 3	JBH - 4	JBH - 5	JBH - 6	JBH - 7
Water Level mbgl	11.99	4.2	1.32	2.98	5.75	4.84	2.44
Ground Level mAD	71.11	56.42	54.74	53.72	50.91	40.61	54.02
Water level mAD	59.12	52.22	53.42	50.74	45.16	35.77	51.58
Well Depth m	17.06	14.65	9.88	15.68	7.69	20.4	7.47
Temp	11	11.8	10.5	11.5	10.8	11.4	10.2
pH	7.4	6.78	6.93	7.05	7.13	7.17	7.02
pHmv	-35.1	0	-8.5	-15.3	-20	-21.9	-13.5
EC	680.2	481	640	588.9	674	743	751
ORPmv	81	99.3	116.6	71.4	81.7	117.8	88.2
Colour	Brown tint	Brown tint	Brownish	Brown tint	Milky brown	Brownish	Milky brown
Odour	None	None	None	None	None	None	

Field Measurements 14/05/2019

Well No.	JBH-1	JBH-2	JBH-3	JBH-4	JBH-5	JBH-6	JBH-7	Spring
Water level mbgl	12.07	4.82	1.30	3.14	5.91	5.17	2.84	
Water level mAD	59.04	51.6	53.44	50.58	45	35.44	51.18	
Well Depth (mbgl)	17.06	14.65	9.88	15.68	7.69	20.40	7.47	
Temp	10.6	11.2	10.9	10.7	10.8	11.3	10.8	11.2
pH	7.35	6.81	6.89	7.07	6.88	7.1	6.81	7.19
Redox	-34.5	-3.3	-8	-18	-7.4	-19.6	-6.1	-24.9
EC	759	550.5	671	619.7	707	751	795	891
ORPmv	7.5	51	82.1	77.1	74.5	74.7	79	77.2
Colour	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Clear
Odour	None	None	None	None	None	None	None	None