

ENERCRET

**Hough End Leisure Centre, Manchester
Geology and Thermal Response Test - Report
13th August 2021**

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Rev: P01

Date: 13th August 2021



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Hydrogeo Geo-report – – HOUGH END LEISURE CENTRE



1. Introduction

We have pleasure in providing the Ground Source System Design for the following project.

Project Number	GSS-030
Customer Name	Ameresco Ltd
Project Address	HOUGH END LEISURE CENTRE 480 PRINCESS ROAD M20 1HD
Building Type	Leisure centre
Building Load Information	Provided by ENERCRET
Borehole Schematic	1 x 21 boreholes
Author	Lee Hormell Managing Director lee@groundsourcesolutions.co.uk

2. Design Requirements

Company	ENERCRET
Ground Source system Designer	Lee Hormell
Ground Loop Design Software	GHLEPRO Version 5

2.1 Quality & Standards

Organisation	Reference
Environment Agency	Environmental good practice guide for ground source heating and cooling
IGSHPA	General Code of practice for closed loop Installations
GSHPA	Vertical Borehole Standards
BDA	Code of Safe Drilling Practice
Coal Authority	Guidance on Managing the Risk of Hazardous Gases When Drilling or Piling Near Coal Measures

During the design and installation of this project we have considered the most up to date versions of the following quality and standards publications which are specifically applicable to ground source array installation



3. Geology

3.1 Summary of Anticipated Geology

ENERCRET Ltd commissioned Hydro Geo to carry out a full borehole prognosis report. (See appendix HYG914). In brief the summary of the underlying Geology is as set out in the table below.

Formation	Description	Estimated Thickness	Depth to base (m)	Elevation of base (m)
Quaternary	Sand and gravel, locally with lenses of silt, clay or organic material; characteristic 'sandur' (sheet) and valley train form; of glaciofluvial origin	0.5	2.0	29.5
Sherwood sandstone	Weakly cemented, red-brown to brick-red, fine- to medium-grained, generally pebble-free, cross-bedded sandstones , with sporadic siltstones	100	102	-72
Sherwood sandstone	Well cemented conglomerates and reddish brown, cross-bedded, pebbly sandstones with subordinate beds of red-brown mudstone	150-400	>232	<202
See appended report HYG914-R Hough end				

3.2 Groundwater

The report indicates the following groundwater conditions are likely to be encountered at the project location.

Anticipated Groundwater Depth	10-20m
Expected Rest Water Level	10-20m
Risk of Artesian Conditions	Not expected
Aquifer Classification	Principle A Aquifer



3.3 Estimated Thermal Properties

The estimated thermal properties are based on the most concentrated formation expected to be encountered on site which is also detailed in report HYG914 and including the ground water movement within this formation.

Quantity	Estimated Value
Thermal Conductivity	3.14 W·mK ⁻¹
Undisturbed Ground Temperature	9.3 °C - Winter – 14.6 °C - Summer
Conductivity Test	To be Done

3.4 Relevant Body Searches

A search of the available records has indicated that the site has the following mining history and requirements.

Historic Mining Activity & Type	None
Coal Authority Reporting Area	No
Historic Coal Mining	None
Likely Depth to Seams	None
Development High Risk Area	No
Proximity to Mine Access	None
Historic Surface Works	None
Notes	None

3.5 Obstacles to Construction

With the information available and the analysis undertaken there appears to be no Geological or Hydro-Geological barriers to construction at the required depths. However, these conditions can never be fully determined until we have commenced the drilling works as the conditions will be generally site specific.



Ground Loop Design

4.1 Building Loads (as determined by Enercret)

	TOTAL HEATING	TOTAL COOLING	PEAK HEATING	PEAK COOLING
JAN	53727		145	
FEB	52385		146	
MARCH	52532		148	
APRIL	53215		145	
MAY	52251		128	
JUNE	46118		42	
JULY	15312		77	
AUGUST	27846		141	
SEPT.	50883		143	
OCT	51354		141	
NOV	50713		141	
DEC	50772		149	



4.2 System Design

Ground Loop Array – 1

Simulated by:	GHLEPRO
Date:	28/05/2021
Simulated by:	Lee Hormell

GLHEPRO SOFTWARE SYSTEM PARAMETERS	
Active borehole length	140
Borehole radius	0.075m
Borehole spacings	12m
Borehole geometry	1 x 21 boreholes
Soil Type Currently Used	Dense Rock
Thermal Conductivity of Ground	4.13 W/ (m.°K)
Volumetric Heat Capacity of Ground	2678.21 kJ/ (°K.m ³)
Volumetric Heat Capacity of Fluid	4066.4348 kJ/ (°K.m ³)
Undisturbed Ground Temperature	11.9°
Borehole Thermal Resistance	0.06 ° K/ (W/m)
Fluid Type Currently Entered	30% Glycol/Water
Mass Flow Rate of Fluid	7.5 l/s

BOREHOLE INFORMATION CALCULATED SIMULATION RESULTS	
Design length of each borehole	140
Total borehole length	2940m
Distance between borehole centres	12m

AVERAGE MONTHLY TEMPERATURES

The end of the month temperatures calculated on the monthly loads.

Maximum average °C = 9.44 at Month 8

Minimum Average °C = 0.01 at Month 290

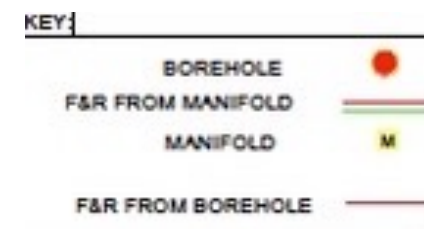


HOUGH END LEISURE CENTRE
480 PRINCESS ROAD
MANCHESTER
M20 1HD

21 BOREHOLES
12M SPACINGS
170M IN DEPTH

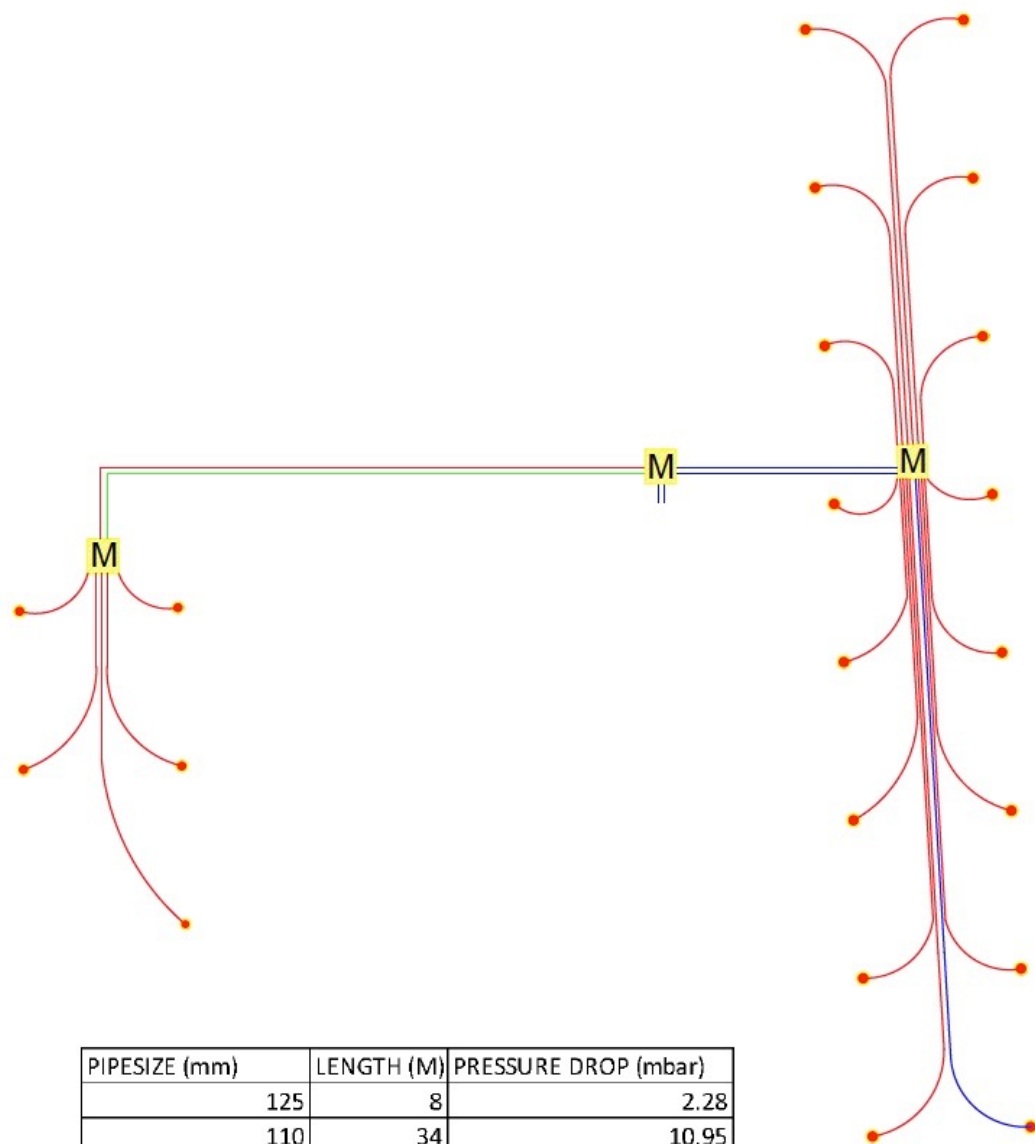
ALL BOREHOLES HAVE NO INTERACTION
WITH TREES AND THEIR ROOT
PROTECTION AREA.

FLOW AND RETURN PIPEWORK TO AND
FROM MANIFOLD AND FLOW AND
RETURN FROM BOREHOLE TO MANIFOLD.
ALL BOREHOLE PIPEWORK EXPECTED TO
BE 40MM.



HOUGH END LEISURE CENTRE
480 PRINCESS ROAD
MANCHESTER
M20 1HD

PRESSURE DROP CALCULATED FROM THE
INDEX ROUTE SHOWN IN BLUE AND A
SYSTEM FLOW RATE OF 7.5 L/S



PIPESIZE (mm)	LENGTH (M)	PRESSURE DROP (mbar)
125	8	2.28
110	34	10.95
40	288	68.1

ENERCRET

Hough End Leisure Centre

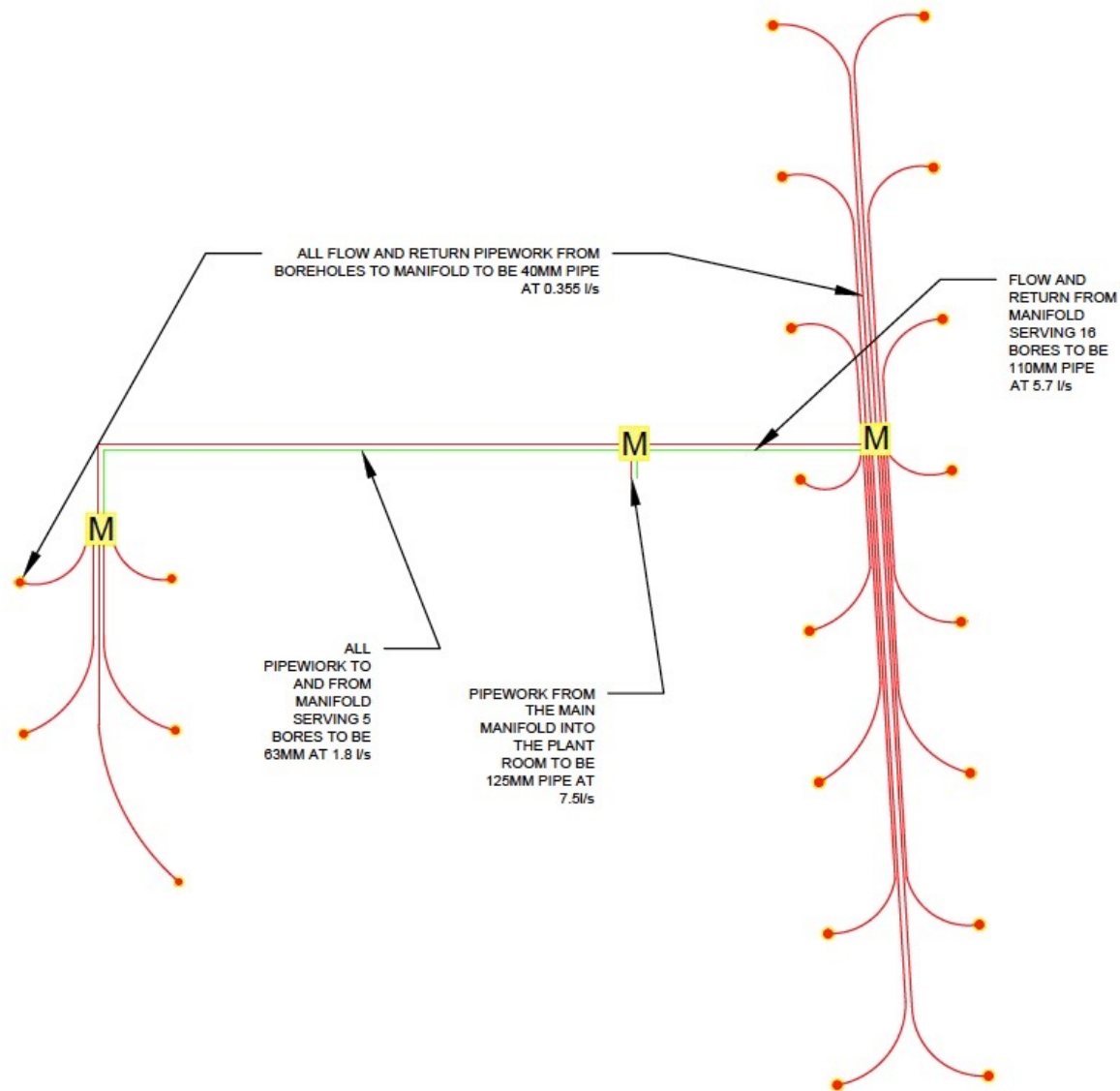
Contract No: EP2012a

Sheet No: 1 of 1

Date: 11-June-2021

Ref: EP2012a-ENR-DR-XX-01

Rev: P01



HOUGH END LEISURE CENTRE
480 PRINCESS ROAD
MANCHESTER
M20 1HD

21 BOREHOLES
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RETURN FROM BOREHOLE TO MANIFOLD.
ALL BOREHOLE PIPE WORK EXPECTED TO
BE 40MM



4.4 Summary

This system has been designed in accordance with the industry standards (IGSHPA/GSHPA). Critical Building energy loads were provided by Enercret and key geological data obtained through Hydro Geo Ltd. Critical design parameters such as the rock and soil classification have been utilised in the modelling of this ground loop array.



Ground Loop Design

Thermal Conductivity Report – 12/07/2021

Project Name: Hough End Leisure Centre

Project Address: 480 Princess Road

City: Manchester **Postcode:** M20 1HD

Prepared by: JH.

Email: jack@groundsourcesolutions.co.uk

Phone: 07725124199

Drill Date:

TC Test Dates: 03/08/21 – 05/08/21

Client Name: Ameresco Ltd

Address line 1: Wesley House

Address line 2: Wesley Street

City: Castleford

Phone:

Postcode: WF10 1JG

Fax:

Email:

Calculation Results

Thermal Conductivity (W/m*K):	4.13
Thermal Diffusivity (est.) (m ² /day)	0.266
Average Heat Flux (W/m)	50.7
BH Thermal Resist (BTR) (m*K/W)	0.06
Average Flow Rate (L/s)	0.25
Test Duration (hr)	28
Calculation Interval	12-40

Borehole Input Parameters

Undisturbed Ground Temperature (C):	11.9
Depth (m):	130
Borehole Diameter (mm):	150
Pipe Size:	1 ½ in. (40mm)
Grout Thermal Conductivity:	2.00
Drilling Method:	Standard
Drilling Time (hr):	5.0

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T:0330 333 9277 E: uk.sales@enercret.com

Diffusivity Parameters

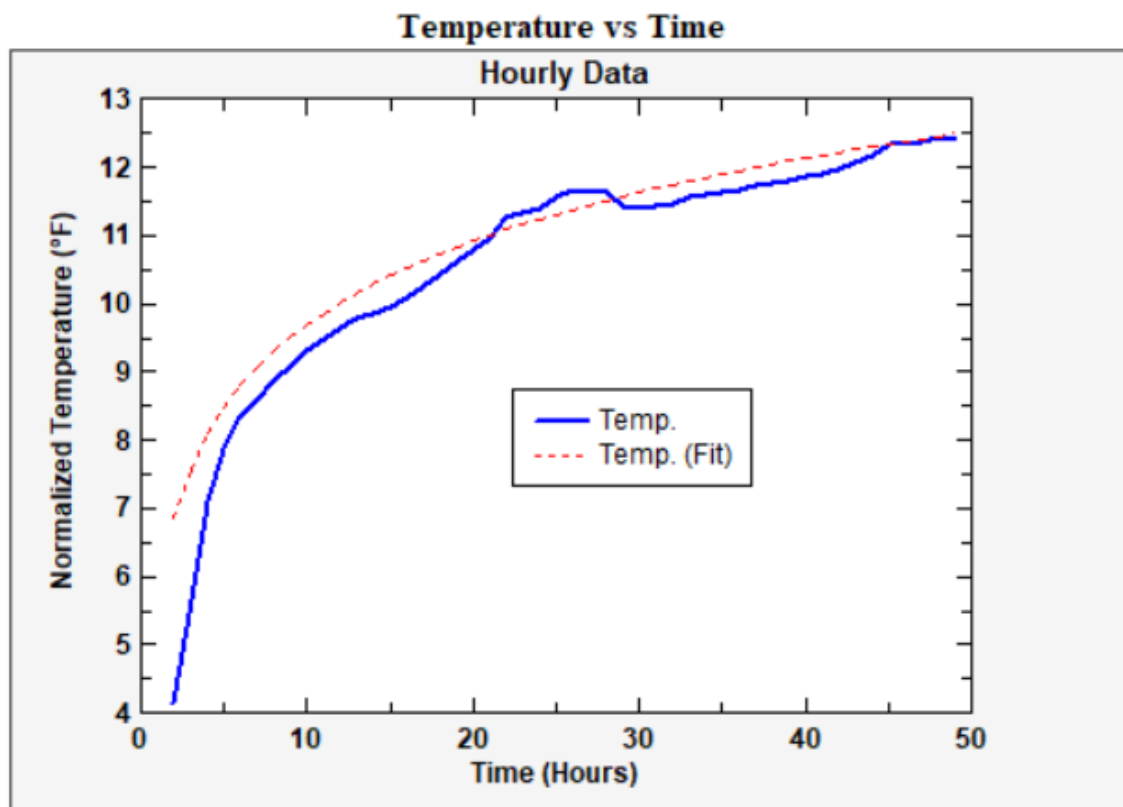
Soil/Rock Specific Heat – Dry (Kj/K*kg):	0.837
Soil/Rock Density – Dry (kg/m ³):	1601.8
Moisture (0-100) (%)	0.0

Data Quality

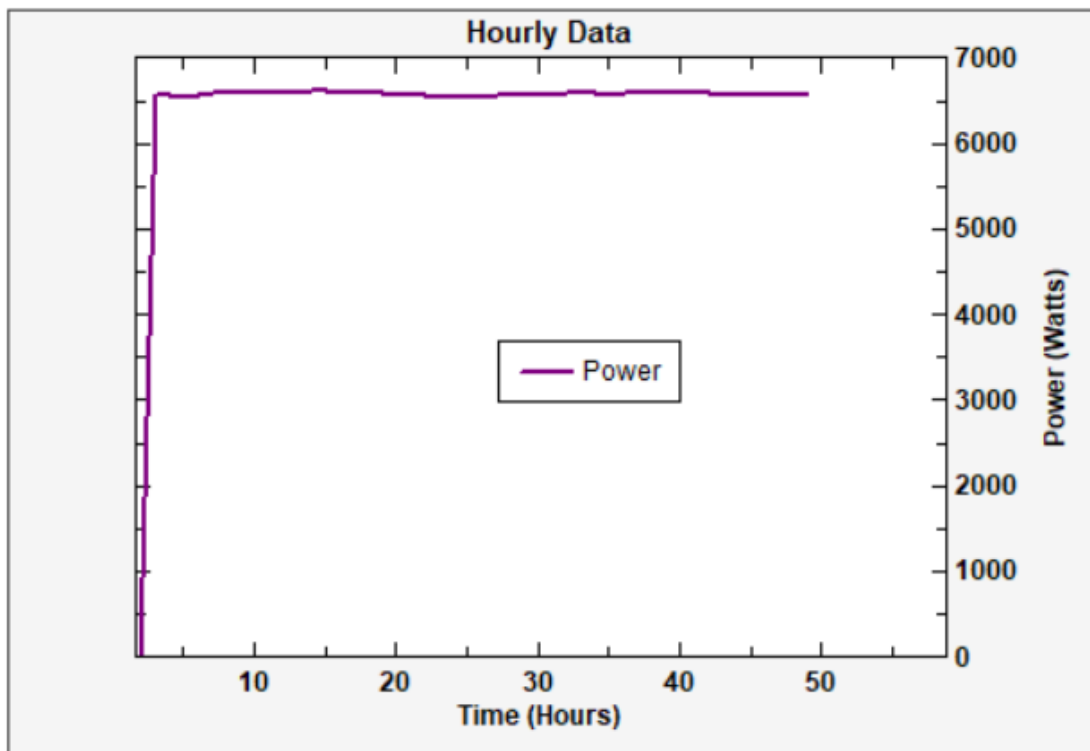
	Threshold		Threshold
Power Standard Deviation: Pass	1.50%	Flow Rate: Pass	5.00%
Power Variation: Pass	10.00%	Slope Stability: Pass	25.00%
Temperature: Pass	5.00%	Water Flow Test: Pass	20.00%

Flow Rate Input Parameters

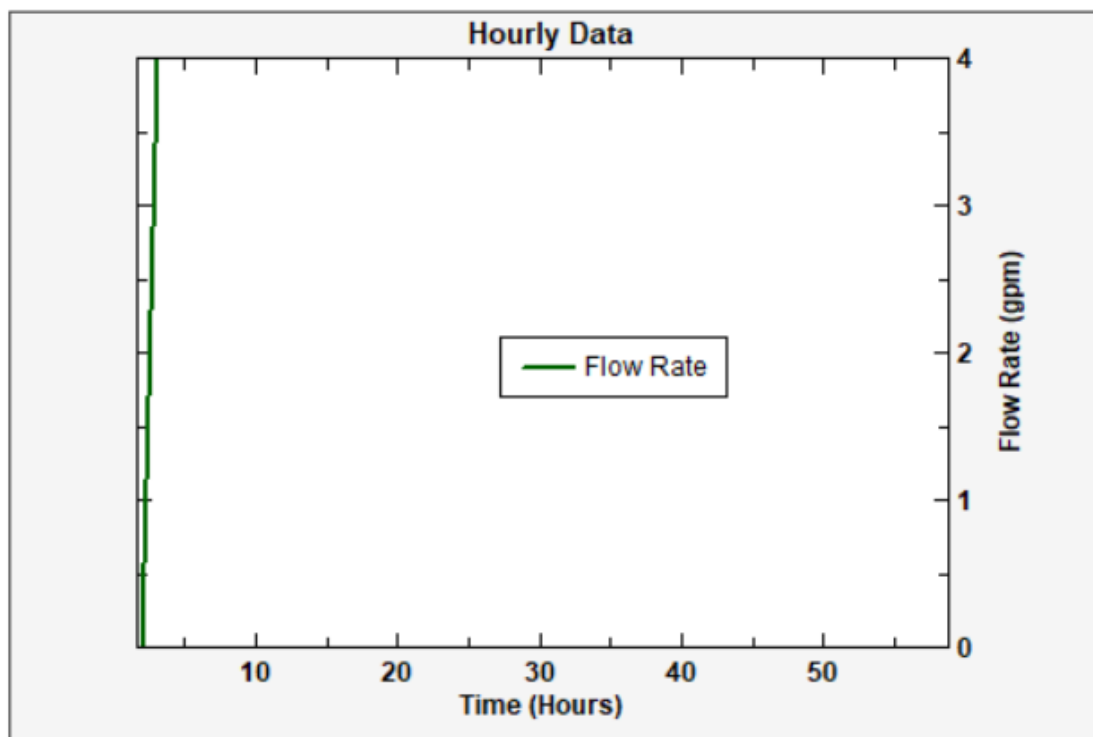
TC Unit Model Name.	GeoCube
---------------------	---------



Power vs Time



Average Power 6586.3 Watts

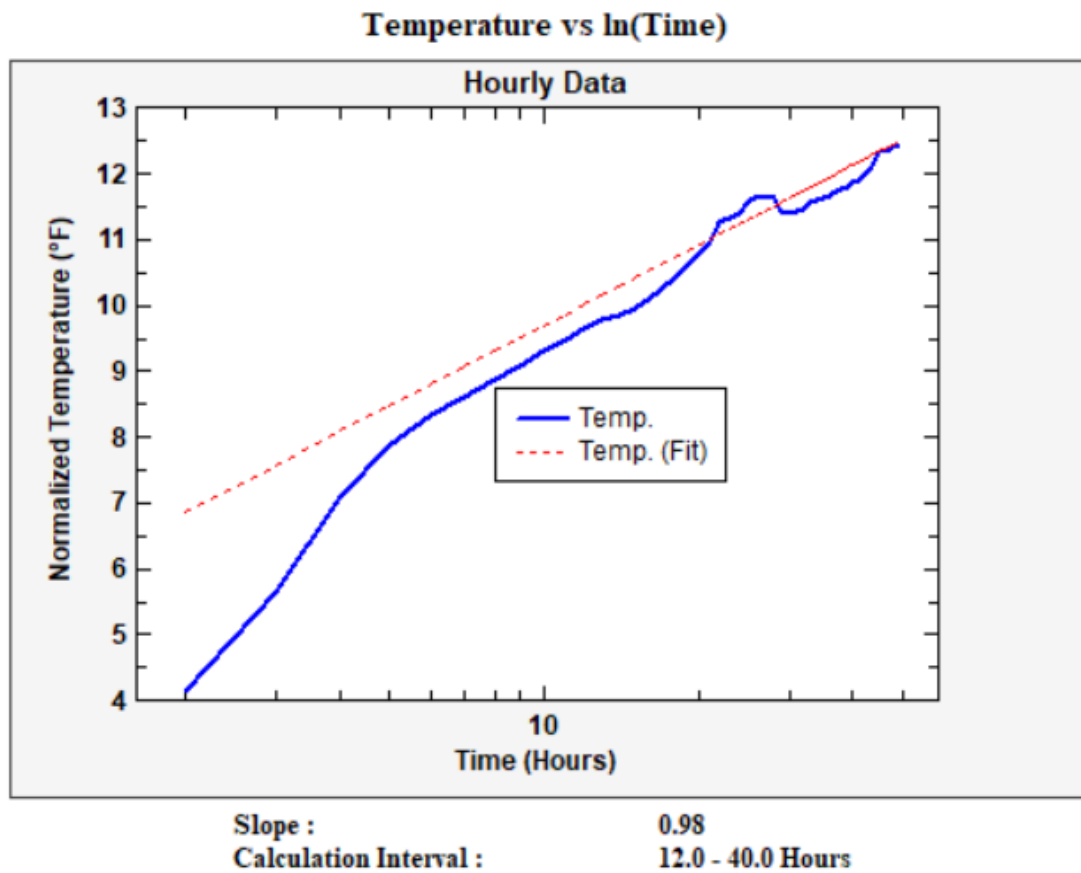


Average Flow Rate 0.25

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Data Quality

		Threshold			Threshold
Power Standard Deviation:	Pass	1.50%	Flow Rate:	Pass	5:00%
Power Variation:	Pass	10.00%	Slope Stability:	Pass	25.00%
Temperature:	Pass	5.00%	Water Flow Test:	Pass	20.00%

Comments



Thermal Conductivity Test Overview

The Thermal conductivity, or thermal response, test is a way to determine ground thermal properties that are critical for ground source heat pump system design. The test is performed by injecting a known and constant amount of heat power into a borehole heat exchanger and then measuring the temperature response. A competent test can provide the undisturbed ground temperature, the calculated thermal conductivity, the calculated borehole thermal resistance and an estimate of the thermal diffusivity. These values critical for the optimal design of a geothermal system, can be used in a geothermal design program to design an optimised, cost effective system.

Undisturbed Ground Temperature Determination

The undisturbed ground temperature is the constant temperature of the formation. Typically, this temperature is measured before starting the active thermal conductivity test. The TC module automatically estimates this value from the first few temperature measurements collected via the TC test unit data logger. The organisation that performs the test also has the option of manually estimating this value with temperature probes or the like. If the TC test is initiated too soon after the installation of the test bore, the undisturbed ground temperature may be inaccurate. In general, it is recommended that the testing company waits a minimum of 3 – 5 days after installing the borehole before initiating the test so as to ensure that the ground has returned to its native and undisturbed ground temperature.

Thermal Conductivity Calculation

Because thermal conductivity cannot be measured directly, the Ground Loop Design Thermal Conductivity Module uses the line source heat transfer model to calculate the required results. The line source model, which assumes an infinitely thin heat source in a homogenous medium, is very broadly referenced in the published literature and is considered to be the standard analysis methodology. To analyse test data, the average temperature of the water entering and exiting the heat exchanger is plotted versus the natural log of time. Using regression analysis, a best fit line is plotted to match the empirical data and the slope of the line is used to calculate thermal conductivity of the formation. Typically, the data analysis procedure maybe repeated several times for several different time intervals to ensure the closest fit between the empirical data and the derived best fit line. In addition, approximately the first 10 hours of temperature data are not included in the analysis so as to ensure that the conductivity value is determined from a steady state rather than a transient heat conduction process.



Thermal Diffusivity Estimation

Thermal Diffusivity may be estimated from a combination of the calculated thermal conductivity value (which is directly related to diffusivity) in conjunction with estimated of the specific heat, density and moisture content of the test bore. The thermal diffusivity reflects the rate of conductive heat transfer in the soil and helps determine the impact of neighbouring borehole interactions on the final geothermal loopfield design.

Test Procedure Recommendations

The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) offers a set of procedural recommendations for in situ-thermal conductivity/response tests. These can be found in the ASHRAE 2007 HVAC Applications handbook. Several of the key recommended procedures are as follows:

- A) Time between test bore and installation and start of the TC test. A 5 day minimum wait time is recommended
- B) Undisturbed ground temperature measurements: The undisturbed ground temperature should be recorded prior to start up
- C) Test duration: Test duration typically should be 48 hours or longer
- D) Power Quality: The power standard deviation should be equal to or less than 1.5% of the average power and the maximum power variation should be less than 10% of the average power. The average heat flux should fall within the 15w/ft to 25w/ft range to best simulate the expected peak loads in the borehole.



Borehole Geology Report

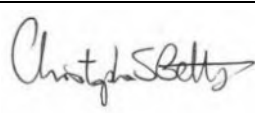
Hough End Leisure Centre

480 Princess Road, Manchester M20 1EP

On Behalf of

C Ltd

Quality Management

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Authorised by:	Chris Betts MSc FGS CGeol	 
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Data Sources

- Ordnance Survey (OS) maps for the site;
- BGS Lexicon of named rock units (online);
- BGS Borehole Records (online);
- BGS Geology of Britain viewer (online);
- Environment Agency Catchment Data Explorer (online);
- BGS Geological Map, 1:50,000 Series Sheet 98, Stockport, Solid (1977);
- BGS Geological Map, 1:50,000 Series Sheet 98, Stockport, Drift (1971);
- BGS Geological Map, 1:50,000 Series Sheet 85, Manchester, Bedrock (2010);
- BGS Hydrogeological Map, Sheet 19 (1:100,000), Hydrogeological Map of Clwyd and the Cheshire Basin (1989);
- BGS, Geology of the Manchester district – a brief explanation of the geological map, 1:50,000 Sheet 85 Manchester (England and Wales);
- The physical properties of major aquifers in England and Wales, Technical Report WD/97/034, British Geological Survey and Environment Agency, 1997;
- The physical properties of minor aquifers in England and Wales, Technical Report WD/00/04, British Geological Survey and Environment Agency, 2000;
- Misstear, B., Banks, D and Clark, L. 2006. Water Wells and Boreholes. John Wiley and Sons Ltd;
- Banks D. 2012, An Introduction to thermogeology: ground source heating and cooling, John Wiley and Sons Ltd;
- Banks, J. G. Withers, G. Cashmore and C. Dimelow, Quarterly Journal of Engineering Geology and Hydrogeology, 46, 281-291, 17 July 2013;
- BGS Hydrogeological Map, Hydrogeological Map of Clwyd and the Cheshire Basin, 1:100,000, Sheet 19, British Geological Survey, 1989;
- Catchment Abstraction Management Strategy, Upper Mersey, Environment Agency, 2013.

Disclaimer

Hydrogeo Limited has undertaken a borehole geology report on behalf of the client. A desk study review of available information has been carried out by an experienced geologist / hydrogeologist and the results of this work are displayed in this report. No responsibility can be accepted for the local conditions which alter the interpretation and predictions of the published data.

The report has been prepared based on limited geological and hydrogeological information. Although we have applied our experience and expertise to the interpretation of the data available, no guarantee can be made as to the amount or quality of water obtained. Development of groundwater sources has an inherent risk. Developers should be aware that it is possible that an insufficient volume or poor quality of water could be encountered.

It is the responsibility of the contractor to check for buried services and underground obstructions, including drainage systems prior to drilling.

Site Location & Proposed Development

- The site is occupied by Hough End Leisure Centre in Chorlton-cum-Hardy, Manchester.
- This report has been commissioned in order to provide details of the geology beneath the site in support of the borehole drilling required for the installation of a closed loop ground source heating system for the property.
- The site location is demarked in red on Figure 1.
- The site is located to the west of the A5103 (Princess Road), approximately 4km south of Manchester city centre.
- Access to the site comprises an entryway to its car park from Princess Street.
- Sports pitches are to the west of the site. The wider area is primarily residential in nature.
- The main site building is located at National Grid Reference (NGR) 383817,393397.
- The site elevation is approximately 35 meters Above Ordnance Datum (mAOD).

Site Location Map

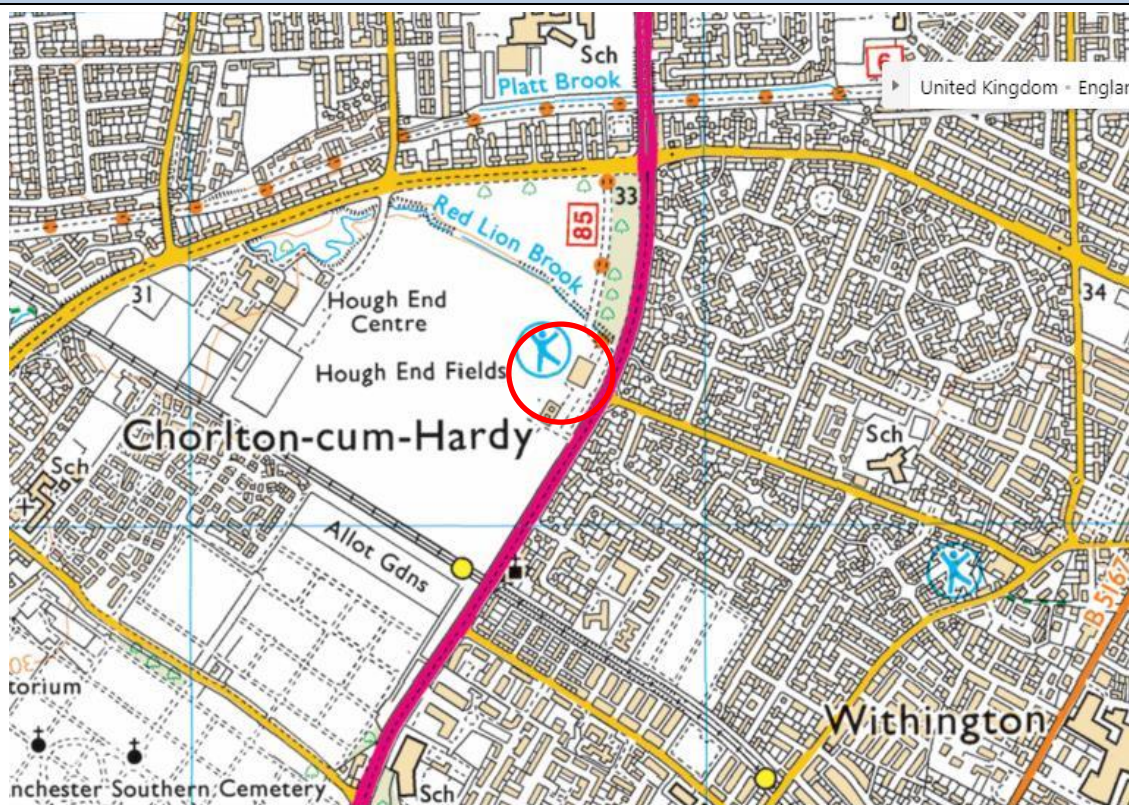


Figure 1 - Map of Site Location
Contains Ordnance Survey Data

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Historic Development

- Historic Ordnance Survey (OS) mapping for the site dated from 1848 to present has been reviewed as part of this report. Mapping from 1848 to 1923 appearing to show the site as undeveloped agricultural land. Mapping dated 1935 to 1966 shows the site having been developed into playing fields.
- Historic Google Earth imagery has been reviewed for the site. Satellite imagery is available dated 1985 to present. Imagery from 1985 to 2013 show the site to be occupied by playing fields and a car park. By March 2016, imagery shows the site to be occupied by the Hough End Leisure Centre. This structure appears to be the structure still present today. No significant changes are noted through to the most recent imagery captured (May 2019).

Local Hydrology

- The closes watercourse is Red Lion Brook, located 100m to the south of the Leisure Centre Building. This watercourse appears to be culverted to the east of the site beneath Withington, but emerges out of the culvert north of the site to the west of Princess Road.
- The Red Lion Brook flows from east to west and converges with the Platt Brook 800m west of the site (potentially culverted).
- The converged watercourses form Chorlton Brook, which flows to the west and discharges into the River Mersey 3.8km to the west of the site.
- No springs are mapped within 1000m of the site boundary.

Site Designations

Statutory

- There are no Statutory Designations within 2.0km of the site.
- The site is not situated within a Nitrate Vulnerable Zone (NVZ).

Non-Statutory

- The site is not situated within a Drinking Water Protected Area (Surface Water), Drinking Water Safeguard Zone (Surface-water) or Drinking Water Safeguard Zone (Groundwater).
- The site is not situated within a groundwater Source Protection Zone (SPZ). The nearest SPZ III Total Catchment is located 1.5km to the north-east.

Water Availability & CAMS (Catchment Area Management Strategy)

- As the proposal involves use of a closed loop system for ground source heating, no abstraction or discharge license is required from the Environment Agency.
- The site is located within the Upper Mersey Management Catchment (February 2013)
- The site is included within the Upper Mersey abstraction licensing strategy, last updated in February 2013.
- In areas of the Upper Mersey catchment area, groundwater is licensed separately from surface water, with the catchment split into separate Groundwater Management Units (GWMU).
- The site is situated within the Trafford GWMU. The Trafford GWMU is shown as *Restricted Water Available* - more water is licensed than the amount available, but that recent actual abstractions are lower than the amount available OR that there are known local impacts

likely to occur on dependent wetlands, groundwater levels or cause intrusions but with management options in place..
Licensed Abstractions
▪ A single licensed groundwater abstraction is located within 2km of the site boundary. The license is located 1950m southwest of the site and supplies Chorlton Cum Hardy Golf Club with a maximum of 70m³/d (8500m³/year) for spray irrigation in industrial, commercial and public services. ▪ No licensed surface water abstractions are present within 2.5km of the site.

Geology
▪ The underlying bedrock geology is presented as Drawing 01; Superficial deposits are presented as Drawing 02. ▪ A generalised vertical geological section is shown in Figure 2.
Artificial Ground
▪ Artificial ground consists of any areas where ground conditions have been significantly modified by man. These include excavations, infilled ground and made up ground. ▪ No artificial ground is shown to be present on BGS geological mapping, however a veneer of made ground is likely across the site.
Superficial Deposits
▪ Superficial Deposits consist of near surface unconsolidated (loose) sedimentary deposits which have not yet become solid rock. ▪ Superficial Deposits beneath the site consist of Glaciofluvial Deposits and Glacial Till. ▪ The uppermost layer of superficial deposits consists of Glaciofluvial deposits, these are described as sand and gravel. ▪ Beneath the Glaciofluvial deposits glacial till may be present described as clay to sandy clay, unsorted, with common pebbles, cobbles and some boulders (diamicton). These were deposited in ice age conditions during the Devensian (last glacial period).
Bedrock Geology
▪ The bedrock beneath the site consists of the Wilmslow Sandstone Formation, a constituent of the Sherwood Sandstone Group. Sherwood Sandstone Group ▪ The Triassic Sherwood Sandstone Group is present beneath the site and described by the BGS as “<i>sandstone, red, yellow and brown, part pebbly; conglomeratic in lower part; pebbles generally extraformational quartz and quartzite, with some intraformational clasts; subordinate red mudstone and siltstone</i>”. ▪ The Wilmslow Sandstone Formation (formerly the Upper Mottled Sandstone) is the uppermost constituent unit of the Sherwood Sandstone Group present beneath the site. The Wilmslow Sandstone Formation is described by the BGS as “<i>red-brown to brick-red, fine- to medium-grained, generally pebble-free, cross-bedded sandstones, with sporadic siltstones</i>”. The formation was deposited during the Triassic and is thought to be approximately 100m thick beneath the site. ▪ The Chester Formation is the lower most constituent unit of the Sherwood Sandstone Group present beneath the site. The Chester Formation is described by the BGS as “<i>Well cemented conglomerates and reddish brown, cross-bedded, pebbly sandstones with subordinate beds of red-brown mudstone</i>”. The formation was deposited during the Triassic and is thought to be over 150m thick beneath the site.

Geological Structure
▪ The BGS map (Stockport, Sheet 98) shows the geology of the area to be dipping to the west at approximately 10°. ▪ No faults are shown passing through the site.
Temperature at Depth & Thermal Geology
▪ Thermal conductivity data is presented as part of the Quarterly Journal of Engineering Geology and Hydrogeology, Vol. 46, An overview of the results of 61 in situ thermal response tests in the UK (17 July 2013). ▪ This 2013 paper presents generalised apparent thermal conductivity (W m⁻¹ K⁻¹ or W/m/K) values for major UK stratigraphy. ▪ Additional thermal conductivity values for UK stratigraphy and rock types are provided within An Introduction to Thermogeology: ground source heating and cooling, by D Banks. ▪ Thermal conductivity data is presented for each stratigraphy within the <i>Summary of Anticipated Underlying Geology</i> section below.

Generalised Vertical Geological Section

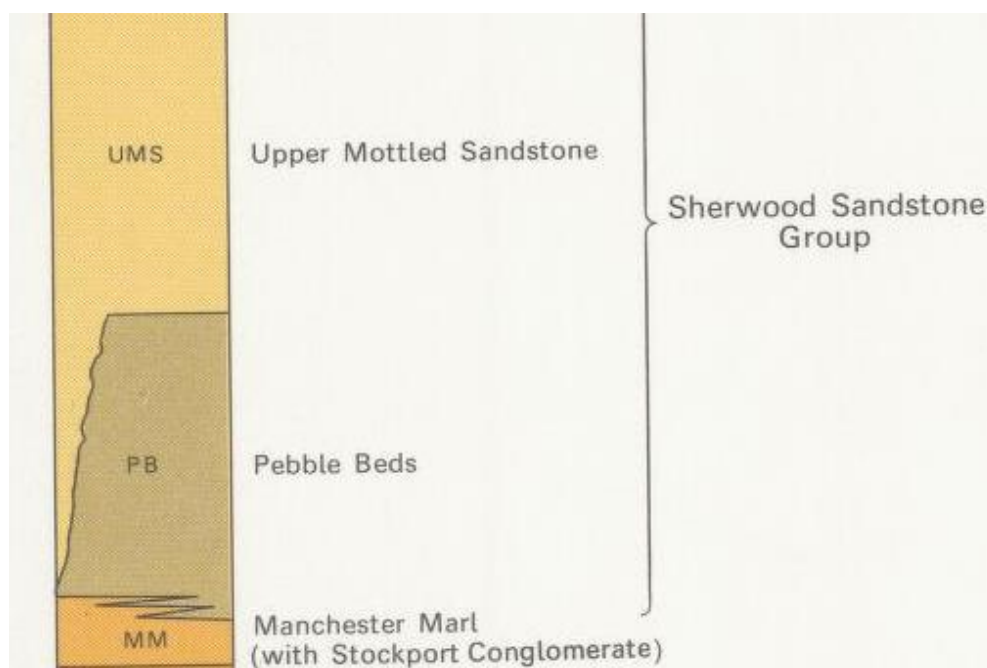


Figure 2 – Generalised Vertical Section of geology beneath the Site.
BGS 1:50,000. Sheet 98 Stockport (1977). Licence number [C10/018-CSL] © NERC.

Borehole Records	
- BGS Borehole records have been reviewed. A selection of the closest/most relevant boreholes to the site has been reviewed to demine the geological succession and records of groundwater abstractions. - Groundwater levels may have changed since the construction of these boreholes. Groundwater levels are known to fluctuate. - BGS Borehole Record locations can be viewed in Figure 3. All distances and direction are given from the site boundary as shown in Figure 1.	
Borehole Details	
SJ89SW44 NWWA HOUGHEND CLOUGH OBSERVATION BH. NGR: 383280,393500 Location: 480m WNW Record Here	- A borehole was progressed by the North West Water Authority The borehole was advanced to 200mbgl from an elevation of 15mAOD. - The geology is not recorded however the casing is as follows: 0 – 3m cased 3 – 10m open hole 10 – 26m cased (butt welded) 26 – 81m open hole - No water strikes/levels shown on log
SJ89SW702 MANCHESTER CORP. BARLOW MOOR ROAD NGR: 383450,392790 Location: 550m SW Record Here	- A borehole was progressed for a road scheme. The borehole was advanced to 12.19mbgl from an elevation of 30.44mAOD. - The borehole records Sand with occasional gravel to 3.97mbgl, then firm to stiff brown clay with pebbles and sand traces (boulder clay) to 12.19m - The record states that water was not encountered.
SJ89SW1013 MANCHESTER METERO LINK NGR: 382634,393374 Location: 1100m W Record Here	- A borehole was progressed for the Manchester Metro link to a depth of 23mbgl from an elevation of 29mAOD. - The borehole records made ground to 1.2mbgl, Sand with gravel to 3.5mbgl, firm gravelly clay to 15.1mbgl, gravelly sand to 16.5mbgl - Bedrock comprising sandstone (recovered as sand) was encountered at 16.5mbgl - No water strikes/levels shown on log

Borehole Records Location Map

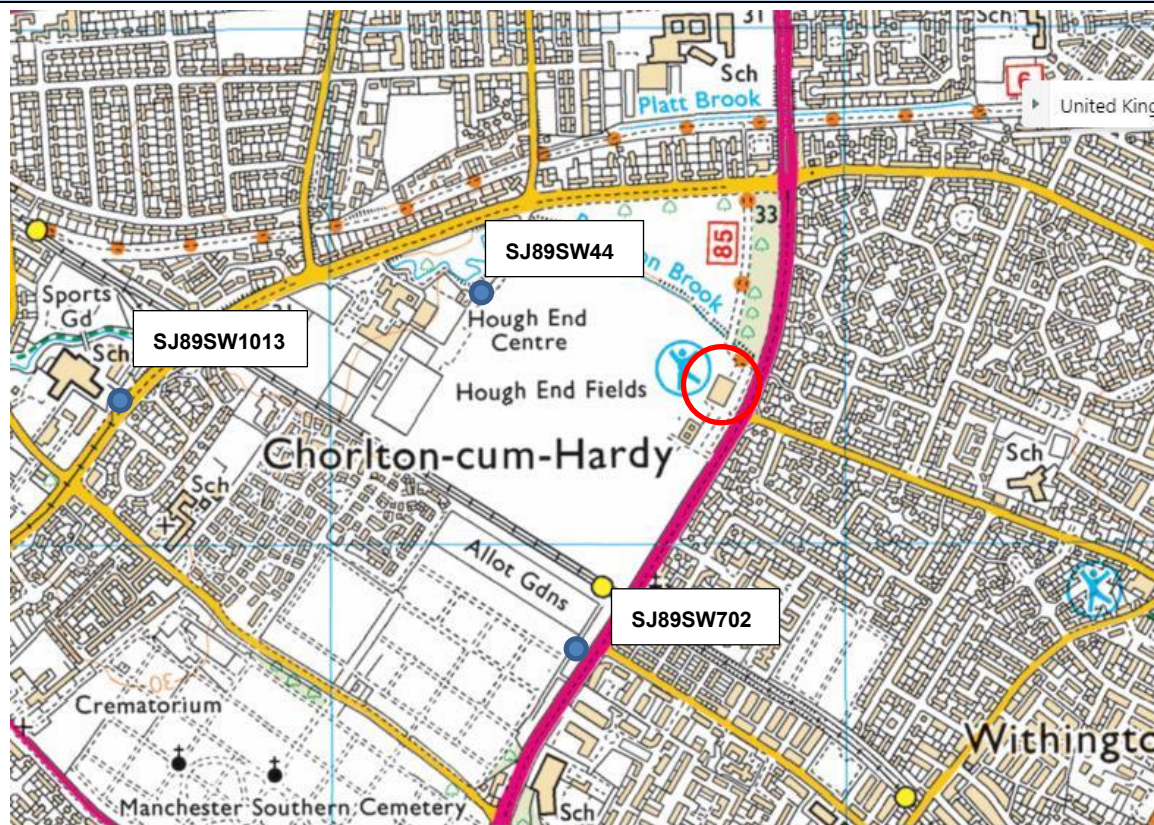


Figure 3 – Ordnance Survey Map of Borehole Locations.

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Summary of Anticipated Underlying Geology

- The sequence of geological units beneath the site is displayed in the table below, assuming a position of 383755,393300 and assumed ground level of approximately 35mAOD at the site.
- The bedrock is assumed to be dipping 10° to the west.
- Thicknesses of all geological formations have been estimated using available investigation records and structural contours. A best estimate has been made from the available data, but depths in the field may vary.
- Thermal conductivity values are based on literature data.

Period	Group	Unit Name (Obsolete Name)	Aquifer	Lithological Colour and Description	Estimated Thickness (m)	Depth to base (mBGL)	Elevation of Base (mAOD)	Thermal Conductivity (W m ⁻¹ K ⁻¹)
		Made Ground		Made Ground: Artificial Ground	0.5	0.5	34.5	N/A
	Quaternary	Glaciofluvial Sheet Deposits	S. A	Sand and gravel, locally with lenses of silt, clay or organic material; characteristic 'sandur' (sheet) and valley train form; of glaciofluvial origin	3.0	3.5	31.5	0.77 (Dry) [#] 2.50 (Wet) [#]
		Glacial Till	S. A	Boulder Clay: Diamicton Clay to sandy clay, unsorted, with common pebbles and some boulders	11.5	15	20.0	1.11 [#]
Triassic	Sherwood Sandstone Group (Keuper / Bunter Sandstone)	Wilmslow Sandstone Formation (Upper Mottled Sandstone)	Principal Aquifer	Weakly cemented, red-brown to brick-red, fine- to medium-grained, generally pebble-free, cross-bedded sandstones , with sporadic siltstones	100 (80 – 280)	115 (82 – 282)	-80	3.14* >3**
		Chester Formation (Chester Pebble Beds Formation) (Bunter Pebble Beds)		Well cemented conglomerates and reddish brown, cross-bedded, pebbly sandstones with subordinate beds of red-brown mudstone	150 – 400	> 232	<-202	3.14* >3**

*data from Table 3.1, D. Banks, *An Introduction to thermogeology: ground source heating and cooling*, 2012

**data from Table 3, D. Banks, J. G. Withers, G. Cashmore and C. Dimelow, *Quarterly Journal of Engineering Geology and Hydrogeology*, 46, 281-291, 17 July 2013

[#]data from BGS GeoReport, 04 May 2011

Recourse Assessment

Superficial Deposits

- Superficial deposits beneath the site are classified by the Environment Agency as Secondary Aquifers. Secondary A Aquifers are permeable layers of rock capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers; while Secondary Undifferentiated aquifers have been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
- The strata primarily comprise loose clays, sands and gravels.

Sherwood Sandstone Group – Principal Aquifer

- The Sherwood Sandstone Group is classified as a Principal Aquifer by the Environment Agency. These are layers of rock or drift deposits that have high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.
- The Sherwood Sandstone Group is the second most important aquifer in England after the Chalk, providing 25% of all licensed abstractions. The aquifer provides important groundwater resources, especially in Northern and Central England. A large number of cities obtain a significant portion of their water supply from the Sherwood Sandstone, including Manchester, Liverpool, Birmingham, Leeds, Doncaster and Nottingham.
- The Sherwood Sandstone Group primarily comprises sandstone strata.
- Groundwater storage and hydraulic conductivity is through both interconnected pore spaces between sand grains and fractures within the rock. Low permeability mudstone interbeds can lead to multi-level aquifer systems with multiple water strikes per borehole.
- The Sherwood Sandstone is generally considered a single aquifer despite its mudstone interbeds.

Groundwater Levels

- The site is underlain by several formations of differing permeability.
- Unconfined shallow groundwater may be present in the Glacial fluvial sands and gravels, perched above the glacial till.
- BGS mapping for the site shows faulting in the immediate vicinity of the site. If encountered, faults can act as conduits to groundwater flow or they can act as a barrier to groundwater flow, where their planes are filled with fault gouge.
- The BGS Hydrogeology Map of Clwyd and the Cheshire Basin shows the 20mAOD groundwater contour in the Permo-Triassic Sandstone to the south and east of the site (10 to 20 m below ground level).
- No nearby BGS Borehole records provided records of groundwater levels.
- Groundwater encountered within the Triassic Sandstone may be confined under pressure beneath Glacial till clays. Following water strikes, groundwater levels are likely to rise inside the borehole, though these are not thought to be artesian.

Drilling Risk & Borehole Stability

- **The driller should be made aware of the following risks:**
- Given the local topography and geology, artesian conditions are not expected to be present beneath the site. The hydrogeology map shows the 20mAOD groundwater contour in the Permo-Triassic Sandstone to the south and east of the site (10 to 20 m below ground level).
- A layer of made ground is expected, although its thickness is unknown. This made ground may be unstable.
- An approximately 3.0m thick layer of Glaciofluvial Sheet deposits and 12m thick layer of Glacial till is expected. These superficial deposits may be unstable.
- The sandstone horizons within the underlying geology may be fractured and/or jointed resulting in a potential for loss of drill flush.
- Weakly cemented sandstone horizons may be present within the Wilmslow Formation resulting in the potential for running sands.
- The geology in the vicinity of the site and the surrounding area has been subjected to faulting which has resulted in a complex geological fault structure. If a fault is encountered this could result in broken ground, loss of drill flush and difficult drilling.

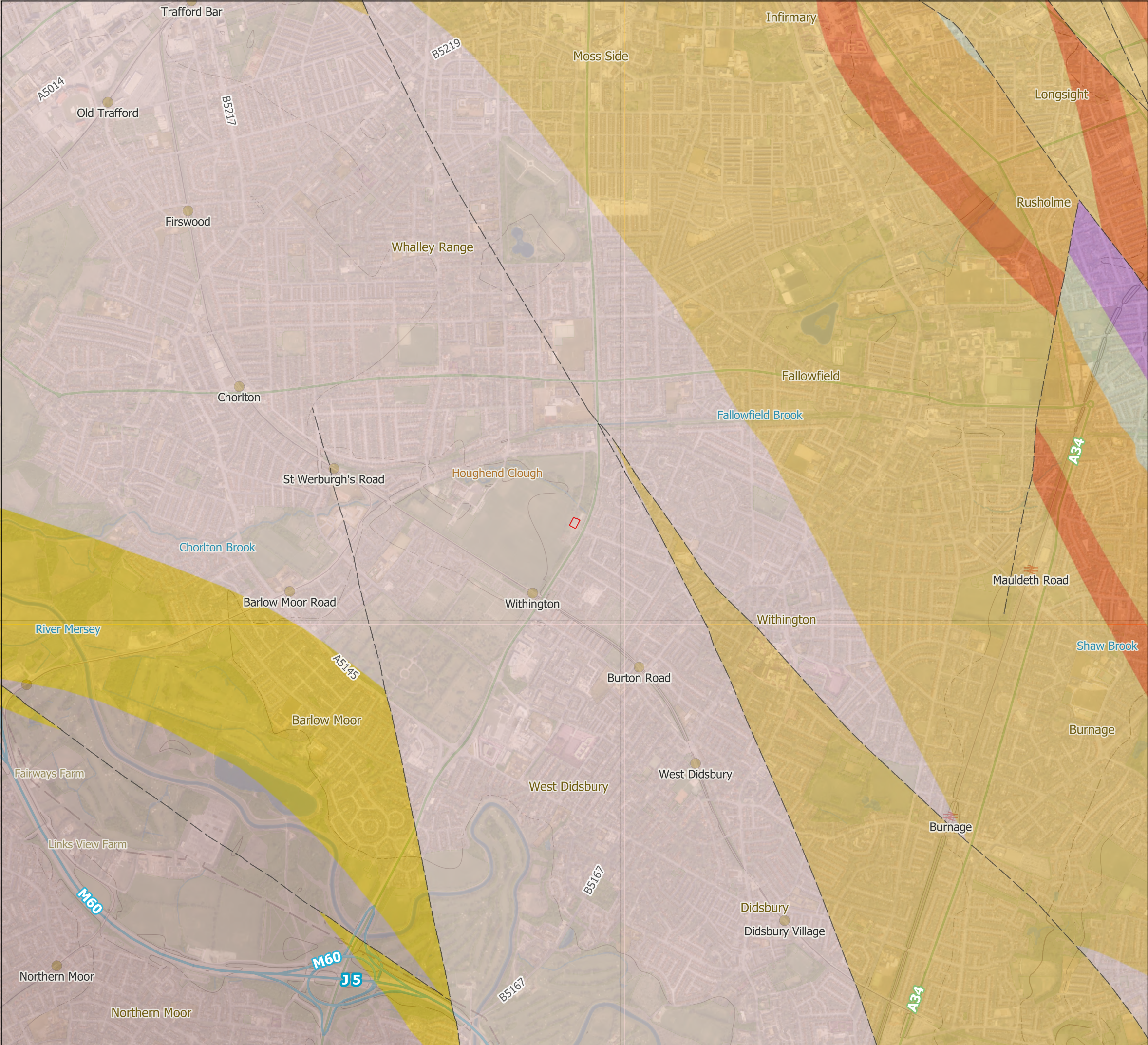
Summary & Recommendations

- This report has been commissioned in order to provide details of the geology beneath the site in support of the borehole drilling required for the installation of a closed loop ground source heating system for the property.
- The site is underlain by Glacial Superficial Deposits and Sherwood Sandstone.
- Rockhead is anticipated to be approximately 15mbgl beneath the site.
- There is a potential for drilling/installation issues to 200mbgl which will need to be controlled by the driller, including:
 - Unstable made ground and (unconsolidated) superficial deposits
 - Loss of flush in sandstone fractures
- Running sands in poorly cemented sandstones
- Groundwater is expected between 10-20mbgl (38-48mAOD).
- Artesian conditions are not expected.

Drawings

Drawing 01

Bedrock Geology



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DRAWING 01
Bedrock Geology

- KEY**
-  Site Outline
- Structural Geology**
-  Fault
- Bedrock Geology**
-  Tarporley Siltstone Formation
- Siltstone Mudstone and Sandstone
 -  Helsby Sandstone Formation
- Sandstone, Pebbly (Gravelly)
 -  Wilmslow Sandstone Formation
- Sandstone
 -  Chester Formation
- Sandstone
 -  Manchester Marls Formation
- Mudstone
 -  Collyhurst Sandstone Formation
- Sandstone
 -  Halesowen Formation
- Mudstone, Siltstone and Sandstone
 -  Etruria Formation
- Sandstone and Mudstone

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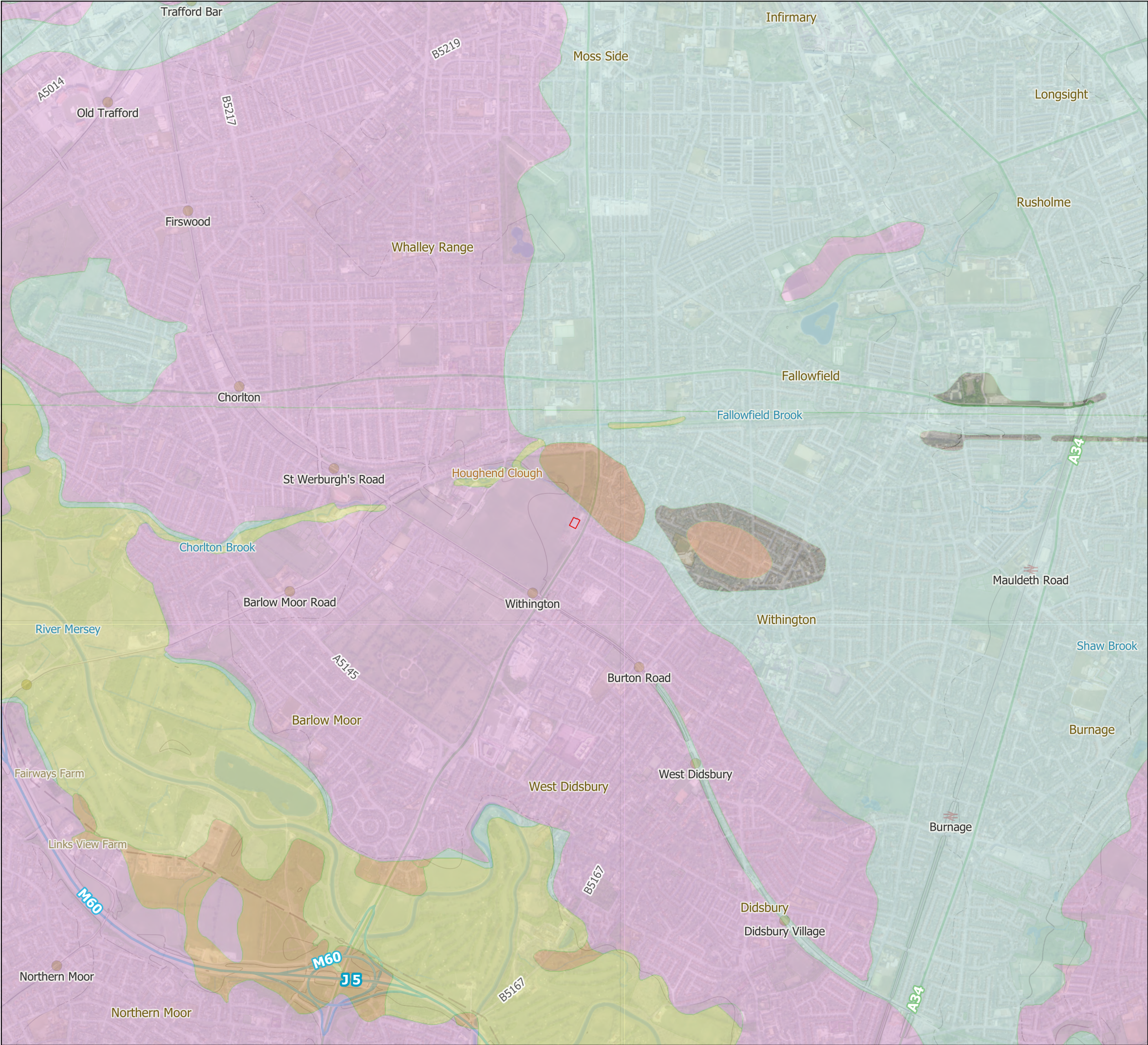
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Drawing 02

Superficial Geology



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DRAWING 02

Superficial Geology

KEY

 Site Outline

Superficial Deposits

 Shirdley Hill Sand Formation
- Sand

 Alluvium
- Clay, Silt, Sand and Gravel

 River Terrace Deposits
- Sand and Gravel

 Glaciofluvial Sheet Deposits
- Sand and Gravel

 Till
- Diamicton

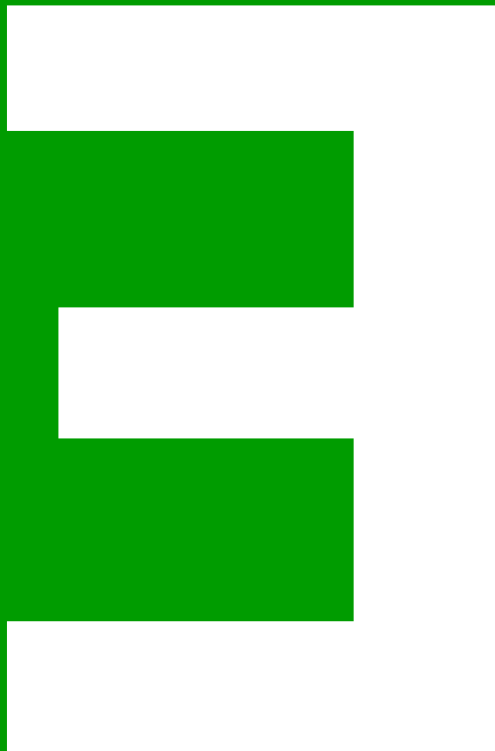
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