

Halsnead - land at rear of Cemetery

Ground Investigation Report

21 June 2018

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Executive summary

Knowsley Metropolitan Borough Council are looking to develop land around Halsnead Park, Whiston into a Garden Village following a UK Government initiative to tackle the housing crises whilst retaining as much green space as possible. The site covered in this Ground Investigation Report (GIR) forms a section of the Garden Village which includes residential housing, streets and a primary school. This GIR will present the findings from the scheme specific ground investigation and evaluate the geotechnical and geo-environmental information obtained in order to identify ground risks and inform subsequent design works for the proposed development.

A ground investigation (GI) was designed and scoped by Mott MacDonald Limited (MML) and undertaken by CC Geotechnical Limited (CCG) in February 2018. Exploratory holes comprised 8 No. rotary boreholes to a maximum depth of 30m bgl; 10 No. windowless samples to a maximum depth of 1.9m bgl; 31 No. Trial Pits to a maximum depth of 3.5m bgl and 18 No. TRL DCP's next to each borehole and windowless sample location. Comprehensive soil, soil leachate and groundwater testing suites were undertaken on selected samples to determine the contamination status of the ground/groundwater underlying the site. A variety of in-situ tests and laboratory tests were undertaken on selected samples to determine the geotechnical properties of the ground and infer parameters which can be used to inform subsequent design.

Results of the February 2018 GI show that the ground on site typically comprises firm to stiff Glacial Till (clay) and medium dense Glaciofluvial Deposits (sand) overlying shallow Sandstone bedrock with a weathered horizon. This is generally in line with the anticipated ground conditions discussed in Section 2.3 except with a higher predominance of Glaciofluvial Deposits instead of Glacial Till. Coal Measures were found to underlie Sandstone at 24.5m bgl (RBH01) at the western edge of the site. The inferred groundwater table is at 17m bgl (29m AOD) monitored in one exploratory hole.

Foundations

Foundations will likely be founded on Glacial Till or Glaciofluvial Deposits assuming that the founding depth of shallow foundations is 1m bgl. Assuming a minimum undrained shear strength of 50 kN/m² for Glacial Till, presumed allowable bearing pressures are given as 130, 90 and 90 kN/m² for foundations that are 1m x 1m, 2m x 2m and <1m wide strips respectively. For founding on Medium dense Glaciofluvial Deposits, presumed allowable bearing pressures are 190, 130, and 120 kN/m² for foundations that are 1m x 1m, 2m x 2m, and <1m wide strips respectively assuming a medium dense sand with a minimum SPT N of 15. Settlements are anticipated to be less than 25 mm but would need to be confirmed by the detailed designer.

There is a risk of settlement and/or differential settlement where soft or loose deposits exist on site, as are identified locally in the region of WS02 and RBH04. Foundations may need to be taken deeper at these locations or alternatively, unsuitable material could be excavated and replaced with suitably compacted engineering fill in order to provide an adequate founding stratum at these locations.

Modified plasticity index values which are derived from results of the February 2018 GI suggest that Glacial Till on site exhibits a low volume change potential. As a result, a minimum

foundation depth of 0.75 m bgl (where planting is outside the zone of influence of trees) or 1m bgl (allowing for restricted new planting) is appropriate when founding in this stratum in accordance with NHBC Standard 2018.

Drainage

Soakaway drainage is considered to be a suitable form of site drainage providing that it is either situated beneath where cohesive Glacial Till has been encountered or is situated away from where cohesive Glacial Till has been encountered, and following drainage tests which confirm its suitability. Given that the site is situated above a Principle Aquifer and a Zone 3 Groundwater Source Protection Zone consultation will be required with the EA/LLFA in order to confirm that soakaway drainage can be adopted on site.

Pavement Design

TRL DCP testing results indicated derived CBR values ranging from 9 – 16 for Glacial Till and 2 – 69 for Glaciofluvial Deposits. The empirical correlation of $CBR = (C_u/27)^{1.7}$ also results in an approximate value of 3% for cohesive strata across the site, assuming a typical undrained shear strength of 50 kN/m². A CBR of 3% is therefore considered to be appropriate for design. In the case that localised ground is encountered which exhibits a CBR of < 2.5%, such is shown at WS02 and RBH04, material can be removed and replaced with suitably compacted granular fill.

Mining

BGS mapping shows the Eccleston West Fault to be situated within the western site boundary separating the Kinnerton Sandstone to the east from Pennine Middle Coal Measures to the west. The Coal Authority indicate the area to the west of the fault to be a Development High Risk Area (Coal Mining Reporting area which contains one or more recorded coal mining related features which have the potential for instability or a degree of risk to the surface from the legacy of coal mining operations). In order to further assess the potential mining risk on site RBH01 and RBH02 were also drilled to depths of 30 m bgl. It was originally expected that given the locality of RBH01 and RBH02 immediately to the west of the Eccleston West fault that the Pennine Middle Coal Measures would be encountered at shallow depth. During the drilling of RBH01 Mudstone with coal fragments within fractures was encountered at 24.5 m bgl. During the drilling of RBH02 Mudstone and potential coal bearing strata was not encountered down to the bottom of the hole at 30 m bgl. It is therefore considered that the Eccleston West Fault actually strikes outside the Halsnead site boundary and because of this the risk from shallow coal mining on the Halsnead site is considered to be low.

The investigation determined Kinnerton Sandstone to be situated beneath the site to minimum depths of 24.5m, hence as detailed above, the investigation appears to confirm geological mapping assertion that Coal Measures have been displaced to greater depth due to the Eccleston West Fault. Coal Authority records present no evidence that shallow coal mine workings are present beneath the site, however, a disused mine entry (Ref. 347390-005) is recorded within 20m of the western site boundary at approximately 347413, 390184. The exact location of this shaft is unknown and there are no records of what steps, if any have been taken to treat the mine entry. There is a further mine entry (Ref. 347390-004) which is situated approximately 50 m to the west of the western site boundary. No other features are mentioned.

Detailed designers should consider the risk posed by potential legacy shafts and the proximity of the Eccleston West Fault and consider whether further investigation along the western boundary by means of geophysics or probe holing is required.

Human Health

Review of geo-environmental data reports soil sample results from the Made Ground and natural deposits indicate no exceedances of the selected human health assessment criteria. It is considered that the proposed development presents a very low risk to end users of the site, and low risk to construction and maintenance workers; due to the nature of works where they will have greater exposure to site soils. Asbestos fibres were reported in two soil samples; quantification analysis undertaken on these samples identified concentrations <0.001% w/w.

Controlled Waters

Soil leachate test results on the topsoil and natural strata identified marginal analyte exceedances, however due to the site soil/environmental conditions and in the context of the proposed works, these do not require further assessment. Groundwater samples identified similar exceedances, with an elevated exceedance of manganese reported for the second round of monitoring. Comparison with soil leachate data does not suggest elevated manganese is due to site soils. It is considered that the proposed development presents a very low risk to controlled waters.

Ground Gas

Based on the ground investigation data the ground gas generation potential at the site and the impact on proposed above ground structures is not considered significant (Characteristic Situation 1) and no protection measures are considered necessary. Residential dwellings on-site are classified as 'Green' for residential gas regime, and gas protection measures are not considered necessary. Ground gas is considered to present a very low risk to site users.

Elevated concentrations of CO₂ (in relation to workspace exposure limits) are reported, and can pose a risk to construction workers working in excavations and confined spaces. A moderate risk to construction workers is considered appropriate and can be mitigated by implementing safe working practices.

Ground Aggressivity

Concrete structures in contact with site soils should have a concrete design class of DS-1, AC-1. There is a risk from site soils to potable water supply pipes, posing a risk to polyethylene, polyvinyl chloride, copper pipes, and wrapped steel pipes. Alternatives to these pipe materials are likely to comprise of Barrier pipes (polyethylene-aluminium-polyethylene) and Wrapped ductile iron pipes however this will need to be confirmed during detailed design.

Vegetation

Assessment of risk to vegetation does indicate some minor exceedances of metals, however the presence of vegetation across the site suggest it is unlikely to have an observable risk to vegetation. Note that Japanese Knotweed is identified at the edge of the site to the north. A management plan should be in place prior to construction works to prevent the spread of invasive plant species on to the site.

Further Recommended Ground Investigation

During detailed design it is recommended that the designer approaches the EA/LLFA to confirm the appropriateness of incorporating shallow soakaways into the proposed works given the nature of the Principal Sandstone Aquifer and the fact that the site is situated in a Zone 3

Groundwater Source Protection Zone. If shallow soakaways are taken forward then soakaway tests to BRE 365 will be required as part of additional ground investigations.

Detailed designers should consider the risk posed by potential legacy shafts and the proximity of the Ecclestone West Fault/Coal Authority Development High Risk and consider whether further investigation along the western boundary by means of geophysics or probe holing is required. The mine shaft which is reported to be outside the western site boundary but within 20m of the boundary (Ref. 347390-005) (Refer to plan in Appendix E) should either be confirmed via geophysical techniques before the construction stage and, if required, backfilled and capped in order to reduce the chance of ground instability at the western edge of the site should the shaft collapse. Alternatively, the proposed development on site could be arranged so that no structures are situated immediately adjacent to the western site boundary where a potential shaft collapse could encroach and instead less sensitive land uses could be adopted within the localised western site boundary.

1 Introduction

1.1 Background

It is understood that Knowsley Metropolitan Borough Council are looking into the development of a currently vacant site at Halsnead Park, Whiston for proposed residential development, green space and a new primary school. The site being investigated forms part of the larger Halsnead Garden Village which is detailed in the Masterplan SPD (Supplementary Planning Document). The purpose of this ground investigation report is to summarise the findings from a recently undertaken intrusive ground investigation on site and provide further guidance on the likely ground related risks on site, as well as to assist in the subsequent design of the works. A site location plan is presented as Figure A.1 and a proposed site layout plan as Figure A.2 in Appendix A.

The proposed site works are located on approximately 10 ha of existing agricultural land approximately 450m north of the M62.

1.2 Purpose

Mott MacDonald Limited (MML) has previously undertaken a Geo-Environmental Desk Study Assessment for the proposed redevelopment of the site (Halsnead Master Plan SPD 11, January 2017, Geo-Environmental and Geotechnical Baseline Assessment). Following on from this, an intrusive ground investigation was scoped in January 2018 by MML.

This Ground Investigation Report (GIR) aims to present the findings from the scheme specific ground investigation undertaken at Halsnead Park in February 2018 and will provide an evaluation of the geotechnical information in accordance with BS EN 1997-1:2004 +A1:2013.

It is understood that the proposed development is likely to comprise a new primary school, residential housing and streets. As per the requirements of Eurocode 7, the works have been classified as Category 2 with the following description:

Category 2 Structures – conventional types of structures and foundation with no exceptional risk or difficult soil or loading conditions

A contaminated land risk assessment is included within this GIR. It uses data collected as part of the GI to assess the risk to human health and controlled waters, ground gas risk, the risk to structures, and risk to flora and fauna. An initial waste classification of excavated material on-site has also been made. Results are cumulated as part of a conceptual site model which identifies the likely geo-environmental risk present on-site.

1.3 Sources of Information

The following sources of information were consulted during the process of compiling the report:

Knowsley Council, Halsnead Garden Village, Masterplan Supplementary Planning Document, June 2017

MML, Geo-Environmental and Geo-Technical Baseline Assessment, Halsnead Master Plan SPD, January 2017

CCG, Ground Investigation for Site at Fox's Bank Lane, Whiston, Final Factual Report, CCG-C-18-10117, April 2018

British Geological Survey 1:50,000 Map (Drift) Sheet 97, Runcorn, 1977.

British Geological Survey 1:50,000 Map (Solid) Sheet 97, Runcorn, 1980

British Geological Survey Open 1:50,000 Geoscience Borehole Scans

British Geological Survey 1:100,00 Hydrological Map of Clwyd and the Cheshire Basin, 1989

Coal Authority Interactive Map Viewer

Zetica Regional Unexploded Bomb Risk Map for Merseyside

2 Review of Existing Information

2.1 Site Location and Description

The site for the proposed development is located on approximately 10 ha of existing agricultural land 450m north of the M62, centred on OS grid co-ordinate 347629, 390265. Falling from north to south, the level of the site changes from approximately 50m AOD to 40m AOD. Site walkover photos are provided in Appendix D.

The site is bounded by the small wooded area of 'Fox Clump' and Cherry Tree Farm on its southern side; wooded areas and some residential properties, including Sandfield Cottage and an associated L-shaped pond at its northern boundary; a cemetery (Fox's Bank Cemetery) at the north-eastern corner; wooded areas at its western side with a mobile residential park at its south-western corner; and open farmland and Fox's Bank Lane at its eastern side.

Access to the site is obtained from Fox's Bank Lane to the east.

2.2 Summary of Site History

The site history has been reviewed in detail within the Geo-environmental desk study. A precis of these findings is provided below.

The earliest available map from 1850 indicates the site to comprise open fields as part of the Halsnead Park estate. Licker's Lane and Fox's Bank Lane are present along the northern and eastern boundaries of the site, as are buildings at the present-day Halsnead mobile home park to the southwest and the L-shaped pond at the northern edge of the site. A pathway and trees are indicated along the southern boundary of the site between Halsnead Park and Fox's Bank Lane. Fairchilds Farm is indicated on the eastern side of Fox's Bank Lane and Sandfield Cottage on the southern side of Licker's Lane.

The site remained undeveloped until a nursery was shown at the central-eastern part of the site by 1937, at which time the site also appears to have been split into rectangular segments separated by pathways or tracks.

By 1990 the fields were re-segregated into the present-day footprint, with tracks running to the west from Fox's Bank Lane at the southern boundary and central section of the site. By 2000 the nursery building was demolished and the cemetery built outside the north-eastern corner of the site.

2.3 Geology

1:50,000 scale BGS Published Geological Map Sheet 97, Runcorn indicates that the superficial deposits on site are Glacial Till comprising red-brown sandy, stony clay with many impersistent beds of sand.

The solid map for the same region indicates that the majority of the site is underlain by solid strata of the Kinnerton Sandstone Formation. This is separated from the Pennine Middle Coal Measures Formation to the west by the north-west trending Ecclestone West Fault, which strikes across the western site boundary. Rocks of the Pennine Middle Coal Measures, including coal seams, are expected to subcrop to the west of the fault within the site boundary.

2.4 Hydrogeology & Hydrology

Land to the east of the Eccleston West Fault where the Kinnerton Sandstone Formation is shown to subcrop coincides with a groundwater source protection zone 3 (Total Catchment). The Kinnerton Sandstone Formation is shown to be a Principal Aquifer. This classification is given to layers that have high intergranular and/or fracture permeability and as a result, a high level of water storage. They may support water supply and/or river base flow on a strategic scale. The Pennine Middle Coal Measures Formation is shown to be a Secondary A Aquifer. This classification is given to permeable layers capable of supporting water supplies at a local rather than strategic scale.

The Glacial Till is shown to be a Secondary (undifferentiated) Aquifer, which is assigned in cases where it has not been possible to attribute either category A or B to a rock/soil 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 material.

There are several ponds situated outside the site boundary approximately 10 m outside the northern site boundary, 25m outside the south western site boundary and 65m outside the southern site boundary. In order to improve the land drainage it is understood that the current tenant farmer installed drainage in 2013 a plan of which was provided to Mott MacDonald by M G Fanten and is presented within Appendix C of this report. The outfall from the field drainage

2.5 Mining

A review of the Coal Authority's interactive map viewer, accessed April 2018 (<http://mapapps2.bgs.ac.uk/coalauthority/home.html>) shows the area of sub-cropping Coal Measures to the west of the Eccleston West Fault as being classified as a Development High Risk Area due to the risk of potential instability from historic coal mining operations. A geotechnical site constraints plan is provided in Appendix E which highlights the extent of the coal authority development high risk area together with the location of mine entries taken from the Coal Authority Interactive map viewer. Following this, a CON29M Non-Residential Mining Report was obtained from the Coal Authority for the site in order to further understand the shallow mining features present and hence the risk to the proposed works. The Coal Authority report is provided in Appendix F.

The Non-Residential Mining Report in Appendix F states that the site is within an area that could be affected by underground mining associated with 2No. seams of coal at 190m to 440m bgl, the last of which was worked in 1902. The report subsequently states though that any movement in the ground due to coal mining activity should have stopped. The Coal Authority also state that the site is in an area where they believe coal is at or close to the surface and which may have been worked at some time in the past.

The Coal Authority has no record of a mine gas emission requiring action.

There is a recorded disused mine entry (Ref. 347390-005) off site but within 20m of the western site boundary at approximately 347413, 390184 however there are no records of what steps, if any have been taken to treat the mine entry. There is a further mine entry (Ref. 347390-004) which is situated approximately 50 m to the west of the western site boundary. No other features are mentioned.

2.6 Unexploded Ordnance

Following a review of the Zetica regional UXO (unexploded ordnance) map for Merseyside, the site is within an area of low bomb risk.

3 Ground Investigation

In order to facilitate planning and outline design of the proposed redevelopment of the Halsnead site, a ground investigation was designed and scoped by Mott MacDonald Limited and undertaken by CC Geotechnical Limited in February 2018. The purpose of the investigation was to further understand the likely ground-related constraints at the site and to obtain more comprehensive information regarding the likely geo-environmental risks for the site, which had previously been identified by the geo-environmental/geotechnical desk study.

A variety of intrusive methods were chosen and distributed across the site at approximate spacings of 50m in accordance with BS:10175¹. These methods are listed in Table 3.1 and include machine excavated trial pits, windowless sampling and rotary boreholes. RBH01 and RBH02 were positioned in a location which was expected to be to the west of the Ecclestone West fault and were scheduled to 30m bgl in order to identify any potential coal seams or mine workings which could pose a risk to the proposed development. A borehole location plan is provided in Appendix B and the CCG Factual Report is provided in Appendix H.

3.1 Description of Fieldwork

The ground investigation works comprised a number of exploratory hole investigation techniques as detailed in Table 3.1:

Table 3.1: Scope of February 2018 Ground Investigation at Halsnead Park

Exploratory Hole Technique	Number of Holes	Maximum Depth (m bgl)
Rotary Boreholes	8 No. rotary boreholes RBH01 to RBH08	11.5 (RBH01 and RBH02, 30 m bgl)
Windowless Sampling	10 No. windowless samples (WS01 to WS10)	1.9
Machine Excavated Trial Pits	31 No. Trial Pits TP01 to TP31	3.5
TRL DCP	18 No. next to each WS and RC location	1.1

Source: CCG-C-18-10117 Factual Report

Rotary boreholes (RBH01 to RBH08, excluding RBH03) were advanced on site with dynamic sampling methods through superficial/weathered rock and then rotary coring following on once refusal had been met with the dynamic sampler. RBH01 and RBH02 were undertaken down to 30 m bgl in order to further investigate the risk from shallow mine workings. Neither RBH01 or RBH02 encountered any voids or evidence of possible shallow mine workings down to 30 m bgl. Mudstone was encountered at 24.5m bgl within RBH01 with inclusions of coal – particularly at 27.7 m bgl. The remaining rotary boreholes on site were terminated at depths of 6.7 – 11.5m bgl. During rotary coring solid core recovery (SCR), total core recovery (TCR) and Rock Quality Designation (RQD) were recorded along core runs.

Windowless sampling was undertaken using dynamic sampling methods to gain samples for geotechnical and geo-environmental testing. A total of 10 No. windowless sample holes (WS01 – WS10) were undertaken on the site. They were positioned to cover the site extent and provide

¹ British Standards (2013): BS 10175:2011+A1:2013, Investigation of potentially contaminated sites – Code of practice

additional information on potential contamination and ground conditions. All windowless sample holes refused at depths between 1.6 – 1.9m bgl on encountering Weathered Sandstone.

Machine excavated trial pits were dug to depths of 1.1 – 3.5m bgl, generally terminating within Weathered Sandstone.

In-situ TRL DCP tests were undertaken at 18 No. locations next to each windowless sample and rotary borehole in order to provide an indication of likely subgrade CBR values.

SPT's were taken at 1m intervals in windowless sample holes and within superficial deposits of rotary boreholes. Alternating SPTs were also undertaken in rotary boreholes within rock where intact core could not be recovered for UCS and point load testing.

Combined groundwater and ground gas monitoring installations (50mm slotted combined gas/gw standpipe) were installed in 6No. rotary boreholes and 4No. windowless sample holes. Following completion of the fieldwork 6 to 7 post fieldwork monitoring visits were undertaken during weekly visits to record groundwater levels gas concentrations of CH₄, CO₂, O₂, H₂S and CO. On completion of the monitoring period, standpipes were decommissioned in line with EA guidance note LIT 6478/657² and backfilled with bentonite/cement grout to 0.5m bgl and arisings from 0.5m bgl to the ground surface, with any headworks or standpipe casing above the ground surface removed to 0.5 m bgl.

3.2 Laboratory Testing

All laboratory testing was scheduled by the Engineer (Mott MacDonald Limited) upon receipt of draft exploratory logs from CCG. Results are presented in Appendix E and F of CCG Factual Report CCG-C-18-10117 (Appendix H of this GIR).

3.3 Geotechnical Tests

All geotechnical laboratory testing was undertaken by the CCG Ltd UKAS accredited laboratory (testing laboratory No. 4515). A summary of the testing undertaken is presented in Table 3.2 below:

Table 3.2: Summary of Geotechnical Testing undertaken as part of the February 2018 GI

Test	Test Standard/Specification	No. of Tests
Natural Moisture Content	BS1377: Part 2 1990	37
Atterberg Limit Determination	BS1377: Part 2 1990	17
Particle Size Distribution (Wet Sieving)	BS1377: Part 2 1990	21
Water Soluble Sulphate and pH	TRL 447	21
Total Sulphur & Acid Soluble Sulphate	TRL 447	3
Organic Matter Content	BS1377: Part 3 1990	4
UCS	ISRM 2007	12
Point Load	ISRM 2007	91

Source: CCG-C-18-10117 Factual Report

² Environment Agency (2012): Guidance Note - Good practice for decommissioning redundant boreholes and wells, LIT 6478 / 657_12

3.4 Contamination Tests

Disturbed environmental samples were collected at regular intervals from Made Ground and underlying natural materials, and were sent to Exova Jones Environmental Limited (MCERTS and UKAS accreditation No. 4225) for chemical testing. Environmental soil (including soil leachate) and groundwater samples were tested for inorganic and organic contaminants, as summarised in Table 3.3. A more detailed table showing the specific depths and location of samples tested is provided as Table J.1 in Appendix J.

Table 3.3: Summary of contamination tests undertaken.

Test	No. of Tests
MM Soil Suite	49
MM Leachate Suite	25
MM Pesticides Suite	4
Asbestos Screen	50
PCOM Asbestos Quantification	2

Chemical testing suites comprised the following:

Soil Suite: Antimony, Arsenic, Asbestos Screen, Barium, Beryllium, Boron, BTEX (speciated), Cadmium, Chromium (III), Chromium (VI), Copper, Cyanide (Free), Fraction of Organic Carbon, Iron, Lead, Manganese, Inorganic Mercury, Methylmercury, Elemental Mercury, Molybdenum, Nickel, pH, Phenols (speciated), Polycyclic Aromatic Hydrocarbons (USEPA 16 speciated), Selenium, Sulphate (Water soluble), Sulphur (Total), Total Petroleum Hydrocarbons – CWG Bands (aliphatic/aromatic split), Vanadium, Volatile Organic Compounds (VOCs), Zinc.

Soil Leachate Suite: Ammoniacal Nitrogen, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chloride, Chromium (III), Chromium (VI), Copper, Cyanide (Free), Cyanide (complex), Fraction of Organic Carbon, Fluoride, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, pH, Phenols (speciated), Selenium, Sulphate, Vanadium, Zinc.

Pesticides Suite: Cypermethrin, Diazinon, Dimethoate, Linuron, Mecoprop, Permethrin, Alachlor, Atrazine, Carbaryl, Chlorfenvinphos, Chlorpyrifos-ethyl, Aldrin, Dieldrin, Endrin, Isodrin, DDT, DDE, DDD, Diuron, Alpha-Endosulfan, Beta-Endosulfan, Isoproturon, Simazine, Trifluralin, Bentazone, Fentitrothion, Malathion, Dichlorvos, Alpha-Hexachlorocyclohexanes (including Lindane), Beta-Hexachlorocyclohexanes (including Lindane), Gamma-Hexachlorocyclohexanes (including Lindane).

Water Suite: Ammoniacal Nitrogen, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chloride, Chromium (III), Chromium (VI), Copper, Cyanide (Free), Cyanide (complex), Fluoride, Hardness (CaCO₃), Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Nitrate, pH, Phenols (speciated), Polyaromatic Hydrocarbons (USEPA 16 speciated), Selenium, Sodium, Sulphate, Sulphur, Total Petroleum Hydrocarbons – CWG Bands (ali/aro split), Vanadium, Volatile Organic Compounds, (speciated), Zinc, Total Dissolved Solids, Alkalinity – bicarbonate.

4 Ground and Groundwater Conditions

4.1 Ground Model

The results of the February 2018 ground investigation were generally consistent with the anticipated ground conditions discussed within section 2.3 of this report, with superficial deposits of cohesive Glacial Till and granular Glaciofluvial Deposits overlying fairly shallow Weathered Sandstone and Sandstone of the Kinnerton Sandstone Formation. Mudstone of the Pennine Middle Coal Measures were encountered at 24.5m bgl at the south-western edge of the site.

A summary of the ground conditions encountered is presented in Table 4.1 below. An exploratory hole location plan for the site is presented in Appendix B and geological cross sections in Appendix G. Exploratory hole logs are presented in CCG's factual report in Appendix H of this GIR.

Table 4.1: Ground Model from February 2018 Ground Investigation

Strata		Typical Description	Depth to base (m bgl)	Typical thickness (m)
Topsoil		<i>Brown to dark brown slightly gravelly silty sandy CLAY or slightly gravelly silty clayey SAND, often described as organic.</i>	0.3 – 0.7	0.3 – 0.4
Glacial Deposits	Glacial Till	Spatially confined to the south-western section of the site (RBH01, RBH04, TP2, TP3, TP7, TP8, TP9, TP15, TP16, TP17, TP18, WS02) <i>Firm to stiff brown slightly sandy slightly gravelly silty CLAY with low cobble content. Locally softened to soft to firm within upper 0.5m of stratum.</i>	0.8 – 3.2	0.35 – 2.65
	Glaciofluvial Deposits (Sand) / Completely Weathered Sandstone	Typically 0.3-0.5m of <i>loose to medium dense brown fine and medium SAND</i> underlying topsoil, underlain locally by Glacial Till or elsewhere by <i>medium dense orange and yellow brown slightly silty slightly gravelly fine to medium grained SAND with increasing content of sandstone gravel. Gravel is fine to coarse sub-rounded to angular sandstone</i>	0.8 – 3.0	0.5 – 2.6
Weathered Sandstone		<i>Very dense/ very weak to weak red, yellow or orange highly weathered to completely weathered SANDSTONE which is typically recovered as slightly gravelly fine to coarse grained SAND</i>	2.0 – 6.0	0.30 – 2.67
Sandstone (Kinnerton Sandstone Formation)		<i>Orange to yellowish-brown fine to medium grained thinly to thickly laminated SANDSTONE which is highly to moderately weathered to at least 10m bgl (recorded as moderately weathered to 30m bgl in RBH02 and highly weathered to 22.3m bgl in RBH01). Discontinuities are very close to medium spaced, horizontal, clean, rough and tight to open.</i>	Depth unproven (24.5m bgl in RBH01 at south-western edge of site)	≥ 30m bgl (22.5m in RBH01 at south-western edge of site)

Strata	Typical Description	Depth to base (m bgl)	Typical thickness (m)
Mudstone (Pennine Middle Coal Measures Formation)	Recorded only in RBH01 at the south-western edge of the site <i>Reddish brown and grey at depth thickly laminated MUDSTONE. Discontinuities are very close to medium spaced, horizontal, clean, smooth, undulating and tight to partly open with occasional coal on fracture faces.</i>	Depth unproven	≥ 5.5m bgl

Note: Made Ground was identified in RBH08 at the eastern edge of the site from 0 – 0.4m bgl, described as grey very gravely slightly silty SAND with medium cobble content. Gravel is fine to coarse angular to sub-angular concrete and brick. This is an isolated occurrence of Made Ground and is likely to be related to imported fill material brought to site in order to form a site compound for the February 2018 ground investigation

4.2 Groundwater

Although water seepages were noted within some exploratory holes on site these were shallow seepages considered to represent perched water sitting directly above the low permeability cohesive Glacial Till between depths of 0.7 and 2.0m bgl. A representative groundwater strike was encountered on site in RBH02 at a depth of 19.5 m bgl. Further water strike details are given in Table 4.2.

Combined gas/groundwater monitoring standpipes were installed upon completion of the exploratory holes listed in Table 4.3. Six to seven rounds of gas/groundwater monitoring were undertaken upon completion of the fieldwork which are discussed in Section 6.4 with the groundwater monitoring results summarised in Table 4.3.

Table 4.2 Groundwater strike details from the February 2018 ground investigation

Exploratory Hole No.	Depth of water strike (m bgl)	Strata	Comments
RBH02	19.5	Sandstone	Water Table
RBH04	1.5	Glacial Till	Seepage
TP08	0.7	Glacial Till	Minor Seepage
TP09	2.0	Glacial Till	Minor Seepage
TP16	1.1	Glacial Till	Minor Seepage
TP17	1.4	Glacial Till	Minor Seepage

Table 4.3 Groundwater monitoring details from the February 2018 ground investigation

Exploratory Hole No.	Response Zone (m bgl)	Response Zone Strata	Recorded Water Level (m bgl)
RBH01	1.45 – 1.85	Glacial Till	Dry
RBH02	17.8 – 19.8	Sandstone	16.92 – 17.36
RBH04	9.5 – 10.5	Sandstone	Dry
RBH05	10.5 – 11.5	Sandstone	Dry

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Exploratory Hole No.	Response Zone (m bgl)	Response Zone Strata	Recorded Water Level (m bgl)
RBH06	1.2 – 1.8	Glaciofluvial Deposits	Dry
RBH08	1.2 – 1.8	Glaciofluvial Deposits	Dry
WS01	1.2 – 1.8	Glaciofluvial Deposits	Dry
WS04	1.2 – 1.8	Glaciofluvial Deposits	Dry
WS06	1.2 – 1.8	Glaciofluvial Deposits	Dry
WS07	1.2 – 1.8	Glaciofluvial Deposits	Dry

5 Derived Geotechnical Parameters

Published empirical correlations have been combined with the results of laboratory and in-situ testing which were undertaken as part of the February 2018 ground investigation in order to derive the geotechnical parameters that are detailed below in Table 5.1. Due to the natural variability of the soils encountered, a range is given for some parameters and the designer should review the results of the specific ground investigation in order to confirm the appropriate value from those presented below.

Summary data plots from which the geotechnical parameters are derived are presented in Appendix I.

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Table 5.1 Summary of Derived Geotechnical Parameters from the February 2018 Ground Investigation

Strata	SPT N (1)	γ_{bulk} Unit Weight (kN/m ³) (2)	ϕ'_{peak} Peak Effective Angle of Shearing Resistance (3)	C_u Undrained Shear Strength (kN/m ²) (4)	c' Drained Cohesion (KPa)	UCS Uniaxial Compressive Strength MPa (5)	E_u Youngs Modulus, MPa (6)	E' Youngs Modulus, MPa (7)	E_m Young's Modulus, MPa (8)
Glacial Till	7 – 32	18	27	50	0	-	15	12	-
Glaciofluvial Deposits (Sand)	11 – 30	17	35	-	-	-	-	11 – 30	-
Weathered Sandstone	*65 – 98	19	39	-	-	-	-	65 – 98	-
Sandstone	*125 – 3000	20	-	-	-	1 – 10	-	-	215 – 2150

1 - Glacial Till - SPT N values range from 7 to 32. Based on a review of the data a lower bound value of 7 and an upper bound value of 32 has been taken for consideration of the engineering properties. Glaciofluvial Deposits - SPT N values range from 11 to 40. Based on a review of the data a lower bound value of 11 and an upper bound value of 30 has been taken for consideration of the engineering properties. Plots of SPT N values is given in Appendix I.

*Results extrapolated from refusal of 50 blows in soil and 100 blows in rock.

2 – γ_{bulk} (KN/m³) taken from Figure 1 of BS8004:2015³ for soil and lab recordings of bulk density for bedrock.

3 - ϕ' In the absence of laboratory test data for cohesive strata, the following formula from BS8004:2015 has been used to calculate the peak angle of friction: $\phi'_{\text{peak}} = (42^\circ - 12.5 \log_{10} I_p) + \phi'_{\text{dil}}$, with ϕ'_{dil} assumed to be 0° and I_p recorded as 16 (average value from range of 11 - 22) for GT. For coarse soils with fines <15%, the peak angle of friction is calculated as $\phi'_{\text{peak}} = 30^\circ + \phi'_{\text{ang}} + \phi'_{\text{PSD}} + \phi'_{\text{dil}}$, with ϕ'_{dil} assumed to be 3° for GFD and 7° for WSST; ϕ'_{ang} assumed to be 0° for GFD and WSST; and ϕ'_{PSD} assumed to be 2° for GFD and WSST based on Uniformity Coefficient values of 2-6. A plot of SPT N_{60} Values for GFD and WSST is given in Appendix I for correlation against density index and hence ϕ'_{dil} .

³ British Standards (2015): BS 8004:2015, Code of practice for foundations, BSI Standards Limited

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4 – C_u is based on hand shear vane values and the empirical formula $C_u = \text{SPT } N \times f_1 \text{ kN/m}^2$ after Figure 31 of CIRIA C143⁴, where $f_1 = 5 \text{ kN/m}^2$. Results typically range from firm to stiff with lower-bound and upper-bound values of 40 kN/m^2 and 120 kN/m^2 . Values of consistency index for Glacial Till range from 0.47 to 1.00 and are typically firm to stiff. This data is in agreement with the C_u values derived from in-situ SPT and HSV testing. Plots of C_u and consistency index are shown in Appendix I.

5 – UCS based on point load tests (conversion factor of 24 from Broch and Franklin, 1972)⁵ and UCS tests undertaken on recovered samples Mudstone and Sandstone. Lower-bound and upper-bound values are given as 4 MPa and 19 MPa. A plot is shown in Appendix I.

6 – E_u for GT assumed as: $E_u = C_u \times 300$ after Geotechnical Parameter Sources (Mott MacDonald)⁶, where $C_u = 50 \text{ kPa}$.

7 – E' is based on the following empirical formula $E' = 1.0 \times N$ (and $E' = E_u \times 0.8$ for cohesive Glacial Till) from CIRIA C143.

8 – E_m is based on the following empirical formula $E_m = 215 \times \text{UCS}$ from Rowe and Armitage (1987a)⁷. Using a lower-bound UCS for Sandstone of 1 MPa and upper-bound UCS of 10 MPa from point load and UCS tests results in a range of E_m from 215 MPa to 2150 MPa. A plot is shown in Appendix I.

⁴ The Standard Penetration Test (SPT) (1995): Methods and Use, Construction Industry Research and Information Associated, CIRIA Report 143

⁵ Broch, E and Franklin, J A (1972): The point-load test, Int. J. Rock Mechanics, 9, 669-697

⁶ Mott MacDonald (internal document) (2014): Geotechnical Parameter Sources Rev 1.3

⁷ Rowe, R K and Armitage, H H (1987a): Theoretical solutions for axial deformation in drilled shafts in rock, Canadian Geotechnical Journal, 24, 114-125

6 Geo-environmental Risks

This section presents the geo-environmental findings of the February 2018 GI, and the likely risks associated with it on-site.

A preliminary qualitative conceptual site model developed in Mott MacDonald's 'Geo-environment and Geo-technical Baseline Assessment'⁸ desk study report is presented (Note that the desk study encompasses an area which extends beyond the current site boundary). Followed by a summary of the geo-environmental risks for the proposed residential development on-site, based on the results of the February 2018 GI. This includes the assessment of the risk to human health and controlled waters, ground gas risk, the risk to structures, and risk to flora and fauna. An initial waste classification of excavated material on-site will also be made. Cumulating with a revised conceptual site model of the site, which is presented in Section 6.9, highlighting the likely geo-environmental risk present on-site.

6.1 Preliminary Conceptual Site Model

An initial qualitative Contaminated Land Risk Assessment was completed in Mott MacDonald's desk study. Note that the desk study encompasses an area which extends beyond the current site boundary, and was written in regards for a proposed Sustainable Urban Extension (SUE) development. The SUE would have comprised of new residential dwellings, "employment land" and a new country park. Current development plans for the site are new residential dwellings, and a new primary school (assumed age range Reception [age 4] to Year 6 [age 11]).

A key element of this was the development of a conceptual model by undertaking a Source – Pathway – Receptor analysis of the Site:

- Sources (S) are potential or known contaminant sources e.g. a former land use;
- Pathways (P) are environmental systems thorough which a contaminant could migrate e.g. air, groundwater; and
- Receptors (R) are sensitive environmental receptors that could be adversely affected by a contaminant. E.g., Site occupiers, groundwater resources.

Where a source, relevant pathway and receptor are present, a contaminant linkage is created whereby there is a circumstance through which environmental harm could occur and a potential environmental liability is considered to exist.

6.1.1 Preliminary Potential Sources

- S1 - Made Ground/ contaminants associated with former/current (non-mining) development;
- S2 - Made Ground associated with former coal mining;
- S3 - Potential for in-filled land;
- S4 - Potential for buried structures;
- S5 - Contaminated leachates generated on-site;
- S6 - Contaminated leachates generated off-site;
- S7 - Ground/mine gases generated on-site;
- S8 - Ground/mine gases generated off-site;

⁸ Mott MacDonald. 2017. Geo-Environmental and Geo-Technical Baseline Assessment, Halsnead Master Plan SPD.

- S9 - Potential for unexploded ordnance (UXO) to be present; and
- S10 - Potential for site soils to contain invasive species (stem, crown, rhizome, seeds).

6.1.2 Preliminary Potential Pathways

- P1 - Human uptake pathways:
 - Inhalation of indoor and outdoor dust and vapours;
 - Direct soil and dust ingestion;
 - Consumption of home grown produce and soil attached to home grown produce;
 - Dermal contact indoors and outdoors;
- P2 - Vertical migration of leachates in the unsaturated zone;
- P3 - Vertical and horizontal migration of contaminants in the saturated zone;
- P4 - Engineered contaminant transport pathways (e.g. piling for foundations, drainage runs);
- P5 - Overland flow (where surfacing/geology is impermeable or saturated);
- P6 - Direct contact with construction materials;
- P7 - Horizontal and vertical migration of ground/mine gases (also via abandoned mine workings and geological faults as well as natural migration);
- P8 - Ground/mine gas accumulation in voids, buildings and confined spaces;
- P9 - Plant uptake pathways; and
- P10 - Wind-blown dusts.

6.1.3 Preliminary Potential Receptors

- R1 - Future site users – occupiers of residential properties across the site and employees within any commercial development/users of the proposed country park across the southern site;
- R2 - Construction and maintenance workers of the proposed Sustainable Urban Extension (SUE);
- R3 - Users of adjacent sites, particularly adjacent residential properties, schools and farmland;
- R4 - Groundwaters – the bedrock Principal Aquifer and SPZ3 beneath the eastern third of the SUE and to a lesser extent the Secondary (A/undifferentiated) Aquifers present as bedrock beneath the western two-thirds of the SUE and within the superficial deposits across the site;
- R5 - Surface waters – Particularly Chapel Brook and Fox's Bank Brook along with numerous small streams, drains and ponds across the SUE;
- R6 – Buried and surface future structures and infrastructure associated with the new SUE development, including concrete foundations; and
- R7 - Fauna and flora.

6.1.4 Existing Conceptual Site Model

Table 6.1 presents the initial conceptual site model, which has been summarised, detailing the contaminant linkages that were identified to be potentially present on-site.

Table 6.1: Preliminary Conceptual Site Model

Sources	Pathways	Receptors
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land.	P1 - Human uptake pathways. P10 - Wind-blown dusts.	R1 - Future site users.
S7 - Ground/mine gases generated on-site. S8 - Ground/mine gases generated off-site.	P1 - Human uptake pathways. P4 - Engineered contaminant transport pathways. P7 - Horizontal and vertical migration of ground/mine gases. P8 - Ground/mine gas accumulation in voids, buildings and confined spaces.	R1 - Future site users.
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land.	P1 - Human uptake pathways. P10 - Wind-blown dusts.	R2 - Construction and maintenance workers.
S7 - Ground/mine gases generated on-site. S8 - Ground/mine gases generated off-site.	P1 - Human uptake pathways. P4 - Engineered contaminant transport pathways. P7 - Horizontal and vertical migration of ground/mine gases. P8 - Ground/mine gas accumulation in voids, buildings and confined spaces.	R2 - Construction and maintenance workers.
S9 - Potential for unexploded ordnance (UXO).	P1 - Human uptake pathways (direct contact).	R2 - Construction and maintenance workers.
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land.	P1 - Human uptake pathways. P10 - Wind-blown dusts	R3 - Users of adjacent sites.
S7 - Ground/mine gases generated on-site.	P1 - Human uptake pathways. P7 - Horizontal and vertical migration of ground/mine gases. P8 - Ground/mine gas accumulation in voids, buildings and confined spaces.	R3 - Users of adjacent sites.
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land. S4 - Potential for buried structures. S5 - Contaminated leachates generated on-site. S6 - Contaminated leachates generated off-site.	P2 - Vertical migration of leachates in the unsaturated zone. P3 - Vertical and horizontal migration of contaminants in the saturated zone. P4 - Engineered contaminant transport pathways.	R4 – Groundwaters.
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining.	P3 - Vertical and horizontal migration of contaminants in the saturated zone. P4 - Engineered contaminant transport pathways.	R5 - Surface waters.

Sources	Pathways	Receptors
S3 - Potential for in-filled land. S4 - Potential for buried structures. S5 - Contaminated leachates generated on-site. S6 - Contaminated leachates generated off-site.	P5 - Overland flow.	
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land. S5 - Contaminated leachates generated on-site. S6 - Contaminated leachates generated off-site.	P6 - Direct contact with construction materials.	R6 – Buried and surface future SUE structures and infrastructure.
S7 - Ground/mine gases generated on-site. S8 - Ground/mine gases generated off-site.	P7 - Horizontal and vertical migration of ground/mine gases. P8 - Ground/mine gas accumulation in voids, buildings and confined spaces.	R6 – Buried and surface future SUE structures and infrastructure.
S10 - Potential for site soils to contain invasive plant species.	P6 - Direct contact with construction materials.	R6 – Buried and surface future SUE structures and infrastructure.
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land. S10 - Potential for site soils to contain invasive species.	P9 - Plant uptake pathways.	R7 - Fauna and flora.

Source: Mott MacDonald's 2017 Desk Study⁹

6.2 Risks to Human Health from Contamination

Risks to human health from historically contaminated soils have been assessed by comparison of laboratory contamination data with generic screening criteria (GSC) established using the UK Contaminated Land Exposure Assessment (CLEA) framework (Nathanail, et al., 2015)⁹ and CL:AIRE (2010)¹⁰.

GSC are based on the principles of “minimal” or “tolerable” risk enshrined within SR2¹¹ and are intended as “trigger values” above which further assessment of the risks may be needed. For each contaminant, GSVs have been calculated for the four standard land use scenarios published within the CLEA model¹² as well as two new land uses for public open space developed by DEFRA¹³.

⁹ Nathanail, C.P. et al. (2015): The LQM/CIEH Suitable 4 Use Levels for Human Health Risk Assessment. Land Quality Press, Nottingham (S4UL3389)

¹⁰ CL:AIRE, AGS, EIC (2010): The Soil Generic Assessment Criteria for Human Health Risk Assessment

¹¹ Environment Agency (2009): Human health toxicological assessment of contaminants in soil (SR2)

¹² Environment Agency (2009): Updated technical background to the CLEA model (SR3)

¹³ Defra, 2014: SP1010 Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, Final Project Report Revision 2

GSC are broadly equivalent to the Soil Guideline Values. DEFRA (2012)¹⁴ recognises the use of these screening values through statutory guidance thereby providing authoritative backing to their use in appropriate circumstances.

In the absence of a GSC, lead has been assessed by reference to Category 4 Screening Levels (C4SLs)¹³; C4SLs have been developed in support of DEFRA's revision to the Statutory Guidance for Part 2A. The revised guidance presents a four-category system for determining land as contaminated land under Part 2A, ranging from Category 4 (the level of risk posed is acceptably low) to Category 1 (the level of risk is clearly unacceptable). The C4SLs provide criteria to determine whether contamination risks are low and do not represent contaminated land (i.e. contaminant concentrations do not present a Significant Possibility of Significant Harm). The published C4SLs, S4ULs and SGVs are therefore conservative thresholds.

GSC have been developed for exposure pathways relevant to a range of generic land use categories. Proposed end use at the Halsnead site are residential development and a primary school, therefore the generic land use considered to be appropriate is the 'Residential with homegrown produce' land use scenario. Soil samples recovered from the Halsnead site were subjected to a range of contaminant tests as previously indicated in Table 3.3 in Section 3.4 of this report. The suite of determinants tested are presented in Section 3.4.

Aside from the thin deposit of Made Ground at one location (RBH08), adjacent to the site access off Fox's Bank Lane, no visual or olfactory evidence of contamination was noted during the 2018 GI. Based on the current and historic site use, it is anticipated that limited deposits of Made Ground will be encountered during the proposed works.

Soil analysis results of samples obtained during the GI has an average soil organic matter of 1.3%. Therefore, a 1.0% soil organic matter has been assumed for assessment.

For a full table of results and the selected assessment criteria used please see Appendix J.1.

6.2.1 Inorganic Contaminants

Soil samples from the GI reported no exceedances of the adopted screening criteria.

6.2.2 Organic Contaminants

Soil samples from the GI reported no exceedances of the adopted screening criteria.

However, it should be noted that vinyl chloride's laboratory limit of detection is 2µg/kg, which is reported for all tested samples; it is greater than its GSC of 0.64µg/kg. It is considered unlikely that vinyl chloride is present as other tested volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs) were reported to be below the limit of detection.

6.2.3 Pesticide Contaminants

A total of 4 selected shallow soil samples (WS7 at 0.2m bgl, WS6 at 0.2m bgl, RB01 at 0.2m bgl and RB05 at 0.5m bgl) were analysed for a pesticide and herbicide suite, due to the current and historic use of the site as agricultural land. Pesticide and herbicide determinants were reported less than the laboratory limit of detection within the tested soil samples.

6.2.4 Risks from Soils to Construction and Maintenance Workers

The CLEA model allows the quantification of chronic (long-term) risks to human health from soil contamination. However, it is not possible to use this framework to quantify acute risks to

¹⁴ Defra (2012): Environmental Protection Act 1990: Part IIA, Contaminated Land Statutory Guidance

construction workers resulting from close short-term exposure to soils. Risks from soils to construction workers are therefore considered on a qualitative basis.

Construction workers are likely to come into close contact with soils particularly during ground works operations. Such operations may include excavation, and processing of potentially contaminated soils. Soil contaminant exposure routes include soil, dust and vapour ingestion and inhalation and dermal contact.

The probability and consequence of contaminated soil exposure have been evaluated in accordance with the qualitative assessment framework established by Rudland et al. (2001). The probability of exposure to contamination is considered **likely** and the consequence of exposure is considered **mild**, assuming the implementation of safe working practices. The overall risk in the absence of precautions is considered **moderate / low**.

Contractors should ensure that all these risks are mitigated through appropriate design of the works and compliance with health and safety legislation.

6.2.5 Asbestos Summary of Factual Data

No suspected asbestos containing materials (ACMs) were identified in the exploratory hole logs. Fifty soil samples from the GI were screened for asbestos. Asbestos was positively identified in two samples (RBH08 and WS01) during an initial asbestos fibre screen. Subsequent asbestos quantification was undertaken on these two samples; the results are summarised in Table 6.2 and the complete set of results included within the GI factual report.

Table 6.2: Asbestos Contamination Summary

Location	Depth (m bgl)	Strata	Asbestos Detected	Gravimetric Quantification (mass %)
RBH08	0.5	Natural sand	Chrysotile - Fibre bundles.	<0.001
WS01	0.2	Topsoil	Chrysotile - Fibre bundles	<0.001

The location of RBH08, adjacent to the site entrance off Fox's Banks Lane, was used by the GI contractor as a site compound area. Approximately 0.4m of Made Ground material, comprising a silty sand with gravel of brick and concrete, was imported to this location to create a level area for the GI site compound. This imported material could be a potential source of the asbestos identified at the location of RBH08 however the true source is still unknown.

The source of the asbestos identified at the location of WS01 is unknown. Given the absence of Made Ground/development in this area, and that asbestos was not encountered at the site (with the exception of RBH08 above), the asbestos identification within the sample from WS01 is possibly a laboratory error.

*Mott MacDonald Limited is not insured to advise on asbestos, and therefore will not give advice on asbestos risks. It is recommended that a specialist is consulted regarding mitigation or remedial measures required relating to the presence of asbestos at the site.

6.3 Risks to controlled waters

6.3.1 Methodology

Defra guidance on the application of Part 2A defines tests for significant pollution of controlled waters. Key tests are as follows:

- Contaminants are continuing to enter into controlled waters additional to entry which has already occurred, and such entry is likely to occur again;
- Contamination on-site has caused and is continuing to cause the following:
 - Pollution equivalent to “environmental damage” to surface water or groundwater as defined by The Environmental Damage (Prevention and Remediation) Regulations 2009, but which cannot be dealt with under those Regulations;
 - Inputs of pollutants resulting in deterioration of the quality of water abstracted, or intended to be used in the future, for use in human consumption such that additional treatment would be required to enable that use;
 - A breach of a statutory surface water Environment Quality Standard, either directly or via a groundwater pathway;
 - Input of a substance into groundwater resulting in a significant and sustained upward trend in concentration of pollutants [as defined in Article 2(3) of the Groundwater Daughter Directive (2006/118/EC/1);
- If the contamination risks to controlled waters can be ascribed to background soil contamination levels effectively from natural or “common” or “widespread” human activity the Local Authority should not normally regard the contamination as representing Significant Possibility of Significant Risk of Pollution to Controlled Waters.

In addition, under the Groundwater Daughter Directive (2006/118/EC), entry of hazardous contaminants into groundwater should be prevented (“prevent objective”). Entry of non-hazardous substances should not result in pollution of controlled waters (“limit objective”). The interpretation of the Groundwater Daughter Directive through the UK contaminated land risk assessment framework is described in EA (2013), “Groundwater Protection: Principles and Practice” (GP3)¹⁵.

Hazardous substances are defined in the Water Framework Directive (2000/60/EC) as “substances or groups of substances that are toxic, persistent and liable to bioaccumulate, and other substances which give rise to an equivalent level of concern”. An ‘equivalent level of concern’ refers to a level of protection prescribed for hazardous substances equivalent to the 1980 Groundwater Directive (which has now been repealed). Non-hazardous (NH) substances are those substances not defined as hazardous substances. Hazardous substances are defined in accordance with the Groundwater Daughter Directive by the Joint Agencies Groundwater Directive Advisory Group (JAGDAG).

GP3 interprets the prevent objective by stating that hazardous substances must “not be discernible after the immediate dilution that occurs after the discharge enters groundwater”. The compliance target used to measure discernibility is the highest of the natural background quality of groundwater, a Minimum Reporting Value (MRV); (typically the laboratory detection limit for that substance (MDL)) or “another value prescribed by legislation”.

The appropriate assessment criteria are the Water Framework Directive¹⁶ Environmental Quality Standards (EQS) for protection of surface waters or Water Supply (Water Quality) Regulations¹⁷ (DWS) for protection of groundwater.

¹⁵ Environment Agency (2013): Groundwater Protection Policy and Practice, GP3, V1.1

¹⁶ Water Framework Directive Standards and Classification) Directions (England and Wales)2015

¹⁷ Water Supply (Water Quality) Regulations (2016)

The hardness of the water supply at the site is obtained from United Utilities¹⁸ for the postcode of L35 3PS, it reports a hardness of 49mg CaCO₃/l. One groundwater sample was tested, reporting a water hardness of 22mg CaCO₃/l; which conforms to reported hardness by United Utilities.

For a full table of results and assessment criteria used please see Appendix J.2 (soil leachate), and Appendix J.3 (groundwater).

6.3.2 Leachate Extract

Twenty-five soil samples obtained from the GI were subjected to soil leachate testing. Several samples exceeded the EQS for copper, and zinc; these are presented in Table 6.3.

It should be noted that a direct comparison of soil leachate result and the exceedance threshold is a conservative method, as it does not allow for attenuation within site soils and leaching tests are an aggressive form of testing. However, it does provide a useful starting point for assessing likely risks.

Table 6.3: Controlled Water Soil Leachate Exceedances

Determinants	Location	Sample Depth (m bgl)	Units	DWS	EQS (Freshwater)	Result
Copper	WS10	0.20	µg/l	2,000	1	18
	RB02	0.20				11
	WS01	0.20				13
	WS4	0.20				9
	RBH07	0.50				10
	WS09	0.50				5
	RBH06	0.20				9
	RBH04	0.20				6
	WS02	0.20				9
	WS03	0.20				20
	TP07	0.2				11
	TP03	0.15				7
Zinc	WS10	0.20	µg/l	5,000	8	8.9
pH	RB03	0.90	pH units	5.5 – 9.5	6 – 9	5.98
	WS01	0.20				4.59
	WS6	0.50				5.96
	WS07	1.80				5.89

6.3.2.1 Inorganic Contaminants

There are several minor exceedances of copper and zinc against their more conservative EQS thresholds. The locations of copper exceedances are dispersed across the site, predominantly within the topsoil deposits which appears to be the organic plough zone and therefore re-worked natural deposits, and does not appear to indicate a point source of the identified contaminants.

¹⁸ United Utilities. 2018. Drinking water quality [Online]. Available at: <http://www.unitedutilities.com/services/your-water-supply/drinking-water-quality/> [Accessed: April 2018]

The pH reported for samples from RB03, WS06, and WS07 were slightly more acidic than the EQS threshold, but within the range of the DWS. Sample at WS01 exceeded the DWS threshold.

It is deemed unlikely that soil leachate will pose a risk to groundwater and surface water quality at the site, as the exceedances identified are minor.

6.3.2.2 Organic Contaminants

Soil leachate samples from the GI reported no exceedances of the adopted screening criteria.

6.3.3 Groundwater

Two groundwater samples were recovered from RBH02 for analysis. The first sample was collected on 09/03/2018 at 17.18m bgl and the second sample was collected on 06/04/2018 at 16.92m bgl. Both samples were collected from the sandstone Principal Aquifer. An exceedance of copper, which is summarised in Table 6.4, was recorded within the first sample.

Table 6.4: Controlled Water Groundwater Exceedances

Determinants	Location	Sample Depth (m bgl)	Units	DWS	EQS (Freshwater)	Result
First sample						
Copper	RBH02	17.18	µg/l	2,000	1	4
Second sample						
Manganese	RBH02	16.92	µg/l	50	123	419.8
Nickel			µg/l	20	4	4.2

6.3.3.1 Inorganic Contaminants

A minor exceedance of copper against the more conservative EQS threshold is identified for the first groundwater sample collected at RBH02. The exceedance is 3µg/l greater than the threshold, and it is deemed unlikely that it will pose a risk to groundwater quality. A copper exceedance is not reported for the second groundwater sample. Given that the soil leachate samples from the natural deposits also recorded elevated copper concentrations above EQS, it is considered that the minor groundwater exceedances recorded are representative of the background conditions at the site.

The second groundwater sample, identified exceedances of manganese and nickel. Nickel exceedance is minor and is 0.2µg/l greater than the more conservative EQS threshold, and unlikely to pose a risk to groundwater quality. Manganese exceeded both the DWS and EQS due to a concentration of 419.8µg/l. It has the potential to have an adverse effect to groundwater quality. It is greater than the concentration reported for the first sample, which is 12.1µg/l. Concentrations of manganese from soil leachate testing do not reflect the high groundwater concentration reported, and did not report exceedances.

The reason for the difference in manganese concentrations between the first and second sample is unknown. However, it is noted that if there is a period of high recharge of oxygenated water from the surface to groundwater, this can prevent the manganese from dissolving¹⁹; resulting in low concentrations. A review of soil leachate data of the site does not report

¹⁹ Oregon Health Authority. Iron (Fe) and Manganese (Mn) in Groundwater [Online]. Available at: <http://www.oregon.gov/oha/ph/HealthyEnvironments/DrinkingWater/SourceWater/Documents/gw/FeMnInGroundwater.pdf> [Accessed April 2018].

elevated concentrations of manganese (<10.3µg/l), suggesting the manganese exceedance in groundwater may not be due to site soils.

6.3.3.2 Organic Contaminants

Samples from the GI reported no exceedances of the adopted criteria.

It should be noted that 1,1-dichloromethane, and hexachlorobutadiene were reported below their limit of detection (3.0µg/l for both), which are greater than their conservative screen thresholds (0.5µg/l DWS and 0.1µg/l EQS, respectively). However, these are unlikely to be present as the groundwater sample reported no other VOCs above their limit of detection.

6.3.3.3 Cyanide

Total cyanide is reported below its limit of detection (0.010mg/l), which is greater than its more conservative EQS screening threshold (0.001mg/l). The presence of cyanide is unlikely as there has been no historical industrial land use, and the depth of groundwater which would cyanide naturally attenuate within the unsaturated zone.

6.4 Ground Gas Risks

6.4.1 Methodology

Ground gas monitoring was undertaken at 10 locations across the site during seven monitoring visits between February 2018 and April 2018.. Parameters recorded included atmospheric pressure, methane, carbon dioxide, oxygen, hydrogen sulphide, carbon monoxide and gas flow rate. Atmospheric pressure varied during the monitoring period, from 994mbar to 1026mbar and atmospheric conditions included one period of falling pressure and precipitation.

BS8485:2015²⁰ and CIRIA C665²¹ provide a risk assessment framework that allows designers to determine appropriate ground gas parameters that can be used to identify a range of possible construction solutions that will mitigate against the presence of ground gas on a development site.

The method uses both gas concentrations and borehole flow rates to define a Characteristic Situation (CS) for a site based on the borehole gas volume flow for methane and carbon dioxide. The borehole gas volume flow is referred to as the gas screening value (GSV). GSV or hazardous flow rate ($Q_{ghs}(l/h) = \text{Borehole flow rate } (q)(l/h) \times \text{gas concentration } (Chg) (\%)$).

To assess the risk to construction and maintenance workers, gas levels are compared to Workplace Exposure Limits (WELs) listed in HSE EH40²².

Additionally, for the proposed residential dwellings, the NHBC 'Traffic Light System' is considered to be appropriate for ground gas risk assessment. This system adopts a risk-based approach to identify gas protection measures required, by comparing calculated gas screening values to thresholds which are categorised as Green, Amber 1, Amber 2 and Red based on the gas screening values.

²⁰ British Standards Institute (2015): *BS8485:2015, Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*

²¹ CIRIA (2007): *Assessing risks posed by hazardous ground gases to buildings, CIRIA C665*

²² Health and Safety Executive (2005): *EH40/2005 Workplace exposure limits, Containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations (as amended)*

6.4.2 Risks from Ground Gas to End Users

A summary of the findings from the gas monitoring visits is included within Table 6.5. The full table of results is presented in Appendix J.4. The summary of the ground gas risk assessments is shown in Table 6.6.

Table 6.5: Gas Monitoring Result Summary

Parameter	Units	February 2018 Investigation
Maximum carbon dioxide concentration	%v/v	2.7
Maximum methane concentration	%v/v	0
Minimum oxygen concentration	%v/v	18.9
Maximum carbon monoxide concentration	ppm	0
Maximum hydrogen sulphide concentration	ppm	0
Maximum flow rate	l/hr	0.1

Table 6.6: Borehole Ground Gas Categorization

Borehole	Response Zone (m bgl)	Material	NHBC Traffic Light System	Characteristic Situation
WS01	1.20 – 1.50	Glaciofluvial Deposits	Green	CS1
WS04	1.20 – 1.80	Glaciofluvial Deposits	Green	CS1
WS06	1.20 – 1.80	Glaciofluvial Deposits	Green	CS1
WS07	1.20 – 1.80	Glaciofluvial Deposits	Green	CS1
RBH01	1.45 – 1.85	Glacial Till	Green	CS1
RBH02	17.80 – 19.8	Sandstone	Green	CS1
RBH04	9.50 – 10.50	Sandstone	Green	CS1
RBH05	10.50 – 11.50	Sandstone	Green	CS1
RBH06	1.20 – 1.80	Glaciofluvial Deposits	Green	CS1
RBH08	1.20 – 1.80	Glaciofluvial Deposits	Green	CS1

The proposed primary school can be characterised as having a very low hazard potential (CS1). In accordance with Table 3 of BS8485:2015²⁰ the proposed school at the site may comprise of the following:

- Type C building (commercial / public).

Table 4 of BS8485 indicates that a Type C building with CS1 requires a minimum gas protection score of 0, i.e. no gas protection measures are considered required.

In accordance with the NHBC 'Traffic Light System' the site overall can be classified as 'Green', which means there is a "negligible gas regime identified and gas protection measures are not considered necessary".

6.4.3 Risks from Vapours to End Users

PID readings of volatiles taken during the monitoring rounds did not record any concentrations of it. It is unlikely that there is a risk from vapours to end users or construction workers on-site.

6.4.4 Risks from Ground Gas and Vapours to Construction Workers

Short-term risks to construction workers from ground gases can be assessed by comparison of gas concentrations with Health and Safety Executive Workplace Exposure Limits (WELs)²³. WELs represent concentrations of hazardous substances in air, averaged over a specified time period, referred to as a time-weighted average (TWA). Two-time periods are used:

- Long-term (8 hours); and
- Short-term (15 mins).

Exceedances of WELs are summarised in Table 6.7.

Table 6.7: Exceedances of WELs

Gas	Long-term exposure limit	Short-term exposure limit	Exceedances	
			Exploratory hole	Max concentration
Carbon dioxide	5,000ppm (0.5%)	15,000ppm (1.5%)	WS01	1.0%–1.3%
			WS07	1.1%–1.4%
			RBH01	0.5%–0.7%
			RBH02	1.0%–1.3%
			RBH04	0.2%–2.7%
			RBH05	1.3%–1.7%
			RBH08	0.4%–0.6%
Carbon monoxide	30ppm	200ppm	No exceedances	No exceedances
Hydrogen sulphide	5ppm	10ppm	No exceedances	No exceedances

All monitored exploratory holes apart from WS04, WS06, and RBH06 reported exceedances of CO₂ with low flow-rates against short-term and long-term limits, posing a risk to construction workers when working in confined spaces.

Assuming the Contractor implements safe working practices, in-particular when working within excavations / confined spaces, risks to site workers will be limited and mitigated. However, the contractor will have to take all readings into account when determining appropriate working methodologies on-site.

6.5 Ground Aggressivity

6.5.1 Methodology

The scheme is likely to involve construction of buried concrete foundations as well as concrete associated with the necessary infrastructure. Risks from aggressive soils to buried concrete have been assessed in accordance with BRE Special Digest 1²⁴ for greenfield locations. Water-soluble sulphate concentrations and pH from soil and soil leachate testing have been collated and assessed.

6.5.2 Risks from Soils to Concrete Structures

The input data and calculations for the assessment is included in Appendix J.5 and the overall concrete classification summary is presented in Table 6.8. Assuming mobile groundwater a

²³ Health and Safety Executive (2005): EH40/2005 Workplace Exposure Limits, Containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations (as amended)

²⁴ BRE Special Digest 1 (2005): Concrete in aggressive ground, third edition

Design Sulphate Class of DS-1, and an Aggressive Chemical Environment for Concrete Class of AC-1 is deemed appropriate for the natural ground on-site.

Table 6.8: Concrete Classification

Ground Material	Characteristic Water-Soluble Sulphate (mg/l)	DS Class	Characteristic pH	ACEC Class
Soil and Soil Leachate Samples				
Topsoil and underlying natural soils	20.0	DS-1	6.0	AC-1
Groundwater Samples				
Kinnerton Sandstone	30.8	DS-1	6.0	AC-1

6.6 Potable Water Supply Pipes

6.6.1 Methodology

Water supply pipes can be at risk from contaminants within site soils. Permeation and accelerated deterioration of the pipe material can occur due to chemical reaction between the pipe and contaminants in the ground in which it is laid. Information on contamination limits suitable for maintaining the integrity of water supply systems through the careful selection of suitable pipe materials is provided within the UK Water Industry Research (UKWIR) publication 10/WM/03/21 "Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites". Note that the site is not considered a brownfield site, and the assessment of the risk to potable water supply pipes is to provide guidance on selecting the correct type of piping.

It should also be noted that the UKWIR guidance stipulates a specific contamination testing suite for selection of appropriate pipe material. Where not all parameters are assessed, some water authorities may not accept selection of a material.

6.6.2 Risks from Soils to Potable Water Supply Pipes

Several determinants were identified as being present at concentrations which may cause the permeation and accelerated degradation of standard potable water supply pipes. The summary is presented in Table 6.9.

Table 6.9: Risks to Potable Water Supply Pipes

Parameter	Risks to Water Supply Pipes
VOCs	No.
BTEX and MTBE	No.
SVOCs	No.
Phenols	No.
Cresols	Yes – Risk to PVC piping from 16-samples. Concentrations range from 0.06mg/kg to 0.42mg/kg
Mineral Oil C11–C20	Yes – Risk to PE piping from 2-samples. Concentrations are 13mg/kg and 14mg/kg.
Mineral Oil C21–C40	No.
pH	Yes – Alkaline pH (pH>8) corrosive to copper pipes, and pH<7 impacting wrapped steel.

PE = Polyethylene; PVC = Polyvinyl chloride

6.7 Risks from Soils to Fauna and Flora

The site is not located within an area with statutory designations for ecological interest. Therefore, risk will focus on the potential impacts from soil contamination on the development of landscape areas and gardens, potentially associated with the residential development and the school.

Soil testing results were screened against EA ecological soil screening values (SSVs)²⁵, Specification for Topsoil (BS 3882:2015)²⁶ phytotoxic contaminant levels and Dutch RIVM (National Institute for Public Health and the Environment) SRC_{eco} Values²⁷ to determine if levels of phytotoxic contaminants in soil are suitable to maintain growth of vegetation.

A summary of exceedances is presented in Table , with the full table of results available in Appendix J.6.

Table 6.10: Risk to Vegetation

Determinant	Location	Depth (m bgl)	Unit	SSV	Topsoil Spec	SRC _{eco}	Result
Cadmium	WS10	0.20	mg/kg	1.15	-	13	1.2
	RBH04	0.20					1.4
Copper	RBH04	0.20	mg/kg	88.4	200	96	95
Nickel	RBH01	0.50	mg/kg	25.1	110	100	32.7
	RBH04	0.20					27.6
	TP02	0.50					26
	TP17	0.60					31
Zinc	WS10	0.20	mg/kg	90.1	300	350	96
	RBH04	0.20					160

Exceedances reported are generally minor and are all against their most conservative thresholds (EA SSVs). Given the presence of vegetation across the site, it is unlikely that that site soils pose an observable risk to vegetation.

It should be noted that considerations should be made to the root depth of future vegetation (within site soils or within imported fill materials).

Additionally, the Knowsley Council Ecologist has identified the presence of Japanese Knotweed in an area at the edge of the woodland along the northern site boundary (close to exploratory hole TP12).

6.8 Initial Waste Classification

6.8.1 Introduction

An assessment of the soil analysis results has been undertaken using HazWaste Online^{TM28} in accordance with Landfill Regulations 2002 (as amended) and EA guidance (WM3)²⁹. It is the responsibility of the producer to ensure that all waste created on-site undergoes basic

²⁵ Environment Agency (2008): Guidance on the use of Soil Screening Values in Ecological Risk Assessment, Science Report SC070009/SR2b

²⁶ British Standards Institution (2015): Specification for Topsoil and Requirements for Use, BS 3882:2007 2015

²⁷ Litzen, J.P.A. et al. (2001): Technical Evaluation of the Intervention Values for Soil / Sediment and Groundwater, Report ref. 211701 023

²⁸ HazWasteOnline Engine: WM3 1st edition (May 2015)

²⁹ Environment Agency (2015): Waste Classification, Guidance on the classification and assessment of waste (1st edition 2015), Technical Guidance WM3

characterisation prior to disposal in an appropriate permitted landfill, and an indication of the likely classification is provided here.

It should be noted that MM is not insured for, and therefore will not give guidance on risks associated with asbestos. The indicative waste classification included in this report therefore does not take into account the impact of potential presence of asbestos on the waste classification.

6.8.2 European Waste Catalogue Codes

The European Waste Catalogue (EWC) classifies waste in accordance with the Hazardous Waste Regulations (2005). The waste is allotted an EWC code and named as a non-hazardous, hazardous absolute, or mirror entry. An absolute entry represents a material that is hazardous based on its description, regardless of its chemical composition, whereas mirror entries may be hazardous only if hazardous substances are present above certain thresholds. Non-hazardous entries are also classified on the basis of their description, regardless of their chemical composition. The Landfill (England and Wales) Regulations 2002 define inert wastes.

The wastes expected to be generated during the construction works at the Site together with their EWC code are included in Table 6.11. This is a non-exhaustive list for guidance only, and the waste producer should record EWC codes for different waste types as they are generated on-site in the Site Waste Management Plan, and on waste transfer or consignment notes.

Table 6.11: EWC Codes for Anticipated Waste

Site Materials	EWC Code	EWC Materials Description	Waste Disposal Classification
Made Ground – gravelly sand with cobbles. Gravel of concrete and brick (RBH08).	17 05 04	Soil and stones other than those mentioned in 17 05 03	Mirror non-hazardous.
Topsoil.	17 05 04	Soil and stones other than those mentioned in 17 05 03	Mirror non-hazardous.
Glacial Till – sand	17 05 04	Soil and stones other than those mentioned in 17 05 03	Mirror non-hazardous.
Glacial Till - clay	17 05 04	Soil and stones other than those mentioned in 17 05 03	Mirror non-hazardous.
Kinnerton Sandstone Formation - sandstone	17 05 04	Soil and stones other than those mentioned in 17 05 03	Mirror non-hazardous.

6.8.3 Non-asbestos Waste Classification of On-site Materials

A summary of the HazWaste Online™ output is presented with Table 6.12. Apart from samples presented in the table, all other samples tested were classified as non-hazardous. For full output sheets, please see Appendix K.

Table 6.12: Waste Classification Summary

No.	Sample	Depth (m bgl)	Classification	Hazard Properties HP 3(i)
1	RBH08	0.50	Potentially Hazardous	✓

No.	Sample	Depth (m bgl)	Classification	Hazard Properties
				HP 3(i)
40	TP09	0.30	Potentially Hazardous	✓
41	TP07	0.20	Potentially Hazardous	✓

Source: HazWasteOnline™ Waste Classification Report 4D2JS-SVZNS-4627F

6.8.3.1 Potentially Hazardous Classification

Three soil samples tested are potentially hazardous due to hazard property HP3(i) flammable “flammable liquid waste: liquid waste having a flash point below 60°C or waste gas oil, diesel and light heating oils having a flash point >55°C and ≤75°C”. This is due to concentrations of Total Petroleum Hydrocarbon (C6 to C40) petroleum group. Free product was not noted in exploratory hole logs; therefore, it is considered that waste soil generated may have a non-hazardous classification.

6.8.4 Asbestos

Two samples had chrysotile asbestos positively identified, with quantification testing undertaken on both samples. The samples (RBH08 at 0.50m bgl and WS01 at 0.20m bgl) reported asbestos concentrations below the limit of detection at 0.001% w/w.

WM3 provides the following advice on waste containing asbestos:

“The assessment of asbestos containing waste considers both the presence of asbestos as

- *fibres that are free and dispersed, and*
- *identifiable pieces of asbestos containing material.*

If the waste contains fibres that are free and dispersed then the waste will be hazardous if the waste as a whole contains 0.1% or more asbestos.

If the waste contains any identifiable pieces of suspected asbestos containing material they must be assessed as set out below. This would also apply to any dispersed fibres produced by deliberately breaking up such identifiable pieces.

Where the waste contains identifiable pieces of asbestos containing material (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then these pieces must be assessed separately. The waste is hazardous if the concentration of asbestos in the piece of asbestos containing material is 0.1% or more. The waste is regarded as a mixed waste and classified accordingly. The following codes should be assigned to the asbestos waste as appropriate:

- *17 06 05* Construction material containing asbestos (Mirror Hazardous)*
- *17 06 01* Insulation material containing asbestos (Mirror Hazardous)*

17 06 05 would normally be used in preference to 17 06 01* for the asbestos in asbestos contaminated soil and stones”.*

6.8.5 Waste Management

To ensure on-site waste management is in line with best practice and the waste hierarchy, the following should be implemented:

- Full characterisation of soil samples in accordance with the EA guidance WM3.

- Once waste characterisation has been undertaken, Waste Acceptance Criteria (WAC) testing must be undertaken for any disposal of waste as hazardous or inert waste.
- It should be noted that the following waste is excluded from the Waste Framework Directive: “uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated”. Uncontaminated superficial and bedrock material may therefore not be classified as a waste.
- Waste must be removed from the site by carriers registered under the Waste (England and Wales) Regulations 2011. The developer as waste producer therefore has a duty of care to ensure all materials removed go to an appropriate permitted facility and all relevant documentation is completed and kept in line with regulations.

Reuse of waste materials, including excavated soils, must be in accordance with the Environmental Permitting Regulations. Reuse of waste is regulated through a variety of mechanisms such as by registering an exemption, by issue of a reuse of waste environmental permit or by use of the CL:AIRE Definition of Waste: Development Industry Code of Practice.

6.9 Revised Conceptual Site Model

6.9.1 Introduction

This section revises the existing conceptual site model produced in Mott MacDonald's desk study⁸ to reflect the updated understanding of the site based on conditions encountered during the 2018 February GI. Potential sources, pathways, and receptors that are no longer deemed applicable to the site are greyed out, with additional entries made **bold**.

6.9.2 Potential Sources of Contamination (excluding asbestos)

The revised list of potential contamination sources comprises:

- S1 - Made Ground / contaminants associated with former/current (non-mining) development;
- S2 - Made Ground associated with former coal mining;
- S3 - Potential for in-filled land;
- S4 - Potential for buried structures;
- S5 - Contaminated leachates generated on-site;
- S6 - Contaminated leachates generated off-site;
- S7 - Ground gases generated on-site;
- S8 - Ground gases generated off-site;
- S9 - Potential for unexploded ordnance (UXO) to be present; and
- S10 - Potential for site soils to contain invasive species (Japanese Knotweed).

6.9.3 Potential Pathways

Revised list of potential pathways:

- P1 - Human uptake pathways:
 - Inhalation of indoor and outdoor dust and vapours;
 - Direct soil and dust ingestion;
 - Consumption of home grown produce and soil attached to home grown produce;
 - Dermal contact indoors and outdoors;

- P2 - Vertical migration of leachates in the unsaturated zone;
- P3 - Vertical and horizontal migration of contaminants in the saturated zone;
- P4 - Engineered contaminant transport pathways (e.g. piling for foundations, drainage runs);
- P5 - Overland flow (where surfacing/geology is impermeable or saturated);
- P6 - Direct contact with construction materials;
- P7 - Horizontal and vertical migration of ground gases;
- P8 - Ground gas accumulation in voids, buildings and confined spaces;
- P9 - Plant uptake pathways; and
- P10 - Wind-blown dusts.

6.9.4 Potential Receptors

Revised list of potential receptors:

- R1 - Future site users – occupiers of residential properties across the site and staff within the school;
- R2 - Construction and maintenance workers;
- R3 - Users of adjacent sites, particularly adjacent residential properties, schools and farmland;
- R4 - Groundwaters – the Kinnerton Sandstone Formation Principal Aquifer and SPZ3, and the Secondary A aquifers of the Pennine Coal Measures bedrock, and Glacial Till.
- R5 - Surface waters – with numerous small streams, drains and ponds;
- R6 – Buried and surface future structures and infrastructure associated with the new development, including concrete foundations;
- R7 - Fauna and flora; and
- **R8 – Future site users – school children of the proposed school (age 4 to 11).**

6.9.5 Contaminant Linkages Identified (S-P-R Model)

The revised Conceptual Site Model is summarised in Table 6.13 and includes contaminant pathways likely to be active from consideration of the risk assessments completed in this section (Section 6). Definitions of risk descriptors are included in Appendix 0.

Table 6.13: Revised Conceptual Site Model

Sources	Identified Contaminants	Pathways	Receptors	Consequence	Likelihood	Risk Classification
S1 - Made Ground/contaminants associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land.	No soil contaminants exceeded the GSC thresholds. Vinyl chloride were reported to be below its laboratory limit of detection, which is greater than the GSC threshold. However, it is determined it will not pose a risk on-site, as the site is a greenfield and its presence unlikely. Therefore, it is deemed not to be an identified contaminant.	P1 - Human uptake pathways. P10 - Wind-blown dusts.	R1 - Future site users - occupiers of residential properties across the site and staff within the school.	Minor – soil samples tested did identify any contaminant concentrations which exceeded the GSC. It is determined that on-site soils will not have measurable effect on human health.	Unlikely – no contaminants were identified based on the GI data; therefore, it is unlikely that residents and school staff will encounter contaminated soils. Additionally, residents at home, and staff and parents at school will generally be within buildings, or on hardstand surfacing. This creates a barrier between the receptors, and underlying soils at the site.	Very low.
			R8 - Future site users - school children of the proposed school (age 4 to 11).		Low likelihood – no contaminants were identified based on the GI data. However, children at the school will have greater exposure to potentially contaminated soil from playing around on school fields, with younger children may inadvertently ingest soil.	Very low.
S7 - Ground gases generated on-site. S8 - Ground gases generated off-site.	Ground gas risk assessment in accordance with BS8485:2015 for the proposed school, and NHBC 'Traffic Light System' for the proposed residential dwellings. The proposed school is assessed to be Characteristic Situation 1 (very low hazard potential), meaning no gas protection measures are considered required. The proposed residential dwellings are categorised as 'Green', which means "gas	P1 - Human uptake pathways. P4 - Engineered contaminant transport pathways. P7 - Horizontal and vertical migration of ground gases. P8 - Ground gas accumulation in voids, buildings and confined spaces.	R1 - Future site users – occupiers of residential properties across the site and staff within the school. R8 - Future site users - school children of the proposed school (age 4 to 11).	Minor – ground gas regime identified should not adversely affect the health of end users.	Unlikely – it is unlikely the ground gas regime on-site will change to require ground gas protection measures.	Very low.

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Sources	Identified Contaminants	Pathways	Receptors	Consequence	Likelihood	Risk Classification
	protection measures are not considered necessary".					
S1 - Made Ground/contaminants associated with former/current development. S2 - Made ground associated with former coal mining. S3 - Potential for in-filled land.	No soil contaminants exceeded the GSC thresholds. Vinyl chloride were reported to be below its laboratory limit of detection, which is greater than the GSC threshold. However, it is determined it will not pose a risk on-site, as the site is a greenfield and its presence unlikely. Therefore, it is deemed not to be an identified contaminant.	P1 - Human uptake pathways. P10 - Wind-blown dusts.	R2 - Construction and maintenance workers.	Minor – soil samples tested did identify any contaminant concentrations which exceeded the GSC. It is determined that on-site soils will not have any measurable effect on human health.	Likely - no contaminants were identified based on the GI data. However, due to the nature of construction works, workers will likely be at greater exposure to soils, which can include excavations and handling of ground material. This increases the possibility of encountering unidentified contaminants. Exposure pathways will be mitigated through the implementation of a safe system of work.	Low.
S7 - Ground gases generated on-site. S8 - Ground gases generated off-site.	Carbon dioxide concentrations with low flow-rates reported exceedances against health and Safety Executive WELs.	P1 - Human uptake pathways. P4 - Engineered contaminant transport pathways. P7 - Horizontal and vertical migration of ground gases. P8 - Ground gas accumulation in voids, buildings and confined spaces.	R2 - Construction and maintenance workers.	Medium – elevated carbon dioxide concentrations can pose an asphyxiation risk to workers when working in confined spaces.	Likely – Workers will likely work in excavations and confined spaces, posing an asphyxiation risk. The risk can be mitigated through implementing safe working practices.	Moderate
S9 - Potential for unexploded ordnance (UXO).	UXO was not encountered during the ground investigation. This does not mean it is not present on-site.	P1 - Human uptake pathways (direct contact).	R2 - Construction and maintenance workers.	-	-	-
S1 - Made Ground/contaminants	No soil contaminants exceeded the GSC thresholds. Vinyl chloride	P1 - Human uptake pathways.	R3 - Users of adjacent sites.	Minor – soil samples tested did identify any contaminant	Unlikely – on-site soils may be transported off-site by wind during construction works, but	Very low.

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Sources	Identified Contaminants	Pathways	Receptors	Consequence	Likelihood	Risk Classification
associated with former/current development. S2 - Made Ground associated with former coal mining. S3 - Potential for in-filled land.	were reported to be below its laboratory limit of detection, which is greater than the GSC threshold. However, it is determined it will not pose a risk on-site, as the site is a greenfield and its presence unlikely. Therefore, it is deemed not to be an identified contaminant.	P10 - Wind-blown dusts		concentrations which exceeded the GSC. It is determined that on-site soils will not have any measurable effect on human health.	no contaminants were identified based on the GI data; therefore, it is unlikely that off-site users will encounter contaminated soils.	
S7 - Ground gases generated on-site.	Ground gas risk assessment in accordance with BS8485:2015 for the proposed school, and NHBC 'Traffic Light System' for the proposed residential dwellings. The proposed school is assessed to be Characteristic Situation 1 (very low hazard potential), meaning no gas protection measures are considered required. The proposed residential dwellings are categorised as 'Green', which means "gas protection measures are not considered necessary".	P1 - Human uptake pathways. P7 - Horizontal and vertical migration of ground gases. P8 - Ground gas accumulation in voids, buildings and confined spaces.	R3 - Users of adjacent sites.	Minor – ground gas regime identified should not have adversely affect the health of users in adjacent sites.	Unlikely – on-site ground gas regime is unlikely to change to require gas protection measures for off-site structures.	Very low.
S1 - Made Ground/contaminants associated with former/current development. S2 - Made ground associated with former coal mining. S3 - Potential for in-filled land. S4 - Potential for buried structures. S5 - Contaminated leachates generated on-site.	Analysis of soil leachate reports several minor exceedances of copper and zinc against their more conservative EQS threshold. The pH for RB03, WS06, WS07, and WS01 were more acidic than the EQS threshold, with WS01 exceeding the DWS threshold. It should be noted that the comparison of soil leachate	P2 - Vertical migration of leachates in the unsaturated zone. P3 - Vertical and horizontal migration of contaminants in the saturated zone.	R4 – Groundwaters.	Minor – The Till on-site is a Secondary A aquifer, and the Kinnerton Sandstone bedrock a Principal aquifer. Both geological units are permeable to allow the storage and transport of groundwater. As the concentrations of exceedances reported are of 3	Low likelihood – based on the exploratory hole logs, there is minimal aquifer protection of overlying soils on-site. The Till generally consist of sand overlying the sandstone bedrock. However, parts of the site will likely be covered in hardstanding forming the roads, pavements, and building footprints of the proposed development. This will limit the generation of leachate, by	Very low.

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Sources	Identified Contaminants	Pathways	Receptors	Consequence	Likelihood	Risk Classification
S6 - Contaminated leachates generated off-site.	results against exceedance thresholds are a conservative method. It does not consider attenuation within site soils, with leaching tests being an aggressive form of testing (which is unlikely to be reflective of site conditions). Therefore, it is determined soil leachate will not have a noticeable impact to water quality.	P4 - Engineered contaminant transport pathways.		determinants, minor and generally against the more conservative thresholds. It is determined that it will not have an observable effect to groundwater quality.	minimising the permeable area of the site for water infiltration. The depth of groundwater will allow natural attenuation any contaminants to occur within the unsaturated zone.	
S1 - Made ground/contaminants associated with former/current development. S2 - Made ground associated with former coal mining. S3 - Potential for in-filled land. S4 - Potential for buried structures. S5 - Contaminated leachates generated on-site. S6 - Contaminated leachates generated off-site.		P3 - Vertical and horizontal migration of contaminants in the saturated zone. P4 - Engineered contaminant transport pathways. P5 - Overland flow.	R5 - Surface waters.	Minor - As the concentrations of exceedances reported are of 3 determinants, minor and generally against the more conservative thresholds. It is determined that it will not have an observable effect to surface water quality.	Low likelihood – groundwater on-site is deep and unlikely to feed to nearby surface water bodies. Overland flow may occur during heavy rainfall, but due to the permeable superficial and bedrock geology, it's more likely to infiltrate and vertically migrate through to groundwater. Water infiltration will be mitigated on-site, due to the proposed development will likely cover parts of the site in hardstanding which forms the roads, pavements, and building footprints. Drainage systems will also mitigate the potential for overland flow.	Very low.
S1 - Made ground/contaminants associated with former/current development. S2 - Made ground associated with former coal mining. S3 - Potential for in-filled land. S5 - Contaminated leachates generated on-site. S6 - Contaminated leachates generated off-site.	Assessment of ground aggressivity has identified a concrete design class of DS-1 AC-1 within topsoil and underlying natural soils, and the Kinnerton Sandstone bedrock. Assessment of the risk to potable water supply pipes have identified a risk to polyethylene pipes, polyvinyl chloride pipes, copper pipes, and wrapped steel pipes.	P6 - Direct contact with construction materials.	R6 - Buried and surface future structures and infrastructure associated with the new development, including concrete foundations.	Minor - the selection of the appropriate construction material, based on the assessment will mitigate the adverse effects of site soils to structures.	Likely – concrete materials and water supply pipes will be buried within the ground, and be in contact with site soils.	Low.
S7 - Ground gases generated on-site.	Ground gas risk assessment in accordance with	P7 - Horizontal and vertical	R6 - Buried and surface future	Minor – identified ground gas regime	Unlikely – ground gas regime unlikely to change on-site, to	Very low.

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Sources	Identified Contaminants	Pathways	Receptors	Consequence	Likelihood	Risk Classification
S8 - Ground gases generated off-site.	BS8485:2015 for the proposed school, and NHBC 'Traffic Light System' for the proposed residential dwellings. The proposed school is assessed to be Characteristic Situation 1 (very low hazard potential), meaning no gas protection measures are considered required. The proposed residential dwellings are categorised as 'Green', which means "gas protection measures are not considered necessary".	migration of ground gases. P8 - Ground gas accumulation in voids, buildings and confined spaces.	structures and infrastructure associated with the new development, including concrete foundations.	does not require gas protection measures for the proposed residential dwellings, and primary school.	require gas protection measures.	
S10 - Potential for site soils to contain invasive species.	Presence of Japanese Knotweed identified in an area at the edge of the woodland along the sites northern boundary.	P6 - Direct contact with construction materials.	R6 - Buried and surface future structures and infrastructure associated with the new development, including concrete foundations.	Mild – Japanese Knotweed is known to have the potential to grow to foundations and structures, by growing through them; damaging the structure in the process.	Low likelihood – Japanese Knotweed was identified at the edge of the woodland along the sites northern boundary, and not widespread across the site. Workers should be made aware of its presence, and ensure appropriate soil management is in place during construction works; to prevent the spread of it.	Low.
S1 - Made ground/contaminants associated with former/current development. S2 - Made ground associated with former coal mining. S3 - Potential for in-filled land. S10 - Potential for site soils to contain invasive species.	Relatively minor exceedances of cadmium, copper, nickel, and zinc against EA SSV threshold. Presence of Japanese Knotweed identified at the edge of the woodland along the sites northern boundary.	P9 - Plant uptake pathways.	R7 - Fauna and flora.	Medium – Japanese Knotweed is an invasive species, and can cause ecological damage to the site. Site soils are unlikely to pose an observable risk to vegetation on-site, based on the generally minor exceedances against the most conservative screening threshold (SSV).		Moderate / low.

6.10 Geo-environmental Summary

This section presents the geo-environmental findings and assessment, based on information obtained from the February 2018 GI. It should be read with reference to relevant sections in the main body of the report.

6.10.1 Risks to Human Health

Seventy-four soil samples obtained during the February 2018 GI were screened against GSC for 'Residential with homegrown produce', as it is deemed appropriate for the proposed development of residential dwellings and a primary school. No determinants tested exceeded the adopted criteria, and it is determined that site soils will not have measurable effect on human health.

As no exceedances were reported, it is unlikely that the end users of residents, and staff and parents at the school will encounter contaminated soils. Furthermore, they will generally be within buildings, or on hardstanding (e.g. pavement), which provide a physical barrier between these receptors and site soils, limiting the pathways. Resulting in a **very low** risk classification.

The school children of the proposed school are at low likelihood to encounter contaminated soil, than staff and parents. This is due to having greater exposure from playing on school fields, with younger children may inadvertently ingest soil. As no contaminants were reported for soil samples at the site, it still results in a **very low** risk classification.

Construction and maintenance workers are likely to have greater exposure to soils and potentially contaminated soils, from excavations and handling of ground material. Resulting in a **low** risk classification. Exposure pathways will be mitigated through the implementation of a safe system of work.

End users of adjacent sites are unlikely to be exposed to soils on-site, as it will be limited to wind-blown transport during construction works. Resulting in a **very low** risk classification.

Two samples reported the presence of chrysotile asbestos, with quantification testing reporting asbestos concentrations below the limit of detection at 0.001%. *Note Mott MacDonald Limited is not insured to advise on asbestos, and therefore will not give advice on asbestos risks. It is recommended that a specialist is consulted regarding mitigation or remedial measures required relating to the presence of asbestos at the site.

6.10.2 Risks to Controlled Waters

Twenty-five soil samples obtained during the February 2018 GI were subjected to soil leachate testing, and two groundwater samples obtained and tested. The results were screened against EQS and UK DWS.

Several soil leachate samples reported minor exceedances of the more conservative EQS for copper (1µg/l) (12 exceedances ranging between 5 to 20µg/l) and zinc (8µg/l) (one exceedance of 8.9µg/l). Acidic pH was reported for four samples (ranging between pH 4.59 to pH 5.98) which are below the lower EQS and DWS pH thresholds (pH 6 and pH 5.5, respectively). Note that leaching test are an aggressive form of testing, which are unlikely to be representative of conditions encountered at the site, and a direct comparison of soil leachate results and the exceedance threshold is a conservative method; it does not allow for natural attenuation within site soils.

The groundwater sample was obtained at 17.18m bgl, and reported one minor exceedance of copper (4µg/l) against the conservative EQS of 1µg/l. The minor exceedance is deemed unlikely to pose a risk to groundwater quality.

The aquifer underlying the site are designated as Secondary A (superficial Till), and Principal (Kinnerton Sandstone), with the risk to groundwater deemed to arise from the minor exceedances reported from soil leachate testing and groundwater testing. A review of exploratory hole logs suggests there is minimal protection of the aquifer from overlying soils on-site (which generally consist of sands), and it is likely that leached contaminants from soils will vertically migrate through to groundwater. However, the proposed development will result in parts of the site being covered in hardstanding, which will form the roads, pavements, and building footprints. This limits the area where surface water can infiltrate the ground, and generate leachate. With leachate generation limited, and exceedances reported are minor and of a limited range contaminant, it is determined that it will not have an observable effect to groundwater. Resulting in a **very low** risk classification.

There are a few surface water bodies near the site, with the closest one within the woods adjacent to the north of the site. Overland flow may occur during periods of heavy rainfall, but contaminants on-site may generally migrate through the unsaturated zone to groundwater, and less likely to reach surface water bodies. Deep groundwater on-site suggests it is unlikely that it will feed to nearby surface water bodies, with contaminants likely to naturally attenuate in the aquifer. Resulting in a **very low** risk classification.

6.10.3 Ground Gas Risk

Ground gas monitoring was undertaken at 10 locations on-site, over seven monitoring visits between February and April 2018. Based on the proposed residential dwellings and a primary school, it is determined that ground gas risk will be assessed in accordance with BS8485:2015, and additionally NHBC 'Traffic Light System' for residential dwellings.

For the proposed primary school, in accordance with Table 3 of BS8485:2015, it can be considered a 'Type C building (commercial / public)'. The assessment reports that the site has classified as CS1 (very low hazard potential) and with reference to Table 4 of BS8485:2015, the primary school requires a minimum gas protection score of 0, i.e. no gas protection measures are considered required.

For the residential dwellings the site is classified as 'Green' under the NHBC 'Traffic Light System'. This means there is a "negligible gas regime identified and gas protection measures are not considered necessary".

The ground gas regime is unlikely to change on-site to require ground gas protection measures, therefore the risk to both future residents, and school staff and children are **very low**.

Risk to construction workers from ground gases is assessed to Health and Safety Executive Workplace Exposure Limits. The assessment identified exceedances of CO₂ with low flow-rates against short and long-term exposure limits; posing a risk to workers working in confined spaces. Construction workers will likely involve working in excavations and confined spaces, with CO₂ posing an asphyxiation risk. Resulting in a **moderate** risk. This can be mitigated by implementing safe working practices.

6.10.4 Risks to Structures

Risk of aggressive soils to buried concrete structures have been assessed in accordance with BRE Special Digest 1, by collating water soluble sulphate concentrations and pH from soil, soil

leachate and groundwater testing. Based on the assessment, a concrete design class of DS-1 AC-1 is deemed appropriate for topsoil and natural soils on-site.

Assessment of the selection of potable water supply pipes have reported there is a risk posed to polyethylene, polyvinyl chloride, copper pipes, and wrapped steel pipes from site soils.

The presence of Japanese Knotweed in an area at the edge of the woodland along the sites northern boundary also poses a risk to structures. They are known to be able to damage structures such as foundations by growing through them.

Selection of the correct concrete class for the site, and for water supply piping material will mitigate the adverse effects of site soils to these structures. During construction works there should be appropriate soil management in place to prevent the spread of Japanese Knotweed on to site. Resulting in a **low** risk classification.

6.10.5 Risks to Vegetation

Results from soil sample testing were screened against EA SSVs, values set within BS3882:2015, and Dutch SRC_{eco}. Minor exceedances of cadmium, copper, nickel, and zinc were reported against the most conservative threshold of EA SSVs. Given the presence of vegetation across the site, it is unlikely that site soils pose an observable risk to vegetation. It is determined that a **low** risk classification is appropriate.

The presence of Japanese Knotweed (an invasive species) is identified at the edge of the woodland north of the site may pose an ecological risk to vegetation on-site. An appropriate soil management should be in place when construction works start, to prevent the spread of it on to site. A **moderate / low** risk classification is determined to be appropriate.

6.10.6 Waste

The waste expected to be generated from construction works are likely to fall under the EWC Code 17 05 04, which has a mirror non-hazardous waste disposal classification.

An assessment of soil testing results using HazWaste Online™ reports three potentially hazardous classification, all due to the having the hazard property of HP3(i) flammable. It is due to the concentrations of Total Petroleum Hydrocarbons reported. As the hazard property only applies to liquid waste, and no free product was noted within exploratory hole logs, it is considered that the waste generated may have a non-hazardous classification.

When construction works begin, on-site waste management should be in line with best practice and the waste hierarchy.

Reuse of waste materials must be in accordance with Environmental Permitting Regulations, which is regulated through a variety of mechanisms such as the CL:AIRE Definition of Waste: Development Industry Code of Practice.

6.11 Preliminary Remedial Scope

The following preliminary remedial scope is provided for information and reflects site understanding at the time of writing:

- The proposed development will cover parts of the site in hardstanding. This acts as a physical barrier between site soils and end users. It will also mitigate the potential for leachate generation, which may affect surface and groundwater quality. However, the contaminant exceedances reported were minor, and are unlikely to have an observable effect to water quality;

- Any imported soils must be suitable for use and not pose a risk to site users;
- Best practice procedures should be implemented during construction to mitigate the risk to construction and maintenance workers. The Contractor must manage any risks to prevent harm to workers or adjacent site users. Workers should be made aware of the presence of Japanese Knotweed by the sites northern boundary, and identification of asbestos at two locations on-site;
- Given the 'Green' NHBC classification and CS1 classification regarding ground gas, no ground gas protection measures are recommended at the current time;
- Concrete structures in contact with site soils will require a design sulphate class DS-1 AC-1;
- Potable water supply pipes should not use polyethylene, polyvinyl chloride, copper pipes, or wrapped steel piping.

7 Geotechnical Risks

Shown below is a summary of the geotechnical risks likely to be present for the proposed redevelopment of the Halsnead site given the results of the February 2018 ground investigation and the findings of the site geo-environmental desk study.

At the time of writing this GIR it is understood that the proposed development will comprise residential properties and a primary school, as well as associated new road infrastructure.

A geo-environmental and geotechnical risk register is provided in Appendix M which highlights the likely geotechnical risks present on site following the February 2018 ground investigation.

7.1 Foundations

As discussed in section 4.1 the ground conditions likely to be encountered on site comprise shallow superficial deposits of Glacial Till (firm to stiff, locally soft clay) and Glaciofluvial Deposits (potentially completely weathered sandstone) (medium dense sand). These are underlain by Weathered Sandstone at around 1.5m bgl, which ranges in thickness from 0.3 – 2.7m, and then Sandstone bedrock. The groundwater table was monitored at a depth of 16.92 to 17.36 m bgl in one borehole on site (29.27 to 28.83m AOD), although seepages were noted above the cohesive Glacial Till at depths ranging from 0.7 to 2.0 m bgl.

Given the proposed development it is anticipated that the proposed building foundations will be founded on Glacial Till or Glaciofluvial Deposits.

Given the nature of the development and ground conditions encountered it is considered unlikely that piled foundations will be required on site. Presented below in Table 7.1 are suggested presumed allowable bearing pressures for pad and strip foundations at 1m bgl assuming a minimum undrained shear strength of 50 kN/m² for the cohesive Glacial Till. Presumed allowable bearing pressures are also given for founding on medium dense Glaciofluvial Deposits (sand) with a minimum SPT N of 15 in Table 7.2.

Table 7.1: Presumed allowable bearing pressure of shallow foundations founded at 1mbgl in Glacial Till at Halsnead

Foundation Type	Pad Foundations		Strip Foundations
Foundation Size	1m x 1m	2m x 2m	<1m wide
Presumed Allowable Bearing Value (kN/m ²)	130	90	90

(Presumed allowable bearing pressure for foundations placed on clays at minimum depth of 1 m bgl, Source Table 2.5 of Foundation Design and Construction, MJ Tomlinson, 7th Edition, 2001)

Table 7.2: Presumed allowable bearing pressure of shallow foundations in Glaciofluvial Deposits at Halsnead

Foundation Type	Pad Foundations		Strip Foundations
Foundation Size	1m x 1m	2m x 2m	1m wide
Presumed Allowable Bearing Value (kN/m ²)	~190	~130	~ 120

These values have been determined in accordance with published literature and usually equate to settlements of less than 25mm. However, during the detailed design stage once the likely loads and foundation details are known, design teams should undertake detailed bearing capacity and settlement analysis to verify the values in Table 7.1 and 7.2. Design teams will need to ensure that likely settlements are still within acceptable tolerances and the bearing pressure does not exceed the allowable limit.

The ground investigation highlighted the presence of localised soft/loose layers within Glacial Till/Glaciofluvial Deposits that will need to be taken into account by the designer during foundation design. Alternatively, soft/loose layers could be excavated and replaced with suitably compacted engineered fill in order to provide an adequate founding stratum at these locations.

The modified Plasticity Index ($I'_p = I_p / \% \text{ passing } 0.425\text{mm}$) can be used to estimate the volume change potential of soil and hence the minimum founding depth for foundations. A range of I_p from 11 to 22 (Figure I.6) results in a range of I'_p from 10 to 21. It can therefore be assumed that Glacial Till exhibits a low volume change potential in accordance with (Table 1, Chapter 4.3, NHBC Standards)³⁰. Given this classification, a minimum foundation depth of 0.75 m bgl (where planting is outside the zone of influence of trees) or 1m bgl (allowing for restricted new planting) is appropriate when founding in this stratum (Table 4, Chapter 4.3, NHBC Standards).

7.2 Drainage

Superficial deposits of cohesive Glacial Till and granular Glaciofluvial Deposits were proven across the site at depths of < 1.5m bgl during the February 2018 ground investigation.

Published literature indicates typical infiltration rates of $< 10^{-9} \text{ ms}^{-1}$ for clay and $10^{-2} - 10^{-5} \text{ ms}^{-1}$ for sand. A soil is considered to be suitable for soakaway drainage where infiltration $> 10^{-6} \text{ ms}^{-1}$ (Wavin Plastics Limited, 2002)³¹. Therefore, in terms of infiltration rate, soakaways could be viable if installed within Glaciofluvial Deposits and are positioned away/beneath impermeable Glacial Till at the southwest section of the site (subject to confirmation via infiltration tests).

Soakaway drainage also has to be considered from an environmental perspective given that superficial deposits are underlain by fairly shallow Sandstone of the Kinnerton Sandstone Formation – a Principle Aquifer. The only DWS exceedance recorded was of manganese of a groundwater sample at 16.92m bgl in RBH02. As discussed in Section 6.3.3.1, these elevated concentrations are not thought to be sourced from soils on site, partly due to the lack of contaminative historical development.

It is recommended that infiltration tests are carried out as part of an additional phase of ground investigation which will confirm the suitability of soakaway drainage on site. If shallow soakaways are adopted on site given the nature of the Principle Sandstone Aquifer and the fact that the site is situated on a Groundwater Source protection Zone 3 consultation with the EA (Environment Agency)/LLFA (Lead Local Flood Authority) will be required to confirm if shallow soakaways are acceptable.

7.3 Pavement Design

As part of the February 2018 ground investigation, in-situ TRL DCP tests were undertaken at each rotary borehole and windowless sampler location in order to assess the likely subgrade CBR strengths for pavement design.

³⁰ National House Building Council (2017): NHBC Standards

³¹ Wavin Plastics Limited (2002): Design: Initial principles and Design considerations, 2.1 – 2.3

Presented below in Table 7.3 is a summary of the in-situ CBR values that were recorded from the TRL DCP tests.

Table 7.3: Summary of in-situ CBR values from TRL DCP tests

Strata	Depth to bottom (m bgl)	CBR (%)
Glacial Till	0.4 – 0.9	9 - 16
*Glaciofluvial Deposits	0.5 – 1.0	2 - 69

*Excluding a CBR value of 106% recorded through Topsoil and Glaciofluvial Deposits to a depth of 0.48m bgl in RBH06

In addition to the TRL DCP tests, the following empirical correlation from P. Jenkins (1998)³² can be applied to cohesive strata in order to determine the subgrade CBR:

$$CBR = (C_u/27)^{1.7}$$

Assuming a typical undrained shear strength of 50 kN/m² for Glacial Till, this equation suggests that a preliminary CBR value of approximately 3 % can be applied to cohesive strata across the site. It should be noted that there are areas of the site where undrained shear strengths of the Glacial Till is less than 40 kN/m² (RBH04 and WS02) these areas are likely to indicate lower CBR values of the order of 1 % however these may be encountered at sufficient depths to not impact the pavement design. Where these softer areas could impact on the pavement design then they can either be locally excavated out or alternatively a reinforcing geogrid could be incorporated into the pavement makeup.

Draft HD25 (2009)³³ states that the minimum permitted Design CBR to support pavement foundation is 2.5%. The results above suggest that Glacial Till can be considered as suitable. Although the lowest derived CBR value for Glaciofluvial Deposits is 2% (WS04, 0.93m bgl depth), the average of 54No. values is 13%, suggesting that this stratum can also be considered as suitable.

In the case that localised ground is encountered which exhibits a CBR of < 2.5%, such is shown at WS04, ground must be permanently improved using one of the options outlined in HD25. A suitable example includes removing material and replacing it with suitably compacted granular fill.

During construction of any road pavements on site the above CBR values will need to be verified by the contractor. It should be noted that cohesive strata will be moisture sensitive and if the cohesive subgrade is left exposed during periods of rainfall, it could soften and subsequently become unstable.

It is recommended that a CBR of 3% is used in pavement design.

7.4 Mining Risk

The BGS 1:50,000 scale Solid Map for Runcorn (Sheet 97) shows the Eccleston West Fault to be situated within the western site boundary separating the Kinnerton Sandstone to the east from Pennine Middle Coal Measures to the west. The Coal Authority indicate the area to the west of the fault to be a Development High Risk Area, defined as follows:

³² P Jenkins (1998): The strength of well graded cohesive fills, Ground Engineering

³³ Highways England (2009): Interim Advice Note 73/06, Design Guidance for Road Pavement Foundations (Draft HD25)

“part of the coal mining reporting area which contains one or more recorded coal mining related features which have the potential for instability or a degree of risk to the surface from the legacy of coal mining operations”.

As part of the desk study phase for these works a “Non-Residential Mining Report” was obtained from the Coal Authority who stated that nearby coal seams were worked at 190m to 440m bgl and that there is a recorded disused mine entry within 20m of the western site boundary. Given the depth of these workings they are considered to be at sufficient depth not to impact the proposed development on site.

In order to further assess the potential mining risk on site RBH01 and RBH02 were also drilled to depths of 30 m bgl. It was originally expected that given the locality of RBH01 and RBH02 immediately to the west of the Eccleston West fault that the Pennine Middle Coal Measures would be encountered at shallow depth. During the drilling of RBH01 Mudstone with coal fragments within fractures was encountered at 24.5 m bgl. During the drilling of RBH02 Mudstone and potential coal bearing strata was not encountered down to the bottom of the hole at 30 m bgl. It is therefore considered that the Eccleston West Fault actually strikes outside the Halsnead site boundary and because of this the risk from shallow coal mining on the Halsnead site is considered to be low.

The investigation determined Kinnerton Sandstone to be situated beneath the site to minimum depths of 24.5m, hence as detailed above, the investigation appears to confirm geological mapping assertion that Coal Measures have been displaced to greater depth due to the Eccleston West Fault. Coal Authority records present no evidence that shallow coal mine workings are present beneath the site, however, a disused mine entry (Ref. 347390-005) is recorded within 20m of the western site boundary at approximately 347413, 390184. The exact location of this shaft is unknown and there are no records of what steps, if any have been taken to treat the mine entry. There is a further mine entry (Ref. 347390-004) which is situated approximately 50 m to the west of the western site boundary. No other features are mentioned.

Detailed designers should consider the risk posed by potential legacy shafts and consider whether further investigation along the western boundary by means of geophysics or probe holing is required.

7.5 Requirement for Further Ground Investigation

During detailed design it is recommended that the designer approaches the EA/LLFA to confirm the appropriateness of incorporating shallow soakaways into the proposed works given the nature of the Principal Sandstone Aquifer and the fact that the site is situated in a Zone 3 Groundwater Source Protection Zone. If shallow soakaways are taken forward then soakaway tests to BRE 365 will be required as part of additional ground investigations.

Detailed designers should consider the risk posed by potential legacy shafts and the proximity of the Eccleston West Fault/Coal Authority Development High Risk and consider whether further investigation along the western boundary by means of geophysics or probe holing is required. The mine shaft which is reported to be outside the western site boundary but within 20m of the boundary (Ref. 347390-005) (Refer to plan in Appendix E) should either be confirmed via geophysical techniques before the construction stage and, if required, backfilled and capped in order to reduce the chance of ground instability at the western edge of the site should the shaft collapse. Alternatively, the proposed development on site could be arranged so that no structures are situated immediately adjacent to the western site boundary where a potential

shaft collapse could encroach and instead less sensitive land uses could be adopted within the localised western site boundary.

As discussed in Section 2.2 of this report a nursery has previously been situated on the central-eastern part of the site from 1937 to around 2000. The February 2018 ground investigation did not encounter any significant thicknesses of Made Ground or signs of the nursery however it is possible that the exploratory hole locations missed the actual location of the former nursery. During construction the contractor should be made aware of the potential for encountering remnants of the former nursery and a plan should be devised as to how to deal with the remnants.

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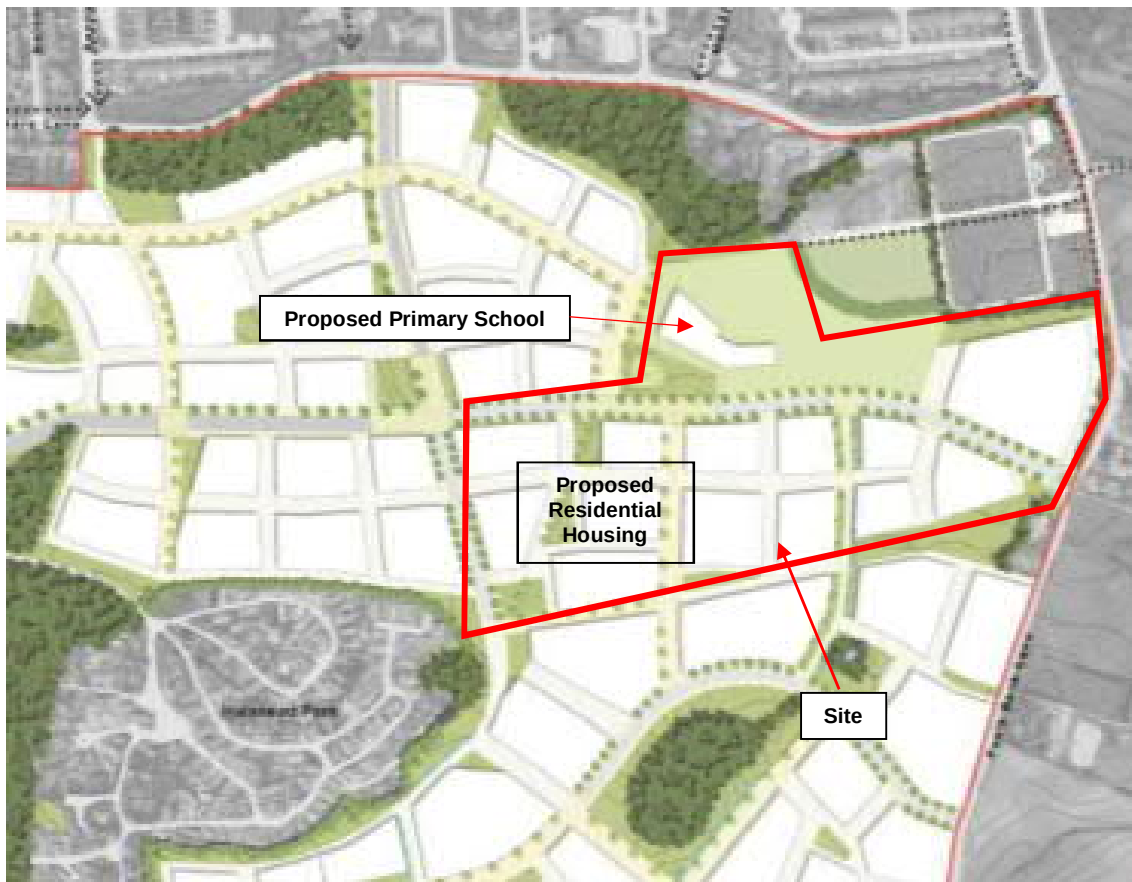
A. Site Plans

Figure A.1: Site Location Plan



© OpenStreetMap contributors

Figure A.2: Site Layout Plan



Extracted from the Illustrative Masterplan of the Halsnead Garden Village Masterplan Supplementary Planning Document

B. February 2018 GI Exploratory Hole Location Plan



N

- Rotary Corred Borehole
- Windrowless Sample
- Machine excavated Trial Pit
- Glacial Till Deposits Encountered
- Completely Weathered Sandstone Contours (mbgl = metres below ground level)
- Cross-Section Lines

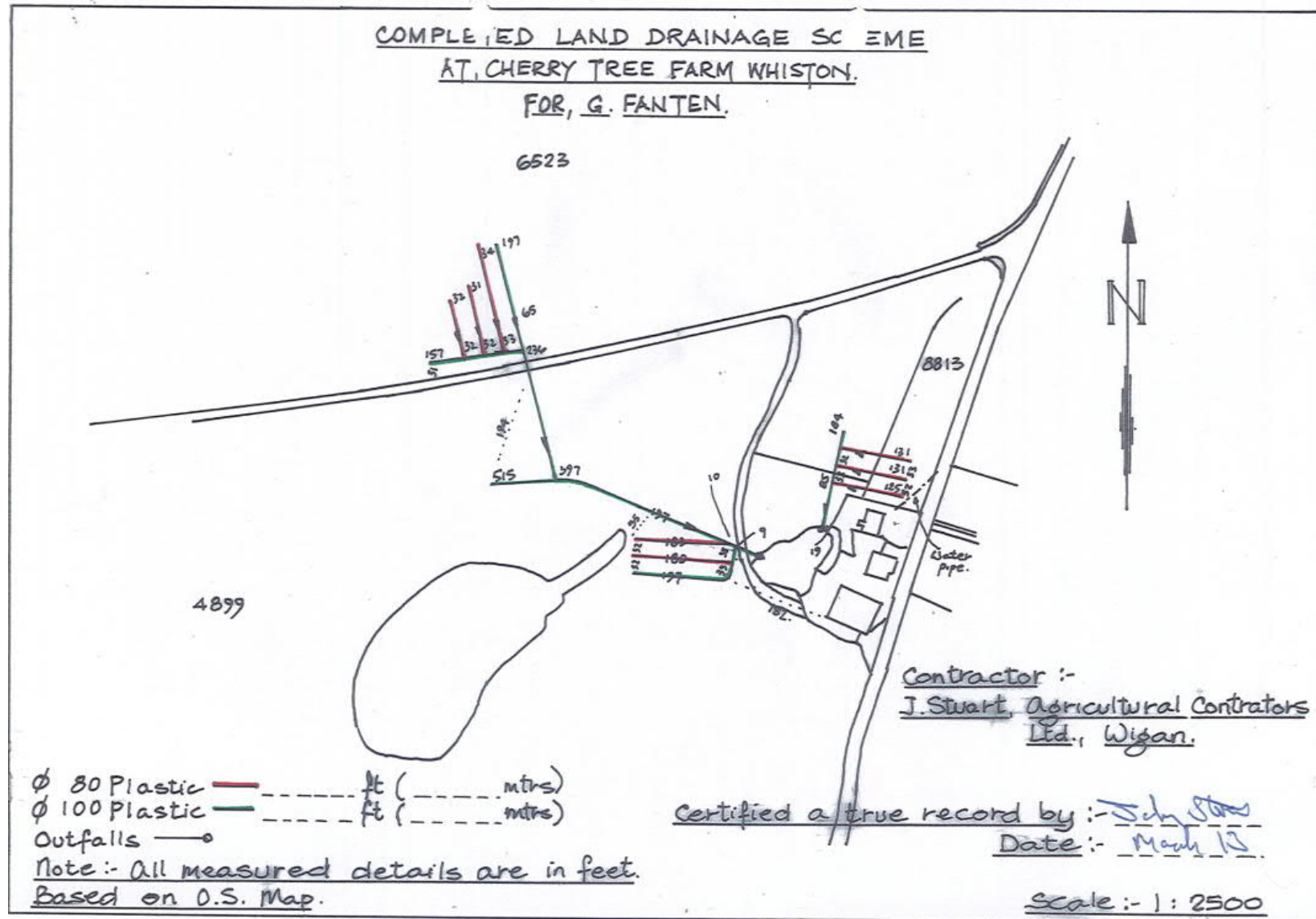
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Client	Kendal Metropolitan Borough Council				
Site	Furness Lane, Whitson				
Drawing	Site Investigation Layout Plan on Topographic Survey				
Job No.	18/0117	Drawn No.	0	Drawn by	LT
Date	18/01/17	Rev. No.	0	Drawn by	27/04/18

C. Land Drainage Plan at Cherry Tree Farm

Ground Investigation Report



D. Site Walkover Photos



Photo 1 looking east

Ground Investigation Report



Photo 2 looking South east



Photo 3 looking South

Ground Investigation Report



Photo 4 looking West



Photo 5 looking South West



Photo 6 looking South



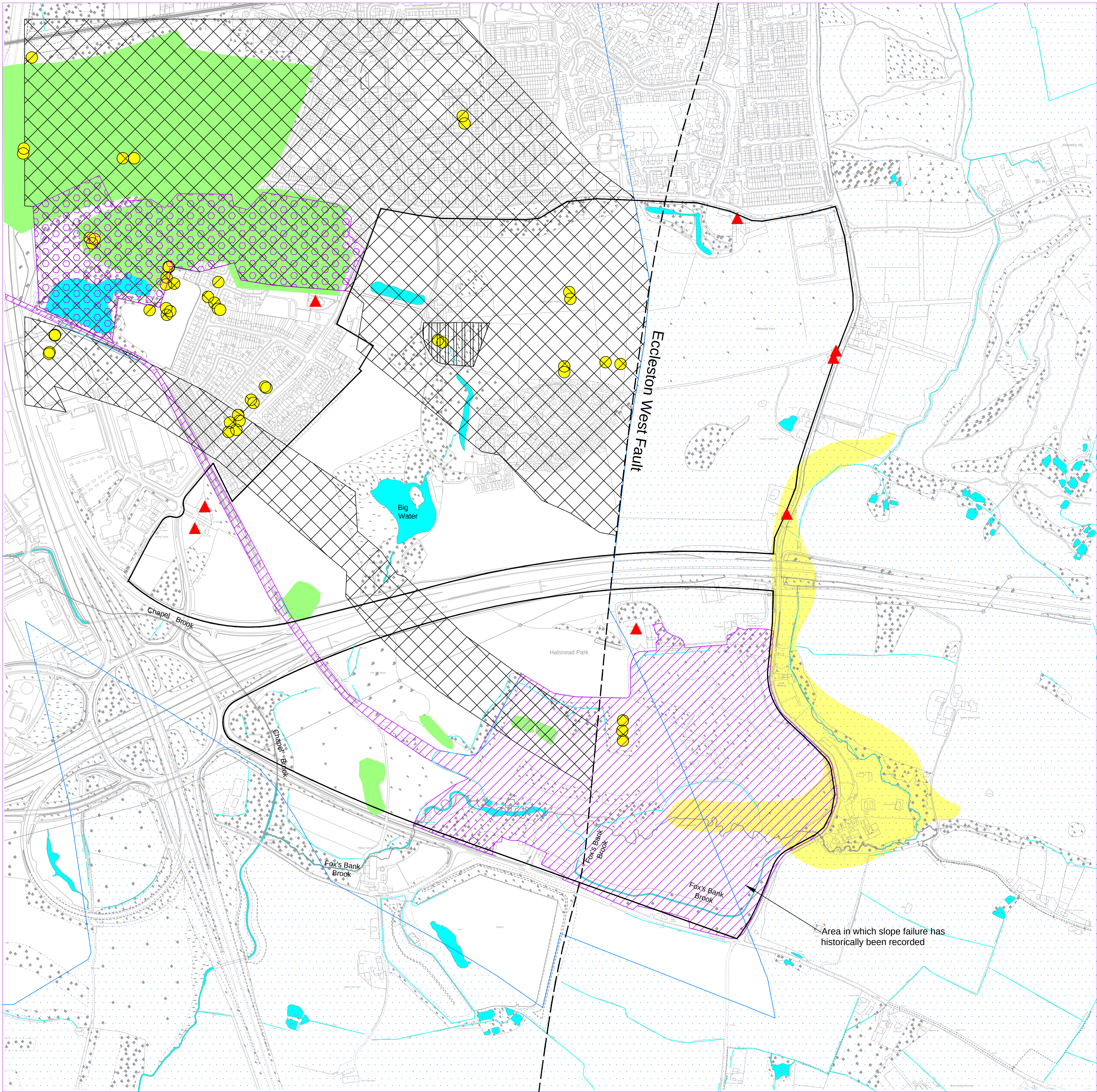
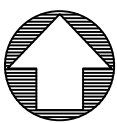
Photo 7 looking South

Ground Investigation Report



Photo 8 looking East

E. Geotechnical Site Constraints Plan



Notes

This drawing is to be viewed in conjunction with MM Report 373379/BNI/MNS/GE/A August 2016: South of Whiston and Land South of the M62 - Phase 1 Geo-Environmental and Geo-Technical Risk Assessment

Key to symbols

Mine Entries (Approximated from Coal Authority Interactive Viewer)

Listed Buildings

Coal Authority Development High Risk Area (Approximated from Coal Authority Interactive Viewer)

Surface Mining - Past and Current (Approximated from Coal Authority Interactive Viewer)

Potentially Infilled Land - Clay Extraction (Data provided by Knowsley Council)

Former Coal Pit (Approximated from historic mapping)

Former Cronton Colliery and associated mineral railway, Local Geological Site 85, to west (Approximated from historic mapping)

Principal Aquifer and Groundwater Source Protection Zone (Approximated from BGS mapping)

Surface Water Features (OS Open Data)

Alluvial Deposits (BGS Map Sheet 97, Drift, 1977)

Approximate Location of Geological Fault (BGS Mapping)

Proposed Site Boundary

Reference drawings

The Coal Authority Interactive Map Viewer App, Available at: <http://mapapps2.bgs.ac.uk/coalauthority/home.html>

British Geological Survey of Great Britain Map Sheet 97 1:50,000 Series Drift Edition, 1977 Available at: <http://www.bgs.ac.uk/data/maps/>

British Geological Survey of Great Britain Map Sheet 97 1:50,000 Series Solid Edition, 1980 Available at: <http://www.bgs.ac.uk/data/maps/>

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P2	08/09/2016	N.B	Hatching amended for clarity	N.S	C.W
P1	15/08/2016	N.B	Preliminary Issue	N.S	C.W
Rev	Date	Drawn	Description	Ch'k'd	App'd

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W www.mottmac.com

Client

Knowsley Council,
Municipal Buildings,
Huyton,
L36 9UX

Title

South of Whiston and Land South of
the M62, Phase 1 Geo-Environmental
and Geo-Technical Risk Assessment,
Constraints Plan

Designed	N/A		Eng check	L McGovern	
Drawn	N Bergeson		Coordination	N Haynes	
Dwg check	N Spofforth		Approved	C Williams	
Scale at A1	1:5000	Status	PRE	Rev	P2
Drawing Number			Security	STD	

373379/MM/GE/001

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P:\Polwyn Bay\373379 South Whiston\373379-MM-GE-001.dwg Aug 15, 2016 - 07:52AM Autodesk

F. Coal Authority CON29M Non-residential mining report



The Coal
Authority

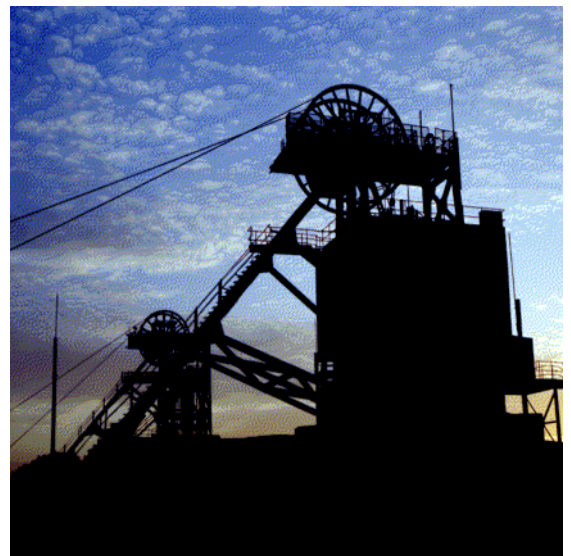
Resolving the **impacts** of mining

CON29M Non-Residential Mining Report

SITE AT WHISTON
KNOWSLEY
MERSEYSIDE

Date of enquiry: 18 January 2018
Date enquiry received: 18 January 2018
Issue date: 18 January 2018

Our reference: 51001773669001
Your reference: 153427655_1 |



CON29M Non-Residential Mining Report

This report is based on, and limited to, the records held by the Coal Authority and the Cheshire Brine Subsidence Compensation Board's records, at the time we answer the search.

Client name

LANDMARK INFORMATION GROUP LIMITED

Enquiry address

SITE AT WHISTON, KNOWSLEY, MERSEYSIDE

How to contact us

0345 762 6848 (UK)
+44 (0)1623 637 000 (International)

200 Lichfield Lane
Mansfield
Nottinghamshire
NG18 4RG

www.groundstability.com

 /company/the-coal-authority

 /thecoalauthority

 /coalauthority



Approximate position of property



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Summary

Has the search report highlighted evidence or potential of		
1	Past underground coal mining	Yes
2	Present underground coal mining	No
3	Future underground coal mining	Yes
4	Mine entries	Yes
5	Coal mining geology	No
6	Past opencast coal mining	No
7	Present opencast coal mining	No
8	Future opencast coal mining	No
9	Coal mining subsidence	No
10	Mine gas	No
11	Hazards related to coal mining	No
12	Withdrawal of support	Yes
13	Working facilities order	No
14	Payments to owners of former copyhold land	No
15	Information from the Cheshire Brine Subsidence Compensation Board	No

Further recommended reports
Mine entry interpretive report
Mine entry plan and data sheets

For detailed findings, please go to page 4.

Detailed findings

1. Past underground coal mining

The property is in a surface area that could be affected by underground mining in 2 seams of coal at 190m to 440m depth, and last worked in 1902.

Any movement in the ground due to coal mining activity should have stopped.

In addition the property is in an area where the Coal Authority believe there is coal at or close to the surface. This coal may have been worked at some time in the past. The potential presence of coal workings at or close to the surface should be considered prior to any site works or future development activity. Your attention is drawn to the Comments on the Coal Authority information section of the report.

2. Present underground coal mining

The property is not within a surface area that could be affected by present underground mining.

3. Future underground coal mining

The property is not in an area where the Coal Authority has plans to grant a licence to remove coal using underground methods.

The property is not in an area where a licence has been granted to remove or otherwise work coal using underground methods.

The property is not in an area likely to be affected from any planned future underground coal mining.

However, reserves of coal exist in the local area which could be worked at some time in the future.

No notices have been given, under section 46 of the Coal Mining Subsidence Act 1991, stating that the land is at risk of subsidence.

4. Mine entries

Within, or within 20 metres of, the boundary of the property there is 1 mine entry, the approximate position of which is shown on the enquiry boundary plot.

There is no record of what steps, if any, have been taken to treat the mine entry.

There may however be mine entries/additional mine entries in the local area which the Coal Authority has no knowledge of.

For an additional fee, the Coal Authority can provide a Mine Entry Interpretive Report. The report will provide a separate assessment for the mine entry/entries referred to in this report. It gives an opinion on the likelihood of mining subsidence damage caused from ground movement as a consequence of the mine entry/entries. It also gives details of the remedies available for subsidence damage where the mine entry was sunk in connection with coal mining.

Please note that it may not be possible to produce a report if the main building to the property cannot be identified from Coal Authority plans (ie for development sites and new build).

For further advice on how to order this additional information please visit www.groundstability.com.

5. Coal mining geology

The Coal Authority is not aware of any damage due to geological faults or other lines of weakness that have been affected by coal mining.

6. Past opencast coal mining

The property is not within the boundary of an opencast site from which coal has been removed by opencast methods.

7. Present opencast coal mining

The property does not lie within 200 metres of the boundary of an opencast site from which coal is being removed by opencast methods.

8. Future opencast coal mining

There are no licence requests outstanding to remove coal by opencast methods within 800 metres of the boundary.

The property is not within 800 metres of the boundary of an opencast site for which a licence to remove coal by opencast methods has been granted.

9. Coal mining subsidence

The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31st October 1994.

There is no current Stop Notice delaying the start of remedial works or repairs to the property.

The Coal Authority is not aware of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991.

10. Mine gas

The Coal Authority has no record of a mine gas emission requiring action.

11. Hazards related to coal mining

The property has not been subject to remedial works, by or on behalf of the Authority, under its Emergency Surface Hazard Call Out procedures.

12. Withdrawal of support

The property is in an area where notices to withdraw support were given in 1976 and 1979.

The property is not in an area where a notice has been given under section 41 of the Coal Industry Act 1994, cancelling the entitlement to withdraw support.

13. Working facilities order

The property is not in an area where an order has been made, under the provisions of the Mines (Working Facilities and Support) Acts 1923 and 1966 or any statutory modification or amendment thereof.

14. Payments to owners of former copyhold land

The property is not in an area where a relevant notice has been published under the Coal Industry Act 1975/Coal Industry Act 1994.

15. Information from the Cheshire Brine Subsidence Compensation Board

The property lies outside the Cheshire Brine Compensation District.

Comments on the Coal Authority information

The Coal Authority own the copyright in this report and the information used is protected by our database right.

The boundary plot shows the approximate location of the disused mine entry/entries referred to in this report. For reasons of clarity, mine entry symbols may not be drawn to the same scale as the plan.

Property owners have the benefit of statutory protection (under the Coal Mining Subsidence Act 1991*). This contains provision for the making good, to the reasonable satisfaction of the owner, of physical damage from disused coal mine workings including disused coal mine entries. A leaflet setting out the rights and obligations of either the Coal Authority or other responsible persons under the 1991 Act can be obtained by visiting www.groundstability.com.

If you wish to discuss the relevance of any of the information contained in this report, you should seek the advice of a qualified mining engineer or surveyor. If you or your advisor wish to examine the source plans from which the information has been taken, these are available to view, free of charge, at our Head Office in Mansfield. To book an appointment please ring 01623 637225. Should you or your advisor wish to carry out a physical investigation that may enter, disturb or interfere with any disused mine entry, prior permission of the owner must be sought. For coal mine entries, the owner will normally be the Coal Authority.

The Coal Authority, regardless of responsibility and in conjunction with other public bodies, provide an emergency call out facility in coalfield areas to assess the public safety implications of mining features (including disused mine entries). Our emergency telephone number is 01623 646333.

*Note, this Act does not apply where coal was worked or gotten by virtue of the grant of a gale in the Forest of Dean, or any other part of the Hundred of St. Briavels in the county of Gloucester.

In view of the mining circumstances a prudent developer would seek appropriate technical advice before any works are undertaken.

Therefore if development proposals are being considered, technical advice relating to both the investigation of coal and former coal mines and their treatment should be obtained before

beginning work on site. All proposals should apply good engineering practice developed for mining areas. No development should be undertaken that intersects, disturbs or interferes with any coal or mines of coal without the permission of the Coal Authority. Developers should be aware that the investigation of coal seams/former mines of coal may have the potential to generate and/or displace underground gases and these risks both under and adjacent to the development should be fully considered in developing any proposals. The need for effective measures to prevent gases entering into public properties either during investigation or after development also needs to be assessed and properly addressed. This is necessary due to the public safety implications of any development in these circumstances.

Additional remarks

Information provided by the Coal Authority in this report is compiled in response to the Law Society's Con29M Coal Mining and Brine Subsidence Claim enquiries. The said enquiries are protected by copyright owned by the Law Society of 113 Chancery Lane, London WC2A 1PL. Please note that Brine Subsidence Claim enquiries are only relevant for England and Wales. This report is prepared in accordance with the Law Society's Guidance Notes 2006, the User Guide 2006 and the Coal Authority and Cheshire Brine Board's Terms and Conditions applicable at the time the report was produced.

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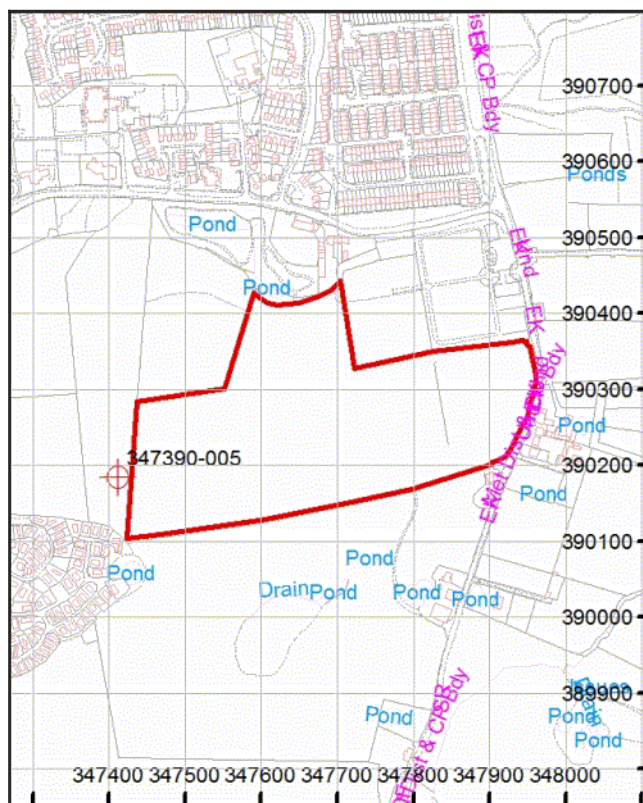
Enquiry boundary

Key

Approximate position of enquiry boundary shown



Disused mineshaft



How to contact us

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Mansfield
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NG18 4RG

www.groundstability.com

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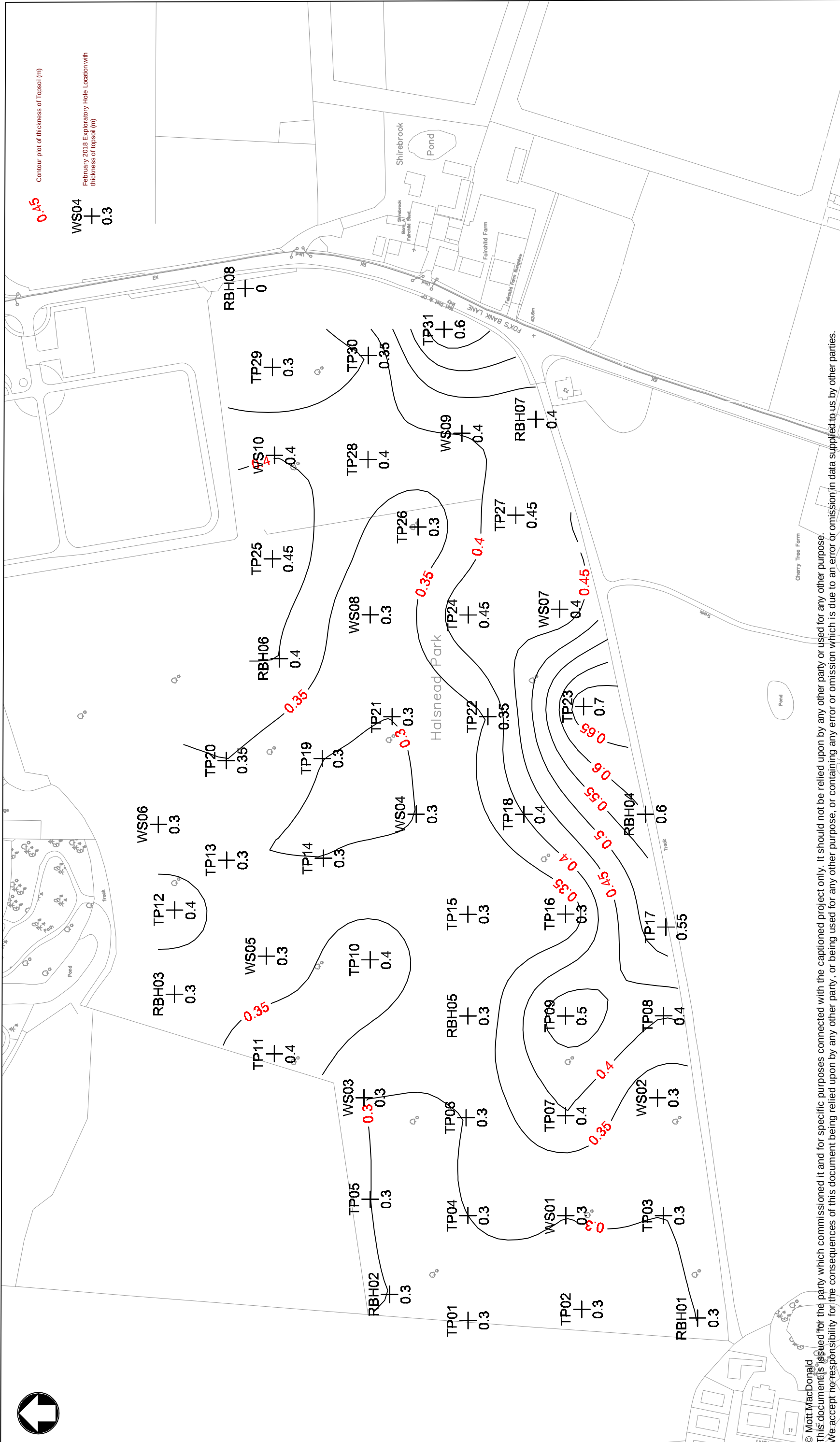
 /coalauthority



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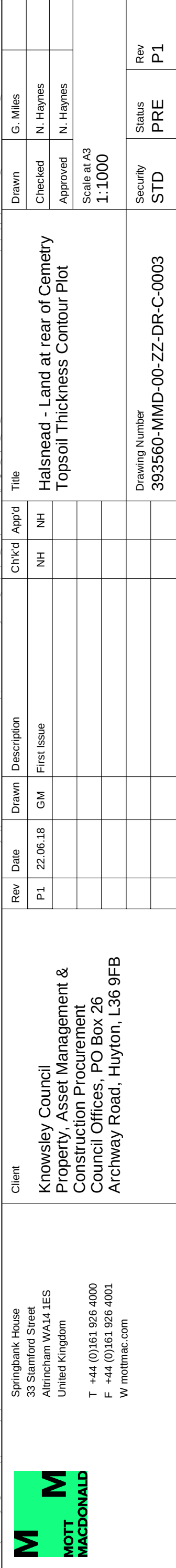
Ordnance Survey Licence number: 100020315

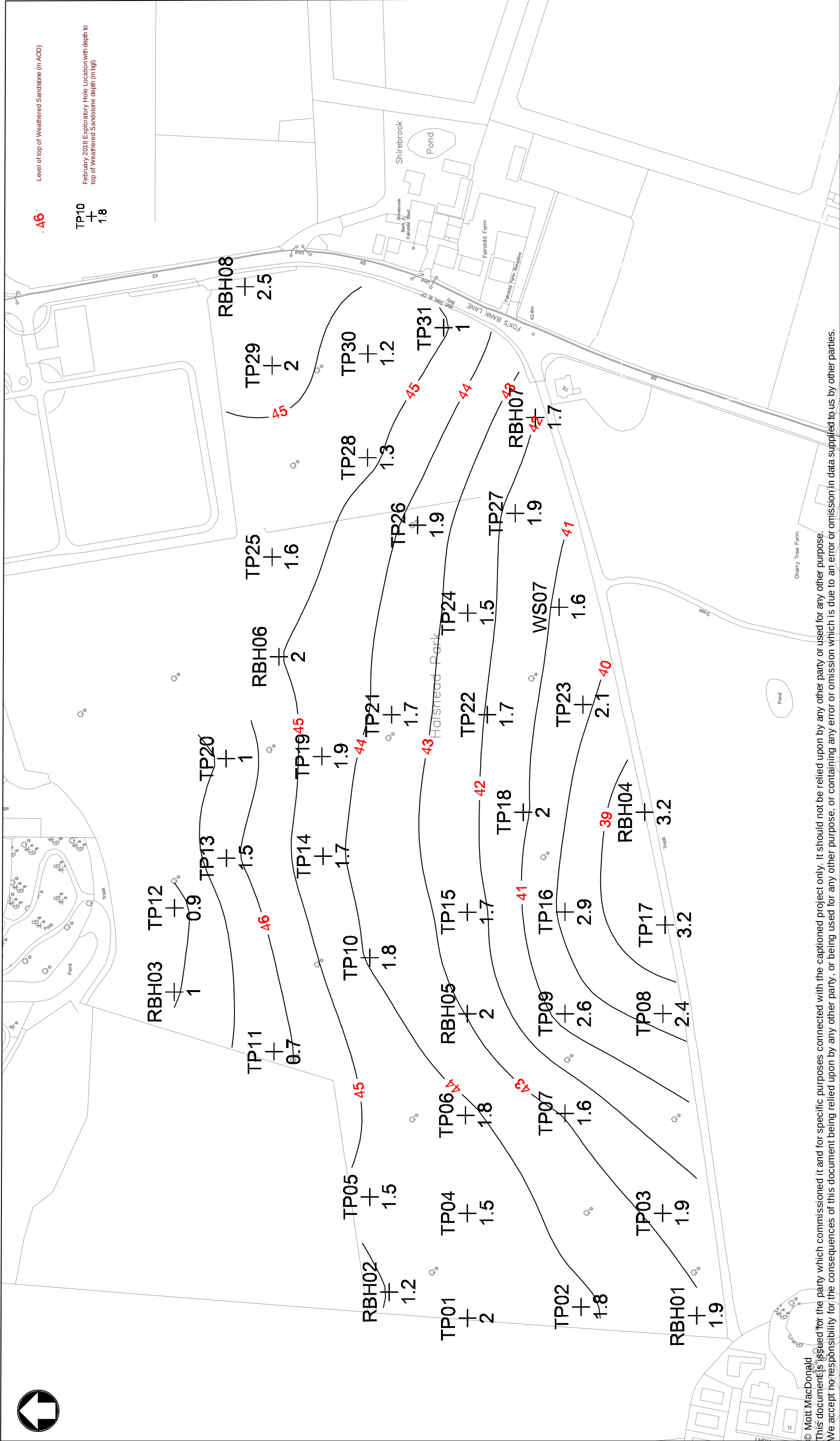
G. Geological Cross Sections



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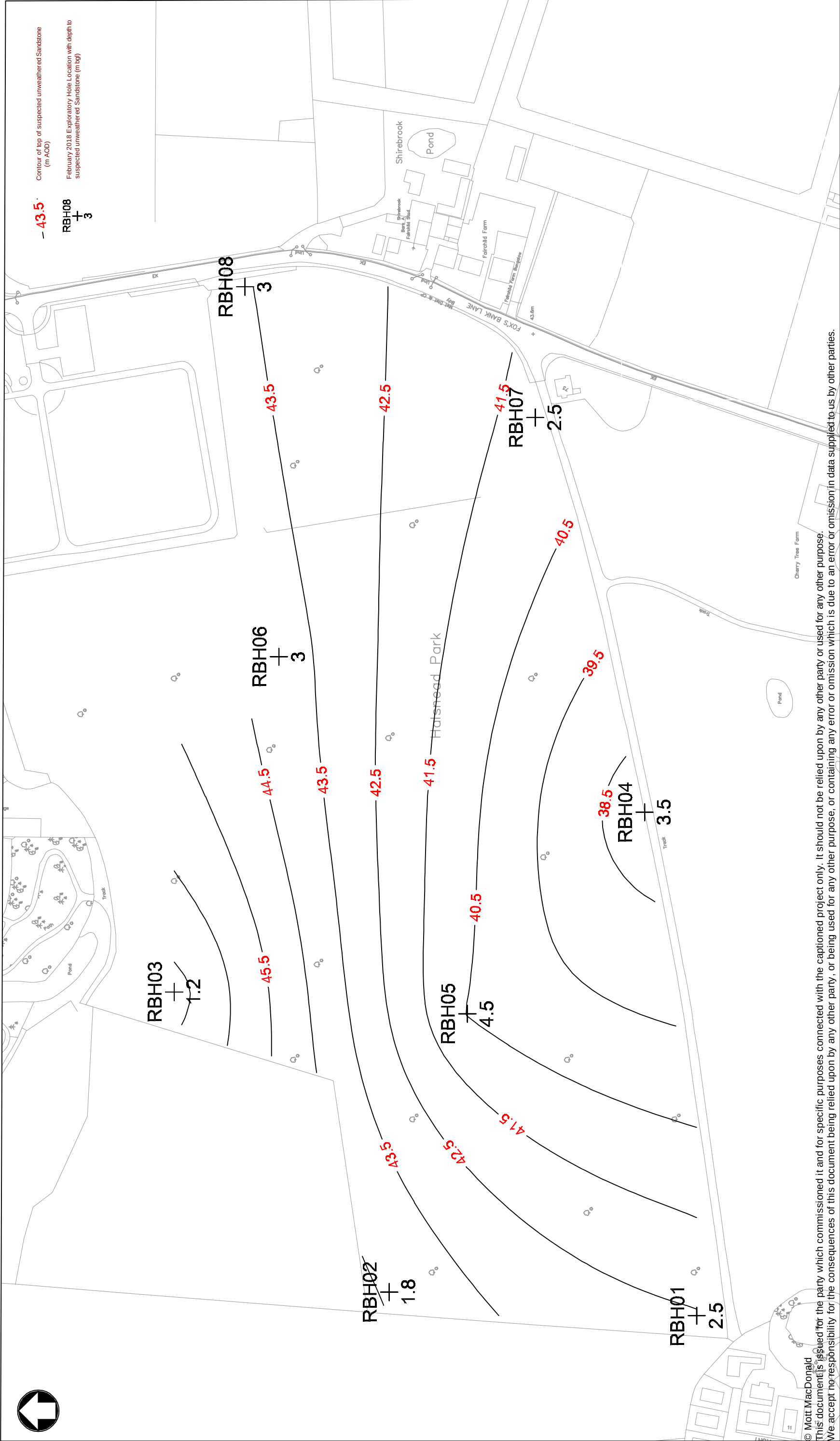
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M MOTT MACDONALD Springbank House 33 Stamford Street Altrincham WA14 1ES United Kingdom T +44 (0)161 926 4000 F +44 (0)161 926 4001 W mottmac.com	Client Knowsley Council Property, Asset Management & Construction Procurement Council Offices, PO Box 26 Archway Road, Huyton, L36 9FB		Rev	Date	Drawn	Description	Ch'k'd	App'd	Title Halshead - Land at rear of Cemetry Weathered Sandstone Contour Plot	Drawn	G. Miles			
			P1	22.06.18	GM	First Issue	NH	NH		Checked	N. Haynes			
										Approved	N. Haynes			
										Scale at A3 1:1000				
Drawing Number 393560-MMD-00-ZZ-DR-C-0002									Security	STD	Status	PRE	Rev	P1

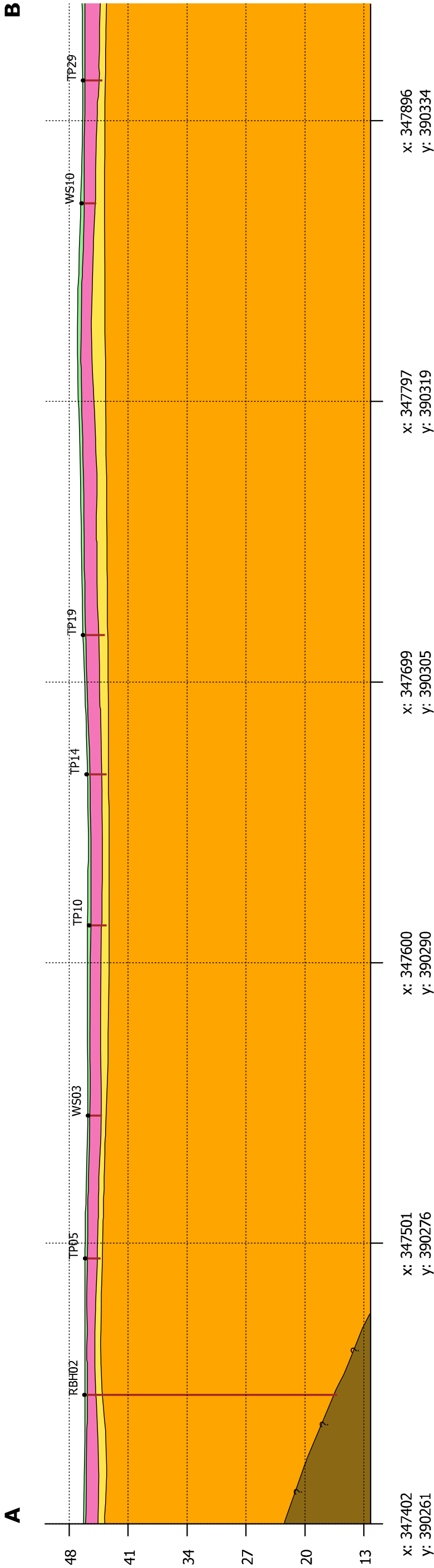


- 43.5
Contour of top of suspected unweathered Sandstone
(m AOD)
RBH08
+ 3
February 2018 Exploratory Hole Location with depth to
suspected unweathered Sandstone (m bgl)

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		P1	22.06.18	GM	First Issue	NH	NH	Halshead - Land at rear of Cemetry Top of suspected unweathered Sandstone	Checked N. Haynes	
									Approved N. Haynes	
									Scale at A3 1:1000	
								Drawing Number 393560-MMD-00-ZZ-DR-C-0004	Security STD	Status PRE Rev P1

Cross Section 1



Lithology

- GFD
- MDST
- SST
- TS
- WSST

Notes

TS: Topsoil
GFD: Glaciofluvial Deposits
WSST: Weathered Sandstone
SST: Sandstone
MDST: Mudstone

Boreholes shown are within 10m of the cross section line and therefore may not directly correspond with the boundary lines along this plane.

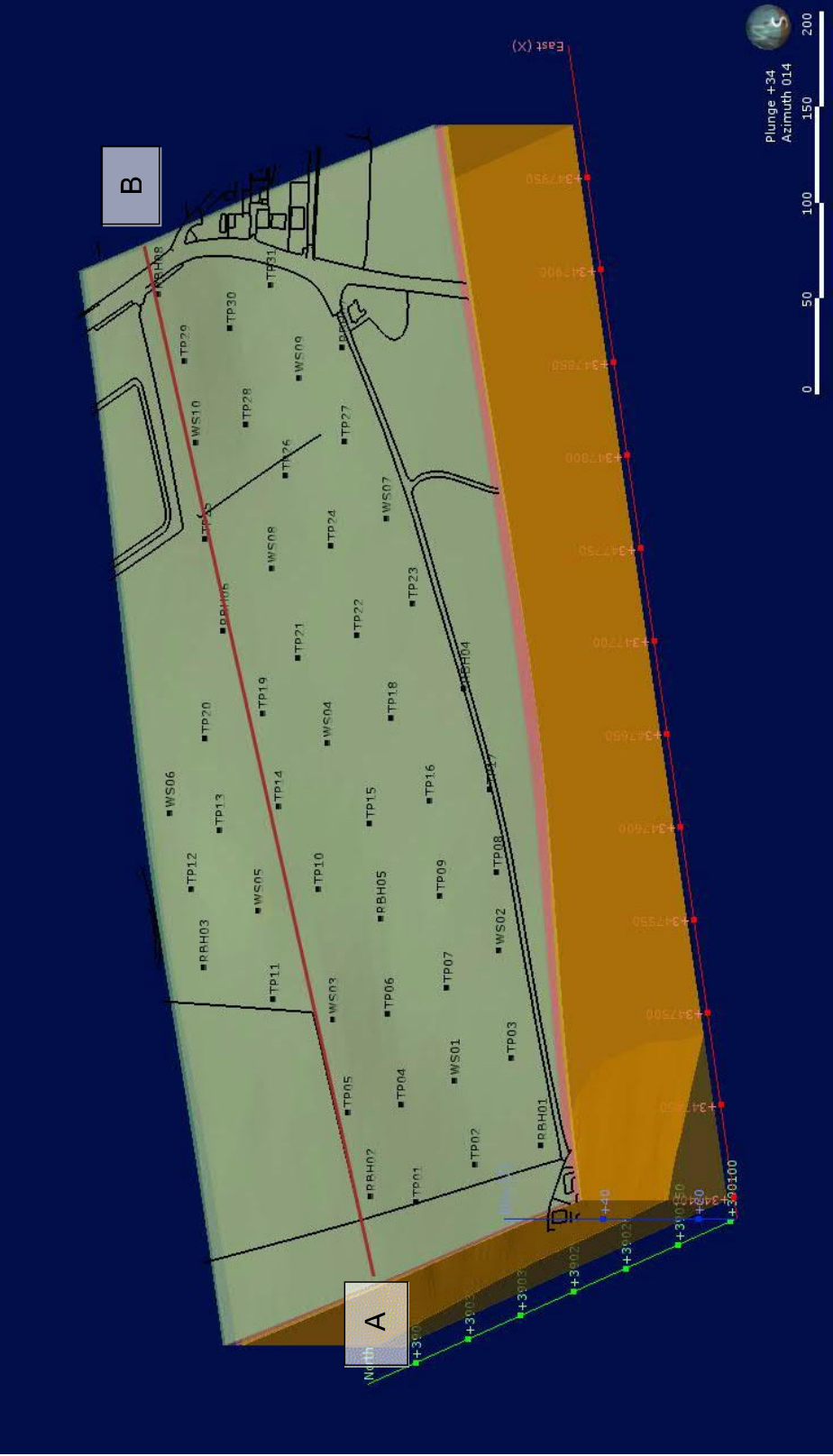
Glacial Till may be present as discontinuous lenses within Glaciofluvial Deposits.

Location

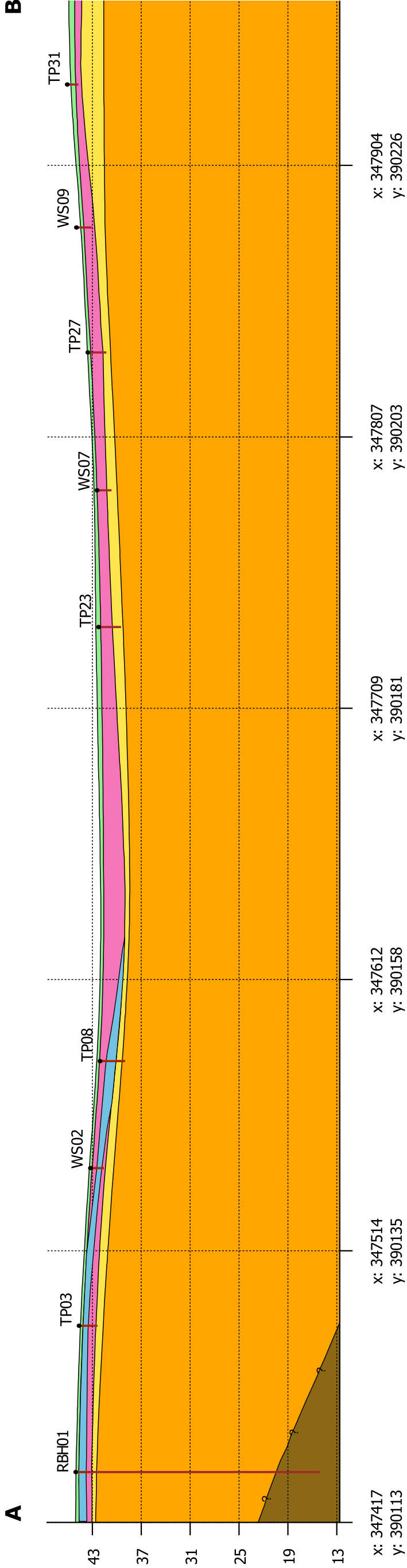
A: 347402, 390261
B: 347938, 390340

Scale: 1:1,500

Vertical exaggeration: 3x



Cross Section 2



Lithology

GFD

MDST

SST

TS

WSST

GT

Notes

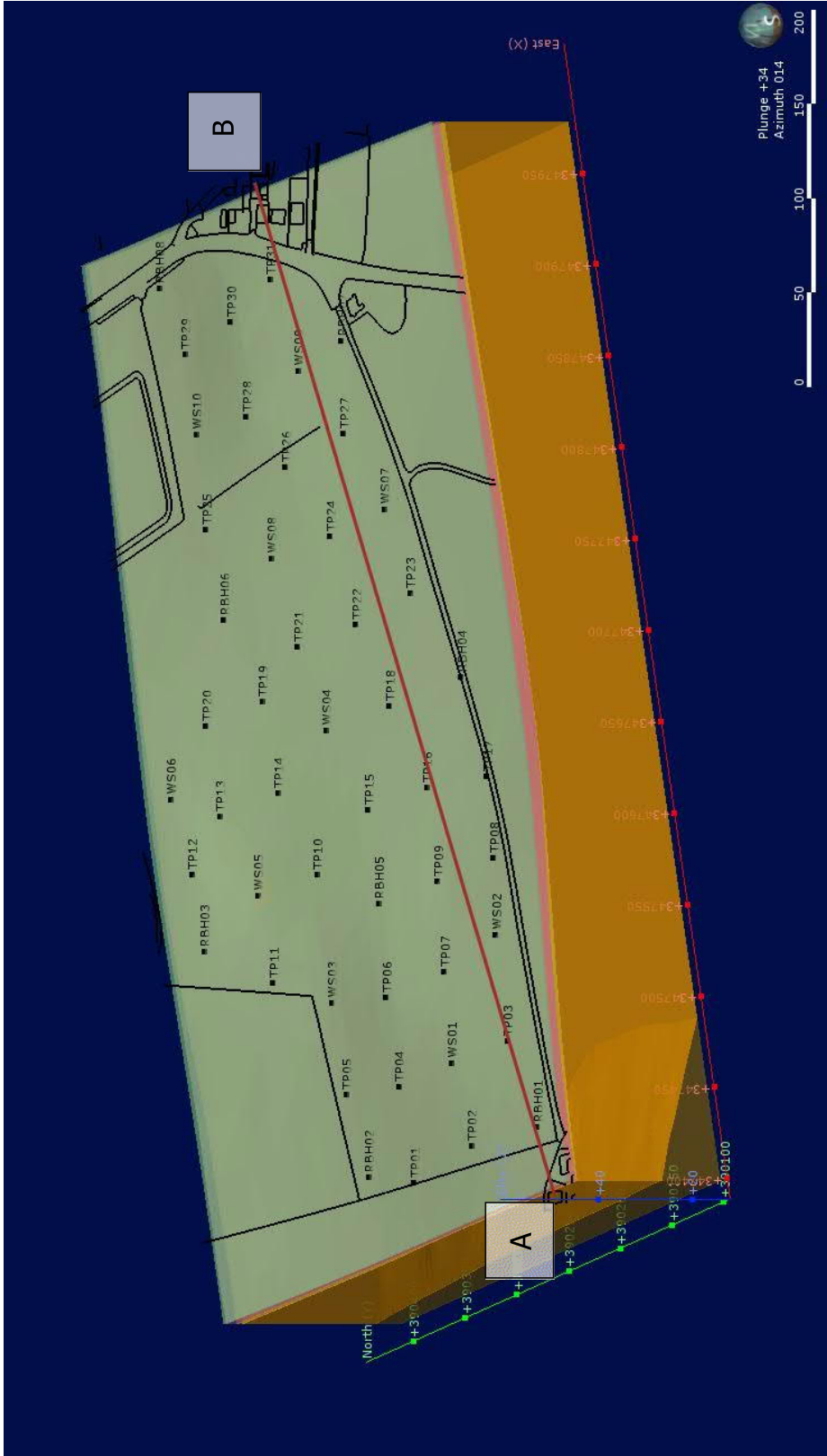
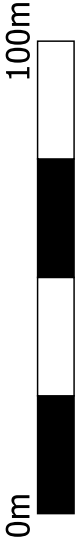
- TS: Topsoil
- GFD: Glaciofluvial Deposits
- GT: Glacial Till
- WSST: Weathered Sandstone
- SST: Sandstone
- MDST: Mudstone
- Boreholes shown are within 20m of the cross section line and therefore may not directly correspond with the boundary lines along this plane.
- Glacial Till may be present as discontinuous lenses within Glaciofluvial Deposits.

Location

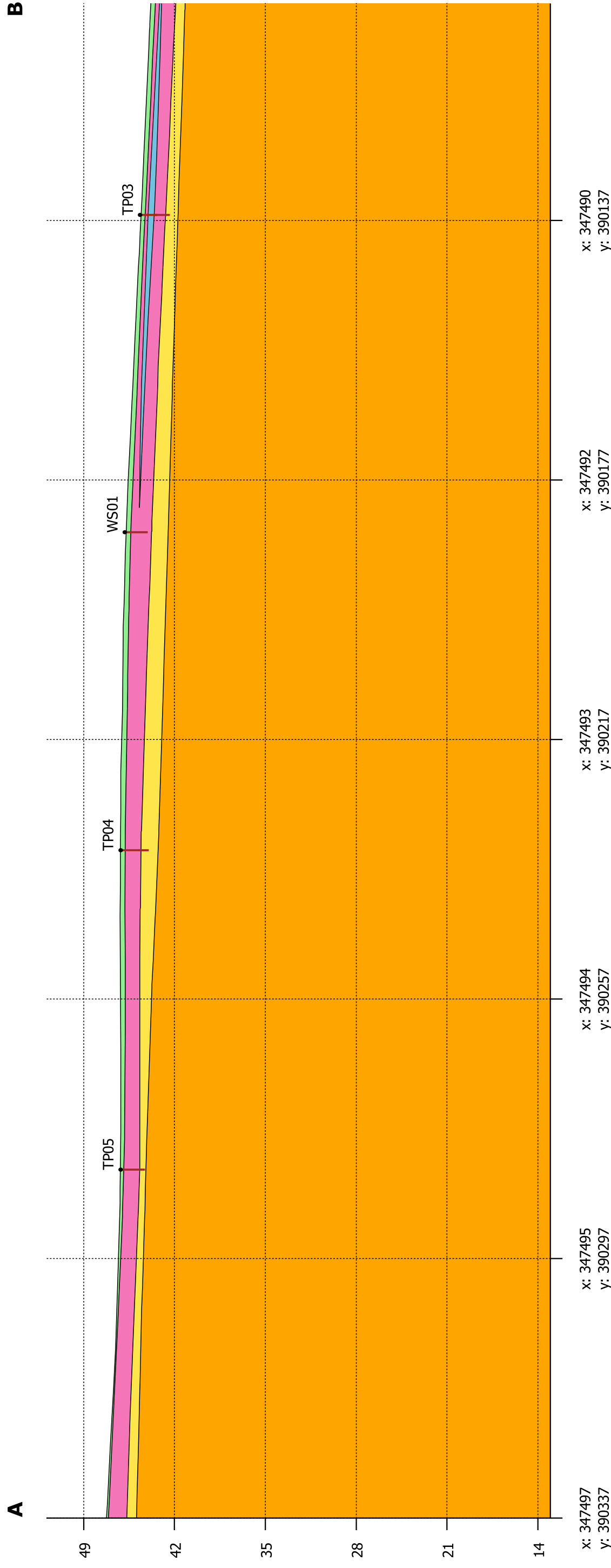
- A: 347417, 390113
- B: 347963, 390240

Scale: 1:1,600

Vertical exaggeration: 3x



Cross Section 3



Lithology

- Legend: GFD MDST SST TS WSST GT

Notes

TS: Topsoil

GFD: Glaciofluvial Deposits

GT: Glacial Till

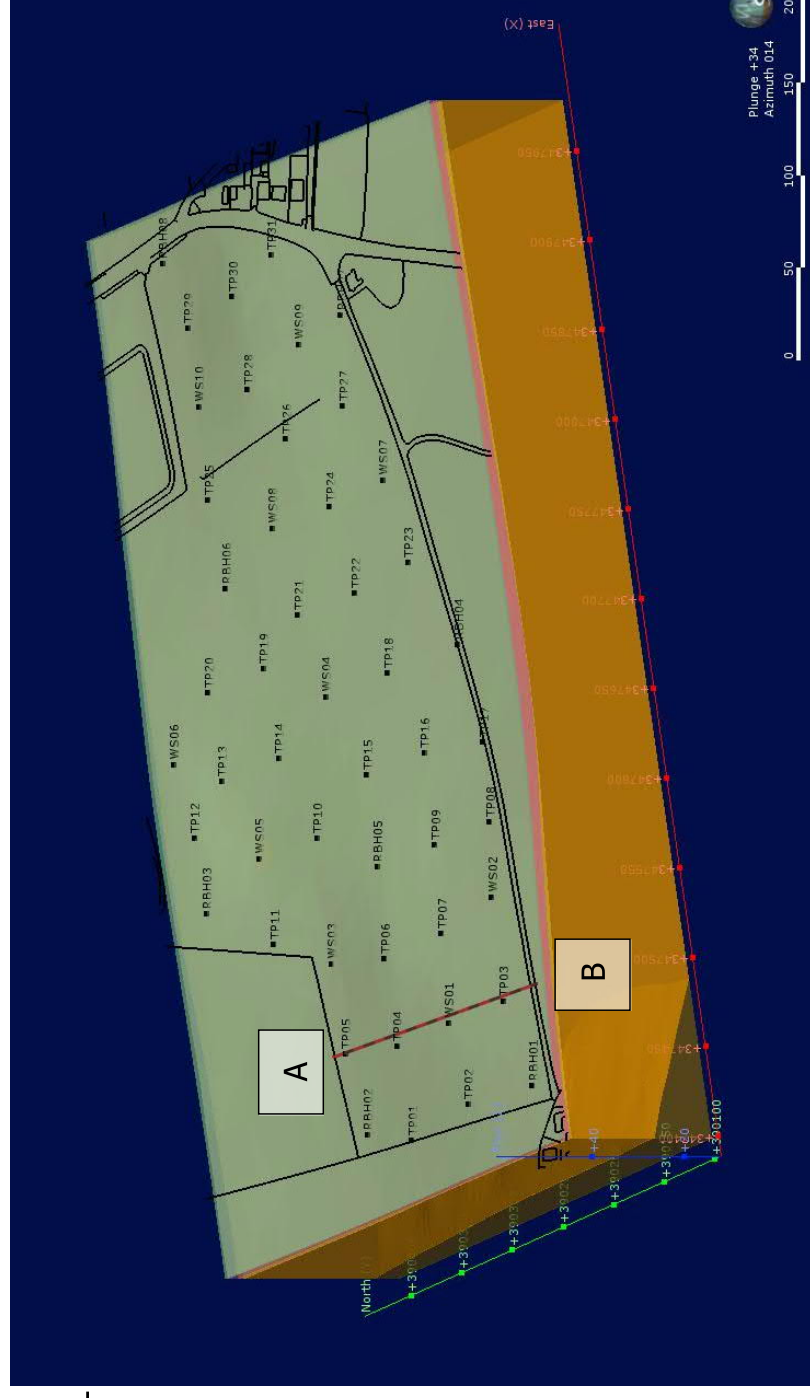
WSST: Weathered Sandstone

SST: Sandstone

MDST: Mudstone

Boreholes shown are within 10m of the cross section line and therefore may not directly correspond with the boundary lines along this plane.

Glacial Till may be present as discontinuous lenses within Glaciofluvial Deposits.



Location

A: 347497, 390337

B: 347489, 390103

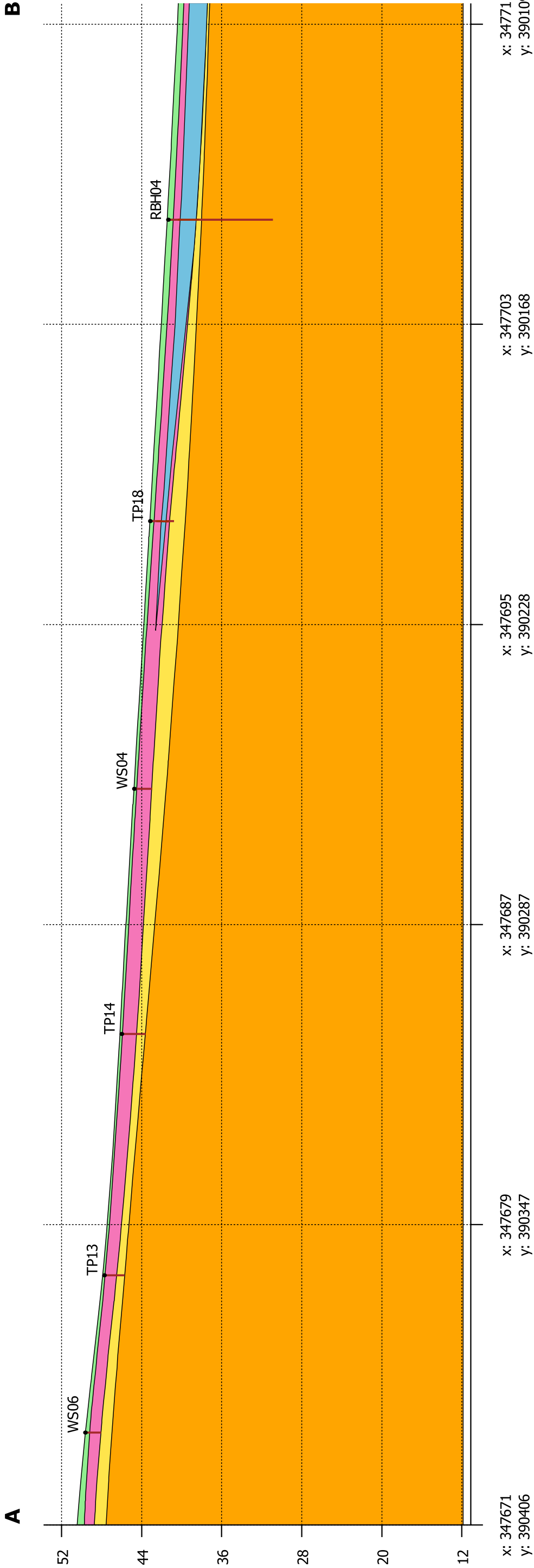
Scale: 1:630

Vertical exaggeration: 2x

0m

50m

Cross Section 4



Lithology

GFD

TS

WSST

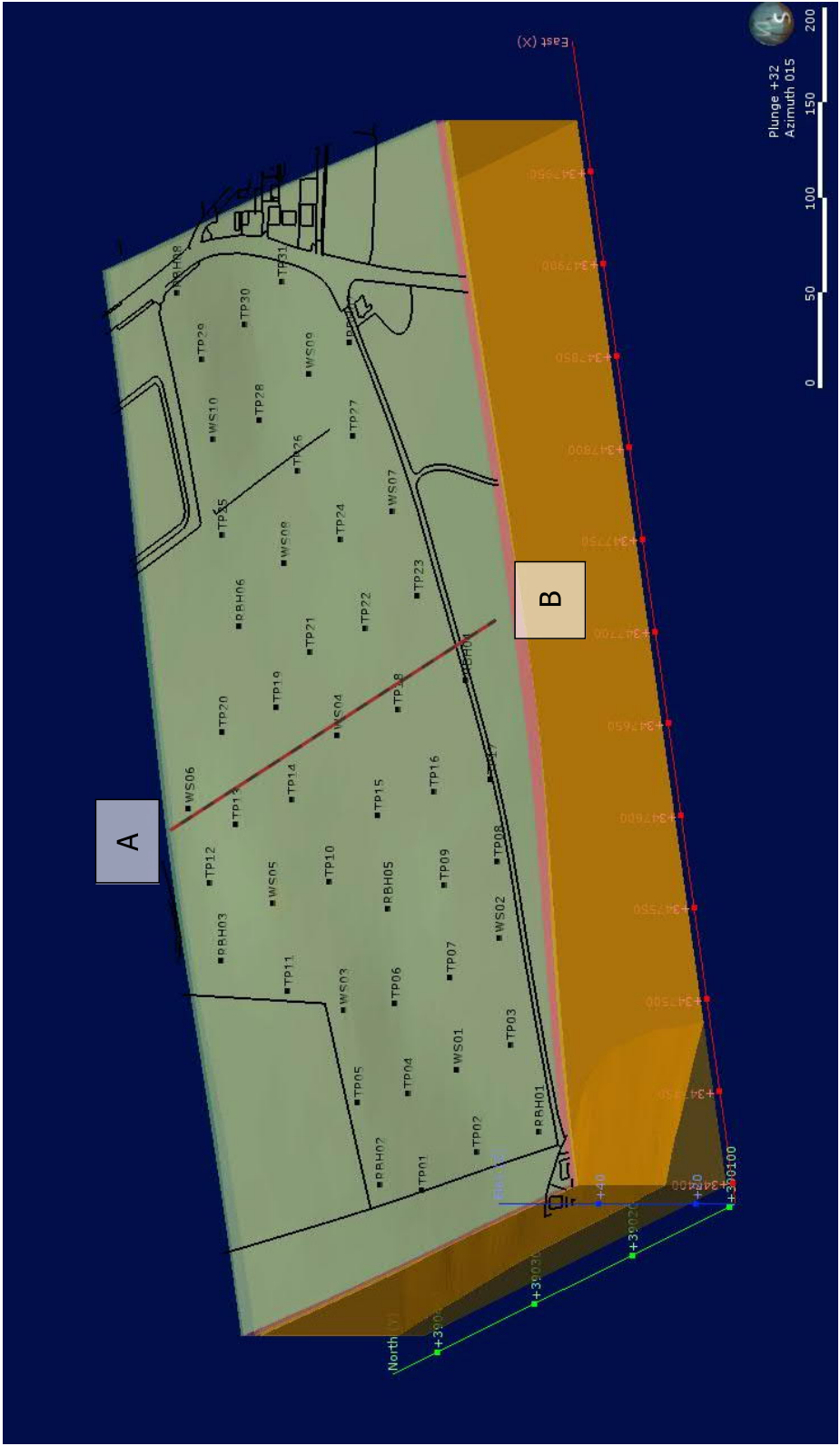
GT

Notes

TS: Topsoil
GFD: Glaciofluvial Deposits
GT: Glacial Till
WSST: Weathered Sandstone
SST: Sandstone
MDST: Mudstone

Boreholes shown are within 10m of the cross section line and therefore may not directly correspond with the boundary lines along this plane.

Glacial Till may be present as discontinuous lenses within Glaciofluvial Deposits.



Location

A: 347671, 390406
B: 347711, 390105

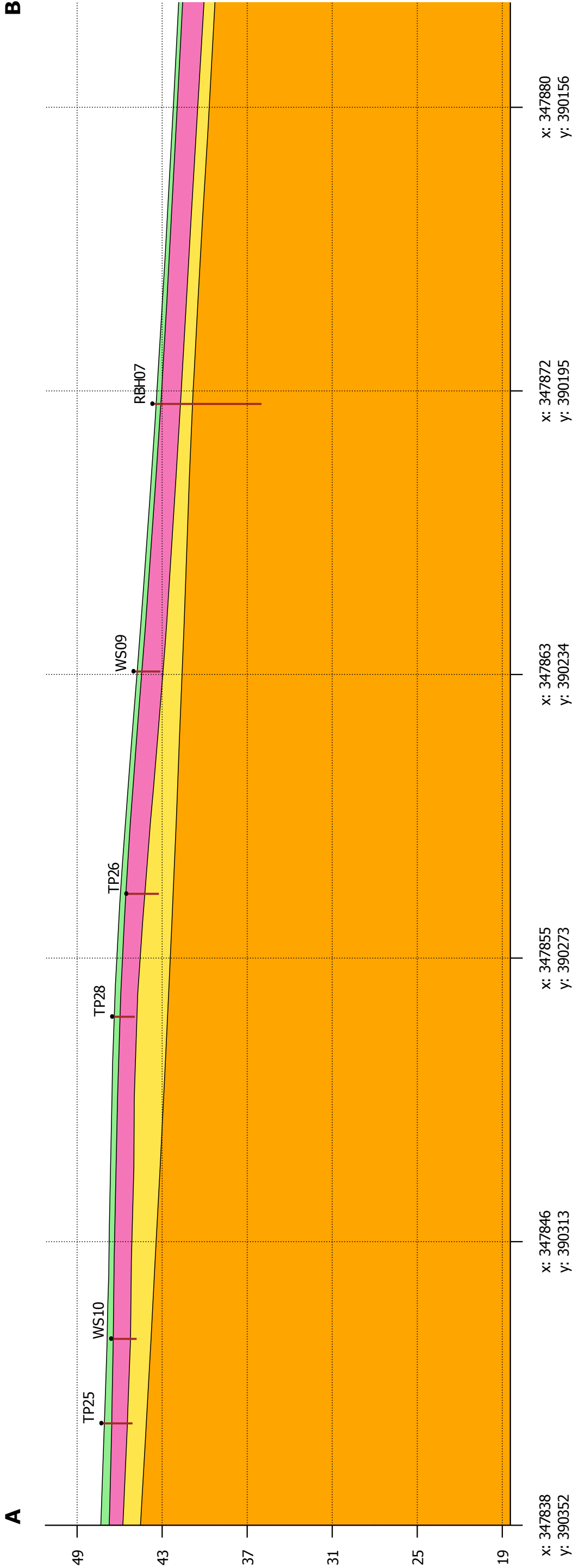
Scale: 1:820

Vertical exaggeration: 2x

0m

50m

Cross Section 5



Lithology

GFD

SST

TS

WSST

Notes

TS: Topsoil

GFD: Glaciofluvial Deposits

WSST: Weathered Sandstone

SST: Sandstone

MDST: Mudstone

Boreholes shown are within 10m of the cross section line and therefore may not directly correspond with the boundary lines along this plane.

Glacial Till may be present as discontinuous lenses within Glaciofluvial Deposits.

Location

A: 347838, 390352

B: 347883, 390142

Scale: 1:580

Vertical exaggeration: 2x

0m

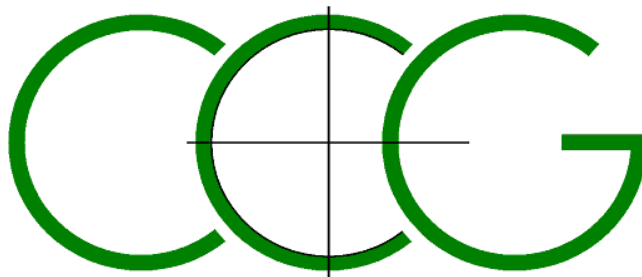
50m

100m

150m

200m

H. CC Geotechnical February 2018 GI Factual Report



CCG-C-18-10117

**GROUND INVESTIGATION FOR SITE AT
FOX`S BANK LANE, WHISTON**

FACTUAL REPORT

APRIL 2018



Prepared by:

CC GEOTECHNICAL LTD
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Telephone: 0151 545 2750
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1.0 INTRODUCTION

CC GEOTECHNICAL LIMITED (CCG) was instructed by **MOTT MACDONALD LTD (The Engineer)** acting on behalf of **KNOWSLEY METROPOLITAN BOROUGH COUNCIL (The Client)** to provide geotechnical fieldwork investigation and laboratory testing services in connection with a potential development of a parcel of agricultural land at Fox's Bank Lane, Whiston. It is understood that the site is proposed for residential development, possibly including a new school.

The site is located approximately 550m North of the M62. The OS grid co-ordinates for the approximate site centre are 347629E 390265N. It extends to an area of approximately 12.5Ha and comprises open farmland. The topography falls from north to south from around 50m AOD to 40m AOD. Access to the site is off Fox Bank Lane to the east.

The location of the site is as shown on **CCG** Drawing No. CCG-C-18-10117-1 presented in Appendix A.

2.0 PURPOSE OF THE INVESTIGATION

The purpose of the ground investigation was to provide geotechnical and geo-environmental information on ground conditions underlying the site, collating factual data on the engineering and chemical properties of the soils, and this document is a factual compilation of the data obtained. No interpretations have been placed on the findings.

The data contained herein should be read in conjunction with the Notes on Limitations, presented in Appendix H.

3.0 DOCUMENTED GEOLOGY

The geology of the site was researched by reference to the **British Geological Survey (BGS)** 1:50, 000 Scale Sheet 97 Runcorn, which indicates that the superficial deposits on site comprise of glacial till comprising red / brown sandy stony clay with impersistent beds of sand.

The documented solid geology comprises Kinnerton Sandstone Formation. It is also noted that along the western site boundary the Eccleston West Fault is shown to be present (within the site), and to the west of this fault the Pennine Middle Coal Measures are shown to subcrop.

3.0 FIELDWORK

3.1 Introduction

The fieldwork associated with this intrusive investigation were carried out in February 2018 and comprised the following:

- Pre/post investigation surveying of borehole / trial pit locations for OS coordinates and elevation (m AOD)
- The sub-scanning of exploratory locations to confirm the absence of buried services
- The undertaking of TRL DCP tests to 1mbgl at all 18nr borehole locations (WS01-WS10 & RBH01-RBH08)
- The manual excavation of 1.2m deep service clearance pit at all 18nr borehole locations (WS01-WS10 & RBH01-RBH08)
- The sinking of 10nr boreholes to refusal by dynamic sampling methods (WS01 – WS10)
- The sinking of a further 8nr boreholes to refusal on rockhead by dynamic sampling methods, further advancing the boreholes by rotary coring or rotary open-hole drilling methods to depths of up to 30mbgl (RBH01 – RBH08).
- The mechanical excavation of 31nr trial pits to bedrock
- The installation of 50mm HDPE plain and slotted well-tube complete with filter pack response zones, bentonite seals and associated headworks at 10nr borehole positions.
- The subsampling of soil arisings for soil contamination / classification testing

The fieldwork was carried out in accordance with the UK Specification for Ground Investigation: 2nd Edition: 2011, and BS10175: 2011, BS5930: 2015, and BS EN 1997-2: 2007 Eurocode 7, insofar as they related to the scope of the investigation.

The locations of the exploratory positions were instructed by **MOTT MACDONALD** with the locations being jointly set out by **CCG / MOTT MACDONALD**. Following completion of fieldwork, all locations were surveyed to OS coordinates and OD elevations. The layout of the investigation is as annotated on the Exploratory Hole Location Plan, provided in Appendix A.

3.1 Dynamic Sampling Boreholes

Following completion of the TRL DCP tests, Dynamic Sampling Boreholes were sunk by tracked Dando Terrier rigs. Each borehole location was commenced at the base of a 1.2m deep manually excavated service clearance pit, scanned using a CAT service scanner before and during the excavation.

All boring tools were decontaminated prior to commencement.

Standard Penetration Tests (SPT) were carried out at 1m depth intervals throughout the borehole depth.

Logs of the boreholes, annotated with SPT 'N' values are given in Appendix B.

3.2 Rotary Boreholes

In accordance with the specified scope of works, 8nr boreholes (RBH01 – RBH08) were advanced to bedrock using dynamic sampling methods, followed by rotary coring, using a rig deploying 90mm diameter coring tools and air / mist flush. In some locations boreholes were further advanced by rotary open hole drilling. The boreholes were terminated at varying depths from a minimum of 6.7mbgl (RBH03) to a maximum of 30mbgl (RBH01 & RBH02).

Each borehole location was commenced at the base of a 1.2m deep manually excavated service clearance pit, scanned using a CAT service scanner before and during the excavation.

Logs of the boreholes, annotated with sampling details in the drift, SPT 'N' values, TCR, SCR, RQD and Fracture Index values are given in Appendix B.

Photographs of the rock core recovery are also contained at Appendix B.

3.3 Trial Pit Excavations

31nr trial pits were excavated by a 13t tracked mechanical excavator to depths of up to 4mbgl.

The exposures were carefully logged and sampled, and the arisings then returned to the excavations in the reverse sequence of their excavation to preserve, insofar as was possible, the original lithology.

Logs of the pits annotated with details of sub-sampling and hand shear vane test data are given in Appendix C.

Photographs of the trial pit exposures and arisings are also provided at Appendix C.

3.4 Monitoring Installations

50mm diameter monitoring standpipes were installed in 10nr boreholes as directed by **MOTT MACDONALD**.

Standpipes comprised 50mm HDPE well pipe, each with a discrete perforated section set in a filter pack response zone, with the plain wall pipe set in bentonite.

Standpipe response details are as tabulated hereunder.

Table 1: Standpipe Response Zones	
BH Number	Standpipe Response Zone
WS01	1.20 – 1.80mbgl
WS04	1.20 – 1.80mbgl
WS06	1.20 – 1.80mbgl
WS07	1.20 – 1.80mbgl
RBH01	1.45 – 1.85mbgl
RBH02	17.80 – 19.80mbgl
RBH04	9.50 – 10.50mbgl
RBH05	10.50 – 11.50mbgl
RBH06	1.20 – 1.80mbgl
RBH08	1.20 – 1.80mbgl

Headworks at each installation comprised of a gas valve, protected by a raised steel cover set in concrete.

Details of the monitoring installations are provided on the borehole logs contained in the relevant appendices.

On completion of the fieldwork, all shallow standpipe installations were recorded to be dry. Groundwater in RBH02 was recorded to stand at around 17mbgl.

Data from subsequent standpipe monitoring visits is presented in Appendix G.

3.5 TRL DCP Tests

CBR profiles were derived to a depth of 1mbgl (WS01-WS10 & RBH01-RBH08), using the TRL DCP apparatus. The results of the tests are provided in Appendix D.

4.0 LABORATORY TESTING

4.1 Soil and Rock Engineering testing

A programme of soil and rock engineering testing was undertaken. The programme comprised the following determinations:

- Determination of Soil Moisture Content in accordance with BS 1377: Part 2: Clause 3.2: 1990
- Determination of Particle Size Distribution by wet sieve in accordance with BS 1377: Part 2: 1990
- Determination of liquid limit, plastic limit, and plasticity index in accordance with BS 1377: Part 2: 1990
- Determination of Uniaxial Compressive Strength of rock in accordance with ISRM 2007: Suggested Methods
- Determination of point load strength of rock in accordance with ISRM 1985: Suggested methods

The soil and rock engineering test results are presented in Appendix E.

4.2 Chemical testing

A chemical analysis programme was undertaken at a UKAS / MCERTS accredited laboratory and comprised the analysis of soil, groundwater and leachates to suites of contaminants, as specified by *The Engineer*.

The results of the chemical analyses are presented along with UKAS / MCERTS test accreditation certification in Appendix F.