

5. GROUND CONDITIONS

The site investigation has confirmed the expected natural geological formation of Glacial Till. Thin Made Ground deposits were encountered overlying the Till within each of the exploratory boreholes.

5.1 MADE GROUND

Made Ground deposits as encountered within the boreholes are described below:

BH	Depth below Ground Surface (m)	Description
BH1	GL – 0.40 0.40 – 0.60	Loose SAND with brick and shale fragments Loose, SHALE fragments
BH2	GL – 0.20 0.20 – 0.40	Loose, ashy, silty SAND with brick and shale. BRICK fragments
BH3	GL – 0.20 0.20 – 0.50	CONCRETE fragments. Medium dense SAND with shale fragments
BH4	GL – 0.20	Loose, silty SAND with brick and shale fragments
BH5	GL – 0.20	Loose, silty SAND with brick and shale fragments

As the above summary table illustrates, Made Ground deposits were present within each of the boreholes to depths of between 0.2m and 0.6m below ground surface. The formation comprised loose, silty sand with shale in Boreholes 4 and 5 (northern development plot) and ashy, silty sand with brick, shale and concrete in Boreholes 1, 2 and 3 (southern development plot).

5.2 GLACIAL TILL

The natural formation present beneath the Made Ground horizon comprises Glacial Till. The formation was encountered as a firm, firm to stiff and then stiff, brown and grey mottled clay. In Borehole 3, the cohesive formation present between 0.5m and 2m depth contained occasional fine, angular gravel.

SPT N values achieved within the formation are summarised below:

Depth Below Ground Surface (m)	SPT 'N' Values	SPT 'N' Range	SPT 'N' Mean Value
1	13, 14, 15, 16, 16	13 - 16	15
2	19, 19, 25, 26, 27	19 - 27	23
3	18, 18, 20, 20, 24	18 - 24	20
4	20, 22, 23, 24, 25	20 - 25	23

5.3 GEOTECHNICAL PROPERTIES

The results of Index test carried out on 5no samples of the cohesive Till formation have resulted in the following Liquid Limit and Plasticity Index values:

Liquid Limit Range (%): 47 - 53

Adjusted Plasticity Index Range (%): 23 - 29

The above values place the cohesive Till within the Intermediate Plasticity category.

A preliminary assessment of the tested cohesive soil's state of desiccation has been arrived at using the conservative empirical relationship between Natural Moisture Content (NMC) and Liquid Limit (LL) derived by Driscoll which considers that if the NMC is less than 40% the LL then the soil may be desiccated. Index test data for this site are summarised below:

Mean value of five determinations of NMC (%): 20.2

Mean value of five determinations of LL (%): 50.2

Ratio of NMC to LL = 0.40

Although the NMC/LL ratio is marginal using the Driscoll relationship, it is not considered that mitigation measures to deal with issues of soil desiccation will be required at the design stage.

5.4 GROUNDWATER

Table 1 illustrates that stabilised groundwater levels were measured in the borehole standpipes at the following depth ranges:

Borehole 1: 0.22 – 0.31 (mbgl)

Borehole 5: 3.27 – 3.37 (mbgl)

The measured values are likely representative of perched water present within the Till with the permanent groundwater table likely present at depth within the underlying Kinnerton Sandstone.

6 GEOTECHNICAL ASSESSMENT

6.1 GENERAL

It is understood that the proposed development will comprise 2no steel portal frame industrial units one to be constructed in the northern sub-site and the second in the southern sub-site. We understand that column loads will be within the light to medium category.

The site is characterised by thin Made Ground deposits overlying firm to stiff, cohesive Glacial Till of intermediate plasticity.

6.2 FOUNDATIONS

The natural firm to stiff Glacial Till formation that underlies the thin Made Ground deposits should be capable of supporting light to medium structural loads whilst maintaining total and differential settlements within accepted tolerances. Conventional strip or pad footings should therefore be suitable for the proposed development. Such foundations taken a minimum depth below finished grade of 900mm to found within the firm or firm to stiff Till may be designed using an allowable bearing capacity of 140kPa.

The cohesive Till present at the approximate foundation horizon is of Intermediate Plasticity and consequently, the recommendations of NHBC Standards Chapter 4.2 should be considered where footings lie within influencing distance of existing, recently felled or recently planted trees.

Foundation excavations should remain stable in the short term although some localised slumping of pit sides may be experienced in the thicker areas of Made Ground. Groundwater levels are variable due to the perched nature of the water within the Till and some seepages may be experienced within foundation excavations although these are unlikely to be fast or significant in volume.

6.3 GROUND FLOOR SLABS

The borehole investigation has revealed that the natural cohesive formation present beneath the thin, superficial Made Ground horizon is of Intermediate Plasticity and as such will potentially be susceptible to volume changes in response to variations in natural moisture content. If the proposed industrial units are sensitive to differential movements between the slab and the structural frame it is recommended that the Made Ground and natural formation beneath the slab are replaced with well compacted engineering fill to a depth that exceeds the zone of seasonal moisture content change which is conventionally about 1m below ground surface. This precaution will minimise the impact of any such volume changes on the integrity of the ground floor slab.

The adoption of a suspended ground floor slab would eliminate this potential differential movement issue without the need for soil excavation and replacement, however; this option may require the construction of internal footings depending upon the dimensions of the slab and its working load bearing requirements.

If the proposed units are relatively tolerant of minor differential movements between the frame and structural slab then conventional slab on grade techniques may be employed whereby the slab is constructed upon a 150mm thick sub-base of well compacted engineering fill.

6.4 BELOW GROUND CONCRETE

The results of Soluble Sulphate and pH tests carried out on samples of the formation are summarised below:

No. of Tested Samples	Range of Water Soluble Sulphate Values (g/l)	Range of pH Values
10	<0.010 – 0.21	8.1 – 9.7

The measured pH and water soluble sulphate values fall within concrete Class DS-1 as defined in BRE Special Digest 1, 'Concrete in aggressive ground', 2005', with a corresponding ACEC class of AC-1s.

6.5 PAVEMENTS

Soil conditions at likely pavement formation level at both sub-sites comprise firm to stiff, intermediate plasticity clay. For such a formation with PI(%) values of around 30%, Interim Advice Note 73/06 Revision 1 (2009) indicates an applicable design CBR Value of 3% for a thin pavement construction and 4% for a thick pavement construction.

7 ENVIRONMENTAL CONSIDERATIONS

7.1 SOIL CONTAMINATION

7.1.1 GENERAL APPROACH

The UK approach to the assessment of contaminated land is based upon the principles of risk assessment. This is founded upon the 'source – pathway – target' model to establish the presence or potential presence of a pollutant linkage. The overall methodology is based upon a tiered approach to determine risk based remedial targets for soil involving site specific data collection.

Should the adopted criteria be exceeded, then two courses of action are available. Firstly, the pollutant link could be broken by undertaking remedial work such as providing clean soil cover. Alternatively, a more detailed risk assessment can be carried out to determine whether a statistically relevant pollutant link actually exists.

The proposed development comprises a pair of industrial units and consequently, for the purposes of risk assessment, an industrial land use has been adopted as the default category.

7.1.2 RISK SCREENING

7.1.2.1 HUMAN SITE OCCUPIERS AND CONSTRUCTION WORKERS

In terms of risk to human health, the results of the chemical testing data enclosed within Appendix E have been compared to the Tier 1 final chemical screening criteria for an industrial land use. A summary of the risk screening exercise is shown on Table 2. Reference to that table shows that the following determinant is present within the tested samples at a concentration that exceeds its Tier 1 screening chemical acceptance criteria value.

Potential Contaminant of Concern	Range of Measured Values (Mg/kg)	Chemical Acceptance Criteria Value (Mg/kg)	Number of Exceedances	Mean Value (Mg/kg)
Lead	73 - 1400	1100	1	263

The above table illustrates that the site wide mean value of Lead is less than its Tier 1 screening value and in accordance with CLR 11 recommendations the risk to human health across the two sub-sites from lead can be considered to be low.

7.1.2.2 STRUCTURES AND INFRASTRUCTURE

The maximum measured water-soluble sulphate value for the near surface natural soil is 0.21g/l with a corresponding pH range of 8.1 – 9.7. These represent benign conditions with respect to sulphate and acid attack on buried concrete and based upon the measured values the risk to buried structures at the site is considered to be very low. Concrete Class DS-1 with an ACEC Class of AC-1s is applicable.

None- barrier buried potable water supply pipework can be attacked by acids and they can be penetrated by hydrocarbons and other substances such as phenols which can have the effect of tainting water supplies. The concentrations of these substances at this site are such that the risk to non-barrier pipework is considered to be low; however, the

chemical data contained within Appendix E should be forwarded to the chosen potable water supplier for their consideration.

7.1.3 PROPOSED SOIL REMEDIAL MEASURES

The Tier 1 screening exercise has shown that the risk to human health at both sub-sites from potential contaminants of concern within the soil is considered to be low and consequently no specific soil remedial measures are proposed.

However, as is the case with all brownfield sites it is recommended that if any areas of potentially contaminated ground become apparent during the construction phase then they should be brought to the attention of the Engineer for further consideration.

Construction workers are considered to represent the highest risk group as they will likely be exposed to the near surface Made Ground materials during the groundworks phase of the development program. It is recommended therefore that appropriate PPE is worn by all site operatives and that clean areas are designated for non-operational time spent on site.

7.2 GROUND GAS

Table 1 shows that methane gas was effectively absent from the borehole standpipe whilst carbon dioxide concentrations were measured at a maximum concentration of 0.9%. Very low gas pressures were detected, whilst flow rates were less than 0.1l/hr.

The ground gas situation has been assessed using the methodology outlined in CIRIA Publication C665 'Assessing risks posed by hazardous ground gases to buildings'. Under that methodology, the site has been assessed as falling within the Characteristic Situation 1 category, where no special precautions are required with respect to carbon dioxide and methane in the ground.

The proposed units will not require radon membranes.

There should be no requirement for the inclusion of gas resistant membranes within the ground floor construction of the proposed structures.

TABLES

Table 1**Proposed Industrial Development, R & R Engineering, Wrexham
Gas and Groundwater Readings****Gas Readings**

Date: 16/03/2021 Atmospheric Pressure: 10303mb

BH	Gas Flow (l/hr)	Borehole Pressure (mb)	Methane (%vol)		Methane (%LEL)		Carbon Dioxide (%vol)		Oxygen (%vol)		Other Gases (ppm)	
			Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	H2s	CO
1	<0.1	0.03	0.2	0.2	<2	<2	0.3	0.3	19.9	19.9	<1	<1
5	<0.1	0.04	0.2	0.2	<2	<2	0.8	0.8	19.0	19.0	<1	<1

Date: 30/03/2021 Atmospheric Pressure: 1015mb

BH	Gas Flow (l/hr)	Borehole Pressure (mb)	Methane (%vol)		Methane (%LEL)		Carbon Dioxide (%vol)		Oxygen (%vol)		Other Gases (ppm)	
			Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	H2s	CO
1	<0.1	0.03	0.2	0.2	<2	<2	0.4	0.4	19.8	19.8	<1	<1
5	<0.1	0.02	0.2	0.2	<2	<2	0.8	0.8	19.1	19.1	<1	<1

Date: 14/04/2021 Atmospheric Pressure: 1012mb

BH	Gas Flow (l/hr)	Borehole Pressure (mb)	Methane (%vol)		Methane (%LEL)		Carbon Dioxide (%vol)		Oxygen (%vol)		Other Gases (ppm)	
			Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	H2s	CO
1	<0.1	0.02	0.2	0.2	<2	<2	0.4	0.4	19.7	19.7	<1	<1
5	<0.1	0.02	0.2	0.2	<2	<2	0.9	0.9	18.8	18.8	<1	<1

Groundwater Readings (mbgl)

BH	16/03/2021	30/03/2021	14/04/2021
1	0.22	0.28	0.31
5	3.27	3.31	3.37

Gas and groundwater monitoring undertaken by: P. Cosgrove
 Equipment used: GA2000 Plus, Flow pod S/N 419

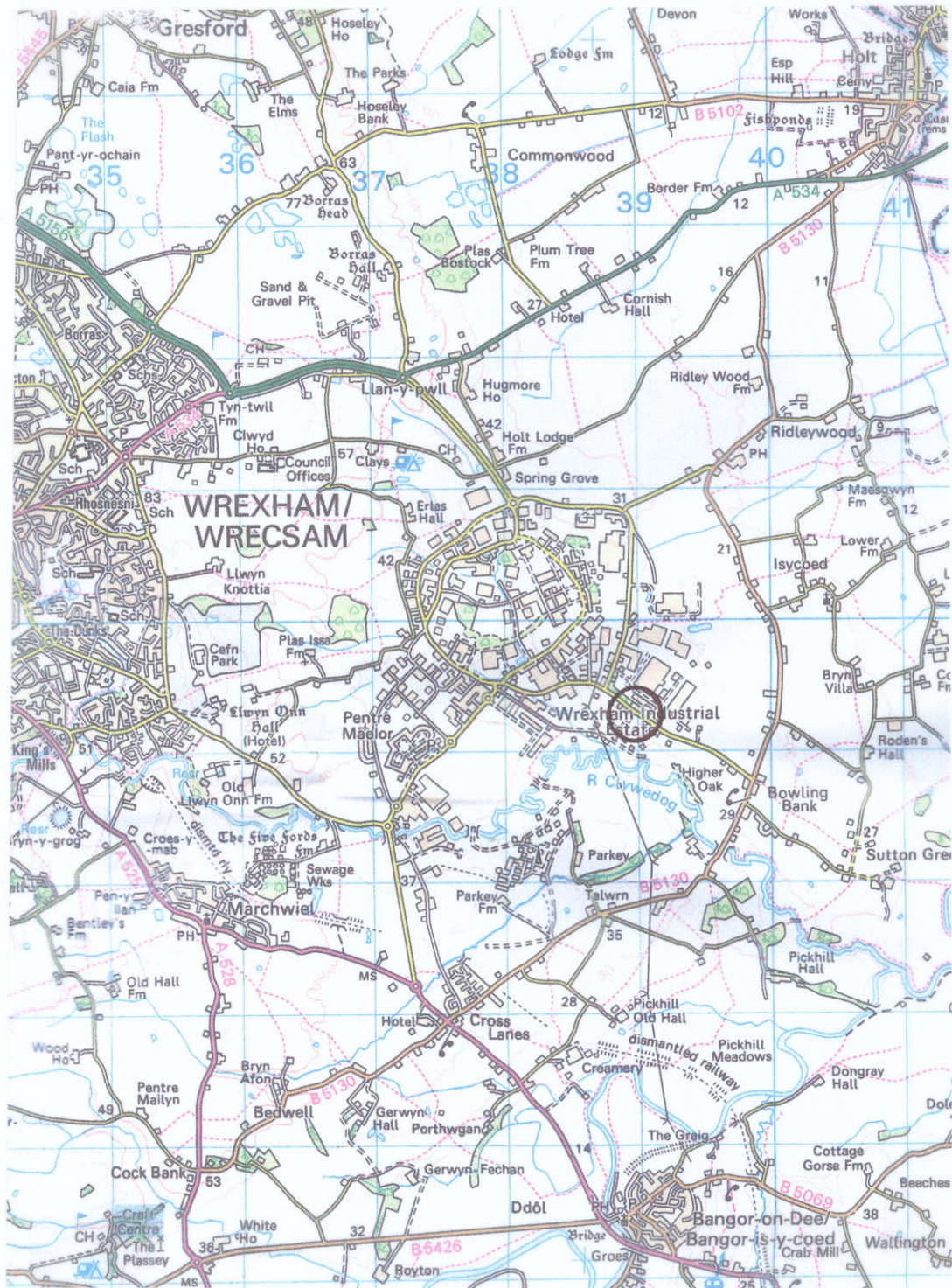
Table 2**Proposed Industrial Development, R and R Engineering****Human Health Screening Values for a Commercial/Industrial Land Use versus Measured Values - Soils**

Determinant	Final screening chemical acceptance criteria mg/kg	Derivation Tool	Range of Measured Values	No. of Values > acceptance criteria (location)
Asbestos	Presence	Stereo Microscope	None Detected	0
Phenols	1500	LQM/CIEH:S4UL	<0.3	0
US EPA Priority PAHs				
Acenaphthene	97000	LQM/CIEH:S4UL	<0.1 – 0.41	0
Acenaphthylene	97000	LQM/CIEH:S4UL	<0.1	0
Anthracene	54000	LQM/CIEH:S4UL	<0.1 – 0.80	0
Benzo(a)Anthracene	170	LQM/CIEH:S4UL	<0.1 – 4.2	0
Benzo (a)pyrene	77	DEFRA:C4SL	<0.1 – 6.3	0
Benzo (b)flouranthene	44	LQM/CIEH:S4UL	<0.1 – 7.4	0
Benzo(k)flouranthene	1200	LQM/CIEH:S4UL	<0.1 – 3.4	0
Benzo(g,h,i) perylene	4000	LQM/CIEH:S4UL	<0.1 – 5.7	0
Chrysene	350	LQM/CIEH:S4UL	<0.1 – 4.2	0
Di-benzo(a,h)anthracene	3.6	LQM/CIEH:S4UL	<0.1 – 2.0	0
Indeno(1,2,3-cd)pyrene	510	LQM/CIEH:S4UL	<0.1 – 5.2	0
Flouranthene	23000	LQM/CIEH:S4UL	<0.1 – 6.8	0
Flourene	68000	LQM/CIEH:S4UL	<0.1 – 0.65	0
Napthalene	400	LQM/CIEH:S4UL	<0.1 – 2.1	0
Phenanthrene	22000	LQM/CIEH:S4UL	<0.1 – 2.9	0
Pyrene	64000	LQM/CIEH:S4UL	<0.1 – 8.1	0
Heavy Metals/ Metalloids				
Arsenic	640	DEFRA C4SL	11 - 19	0
Cadmium	420	DEFRA C4SL	0.19 – 0.62	0
Chromium	86000	LQM/CIEH:S4UL	12 - 74	0
Copper	68000	LQM/CIEH:S4UL	18 - 77	0
Lead	1100	DEFRA C4SL	73 - 1400	1
Mercury	1100	LQM/CIEH:S4UL	<0.12 - 0.58	0
Nickel	980	LQM/CIEH:S4UL	8.1 - 36	0
Selenium	12000	LQM/CIEH:S4UL	<0.20 – 0.37	0
Zinc	730000	LQM/CIEH:S4UL	79 - 260	0

Petroleum Hydrocarbons				
TPH Aliphatic C5-6	5900	LQM/CIEH:S4UL	<0.1	0
C6-8	7800	LQM/CIEH:S4UL	<0.1	0
C8-10	4800	LQM/CIEH:S4UL	<1	0
C10-12	23000	LQM/CIEH:S4UL	<1	0
C12-16	82000	LQM/CIEH:S4UL	<1 - 4.6	0
C16-21	1700000	LQM/CIEH:S4UL	<1 - 5.3	0
C21-35	170000	LQM/CIEH:S4UL	<1 - 34	0
C35-44	1700000	LQM/CIEH:S4UL	<1 - 5.3	0
TPH Aromatic C5-7	46000	LQM/CIEH:S4UL	<0.1	0
C7-8	110000	LQM/CIEH:S4UL	<0.1	0
C8-10	8100	LQM/CIEH:S4UL	<1	0
C10-12	28000	LQM/CIEH:S4UL	<1	0
C12-16	37000	LQM/CIEH:S4UL	<1 - 9.3	0
C16-21	28000	LQM/CIEH:S4UL	<1 - 18	0
C21-35	28000	LQM/CIEH:S4UL	<1 - 210	0
C35-44	28000	LQM/CIEH:S4UL	<1 - 19	0

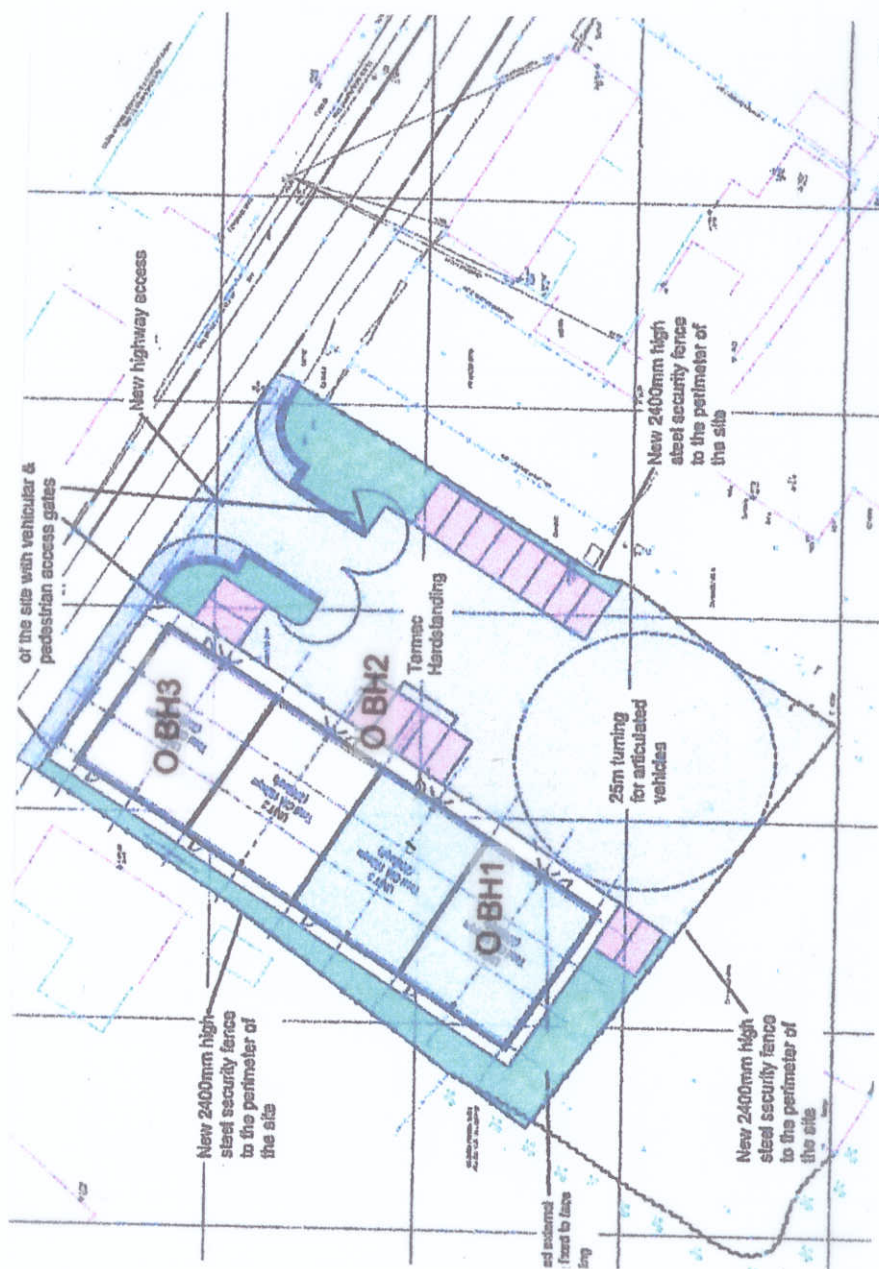
1% SOM adopted for SGV calculation

FIGURES



Site Location Plan

SP ASSOCIATES	Report: S1727	Site: R & R Engineering, Wrexham	Figure: 1
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Borehole Location Plan – South of Oak Road



APPENDIX A

Historical Ordnance Survey Maps

Historical Mapping Legends

Ordnance Survey County Series and Ordnance Survey Plan 1:10,560

Gravel Pit	Sand Pit	Other Pits	Quarry	Single	Orchard	Marsh	Oslers	Reeds	Deciduous	Brushwood	Fir	Furze	Rough Pasture	Trigonometrical Station	Bench Mark	Well, Spring, Boundary Post	Surface Level
Arrow denotes flow of water	Site of Antiquities	Pump, Guide Post, Signal Post	Instrumental Contour	Main Roads	Minor Roads	Sunken Road	Road over Railway	Railway over Road	Road over River or Canal	Road over Stream	County Boundary (Geographical)	County & Civil Parish Boundary	Administrative County & Civil Parish Boundary	County Borough Boundary (England)	County Borough Boundary (Scotland)	Rural District Boundary	Civil Parish Boundary
Sketches of various features including pits, woodlands, roads, railways, and boundaries.																	

Ordnance Survey Plan 1:10,000

Chalk Pit, Clay Pit or Quarry	Sand Pit	Refuse or Slag Heap	Dunes	Coniferous Trees	Orchard	Bracken	Marsh	Reeds	Saltings	Direction of Flow of Water	Building	Glasshouse	Sloping Masonry	Pylon	Electricity Transmission Line	Pole	Cutting	Embankment	Standard Gauge Multiple Track	Standard Gauge Single Track	Siding, Tramway or Mineral Line	Narrow Gauge	Geographical County	Administrative County, County Borough or County of City	Municipal Borough, Urban or Rural District, Borough or District Council	Borough, Borough or County Constituency	Civil Parish	Shows alternately when coincidence of boundaries occurs
Sketches of various features including pits, dunes, trees, orchards, marshes, buildings, and infrastructure.																												

1:10,000 Raster Mapping

Gravel Pit	Rock	Boulders	Shingle	Sand	Slopes	General detail	Overhead detail	Multi-track railway	County boundary (England only)	District, Unitary, Metropolitan, London Borough boundary	Civil, parish or community boundary	Constituency boundary	Non-coniferous trees	Coniferous trees	Positioned tree	Coppice or Oslers	Heath	Marsh, Salt Marsh or Reeds	Flow arrows	Mean low water (springs)	Electricity transmission line (with poles)	Triangulation station	Pylon, flare stack or lighting tower	Glasshouse	Important Building
Sketches of various features including pits, rocks, boulders, shingle, sand, slopes, and infrastructure.																									

Mapping Type	Scale	Date	Pg
Denbighshire	1:2,500	1873	3
Denbighshire	1:10,560	1881	4
Cheshire	1:10,560	1881	5
Denbighshire	1:2,500	1889	6
Denbighshire	1:10,560	1889	7
Denbighshire	1:2,500	1911 - 1912	8
Denbighshire	1:10,560	1914	9
Denbighshire	1:10,560	1938	10
Ordnance Survey Plan	1:2,500	1961 - 1986	11
Additional SIMs	1:2,500	1964	12
Ordnance Survey Plan	1:10,560	1964	13
Ordnance Survey Plan	1:2,500	1972	14
Ordnance Survey Plan	1:10,000	1979	15
Additional SIMs	1:2,500	1988 - 1990	16
Additional SIMs	1:2,500	1989	17
Ordnance Survey Plan	1:2,500	1990	18
Ordnance Survey Plan	1:10,000	1992	19
Ordnance Survey Plan	1:2,500	1992	20
Large Scale National Grid Data	1:2,500	1992	21
Large Scale National Grid Data	1:2,500	1994	22
10K Raster Mapping	1:10,000	2000	23
10K Raster Mapping	1:10,000	2006	24
VectorMap Local	1:10,000	2020	25

Ordnance Survey mapping included:

Sitecheck Historical Maps

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Customer Ref: S1728
National Grid Reference: 339070_349200
Site Area (Ha): 1.2

Site Details

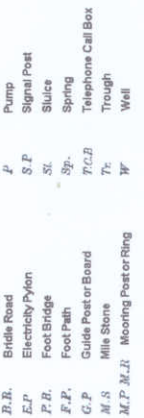
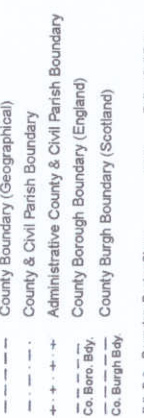
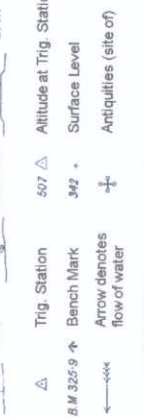
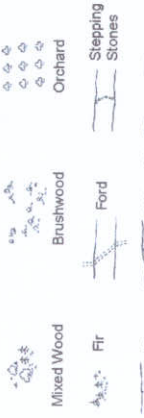
R and R Engineering, R and R Engineering Workshop, Oak Road, Wrexham Industrial Estate, WREXHAM, LL13 9RG
Full Terms and Conditions can be found on the following link:
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Landmark

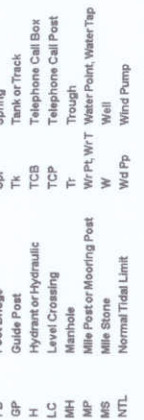
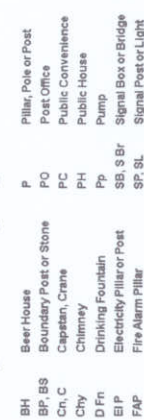
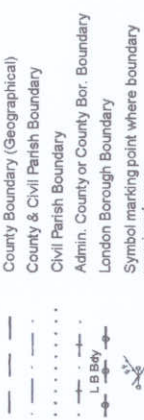
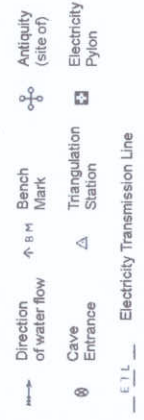
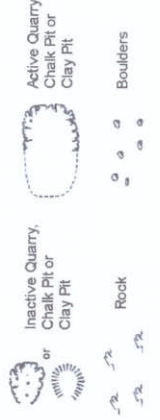
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Historical Mapping Legends

Ordnance Survey County Series and Ordnance Survey Plan 1:2,500

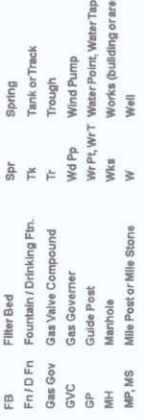
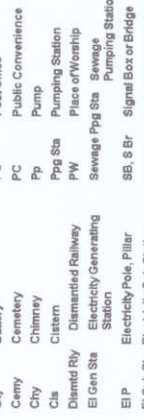
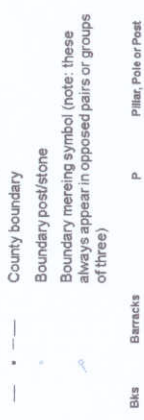
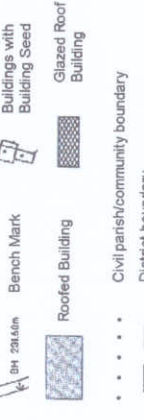
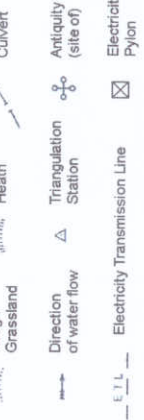


Ordnance Survey Plan, Additional SIMs and Supply of Unpublished Survey Information 1:2,500 and 1:1,250



Sitecheck Historical Maps

Large-Scale National Grid Data 1:2,500 and 1:1,250



Order Details

Order Number: 274153256_2_1
Customer Ref: S1728
National Grid Reference: 339070_349200
Site Area (Ha): 1.2

Site Details

R and R Engineering, R and R Engineering Workshop, Oak Road, Wrexham Industrial Estate, WREXHAM, LL13 9RG
Full Terms and Conditions can be found on the following link:
<http://www.landmarkinfo.co.uk/Terms/Show/515>

Landmark

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A Landmark Information Group Service v50.0 01-Mar-2021 Page 2 of 25