

SP ASSOCIATES

**PHASE II GEO-ENVIRONMENTAL
ASSESSMENT
PROPOSED INDUSTRIAL DEVELOPMENT
SITE 2
WREXHAM INDUSTRIAL ESTATE**

Client: FI Real Estate Management Ltd

Report Number: S1671- 2

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PROPOSED INDUSTRIAL DEVELOPMENT
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WREXHAM INDUSTRIAL ESTATE**

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REPORT No S1671-2

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EXECUTIVE SUMMARY

The Site	The site is located within Wrexham Industrial Estate which is a large industrial area located about 4km to the east of Wrexham town centre. The site's National Grid reference is 337428 349683 (site centre) and its location within the industrial estate is shown on Figure 1. The site is rectangular in shape and occupies an area of about 0.89 hectares. It is relatively flat with a very slight fall of about 1.5m from north-west to south-east. A densely vegetated area lies within the north-western part of the site with a number of mature trees present along its north-eastern boundary. A few semi-mature trees are present within the southern site area and a brick-built sub-station is located within the south-eastern site area. The site is bounded by industrial/commercial properties to the north-east, south-east and north-west and by Clywedog Road North to the south-west. Access to the site can be gained from Clywedog Road North.
History	Prior to the late 1930s the site comprised agricultural land and was characterised by the presence of a track which cut across the northern site area and by the presence of several small ponds two of which were located in the central north-eastern site area and one in the central north-western site area. At some time around the end of the 1930s and the beginning of the 1940s the wider area was developed as ROF Wrexham which was created to manufacture Cordite. By the late 1940s the ponds had been infilled and a number of structures were present along with woodland, paths often in cutting, and mounds (refer Figure 4). At some point in time between 1964 and 1978 all site structures with associated cuttings, mounds and hydrants had been removed although a number of paths within cutting remained.
Geology	The site is underlain by solid strata of the Salop Formation which comprises sequences of mudstone, sandstone and conglomerate. It is overlain by up to 55m of Devensian Till that typically comprises firm to stiff, sandy, gravelly clay with occasional lenses and beds of sand and gravel with inter-bedded laminated silts. It is anticipated that due to the site's historical use as part of ROF Wrexham there may be pockets and areas of Made Ground present along potentially with some buried structures. The site lies within a Coal Authority Coal Mining Reporting Area; however, the mineral resources lie beneath a thick cover of Drift deposits (about 55m) and are located at considerable depth beneath rockhead.
Hydrogeology	The Salop Formation is classified as a Secondary A aquifer whilst the overlying Till is classified as a Secondary Undifferentiated Aquifer.
Radon Gas	The site is in a Lower Probability radon area where less than 1% of properties are above the Radon action level. Radon protection will not be required for the proposed development.
Ground Investigation	Boreholes: A total of 5no boreholes were sunk across the site on the 5th March 2020 using a window sampler drilling rig. The boreholes were positioned to coincide with the location of the proposed

	development unit and were taken to depths of between 4.45m and 6.45m below ground surface. Standard Penetration Tests were carried out at 1m intervals within each borehole with full depth liner soil samples being recovered for soil description and testing requirements. Trial Pits: A total of 4no trial pits were excavated across the site on the 12th March 2020 using a wheeled excavator with back-actor. The pits were positioned so as to coincide with historic site features and were taken to depths of 2m and 2.2m below ground surface where they were terminated within stiff natural formation. Laboratory Testing: The following list of potential contaminants of concern has been specified for the laboratory testing program on soil samples: Asbestos, phenols, heavy metals, inorganic chemicals, Speciated Petroleum Hydrocarbons, PAHs, acetone and explosives. With regard to geotechnical testing, 4no samples of the cohesive formation taken from the approximate foundation horizon have been tested for Index properties in the laboratories of Socotec. In addition to the soil sampling and testing program, groundwater samples collected from the borehole standpipes have been tested in the laboratory of Chemtest to UK Drinking Water Standards. Dynamic Probes: A total of 6no dynamic probes were carried out in the locations shown on Figure 3 with each probe being taken to a depth of 3m below ground surface. Standpipe Monitoring: Concentrations of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide gas have been measured within the three borehole standpipes on four occasions within the period 25th February 2020 to the 27th March 2020. Total gas concentrations were taken using a GA2000 Plus meter with atmospheric pressure meter. The rate of gas flow from the standpipes was measured using a flow meter. Groundwater levels within the standpipes were also measured at each monitoring visit.
Ground Conditions	Made Ground: Made Ground deposits of up to 0.9m in thickness have been encountered within the trial pits which were positioned so as to coincide with historical site features to include a mound, a former pond and above ground structures. Glacial Till: The formation was encountered predominantly as a firm to stiff, brown mottled grey clay. The cohesive Till lies within the High Plasticity/Medium Shrinkage potential category. The relationship between natural moisture content and Liquid Limit suggests that the tested soils are not desiccated.

	Groundwater: During the monitoring period groundwater was measured at depths of between 1.42m and 1.80m below ground surface within Borehole 1, between 0.29m and 0.35m in Borehole 3 and at depths of between 0.67m and 0.72m in Borehole 5.
Foundations	Conventional strip or pad footings should be suitable for the proposed development and such foundations taken through any Made Ground or soft natural soils to found a minimum depth of 900mm below finished grade may be designed using an allowable bearing capacity of 130 kPa. The clay formation lies within the High Plasticity with Medium shrinkage potential category. Consequently, the recommendations of NHBC Standards Chapter 4.2 should be followed where foundations lie within influencing distance of existing, recently planted or recently felled trees. The relationship between Natural Moisture Content and Liquid Limit values indicate that the tested samples are not desiccated and based upon that data there should be no requirement for precautions to be taken to accommodate the potential effects of heave on foundations and slabs.
Ground Floor Slabs	The near surface natural formation comprises high plasticity clay and such materials can display significantly high volume change potential in response to moisture content variations. Such changes in volume post construction can induce undesirable differential movements between the slab and the frame of the structure if slab on untreated grade construction techniques have been adopted. If slab on grade construction is desirable it is recommended that the natural formation beneath the slab is excavated and replaced with well compacted engineering fill to a minimum depth of 900mm below finished grade. This will reduce the impact of potential post construction ground movements on the performance of the slab. As an alternative to the above construction method, a suspended slab could be adopted. Given the medium plasticity nature of the natural formation it is recommended that an under-slab void of at least 150mm is maintained. The adoption of a suspended slab may require the construction of internal footings depending upon the dimensions of the slab and its working load bearing requirements.
Below Ground Obstructions	The boreholes have failed to encounter any Made Ground or buried obstructions; however, the trial pits, which were located so as to intercept historical site features such as mounds, cuttings and structures, have each encountered Made Ground deposits of up to 0.90m in thickness. Within that formation, some of the trial pits have encountered boulders of concrete and bricks which are indicative of former foundations and below ground walls. The historical development drawing enclosed within Appendix C shows that there were a number of above ground structures present on the site as late as 1980 and anecdotal evidence suggests that such structures across the entire ROF Wrexham site may have been demolished to ground level only. The presence of buried obstructions such as brick walls, concrete footings and potentially basements within some areas of the site cannot therefore be entirely ruled out and it may be prudent to

	make an allowance within the development contract for their removal from foundation and slab excavations. It is possible that some overbreak may be experienced when such features are being removed. It is also possible that remnant pipework may be present within some areas of the site and precautions should be taken if any such structures are encountered as they may contain remnant deposits that could be contaminated with explosive residue. If below ground pipework is encountered during the site enabling works its presence should be brought to the attention of the Engineer for further assessment.
Pavements	The mean of the achieved DCP values equates to a DCP Blows per 100mm of 2.2 which places the formation from ground level to 1m depth in the soft category. Utilising that information in association with the recommendations provided within Interim Advice Note 73/06, 2009 for a clay with a PI value of 25% results in a recommended CBR value for design of between 2.5% and 5% for a thin layered pavement construction.
Below Ground Concrete	Below ground conditions with respect to concrete specification conform with Class DS-1 as defined in BRE Special Digest 1, 'Concrete in aggressive ground', 2005, with a corresponding ACEC class of AC-1s.
Soil Remedial Measures	Soil remedial measures should not be required at the site.
Groundwater Remedial Measures	No groundwater remediation measures should be required.
Gas Membranes	No gas protection measures should be required for the proposed development.

REPORT No S1671-2

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WREXHAM INDUSTRIAL ESTATE**

1. INTRODUCTION

SP Associates (SPA) has been appointed by FI Real Estate Management Ltd to carry out a Geo-Environmental Assessment at the site of a proposed industrial development located on a parcel of land within the Wrexham Industrial Estate known as Site 2. This study is predicated upon the findings of a Phase I, Geo-Environmental Desk Study Assessment carried out by Integra Consulting in September 2018, their reference 3036-13. That report should be referenced for specific historical land use and environmental data; however, for completeness, elements of that study are included within this report.

The scope of the investigation that forms the basis of this Phase II Assessment is as follows:

- Trial pits excavated using a wheeled excavator with back actor;
- Boreholes sunk using a windowless sampler drilling rig;
- Borehole instrumentation comprising gas and groundwater monitoring standpipe;
- Standpipe monitoring for ground gas and groundwater levels;
- Dynamic probing in proposed areas of pavement;
- Testing of selected soil samples in the laboratory for chemical and geotechnical parameters;
- Testing of groundwater samples for Drinking Water parameters;
- Analysis of data and reporting.

We understand that it is proposed to develop the site with a new industrial unit along with an associated service yard, car parking and external hardstanding and soft landscaping. The current investigation was implemented in order to assess the geotechnical and geo-environmental conditions at the site and to identify potential geotechnical and geo-environmental issues related to the construction of the proposed industrial development. This report presents the factual data from the investigation and makes recommendations on foundations and ground floor slab design, pavement design and issues associated with soil, ground gas and controlled waters contamination.

2. THE SITE

2.1 LOCATION AND SURFACE CONDITIONS

The site is located within Wrexham Industrial Estate which is a large industrial area located about 4km to the east of Wrexham town centre. The site's National Grid reference is 337428 349683 (site centre) and its location within the industrial estate is shown on Figure 1.

The site is rectangular in shape and occupies an area of about 0.89 hectares. It is relatively flat with a very slight fall of about 1.5m from north-west to south-east.

A densely vegetated area lies within the north-western part of the site with a number of mature trees present along its north-eastern boundary. A few semi-mature trees are present within the southern site area and a brick-built sub-station is located within the south-eastern site area.

The site is bounded by industrial/commercial properties to the north-east, south-east and north-west and by Clywedog Road North to the south-west. Access to the site can be gained from Clywedog Road North.

2.2 HISTORY

The Phase I Assessment should be accessed for details of the site's history. A summarised version follows.

Prior to the late 1930s the site comprised agricultural land and was characterised by the presence of a track which cut across the northern site area and by the presence of several small ponds two of which were located in the central north-eastern site area and one in the central north-western site area. At some time around the end of the 1930s and the beginning of the 1940s the wider area was developed as ROF Wrexham which was created to manufacture Cordite. By the late 1940s the ponds had been infilled and a number of structures were present along with woodland, paths often in cutting, and mounds (refer Figure 4). At some point in time between 1964 and 1978 all site structures with associated cuttings, mounds and hydrants had been removed although a number of paths within cutting remained.

ROF Wrexham ceased to operate in August 1945 shortly after which it was sold for industrial development. Records indicate that remediation works were carried out at this time; however, no specific details of that process remain. The site has remained undeveloped to the present day.

2.3 GEOLOGY AND MINING

Geological records indicate that the site is underlain by solid strata of the Salop Formation which comprises sequences of mudstone, sandstone and conglomerate. It is overlain by up to 55m of Devensian Till that typically comprises firm to stiff, sandy, gravelly clay with occasional lenses and beds of sand and gravel with inter-bedded laminated silts.

It is anticipated that due to the site's historical use as part of ROF Wrexham there may be pockets and areas of Made Ground present along potentially with some buried structures.

The site lies within a Coal Authority Coal Mining Reporting Area; however, the mineral resources lie beneath a thick cover of Drift deposits (about 55m) and are located at considerable depth beneath rockhead. Consequently, the risks posed to the site from mining activities are considered to be very low.

2.4 HYDROGEOLOGY AND HYDROLOGY

The nearest significant surface water feature is a small stream that lies approximately 72m to the south-west of the site.

The Salop Formation is classified as a Secondary A aquifer whilst the overlying Till is classified as a Secondary Undifferentiated Aquifer.

The site does not lie within a Source Protection Zone.

There are no groundwater or surface water abstraction licenses within 500m of the site.

2.5 RADON GAS

The site lies in a radon area where between 1% and 3% of homes are estimated to be at or above the action level. No radon protection measures should be required for the proposed new development.

2.6 GROUND STABILITY

The Phase I Assessment indicates that the risks to the site from compressible ground, collapsible ground, ground dissolution, landslides, running sand and shrinking or swelling ground are very low or no hazard.

3 RISK SUMMARY AND CONCEPTUAL SITE MODELS

The following risk summary is predicated upon the findings of the Phase I Assessment.

3.1 HUMAN HEALTH RISKS

The site is considered to pose a low to moderate risk to human health. This risk category has been arrived at on the basis that those ROF activities that were carried out on site and within the immediate surrounding area are considered to have a significantly reduced contaminative potential compared to those activities carried out over other areas of the ROF site.

Construction workers are considered to be the most significant human health receptor and a moderate risk is envisaged as significant harm is possible in the short term. However, this increased risk can be mitigated by ensuring that appropriate work procedures are adhered to and that direct contact with potentially contaminated or explosive material is avoided through the wearing of appropriate PPE.

For future site occupants the majority of pathways between source and receptor are anticipated to be negated or significantly reduced resulting in betterment to the site. Consequently, a low risk is envisaged as it is improbable that significant harm would occur even in the long term.

3.2 GROUND GAS

The site is considered to be at a low level of risk from ground gases due to the very low ground gas generating potential of most of the identified sources, the very low probability of harm occurring to a receptor and the low sensitivity of the proposed development.

3.3 CONTROLLED WATERS

A low risk is considered to be appropriate at this stage for controlled waters. The risk has been assigned on the basis that it is unlikely that any significant harm would occur, even in the very long term, due to the significant thickness of predominantly low permeability superficial deposits that overlie the Secondary A aquifer. It is also unlikely that any significant contamination would migrate to sensitive surface water receptors. In addition, the Secondary Undifferentiated Aquifer is not considered to be overly sensitive.

3.4 BUILDINGS AND SERVICES

The Phase I Assessment indicates that the site is at low to moderate risk from aggressive contaminants within soil and groundwater that have the potential to attack building materials and services. A moderate risk is envisaged during construction works due to the explosive risk to building materials and services.

3.5 CONCEPTUAL SITE MODELS

The development of Conceptual Models for the site involves the determination of potential pollutant linkages through the identification of likely sources of contamination from previous and current site uses and the identification of potential receptors such as site users and controlled waters. Conceptual Site Models developed by the Phase I Assessment for Human Health, Geotechnical Issues, Ground Gas and Controlled Waters are enclosed within Appendix A.

4 GROUND INVESTIGATION

4.1 GENERAL

The fieldwork was carried out generally where relevant in accordance with BS5930 (1999) 'Code of Practice for Site Investigations', BS10175 Investigation of Potentially Contaminated Sites, and the Association of Geotechnical and Geoenvironmental Specialist Guidelines for Good Practice in Site Investigations (1998).

The locations of the exploratory boreholes and trial pits were chosen so as to provide specific coverage relative to the proposed development layout and to the recorded locations of historical structures.

4.2 PRE-INVESTIGATION SURVEY

The site, being operational during the second world war and being a facility that manufactured explosives for the war effort, was an obvious potential target for bombardment by enemy aircraft. Consequently, a Detailed UXO Threat and Risk Assessment report has been obtained a copy of which is enclosed within Appendix B.

That report states that the site is located within Wrexham Rural District which recorded one High Explosive bomb strike per 100 hectares which is a very low level of bombing. ARP records associated with the site did not note any High Explosive bomb strikes within its boundaries. Additional supplementary research of historical records did not find any evidence of High Explosive bomb strikes within 1000m of the site.

Despite the absence of recorded attacks, precautions were taken by site operatives during the intrusive investigative work and this commenced with a metal detector scan at each borehole and trial pit location. Subsequent to this, hand dug trial pits were excavated at each borehole and trial pit location prior to the employment of mechanical equipment. No objects that could be considered to represent UXO were encountered.

Explosive residues within the site soils were also considered to be a potential risk to site operatives and also subsequently to laboratory staff. In order to mitigate the risk a program of in-situ screening tests was carried out on those soil samples selected for laboratory testing. All in-situ tests returned a negative result for explosive residues.

4.3 WINDOW SAMPLER BOREHOLES

A total of 5no boreholes were sunk across the site on the 5th March 2020 using a window sampler drilling rig. The boreholes were positioned to coincide with the location of the proposed development unit and were taken to depths of between 4.45m and 6.45m below ground surface. Standard Penetration Tests were carried out at 1m intervals within each borehole with full depth liner soil samples being recovered for soil description and testing requirements.

Borehole locations are shown on Figure 2 with borehole logs enclosed within Appendix D.

4.4 STANDPIPES

Groundwater and gas monitoring standpipe were installed into augered boreholes on the 24th February 2020 some weeks prior to the sinking of the window sampler boreholes. At the time of their installation the auger rig was able to handle the very wet ground conditions better than the window sampler and a decision was made to use that rig to

ensure that the standpipes were correctly installed. They were sunk at the proposed locations of Boreholes 1, 3 and 5. Standpipe details are summarised below:

Borehole	Depth to Base (m)	Response Zone (m bgl)	Pipe Diameter (mm)	Gas Valve/Lockable Cover
1	5.0	1.0 – 5.0 (firm to stiff clay)	50	Yes
3	5.0	1.0 – 5.0 (firm to stiff clay)	50	Yes
5	5.0	1.0 – 5.0 (firm to stiff clay)	50	Yes

4.5 TRIAL PITS

A total of 4no trial pits were excavated across the site on the 12th March 2020 using a wheeled excavator with back-actor. The pits were positioned so as to coincide with historic site features and were taken to depths of 2m and 2.2m below ground surface where they were terminated within stiff natural formation.

Trial pit locations are shown on Figure 2 with trial pit logs enclosed within Appendix D.

4.6 DYNAMIC PROBES

It was proposed to carry out in-situ CBR tests at the site to provide pavement design data; however, due to restrictions imposed by the COVID-19 lockdown, the tests crews were unable to access the site during the proposed site investigation window. In the circumstances, and as an expedient, an operational window sampling crew were engaged to carry out a series of dynamic probes the results of which have been utilised to provide CBR data.

A total of 6no dynamic probes were carried out in the locations shown on Figure 3 with each probe being taken to a depth of 3m below ground surface. The results of the probing exercise are enclosed within Appendix G.

4.7 SAMPLING AND LABORATORY TESTING

Soil samples was carried out in the knowledge that although considered to be unlikely they could contain explosive contaminants with particular attention to the following:

- Samples were taken using non-sparking implements;
- They were placed in amber glass jars with PTFE liners and a sealing lid suitable for use with primary explosives;
- Samples to be tested for explosive contamination were tested prior to transportation on the public roads;
- All sample packaging complied with the Packaging of Explosives for Carriage Regulations and the Classification and Labelling of Explosives Regulations.

The Phase I environmental database has indicated that the site has historically comprised part of ROF Wrexham and consequently, the following list of potential contaminants of concern has been specified for the laboratory testing program:

Asbestos, phenols, heavy metals, inorganic chemicals, Speciated Petroleum Hydrocarbons, PAHs, acetone and explosives.

Selected soil samples from the borehole and trial pit investigation have been tested in the laboratories of Chemtest for the above range of chemical determinants.

With regard to geotechnical testing, 4no samples of the cohesive formation taken from the approximate foundation horizon have been tested for Index properties in the laboratories of Socotec.

In addition to the soil sampling and testing program, groundwater samples collected from the borehole standpipes have been tested in the laboratory of Chemtest for UK Drinking Water parameters.

Chemical test results are enclosed within Appendix E, with geotechnical test results enclosed within Appendix F.

4.8 MONITORING

Concentrations of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide gas have been measured within the three borehole standpipes on four occasions within the period 25th February 2020 to the 27th March 2020. Total gas concentrations were taken using a GA2000 Plus meter with atmospheric pressure meter. The rate of gas flow from the standpipes was measured using a flow meter.

Groundwater levels within the standpipes were also measured at each monitoring visit.

The results obtained from the monitoring exercise are summarised on Table 1.

5. GROUND CONDITIONS

The site investigation has confirmed the expected natural geological formation of Glacial Till. Made Ground deposits were present overlying the Glacial Till within the trial pits.

5.1 MADE GROUND AND BURIED OBSTRUCTIONS

Made Ground deposits were absent from the boreholes but were encountered within each of the trial pits as summarised below:

BH/TP	Depth below Ground Surface (m)	Description
TP1	GL – 0.1	Soft, brown CLAY
	0.1 – 0.7	Firm to stiff CLAY with occasional pockets of ashy sand with some boulders of concrete
TP2	GL – 0.1	Soft CLAY
	0.1 – 0.9	Firm to stiff CLAY with some brick and concrete fragments
TP3	GL – 0.1	Soft CLAY
	0.1 – 0.4	Firm to stiff CLAY with some boulders of concrete, some brick fragments and occasional shale and fine coal fragments
TP4	GL – 0.2	Soft CLAY
	0.2 – 0.4	Soft to firm CLAY with occasional brick fragments

As the above summary table illustrates Made Ground deposits of up to 0.9m in thickness have been encountered within the trial pits which were positioned so as to coincide with historical site features to include a mound, a former pond and above ground structures (see Appendix C and Figure 4).

5.2 GLACIAL TILL

The natural formation present beneath the Made Ground and topsoil horizons comprises Glacial Till which was encountered predominantly as a firm to stiff, brown mottled grey clay.

SPT N values achieved within the formation are summarised below:

Depth Below Ground Surface (m)	SPT 'N' Values
1	13, 13, 16, 18, 20,
2	15, 15, 19, 22, 23,
3	16, 16, 20, 23, 29,
4	11, 11, 15, 17, 32,
5	12, 14, 20, 26,
6	21

The results of index test carried out on 4no samples of the cohesive Till formation have resulted in the following Liquid Limit and Plasticity Index values:

Liquid Limit Range (%): 49 – 53

Plasticity Index Range (%): 25 – 29

The above values place the cohesive Till within the High Plasticity/Medium Shrinkage potential category.

The relationship between natural moisture content and Liquid Limit suggests that the tested soils are not desiccated.

5.3 GROUNDWATER

All of the boreholes and trial pits remained dry during the drilling and excavation program.

During the monitoring period groundwater was measured at depths of between 1.42m and 1.80m below ground surface within Borehole 1, between 0.29m and 0.35m in Borehole 3 and at depths of between 0.67m and 0.72m in Borehole 5.

The disparity in groundwater levels within the three standpipes is an illustration of the perched and laterally discontinuous nature of groundwater that often occurs within Till formations.

6 GEOTECHNICAL ASSESSMENT

6.1 GENERAL

It is understood that the proposed development will consist of an industrial unit in the configuration shown on Figure 2. No precise details are available at the time of writing with respect to foundation loads; however, we understand that such loads will be within the light to medium category.

6.2 FOUNDATIONS

The boreholes, all of which were sunk within the footprint of the proposed industrial unit, are characterised by an absence of Made Ground materials and the presence of a thin superficial Topsoil horizon which overlies firm and firm to stiff Glacial Clay. The natural firm to stiff natural clay present at shallow depth 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 and such foundations taken through any Made Ground or soft natural soils to found a minimum depth of 900mm below finished grade may be designed using an allowable bearing capacity of 130 kPa.

The clay formation lies within the High Plasticity with Medium shrinkage potential category. Consequently, the recommendations of NHBC Standards Chapter 4.2 should be followed where foundations lie within influencing distance of existing, recently planted or recently felled trees.

The relationship between Natural Moisture Content and Liquid Limit values indicate that the tested samples are not desiccated and based upon that data there should be no requirement for precautions to be taken to accommodate the potential effects of heave on foundations and slabs.

6.3 BURIED OBSTRUCTIONS

The boreholes have failed to encounter any Made Ground or buried obstructions; however, the trial pits, which were located so as to intercept historical site features such as mounds, cuttings and structures, have each encountered Made Ground deposits of up to 0.90m in thickness. Within that formation, some of the trial pits have encountered boulders of concrete and bricks which are indicative of former foundations and below ground walls. The historical development drawing enclosed within Appendix C shows that there were a number of above ground structures present on the site as late as 1960 and anecdotal evidence suggests that such structures across the entire ROF Wrexham site may have been demolished to ground level only. The presence of buried obstructions such as brick walls, concrete footings and potentially basements within some areas of the site cannot therefore be entirely ruled out and it may be prudent to make an allowance within the development contract for their removal from foundation and slab excavations. It is possible that some overbreak may be experienced when such features are being removed.

It is also possible that remnant pipework may be present within some areas of the site and precautions should be taken if any such structures are encountered as they may contain remnant deposits that could be contaminated with explosive residue. If below ground pipework is encountered during the site enabling works its presence should be brought to the attention of the Engineer for further assessment.

6.4 GROUND FLOOR SLABS

The near surface natural formation comprises high plasticity clay and such materials can display significantly high volume change potential in response to moisture content variations. Such changes in volume, post construction, can induce undesirable differential movements between the slab and the frame of the structure if slab on untreated grade construction techniques have been adopted.

If slab on grade construction is desirable it is recommended that the natural formation beneath the slab is excavated and replaced with well compacted engineering fill to a minimum depth of 900mm below finished grade. This will reduce the impact of potential post construction ground movements on the performance of the slab.

As an alternative to the above construction method, a suspended slab could be adopted. Given the high plasticity nature of the natural formation it is recommended that an under-slab void of at least 150mm is maintained. The adoption of a suspended slab may require the construction of internal footings depending upon the dimensions of the slab and its working load bearing requirements.

6.5 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
6	<0.010 – 0.21	7.8 – 8.6

The results 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.

6.6 PAVEMENTS

Within the ground investigation window in-situ CBR crews were generally not available due to COVID-19 lockdown. In the circumstances, a number of dynamic probes were carried out using a tracked rig the results of which have been interpreted using the following correlation after Huntley, 1999.

DOP Blows (per 100mm)	Classification (BS 5930)	Strength Cu (kPa) (BS 5930)	Equivalent SPT N (300mm)
<1	very soft	20	< 2
1 - 2	soft	20 - 40	2 - 4
3 - 4	firm	40 - 75	5 - 8
5 - 8	stiff	75 - 150	9 - 15
>8	Very stiff	>150	>16

The dynamic probe data in Appendix G can be summarised as follows:

DP1: Blows GL – 1m, 19

DP2: Blows GL – 1m, 23

DP3: Blows GL – 1m, 22

DP4: Blows GL – 1m, 21

DP5: Blows GL – 1m, 24

DP6: Blows GL – 1m, 20

The mean of the achieved values equates to a DCP Blows per 100mm of 2.2 which places the formation from ground level to 1m depth in the soft category. Utilising that information in association with the recommendations provided within Interim Advice Note 73/06, 2009 for a clay with a PI value of 25% results in a recommended CBR value for design of between 2.5% and 5% for a thin layered 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 is industrial in nature and for the purposes of risk assessment an industrial/commercial land use has been adopted as the default category.

7.1.2 RISK SCREENING

7.1.2.1 EXPLOSIVE RISK

Both the screening exercise that took place on soil samples on site and the testing that took place on samples in the laboratory have returned values lower than detection limits for explosives. This would tend to reinforce the historical evidence that this site was developed towards the end of the ROF Wrexham operation and that it was not used for primary production purposes. The risk to human site occupiers and construction workers from explosives within the near surface soils at the site can be considered to be low based upon the available test results.

7.1.2.2 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/commercial land use. A summary of the risk screening exercise is shown on Table 2. Reference to that table shows that none of the potential contaminants of concern that constitute the test suite are present within the tested samples at concentrations that exceed their chemical acceptance criteria values.

The risk to human health at the site resulting from the potential presence of contaminants of concern within the near surface soils is considered to be low.

7.1.2.3 STRUCTURES AND INFRASTRUCTURE

The range of measured water soluble sulphate values within the near surface soil samples range from <010g/l to 0.21g/l whilst pH values are in the range 7.8 – 8.6. These represent very 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.

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 such substances at this site are such that the risk to non-barrier pipework is considered to be low.

7.1.3 PROPOSED SOIL REMEDIAL MEASURES

The risk screening exercise has shown that the risk to human health at the site from explosives and potential contaminants of concern within the soil is 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.

Although the testing program has failed to detect explosives within the soil samples it is recommended at the groundworks stage of the project that suitable screening measures are put in place and that such a program forms part of the H & S file. If buried pipework is encountered its presence should be brought to the attention of the Engineer as such features can contain deposits that may include explosive residues. It is recommended that procedures are put in place to locate any such buried features as part of the preliminary site enabling works.

7.2 CONTROLLED WATERS

Selected groundwater samples taken from the standpipes have been tested in the laboratory for those determinants that comprise the UK Drinking Water Standards. Table 3 summarises those results and compares them to the Maximum Allowable Concentrations as defined by the above standards.

Reference to Table 3 shows that the following determinants are present within the tested samples at concentrations that exceed the defined maximum allowable concentration for drinking water:

Determinant	Maximum Allowable Concentration (MAC)	Range of Measured Values	No. of Values > MAC	Mean Value
Electrical Conductivity	2500us/cm	1100 - 5200	2	3100
Chloride	250mg/l	33 - 360	1	174
Sulphate	250mg/l	64 - 3000	2	1245
Sodium	200mg/l	356g - 360	1	179
Aluminium	200mg/l	<10 - 210	1	77
Boron	1000ug/l	20 - 1400	1	563
Manganese	50ug/l	1.9 - 63	1	23
Ammonium	0.5mg/l	<0.055 - 0.70	1	0.27

The mean values of chloride, sodium, aluminium, boron, manganese and ammonium are lower than their respective MAC values and such concentrations are considered to represent a low risk to human health and controlled waters. The mean values of both electrical conductivity and sulphate exceed their corresponding MACs, however, both exceedances are considered to be marginal and not representative of gross contamination. Due to the significant thickness of predominantly low permeability superficial deposits that overlie the Secondary A aquifer, the risk to that aquifer from aluminium and ammonium is considered to be low. It is also unlikely that any significant contamination would migrate to sensitive surface water receptors through the Glacial Till formation that contains significant horizons of low permeability cohesive soils. In addition, the Secondary Undifferentiated Aquifer is not considered to be overly sensitive.

The results of the groundwater analyses are such that a quantified controlled waters risk assessment is considered to be unnecessary.

7.3 GROUND GAS

Table 1 shows that methane gas was effectively absent from the borehole standpipes. Carbon dioxide concentrations were measured within Borehole 1 at a maximum concentration of 2.4%, within Borehole 3 at a maximum concentration of 1.1%, and within Borehole 5 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. For these gases, the installation of a gas resistant membrane within the new industrial unit should not be required.

The unit will not require a radon membrane.

TABLES

Table 1
Wrexham Industrial Estate – Site 2
Gas and Groundwater Readings

Gas Readings

Date: 25/02/2020 Atmospheric Pressure: 998mb

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	2.0	2.0	18.8	18.8	<1	<1
3	<0.1	0.03	0.2	0.2	<2	<2	0.7	0.7	19.0	19.0	<1	<1
5	<0.1	0.04	0.2	0.2	<2	<2	0.9	0.9	19.1	19.1	<1	<1

Date: 02/03/2020 Atmospheric Pressure: 990mb

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	0.06	0.2	0.2	<2	<2	2.4	2.4	17.8	17.8	<1	<1
3	<0.1	0.04	0.2	0.2	<2	<2	1.1	1.1	19.4	19.4	<1	<1
5	<0.1	0.04	0.2	0.2	<2	<2	0.8	0.8	19.0	19.0	<1	<1

Date: 13/03/2020 Atmospheric Pressure: 1016mb

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	2.3	2.3	18.1	18.1	<1	<1
3	<0.1	0.07	0.2	0.2	<2	<2	0.9	0.9	19.2	19.2	<1	<1
5	<0.1	0.05	0.2	0.2	<2	<2	0.7	0.7	19.1	19.1	<1	<1

Date: 27/03/2020 Atmospheric Pressure: 1001mb

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	0.04	0.2	0.2	<2	<2	1.9	1.9	18.2	18.2	<1	<1
3	<0.1	0.06	0.2	0.2	<2	<2	0.8	0.8	19.2	19.2	<1	<1
5	<0.1	0.04	0.2	0.2	<2	<2	0.8	0.8	18.9	18.9	<1	<1

Groundwater Readings (mbgl)

BH	23/02/2019	02/03/2020	13/03/2020
1	1.80	1.79	1.42
3	0.35	0.33	0.29
5	0.67	0.67	0.69

BH	27/03/2020		
1	1.42		
3	0.30		
5	0.72		

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

Table 2

Proposed Industrial Development, Wrexham Industrial Estate – Site 2
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		None Detected	0
Phenols	1500	LQM/CIEH:S4UL	<0.3	0
US EPA Priority PAHs				
Acenaphthene	97000	LQM/CIEH:S4UL	<0.1 – 0.23	0
Acenaphthylene	97000	LQM/CIEH:S4UL	<0.1 – 0.28	0
Anthracene	54000	LQM/CIEH:S4UL	<0.1 – 0.74	0
Benzo(a)Anthracene	170	LQM/CIEH:S4UL	<0.1 – 1.7	0
Benzo (a)pyrene	77	DEFRA:C4SL	<0.1 – 2.7	0
Benzo (b)fluoranthene	44	LQM/CIEH:S4UL	<0.1 – 1.5	0
Benzo(k)fluoranthene	1200	LQM/CIEH:S4UL	<0.1 – 1.5	0
Benzo(g,h,i) perylene	4000	LQM/CIEH:S4UL	<0.1 - 2.3	0
Chrysene	350	LQM/CIEH:S4UL	<0.1 – 1.9	0
Di-benzo(a,h)anthracene	3.6	LQM/CIEH:S4UL	<0.1 – 0.86	0
Indeno(1,2,3-cd)pyrene	510	LQM/CIEH:S4UL	<0.1 – 2.2	0
Fluoranthene	23000	LQM/CIEH:S4UL	<0.1 – 2.1	0
Flourene	68000	LQM/CIEH:S4UL	<0.1 – 0.45	0
Napthalene	400	LQM/CIEH:S4UL	<0.1 – 0.18	0
Phenanthrene	22000	LQM/CIEH:S4UL	<0.1 – 2.1	0
Pyrene	64000	LQM/CIEH:S4UL	<0.1 – 3.0	0
Heavy Metals/ Metalloids				
Arsenic	640	DEFRA C4SL	11 - 14	0
Cadmium	420	DEFRA C4SL	0.19 – 1.2	0
Chromium	86000	LQM/CIEH:S4UL	32 - 39	0
Copper	68000	LQM/CIEH:S4UL	19 - 44	0
Lead	1100	DEFRA C4SL	36 - 390	0
Mercury	1100	LQM/CIEH:S4UL	<0.10	0
Nickel	980	LQM/CIEH:S4UL	34 - 50	0
Selenium	12000	LQM/CIEH:S4UL	<0.2	0
Zinc	730000	LQM/CIEH:S4UL	82 - 780	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	<0.1	0
C10-12	23000	LQM/CIEH:S4UL	<1	0
C12-16	82000	LQM/CIEH:S4UL	<1	0
C16-21	1700000	LQM/CIEH:S4UL	<1	0
C21-35	170000	LQM/CIEH:S4UL	<1	0
C35-44	1700000	LQM/CIEH:S4UL	<1	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	<0.1	0
C10-12	28000	LQM/CIEH:S4UL	<1	0
C12-16	37000	LQM/CIEH:S4UL	<1	0
C16-21	28000	LQM/CIEH:S4UL	<1 - 15	0
C21-35	28000	LQM/CIEH:S4UL	<1 - 67	0
C35-44	28000	LQM/CIEH:S4UL	<1	0
Acetone			*	
Explosives Suite	Presence		*	

1% SOM adopted for SGV calculation

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*Below Detection Limit

Table 3
Wrexham Industrial Estate – Site 2
Groundwater Test Results Compared to UK Drinking Water
Standards Maximum Allowable Concentrations

Determinant	Maximum Allowable Concentration (MAC)	Range of Measured Values	No. of Values > MAC
Conductivity	2500 (us/cm)	1100 - 5200	2
Chloride	250mg/l	33 - 360	1
Flouride	1.5mg/l	0.16 - 0.27	0
Ammonium	0.5mg/l	<0.05 - 0.70	1
Nitrite	0.5mg/l	<0.020	0
Nitrate	50mg/l	<0.50	0
Sulphate	250mg/l	64 - 3000	2
Cyanide	50ug/l	<0.050	0
Sodium	200mg/l	36 - 360	1
Aluminium	200ug/l	<10 - 210	1
Arsenic	10ug/l	<1.0 - 1.7	0
Boron	1000ug/l	65 - 1400	1
Cadmium	5ug/l	0.10 - 0.15	0
Chromium	50ug/l	<1.0 - 2.4	0
Copper	2000ug/l	1.0 - 5.4	0
Iron	200ug/l	210 - 820	0
Mercury	1ug/l	<0.50	0
Manganese	50ug/l	1.9 - 63	1
Nickel	20ug/l	3.3 - 3.7	0
Lead	25ug/l	<1.0 - 1.6	0
Antimony	5ug/l	<1.0	0
Selenium	10ug/l	1.2 - 4.4	0
Zinc	5000ug/l	<10 - 32	0
Mineral Oil	10ug/l	<10	0
Total PAHs	0.1ug/l	<2	0
Solvents and Organics	*	*	0

*Below Detection Limit

FIGURES



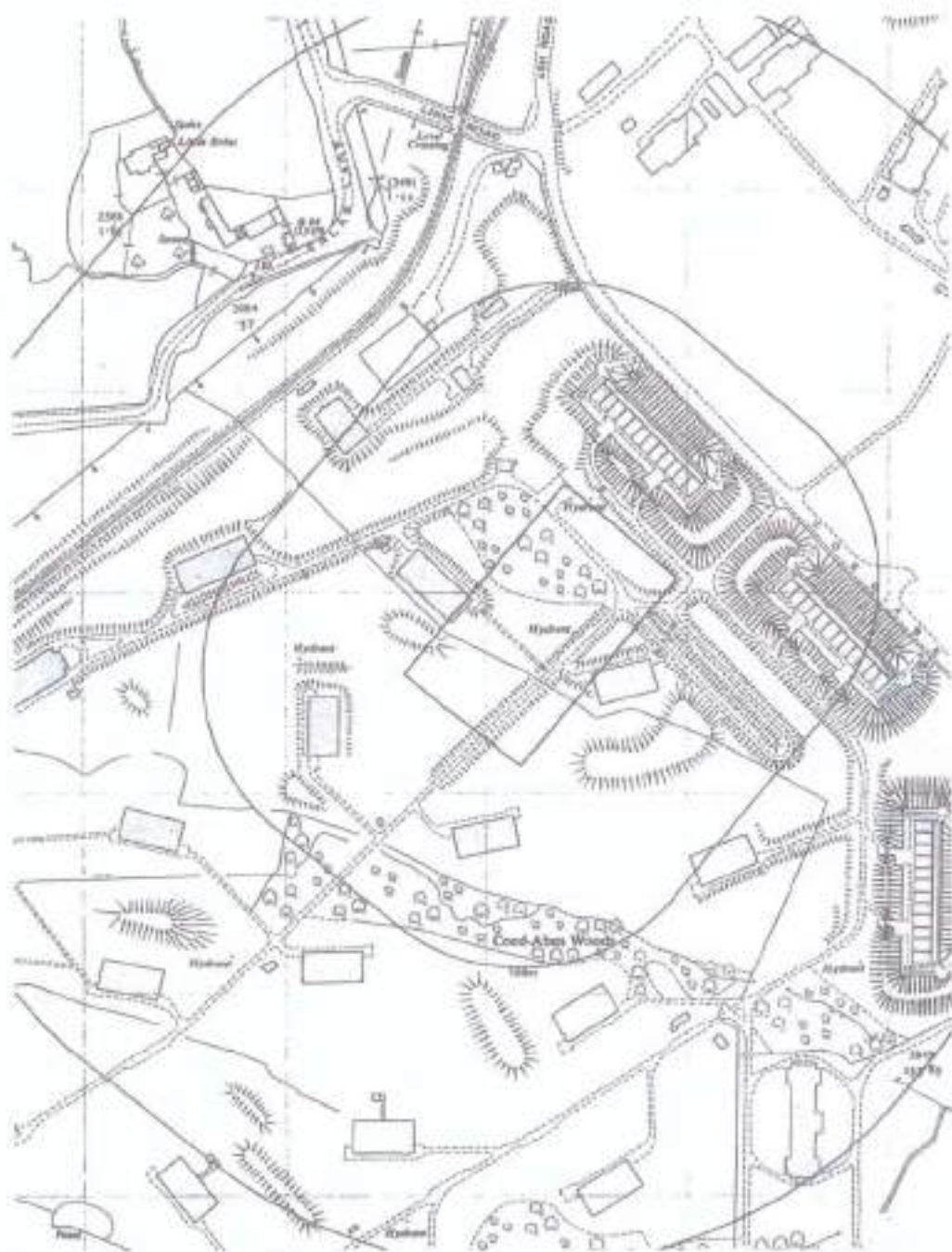
Site Location Plan

**SP
ASSOCIATES**

Report:
S1671-2

Site:
Wrexham Industrial Estate, Site 2

Figure:
1



Historic Site Features - 1960

**SP
ASSOCIATES**

Report:
S1671-2

Site:
Wrexham Industrial Estate - Site 5b

Figure:
4

APPENDIX A

Preliminary CSMs

Source	Potential Pollutants	Pathways	Receptors	Hazard Severity ⁴¹	Likelihood ⁴²	Discussion	Risk
Former on and off-site RCF Wharfedale		Migration of water through ground (vertical and lateral)	Groundwater within Secondary Undifferentiated Aquifer (Deverean Till)	Effects in controlled waters Mild	Current Development Low Likelihood	Receptor Sensitivity: The receptor is not overly sensitive but is recorded to be an important source of groundwater within the district. 10 No. groundwater abstraction licenses are recorded within 2km. Hazard Severity / Presence: As above for Groundwater within Secondary A Aquifer. Receptor Presence: Shallow perched waters and deeper perched waters have been recorded in the area at depths of between 5 – 7m bgl between 9 – 10m bgl between 10 – 22m bgl and between 25 – 27m bgl indicating that several perched water tables may be present. These perched water levels could vary seasonally but there is a low likelihood of interconnectivity. Pathway Integrity: Predominantly low permeability superficial deposits are envisaged but backfilled areas (e.g. backfilled structures) may have higher permeability or silted foundations could provide pathways to deeper water bearing layers. Fractures and sand channels / lenses are present within the Deverean Till that could increase and have high permeability, respectively. Water bearing sand channels / lenses are unlikely to be interconnected at shallow depth but may be more continuous beneath the uppermost Deverean Till. However, vertical interconnectivity is considered unlikely.	Low
On-site Landscaped Ground / Mire Ground Deposits	Metals: TPH, PAH, SVOCs, VOCs, PCBs, BTEX, Phenols, Explosive				Post Development Site Low Likelihood	Receptor Sensitivity: As above for current development. Hazard Severity / Presence: As above for current development. Receptor Presence: As above for current development. Pathway Integrity: As above for current development. Potential for mobilization of any contaminants during rainfall events that may expose high permeability and water bearing layers. If a piled foundation solution is required then additional pathways may be present. However, an increase in handstanding is also envisaged reducing infiltration and vertical migration.	Low
Existing and Abandoned On-site Drainage / Infrastructure	Compounds: Explosive, Chlorides, Arsenic, Asbestos, Solvents, Acids, Alkali, Nitro, Nitrate, Chlorides, Ammonium, Cyanide and fluor other contaminants within sections 7.4.1 & 7.4.2	Migration of water through ground (vertical and lateral) Near surface water run-off / overland flow	Surface water receptors (Stream / drain, Radcliffe Brook and River Clywedog)	Effects in controlled waters Medium	Current Site Unlikely	Receptor Sensitivity: The area stream / drain along the sites south eastern boundary and within the immediately surrounding area (including Radcliffe Brook) are not considered to be overly sensitive. The River Clywedog, is considered a sensitive receptor. Hazard Severity / Presence: As above for Groundwater within Secondary A Aquifer. Receptor Presence: Natural surface water receptor is located 72m to the south west of the site. Pathway Integrity: Any significant contamination or contaminated waters are likely to be trapped on-site at the location of back-filled structures / excavations where they will be perched on low permeability Deverean Till. Vertical migration may occur where permeable backfill is present that intersects permeable layers within the natural Deverean Till. If these permeable layers are underlain by low permeability deposits lateral migration to receptors could occur if continuity exists but this is dependent on the orientation of any sand lenses / channels and their lateral interconnectivity. Due to the predominantly low permeability of the underlying soils it is likely that any near surface water run-off will migrate downgradient to the south east where it is likely to be captured within drainage. However, while these drains freely discharge to the surface water receptors noted there is limited potential for any leachable contaminants to be entrained within surface waters due to the anticipated low concentrations of contaminants at the surface. There is a limited distance between the source and the immediate receptor, but significant dilution and attenuation is likely to have occurred before any potentially contaminated waters reach the most sensitive receptor (River Clywedog).	Low
Current on-site electrical substation					Post Development Site Unlikely	Receptor Sensitivity: As above for current development. Hazard Severity / Presence: As above for current development. Receptor Presence: As above for current development. Pathway Integrity: As above for current development. Potential for mobilization of any leached contaminants or contaminated waters during earthworks that may expose high permeability and water bearing layers or result in surface water run-off to drains. However, due to the distance from the site to the most sensitive receptor significant attenuation and dilution is likely to occur. Due to an increase in handstanding surface water run-off to drainage is considered a more viable pathway and any vertical migration will be largely negated.	Low

⁴¹ Considers both the potentially severity of the hazard and the sensitivity of the receptor. The most sensitive receptor / hazard has been used for the overall assessment.

⁴² Considers both the presence of the hazard and the integrity of the pathway. The most likely hazard / pathway has been used for the overall assessment.

Source	Potential Pollutants	Pathways	Receptors	Hazard Severity ⁴	Likelihood ⁴	Discussion	Risk
Former on and off-site ROF Wreckham On-site Landscaped Ground / Made Ground Deposits Existing and Abandoned On-Site Drainage / Infrastructure On-site Historic Infilled Inland Ponds Current on-site electrical adaption Current and Historic On-Site Sources	Metals: TPH, PAH, SVOCs, VOCs, PCBs, BTEX, Phenols, Explosive Compounds: Explosive Devices: Asbestos, Solvents Acids, Alkalis, Metals, Minerals, Chemicals, Ammonium, Cyanide and other contaminants outlined in sections 7.4.1 & 7.4.2	Migration of water through ground (vertical and lateral)	Groundwater within Secondary A Aquifer (Salop Formation)	Effects to controlled waters: Medium	Current Development: Unlikely	Receptor Sensitivity: Not an overly sensitive receptor but an SP2 is approximately 246m to the north west of the site. 10 No. groundwater abstraction boreholes are recorded within 2km of the site. Hazard Severity / Presence: ➤ Several potentially contaminative sources identified with the highest risk pertaining to ROF Wreckham, which may have resulted in explosive contamination being present at the site (see Section 7.4.1). However, three ROF activities undertaken at the site and within the surrounding area have a low to moderate contaminative potential compared to other sections of ROF Wreckham. Those activities associated with SP2 Wreckham with a higher contaminative potential are generally located downgradient of the site and any contamination is likely to have migrated away from the site. However, unrecorded and unauthorised disposal of contamination from other parts of ROF Wreckham may have occurred at the site (e.g. unrecorded burning grounds of wastes being dumped into ponds). ➤ Site investigations undertaken immediately to the north of the site recorded low concentrations of contaminants but only shallow testing was undertaken and explosive contaminants were not tested for. ➤ Site investigations undertaken at the former Firestone site approximately 520m to the south east of the site recorded 'contaminated' and 'highly contaminated' soils that included elevated metals, hydrocarbons, sulphate, toluene extractable material, pH, phenol and PAHs but these may be associated with the Firestone Firestone itself. Testing indicated that shallow peatified waters within Made Ground are being impacted by arsenic, ammoniacal nitrogen and sulphate but these tests were undertaken at shallow depth and following the remediation of the site. ➤ Due to the landscaping that is recorded to have occurred the soils are likely to have been reworked and this could have resulted in localised contamination from on and off-site sources being spread over a much larger area. Consequently, low concentrations of contamination may be present within the uppermost layer but contamination could be more widespread. ➤ During landscaping many of the more volatile contaminants are likely to have been lost to atmosphere. ➤ High concentrations of contaminants may still be present in areas below the level of remediating (e.g. at the location of backfilled structures / excavations and within historic drainage). Receptor Presence: Groundwater depth unknown but is anticipated to be present at depths <55m. Pathway Integrity: While the Salop Formation is recorded to have a high leaching potential it is overlain by approximately 50m of predominantly low permeability superficial drift. While fissures and sand beds / lenses are present that could provide pathways to bedrock, it is unlikely that these are vertically interconnected and / or extend to bedrock. Even if pathways were present, due to the thickness of these deposits it is likely that significant dilution and attenuation would occur before the deeper groundwaters of the Secondary A Aquifer are reached.	Low
					Post Development Site: Unlikely	Receptor Sensitivity: As above for current development. Hazard Severity / Presence: As above for current development. Receptor Presence: As above for current development. Pathway Integrity: As above for current development. However, if a piled foundation solution is required then pathways may be created but piled foundations to bedrock are considered unlikely. An inclusion in hardstanding is also envisaged reducing infiltration and vertical migration.	Low

Source	Potential Ground Gases	Pathways	Receptors	Hazard Severity ¹¹	Likelihood ¹²	Discussion	Risk
Off-site Landfills	Methane / Carbon dioxide / Hydrogen Sulphide / Trace Gases	Migration Ingress and accumulation Inhalation	Current & future human occupants Ground and construction workers Building and structures	Effect on human health / Damage to Buildings: Medium	Unlikely	Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration (e.g. asphyxiation) are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: Compares a number of relatively small landfills that are located approximately 47m to the east of the site. Recorded to have received industrial and liquid sludge wastes between December 1953 and December 1983. Ground gas generation potential largely unknown due to the presence of industrial wastes but sludge wastes may have a moderate gas generation potential. May be past its primary methanogenic phase due to the age of the landfill. Receptor Presence: Buildings and structures are permanent whereas human receptors are only likely to spend moderate periods of time on-site (typically an 8-hour work day) with a high frequency of visits, the exception being current site users where limited presence is anticipated. Pathway Integrity: These landfills are located approximately 47m to the east and downgradient of the site. Possible driving force for gas migration due to possible moderate ground gas generation potential. Predominantly low permeability of the natural superficial deposits will likely inhibit any lateral or vertical migration to the site. However, sand beds / lenses and fissures may provide pathways but limited interconnectivity is envisaged over such a distance. Groundwater flow is towards the south east and away from the site so any gas migration via groundwater is also considered unlikely.	Low
On-site Landscaped Ground / Made Ground Deposits	Methane / Carbon Dioxide	Migration Ingress and accumulation Inhalation	Current & future human occupants Ground and construction workers Building and structures	Effect on human health / Damage to Buildings: Medium	Unlikely	Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: The source is anticipated to be widespread but limited thicknesses envisaged and no degradable materials were noted during the previous 50 weeks with low total organic contents (0.7 and 1.3%) recorded. However, thicker deposits may be present in areas of infilled excavations or backfilled structures and unconsolidated degradable materials may be present. Ground gas generation is anticipated to be very low with a lack of driving force for gas migration. Receptor Presence: Buildings and structures are permanent whereas human receptors are only likely to spend moderate periods of time on and off-site (typically an 8-hour work day) with a high frequency of visits, the exception being current site users where limited presence is anticipated. Pathway Integrity: The source is anticipated to be widespread and located at the surface with no overriding low permeability soils so most pathways are visible, although ingress and accumulation is not considered a viable pathway for current site users.	Low
Historic On-site Infilled Ponds	Methane / Carbon dioxide	Migration Ingress and accumulation Inhalation	Current & future human occupants Ground and construction workers Building and structures Off-site buildings and structures	Effect on human health / Damage to Buildings: Medium	Unlikely	Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: Unknown thickness and constituents of infilled material but anticipated to be associated with historic ROF Warrington. Limited volume of infill is envisaged due to the size of the ponds. Any infill is at least 60 years old so a low ground gas generation potential is envisaged unless any degradable materials have remained dry. Ground gas generation is anticipated to be very low with a lack of driving force for gas migration. Receptor Presence: Buildings and structures are permanent whereas human receptors are only likely to spend moderate periods of time on and off-site (typically an 8-hour work day) with a high frequency of visits, the exception being current site users where limited presence is anticipated. Pathway Integrity: Overlying and surrounding low permeability soils anticipated to be present and likely inhibiting any lateral or vertical migration. Lack of driving force for gas migration anticipated due to low ground gas generation potential. However, pathways may be present during construction works and following development due to future foundations penetrating low permeability strata.	Low

Source	Potential Ground Gases	Pathways	Receptors	Hazard Severity ^a	Likelihood ^a	Discussion	Risk
Residual hydrocarbon and VOC vapours associated with current and historic on-site activities	Hydrocarbons / VOC's / SVOC's	Migration Ingress and accumulation Inhalation	Current & future human occupants Ground and construction workers Building and structures Off-site buildings and structures	Effect on human health / Damage to buildings Medium	Unlikely	Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: Historic on-site activities may have resulted in hydrocarbon or VOC contamination but these are not anticipated to be significant (e.g. heating for drying houses). Most historic contamination now <70 years old and due to the inherent mobility / volatility of most hydrocarbons / VOCs, the potential presence of pathways via permeable soils and the remitting of soils that likely occurred during landscaping, significant sources of vapours are unlikely to remain. However, sources of vapours may be present at the locations of backfilled structures / infilled excavations. No significant hydrocarbon or VOC concentrations noted for those 51 works undertaken within the surrounding area. Receptor Presence: Buildings and structures are permanent whereas human receptors are only likely to spend moderate periods of time on and off-site (typically an 8-hour work day) with a high frequency of visits; the exception being current site users where limited presence is anticipated. Pathway Integrity: Any remaining source of vapours are likely to be overlain and surrounded by low permeability soils likely inhibiting any lateral or vertical migration. However, pathways may be present during construction works and following development due to future foundations penetrating low permeability strata.	Low
Historic Off-Site Infilled Ponds	Methane / Carbon dioxide	Migration Ingress and accumulation Inhalation	Current & future human occupants Ground and construction workers Building and structures	Effect on human health / Damage to buildings Medium	Unlikely	Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: Numerous ponds located between 50 - 250m of the site. Unknown thickness and constituents of infilled material but anticipated to be associated with historic ROP. Wherein, limited volume of fill is envisaged due to the size of the ponds. Any still is at least 50 years old so a low ground gas generation potential is envisaged unless any degradable materials have remained dry. Ground gas generation is anticipated to be very low. Receptor Presence: Buildings and structures are permanent whereas human receptors are only likely to spend moderate periods of time on-site (typically an 8-hour work day) with a high frequency of visits; the exception being current site users where limited presence is anticipated. Pathway Integrity: While some of these ponds are located downgradient of the site the predominantly low permeability of the natural superficial deposits will likely inhibit any lateral or vertical migration to the site. However, sand beds / lenses and fissures may provide pathways but limited permeability is envisaged at shallow depths. Lack of driving force for gas migration anticipated due to low ground gas generation potential.	Low
Residual hydrocarbon and VOC vapours associated with historic and current off-site activities	Hydrocarbons / VOC's / SVOC's	Migration Ingress and accumulation Inhalation	Current & future human occupants Ground and construction workers Building and structures	Effect on human health / Damage to buildings Medium	Unlikely	Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: Historic off-site activities may have resulted in hydrocarbon or VOC contamination but these are not anticipated to be significant. No significant hydrocarbon or VOC concentrations noted for those 51 works undertaken within the surrounding area. Most historic contamination is now <70 years old and due to the inherent mobility / volatility of most hydrocarbons / VOCs, the potential presence of pathways via permeable soils and the remitting of soils that likely occurred during landscaping, significant sources of vapours are unlikely to remain. However, sources of vapours may be present at the locations of backfilled structures / infilled excavations. Receptor Presence: Buildings and structures are permanent whereas human receptors are only likely to spend moderate periods of time on-site (typically an 8-hour work day) with a high frequency of visits; the exception being current site users where limited presence is anticipated.	Low

Source	Potential Ground Gases	Pathways	Receptors	Hazard Severity ¹¹	Likelihood ¹²	Discussion	Risk
(Continued) Residual hydrocarbon and VOC vapours associated with historic and current off-site activities	Hydrocarbons / VOC's / SVOC's	Migration Ingress and accumulation Inhalation	Current & future human occupants Ground and construction workers Building and structures	Effect on human health / Damage to Buildings Medium	Unlikely	Pathway Integrity: The presence of any potential plumes and vapour migration beneath the site is considered unlikely as most sources are / were located downgradient of the site to the migration of contaminants would be away from the site and towards the south east provided that sand beds / lenses are lithically inter-connected. Limited contributory potential for these current off-site sources due to modern working practices and the presence of extensive freelanding and drains. Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: The site lies within a Reason Affected Area where less than 1 - 2% of properties are above the action level. Receptor Presence: Buildings and structures are permanent whereas human receptors likely to spend moderate periods of time on-site (typically an 8-hour work day) with a high frequency of visits. The receptor being current site users where limited presence is anticipated. Pathway Integrity: Proximity to permeability soils will likely inhibit any migration of radon gas from any concentrated radon sources located at depth (i.e. bedrock). However, soils may also constitute a radon source but again the low permeability of the soils will inhibit the migration of radon gas.	Low
Soil Geology	Radon	Inhalation	Current & future human occupants Ground and construction workers	Effect on human health Medium	Unlikely	Receptor Sensitivity: For commercial / industrial buildings with large well-ventilated open spaces the consequences of gas migration are significantly reduced due to the lack of confined spaces. Increased severity for construction workers who may be working in confined trenches. Hazard Severity / Presence: The site lies within a Reason Affected Area where less than 1 - 2% of properties are above the action level. Receptor Presence: Buildings and structures are permanent whereas human receptors likely to spend moderate periods of time on-site (typically an 8-hour work day) with a high frequency of visits. The receptor being current site users where limited presence is anticipated. Pathway Integrity: Proximity to permeability soils will likely inhibit any migration of radon gas from any concentrated radon sources located at depth (i.e. bedrock). However, soils may also constitute a radon source but again the low permeability of the soils will inhibit the migration of radon gas.	Low

¹¹ Considers both the potentially severity of the hazard and the sensitivity of the receptor. The most sensitive receptor / hazard has been used for the overall assessment.

¹² Considers both the presence of the hazard and receptor and the integrity of the pathway. The most likely hazard / pathways have been used for the overall assessment.

Source	Potential Contaminants	Pathways	Receptors	Hazard Severity ⁴⁴	Likelihood ⁴⁵	Discussion	Risk
Former on and off-site ROF Wrexham						Receptor Sensitivity: Surrounding commercial / industrial land use. The most sensitive receptor is likely to be an adult working indoors. Hazard Severity / Presence: ➤ Several potentially contaminative sources identified with the highest risk pertaining to ROF Wrexham, which may have resulted in explosive contamination being present at the site (see Section 7.4.1). However, those ROF activities undertaken at the site and within the surrounding area have a low to moderate contaminative potential compared to other sections of ROF Wrexham. ➤ Those activities associated with ROF Wrexham with a higher contaminative potential are generally located downwind of the site and any contamination is likely to have migrated away from the site. However, unrecorded and unauthorised disposal of contamination from other parts of ROF Wrexham may have occurred at the site (e.g. unrecorded burning grounds or wastes being dumped into ponds). ➤ Those explosive contaminants most likely to be present (Cordite, NG, MC, Picric and possible explosive devices) represent a potential hazard to humans due to their explosive and highly flammable properties. Some of the explosive contaminants are also toxic to humans at concentrations below those for which an explosive hazard is present. ➤ Most of the explosive materials associated with Cordite manufacture and Cordite itself are environmentally persistent and relatively immobile. ➤ Site investigations undertaken immediately to the north of the site recorded low concentrations of contaminants but only shallow testing was undertaken and explosive contaminants were not tested for. ➤ Site investigations undertaken at the former Firestone site approximately 520m to the south east of the site recorded contaminated and highly contaminated soils that included elevated metals, hydrocarbons, sulphates, various extractable material, pH, phenol and PAHs but those may be associated with the Firestone Factory itself. All explosive compounds tested for were below their detection limits but these tests were undertaken at shallow depth and following the remediation of the site. ➤ Due to the landscaping that is reported to have occurred the soils are likely to have been reworked and this could have resulted in localised contamination from on and off-site sources being spread over a much larger area. Consequently, the concentrations of contamination may be present within the uppermost layers but contamination could be more widespread. ➤ During landscaping many of the more volatile contaminants are likely to have been lost to atmosphere or potentially migrated from site. However, due to the predominantly low permeability of the soil adoption of contaminants is likely to have occurred and this would have reduced migration of many of the less mobile contaminants. ➤ While high permeability strata may be present in places, they are unlikely to be interconnected at shallow depth, so the effects of migration and dilution are unlikely to be significant. ➤ High concentrations of contaminants may still be present in areas below the level of remediation (e.g. at the location of backfilled structures / excavations and within historic drainage). ➤ Adhesion fibres from demolished ROF structures may be found within the soil due to its predominantly clayey nature. ➤ Construction materials used in brick buildings etc. may have been contaminated with explosives materials prior to backfilling as some explosives are particularly prone to contaminating porous surfaces such as building fabrics and can even be absorbed through painted surfaces into underlying brickwork. ➤ Historic and current off-site sources are unlikely to have impacted the site either due to their low severity and that any contamination would have previously migrated downgradient to the south east or be captured in drainage. However, materials may have been windblown to the site or deposited directly to the site during or after landscaping.	Low to moderate
On-site Landscaped Ground / Made Ground Deposits							
Existing and Abandoned On-Site Drainage / Infrastructure	Metals, THT, PAHs, DVOCH, VOCs, PCBs, BTEX, Phenols, Explosive Compounds, Explosive Devices, Asbestos, Sulphate, Acids, Alkalies, Nitric, Chlorides, Ammonium, Cyanide and those other contaminants outlined in sections 7.4.1 & 7.4.2	Ingestion through the mouth of airborne dust and indoor air (indoor and outdoor)	Current site users	Effect on human health: Medium	Low likelihood		
On-site Historic Infiltrated Ponds		Exposure through the mouth of airborne dusts and vapours (indoor and outdoor)					
Current on-site electrical substation		Absorption through the skin due to contact with dust and soil					
Current and Historic On-Site Sources							

Source	Potential Contaminants	Pathways	Receptors	Hazard Severity ^a	Likelihood ^a	Discussion	Risk
Former on and off-site ROF Workroom			Current site users (continued)	Effect on human health: Medium	Low likelihood	Receptor Presence: The site is easily accessible but any current site users are unlikely to spend a significant amount of time on-site and the frequency of visits are anticipated to be low as the site has no adjacent use. Pathway Integrity: It is unlikely that current site users will come into contact with contaminated soils in the near surface during their visits. However, as potentially contaminated soils are present at the surface pathways are considered to be viable.	Low to moderate
On-site Landscaped Ground / Made Ground Deposits	Metals: Pb, PAH, SVOCs, VOCs, PCBs, BTEX, Phenols, Explosive Compounds, Cyanide, Cyanide and other contaminants outlined in sections 7.4.1 & 7.4.2	Ingestion through the mouth of airborne dust and soil (indoor and outdoor)	Ground & Construction Workers	Effect on human health: Medium	Likely	Receptor Sensitivity: Sensitive receptor is this instance would be an adult likely using personal protective equipment. Hazard Severity / Presence: As above for Current Site Users Receptor Presence: Groundworkers likely to spend moderate periods of time on-site (typically an 8-hour work day) with a high frequency of visits until the work is complete. However, construction works are relatively short-term in the grand scheme of things. Pathway Integrity: Acute interaction with soil and materials during ground works, including works, construction of foundations etc. so most pathways are viable. Any asbestos fibres that are present could be released from the soil during earthworks and construction activities. Any potential significant contamination of explosive devices that are located at depth or within areas that have been backfilled (e.g. former buildings and trenches) may be encountered during excavations. Historic infrastructure possibly containing residual explosive compounds or contamination are most likely to be encountered or broken-up during construction works.	Moderate
Existing and Abandoned On-Site Drainage / Infrastructure		Inhalation through the nose and mouth of airborne dusts and vapours (indoor and outdoor)	Adjacent site users and general public	Effect on human health: Medium	Unlikely	Receptor Sensitivity: Surrounding commercial / industrial land use. The most sensitive receptor is likely to be an adult working indoors. Hazard Severity / Presence: As above for current site users. Receptor Presence: Adjacent site users likely to spend moderate periods of time off-site (typically an 8-hour work day) with a high frequency of visits. However, indoor working is envisaged. Pathway Integrity: As Landscaped Ground is present at the surface soil derived dust may be windblown in off-site receptors but this is considered unlikely due to the predominantly clayey nature of the soils. In the short-term problems with soil derived dust are more likely during development of the site unless appropriate health and safety measures are undertaken (e.g. spraying down dust). Following development most pathways (except for vapour) are anticipated to be negatively impacted due to an increase in landscaping areas. Potential pathways may remain for any areas of PQS or soft landscaping. During construction works there could be risk to off-site users from an explosive incident.	Low
On-site Historic Infiltrated Pores		Absorption through the skin due to dermal contact with dust and soil	Future site users	Effect on human health: Medium	Unlikely	Receptor Sensitivity: Industrial / Commercial land use so the most sensitive receptor would be an adult. Hazard Severity / Presence: As above for adjacent site users. Receptor Presence: Future site users likely to spend moderate periods of time on-site (typically an 8-hour work day) with a high frequency of visits. However, indoor working is envisaged. Pathway Integrity: Following development of the site there is expected to be an increase in landscaping and indoor working areas. Consequently, most pathways (except for vapours) are anticipated to be negatively impacted. Potential pathways may be present for any areas of PQS or soft landscaping.	Low

^a Considers both the potentially severity of the hazard and the sensitivity of the receptor. The most sensitive receptor / hazard has been used for the overall assessment.

^d Considers both the presence of the hazard and receptor and the integrity of the pathway. The most likely hazard / pathways have been used for the overall assessment.

APPENDIX B

UXO Threat Assessment

Detailed Unexploded Ordnance (UXO) Threat & Risk Assessment

Meeting the requirements of CIRIA C681 'Unexploded Ordnance (UXO)
A guide for the Construction Industry' Risk Management Framework



6 ALPHA PROJECT NUMBER	8004	ORIGINATOR	D. Barrett
LANDMARK ORDER NUMBER	243406868_1	REVIEWED BY	B. Wilkinson (4 th June 2020)
CLIENT REFERENCE	PO 1671 – 8	RELEASED BY	R. Griffiths (8 th June 2020)
STUDY SITE	Tritech, Unit 69, Clywedog Road East, Wrexham Industrial Estate, Wrexham, LL13 9XE		
RATING	VERY HIGH - This Study Site requires extensive further action to reduce risk to ALARP during intrusive activities.		

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Acronyms and Abbreviations

AA	Anti-Aircraft	NEQ	Net Explosive Quantity
AAA	Anti-Aircraft Ammunition	NFF	National Filling Factory
ALARP	As Low As Reasonably Practicable	NGR	National Grid Reference
AOD	Above Ordnance Datum	OD	Ordnance Datum
ARP	Air Raid Precaution	OS	Ordnance Survey
AXO	Abandoned Explosive Ordnance	PM	Parachute Mine
BD	Bomb Disposal	PoW	Prisoner of War
BDO	Bomb Disposal Officer	RADAR	Radio Detection And Ranging
bgl	Below Ground Level	RAF	Royal Air Force
BGS	British Geological Survey	RN	Royal Navy
BH	Borehole	RNAS	Royal Naval Air Service
BPD	Bomb Penetration Depth	ROF	Royal Ordnance Factory
CDP	Cast Driven Piles	SAA	Small Arms Ammunition
CFA	Continuous Flight Auger	TA	Territorial Army
CIRIA	Construction Industry Research and Information Association	TNT	Trinitrotoluene
CPT	Cone Penetration Testing	UK	United Kingdom
CS	County Series	UN	United Nations
EO	Explosive Ordnance	USAAF	United States Army Air Force
EOC	Explosive Ordnance Clearance	UXB	Unexploded Bomb
EOD	Explosive Ordnance Disposal	UXO	Unexploded Ordnance
GI	Ground Investigation	V Weapons	<i>Vergeltungswaffe</i> – Vengeance Weapons
GIS	Geographic Information Systems	WD	War Department
GL	Ground Level	WWI	World War One
GP	General Purpose	WWII	World War Two
GPS	Global Positioning Systems		
HAA	Heavy Anti-Aircraft		
HE	High Explosive		
HO	Home Office		
HSE	Health and Safety Executive		
IB	Incendiary Bomb		
kg	Kilograms		
km	Kilometres		
LAA	Light Anti-Aircraft		
LCC	London County Council		
LE	Low Explosive		
LSA	Land Service Ammunition		
m	Metres		
MoD	Ministry of Defence		
mm	Millimetres		

EXECUTIVE SUMMARY

Study Site

The Client has defined the Study Site as "Tritech, Unit 69, Clywedog Road East, Wrexham Industrial Estate, Wrexham, LL13 9XE" and is centred on NGR 337470, 349490.

Risk Level

VERY HIGH

Potential Threat Sources

The most probable UXO threat items are AXO/LSA/SAA and munitions materials associated with *ROF Wrexham* which, if present, are likely to be encountered in previously undisturbed ground to depths of circa 2.0m. *German HE bombs*, *IBs* and *British AAA projectiles* pose a residual threat. The consequences of initiating *German HE bombs* are more severe than initiating *IBs* or *AAA projectiles*.

Risk Pathway

Given the types of UXO that might be present on-site, all types of aggressive intrusive engineering activities may generate a significant risk pathway.

Key Findings

During WWII, the Study Site was situated within *Wrexham Rural District*, which recorded one HE bomb strike per 100 hectares, a very low level of bombing.

Luftwaffe aerial reconnaissance photography associated with the Study Site identified the Royal Ordnance Factory (ROF) Wrexham complex (located partially on-site) as a primary bombing target. *ROF Wrexham* primarily produced cordite, an explosive propellant used in shells and ammunition during WWII. Due to this, it is considered possible that munitions, and materials involved in munitions production, were manufactured, located, or stored on or near the Study Site during WWII.

ARP records associated with the Study Site did not note any HE bomb strikes within it. Further research of historical records also did not find any evidence of HE bomb strikes on or near the Study Site.

Official bomb damage mapping associated with the Study Site was not available. It should be noted that it is likely that bomb damage records associated with *ROF Wrexham* were recorded privately and not released into the public domain as a matter of national security. Nonetheless, an analysis of post-war mapping and further research of historical records did not identify any potential bomb damage on-site or in close proximity to it.

Pre-WWII mapping (1938) associated with the Study Site shows that it was located within an undeveloped rural area during WWII, with the Study Site itself consisting of mainly undeveloped ground, although *Redwither Lane* was located in the northern section, *Coed-Aber Woods* in the central and southern sections. However, an analysis of *Luftwaffe* aerial photography suggests that explosives warehouses and other structures were located on part of the Study Site – or in very close proximity to it – during WWII. As a result, it is considered plausible that the Study Site may have been inspected for UXB entry holes following any raids.

By 1982, the Study Site had been cleared of structures. By 1985 a hardstanding road had been built which ran through the Study Site. Consequently, it is considered likely that any UXO within post-war disturbed and developed ground would potentially have been discovered and removed, however, the potential for deep buried UXO to be present within remaining areas is assessed to be extant.

Given that explosives warehouses associated with *ROF Wrexham* were potentially located on-site and/or in close proximity to it, the following risk mitigation measures are recommended as a minimum, in order to reduce risks ALARP, during intrusive works in all previously undisturbed ground i.e. that which has not previously been excavated, probed, drilled or otherwise intrusively disturbed since it was potentially contaminated with UXO.

EXECUTIVE SUMMARY (...continued)

Recommended Risk Mitigation

All Groundworks in All Areas:

1. Operational UXO Emergency Response Plan; appropriate site management documentation should be held on-site to guide and plan for the actions which should be undertaken in the event of a suspected or confirmed UXO discovery (this plan can be supplied by *6 Alpha*);

2. UXO Safety & Awareness Briefings; the briefings are essential when there is a possibility of an-UXO / UXB encounter and are a vital part of the general safety requirement. All personnel working on the site should receive a briefing on the identification of an UXO / UXB, what actions they should take to keep people and equipment away from such a hazard and to alert site management. Information concerning the nature of the UXO / UXB threat should be held in the site office and displayed for general information on notice boards, both for reference and as a reminder for ground workers. The Safety & Awareness briefing is an essential part of the *Health & Safety Plan* for the site and helps to evidence conformity with the principles laid down in the *CDM regulations 2015* (this briefing can be delivered directly, or in some cases remotely, by *6 Alpha*).

Trial Pits into Previously Undisturbed Ground:

3. Non-intrusive UXO Survey and/or EOD Engineer in the Watching Brief Role; Where 'open' intrusive works into previously undisturbed ground are proposed and where the extent is considered to be within the capabilities of non-intrusive UXO survey equipment and implementation of this is assessed as likely to prove effective, a non-intrusive geophysical UXO survey should be trialed and, if it proves successful, should be employed to survey site-wide, or in specific areas where 'open' intrusive works are to be implemented to identify for signs of sub-surface anomalies which may model as the target UXO in advance of said works. If the survey proves partially or wholly ineffective, an EOD Engineer should be present in the UXO Watching Brief role to monitor ongoing 'open' intrusive works to identify any suspicious items that may be UXB or UXO related (this service can be provided by *6 Alpha*).

Window Sampling and Boreholing (*add/delete as appropriate*) into Previously Undisturbed Ground:

4. Intrusive UXO Survey; Where 'blind' intrusive works into previously undisturbed ground are proposed, an intrusive UXO survey (employing down-hole magnetometer or MagCone techniques) is strongly recommended. Such a survey should extend to the *assessed average bomb penetration depth* or to the maximum depth of the works, whichever is encountered first, or until geology is encountered through which it is assessed a UXB would not penetrate, to identify for signs of sub-surface anomalies which may model as the target UXO in advance of said works. (this service can be provided by *6 Alpha*).

For further information, please contact Envirocheck:

Website: <http://www.envirocheck.co.uk>

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ASSESSMENT METHODOLOGY

Approach

6 Alpha Associates is an independent, specialist risk management consultancy practice, which has assessed the risk of encountering UXO (as well as buried bulk high explosives) at this Study Site, by employing a process advocated for this purpose by CIRIA. The CIRIA guide for managing UXO risks in the construction industry (C681) not only represents best practice but has also been endorsed by the HSE. Any risk mitigation solution is recommended *only* because it delivers the Client a risk reduced to ALARP at best value.

UXO hazards can be identified through the investigation of local and national archives associated with the Study Site, MoD archives, local historical sources, historical mapping as well as contemporaneous aerial photography (if it is available). Hazards will have only been recorded if there is specific information that could reasonably place them within the boundaries of the Study Site. The amalgamation of information is then assessed to enable the researcher to provide relevant and accurate risk mitigation practices.

The assessment of UXO risk is a measure of *probability of encounter and consequence of encounter*; the former being a function of the identified hazard and proposed development methodology; the latter being a function of the type of hazard and the proximity of personnel (and/or other 'sensitive receptors', such as equipment) to the hazard, at the moment of encounter.

If UXO risks are identified, the methods of mitigation we have recommended are considered reasonably and sufficiently robust to reduce them to ALARP. We advocate the adoption of the legal ALARP principle because it is a key factor in efficiently and effectively ameliorating UXO risks. It also provides a ready means for assessing the Client's tolerability of UXO risk. In essence, the principle states that if the cost of reducing a risk significantly outweighs the benefit, then the risk may be considered tolerable. This does not mean that there is never a requirement for UXO risk mitigation, but that any mitigation must demonstrate that it is beneficial. Any additional mitigation that delivers diminishing benefits and that consume disproportionate time, money and effort are considered *de minimis* and thus unnecessary. Because of this principle, UXB and UXO risks will rarely be reduced to zero (nor need they be).

Important Notes

Key source material is referenced within this document, whilst secondary/anecdotal information may be available upon request.

Although this report is up to date and accurate at the time of writing, our databases are continually being populated as and when additional information becomes available. Nonetheless, 6 Alpha have exercised all reasonable care, skill and due diligence in providing this service and producing this report.

The assessment levels are based upon our professional opinion and have been supported by our interpretation of historical records and third party data sources. Wherever possible, 6 Alpha has sought to corroborate and to verify the accuracy of all data we have employed, but we are not accountable for any inherent errors that may be contained in third party data sets (e.g. *National Archive* or other library sources), and over which 6 Alpha cannot exercise control.

STAGE ONE – STUDY SITE LOCATION AND DESCRIPTION

Study Site

The Client has defined the Study Site as "Tritech, Unit 69, Clywedog Road East, Wrexham Industrial Estate, Wrexham, LL13 9XE". The Study Site is centred at NGR 337470, 349490 as presented at *Figures 1 and 2* respectively.

Location Description

The Study Site is situated on the *Wrexham Industrial Estate* and totals an area of approximately three hectares (ha). Furthermore, the Study Site is bounded by:

- North: Various industrial and commercial structures, areas of hardstanding, areas of undeveloped ground and *Coed Aben Road*;
- East: Various industrial and commercial structures, areas of hardstanding and areas of undeveloped ground;
- South: Various industrial and commercial structures, areas of hardstanding, areas of undeveloped ground and *Clywedog Road East*;
- West: Various industrial and commercial structures, areas of hardstanding and areas of undeveloped ground.

Aerial Photography (2018) (*Figure 3*)

Current aerial photography corroborates the information above and shows that the Study Site is situated within a densely developed urban-industrial area. The Study Site itself consists of mostly undeveloped ground, although *Clywedog Road North* runs through the Study Site.

Proposed Works

The Client has informed *6 Alpha* via email correspondence of the following proposed works:

- "Ground Investigations: Medium Trial Pit between 1m and 5m below ground level"
- Borehole Depth: Window sampler boreholes to 5m."

Ground Conditions

It is important to establish the specific ground conditions in order to determine the maximum *German UXB* penetration depth as well as the potential for other types of munitions to be buried.

If the site investigations and/or construction methodologies change, and/or if a specific methodology is to be employed, and/or if the scope of work is focused upon a specific part of the Study Site, then *6 Alpha* are to be informed so that the prospective UXO risks and the associated risk mitigation methodology might be re-assessed. Certain ground conditions may also constrain certain types of UXO risk mitigative works e.g. magnetometer survey is adversely affected in mineralised and made ground.

It is important to establish the provenance of made ground, where this is recorded as being part of the ground make-up, in order to accurately determine the ground levels at the time when UXO contamination may have occurred so as to accurately determine the average / maximum bomb penetration depths and make appropriate recommendations aimed at reducing the risk to ALARP.

STAGE ONE – STUDY SITE LOCATION AND DESCRIPTION (...continued)

Ground Conditions

BGS borehole log "SJ34NE45/C – Wrexham Aluminum Ingot Plant. 3" (located 65m to the south-east of the Study Site), recorded the following strata:

Depth bgl (m)	Strata	Description
0.00m to 0.70m	Fill	Grey, clayey, sandy soil FILL with brick fragments
0.70m to 0.80m	Fill	Stiff brown clay FILL
0.80m to 1.20m	Fill	Firm, brown, shaley Clay FILL with brick, slate and some coal
1.20m to 2.00m	Fill	Stiff, light brown, silty clay with brick. FILL.
2.00m to 6.50m	Clay/Sand	Very stiff, brown, slightly sandy, silty, fissured CLAY with some fine gravel (slightly laminated). The fissures are mainly vertical and are present or a thin veining of firm, grey silty clay with fine rootlets. From 5.00m the clay contains thin laminations and light brown, fine SAND. From 5.60m the fissures are not apparent, the clay is very silty and laminated.
6.50m to 8.00m	Clay	Firm to stiff, brown, veiny, silty, laminated CLAY with layers of silt and fine sand. Clay is soft from 7.20m.
8.00m to 10.00m	Silt	Very soft, brown, clayey SILT with some fine sand containing thin sand banks and pockets of clay.
10.00m to 10.20m	Silt	Very soft, brown, clayey SILT
10.20m to 15.00m	Clay	Firm to stiff, brown, silty, sandy CLAY with a little fine to medium gravel. 13.75m to 14.70m clay is firm. From 14.70m clay is stiff.

STAGE TWO – REVIEW OF HISTORICAL DATASETS

Sources of Information Consulted

The following primary information sources have been used in order to establish the background UXO threat:

1. *6 Alpha's Azimuth Database*;
2. *Home Office WWII Bomb Census Maps*;
3. *WWII and post-WWII aerial photography*;
4. *Official Abandoned Bomb Register*;
5. Information gathered from the *National Archives at Kew*;
6. Historic UXO information provided by *33 Engineer Regiment (Explosive Ordnance Disposal)* at *Carver Barracks, Wimbish*.

Potential Sources of UXO Contamination

In general, there are several activities that might contaminate a site with UXO but the three most common ways are: legacy munitions from military training/exercises, deliberate or accidental dumping (AXO) and ordnance resulting from war fighting activities (also known as the Explosive Remnants of War (ERW)).

During WWII, the *Luftwaffe* undertook bombing campaigns all over the UK. The most common type of UXO discovered today is the aerially delivered high explosive (HE) bomb, which are comparatively thick-skinned and dropped from enemy aircraft. If the bomb did not detonate when it was dropped, the force of impact enabled the UXO to penetrate the ground, often leaving behind it a UXB entry hole. These entry holes were not always apparent and some went unreported, leaving the bomb buried and unrecorded. More rarely, additional forms of German UXO are occasionally discovered including *inter alia* V1 and V2 rockets, Incendiary Bombs (IBs), and Anti-personnel (AP) bomblets.

Although the *Luftwaffe* had designated primary bombing targets across the UK, their high-altitude night bombing was not accurate. As a result, thousands of buildings were damaged and civilian fatalities were common. Bombs were also jettisoned over opportunistic targets and residential areas were sometimes struck.

As the threat of invasion lingered over Britain during WWII, defensive actions were undertaken. The British and Allied Forces requisitioned large areas of land for military training and bomb storage (including HE bombs, naval shells, artillery and tank projectiles, explosives, LSA and SAA). Thousands of tonnes of these munitions were used for the Allied Forces weapon testing and military training alone. It has been estimated that at least 20 per cent of the UK's land has been used for military training at some point.

The best practice guide for dealing with your UXO risks on land (CIRIA publication C681) suggests that approximately 10 per cent of all munitions deployed failed to function as designed. ERW are therefore, still commonly encountered, especially whilst undertaking construction and civil engineering groundwork.

Furthermore, in exceptional circumstances, UXO is discovered unexpectedly and without apparent rational explanation. There are several ways this might occur:

- When *Luftwaffe* aircraft wished to swiftly escape e.g. from an aerial attack, they would jettison some or all of their bombs and flee. This is commonly referred to as *tip and run* and it has resulted in bombs being found in unexpected locations;
- Transportation of aggregate containing munitions to an area that was previously free of UXO, usually related to construction activities employing material dredged from a contaminated offshore borrow site;
- Poor precision during targeting (due to high altitude night bombing and/or poor visibility) resulted in bombs landing off target, but within the surrounding area.
- British decoy sites were also constructed to deliberately cause incorrect targeting. For obvious reasons, such sites were often built in remote and uninhabited areas.

Study Site History

From an analysis of the CS and OS historical mapping associated with the Study Site, the following history can be deduced:

Year	On-site
1899 CS Map	The Study Site was located in an undeveloped rural area. The Study Site did not consist of any structures, although a road ran through the northern section of the Study Site and <i>Coed-Aben Woods</i> was located in the central and southern sections of the Study Site.
1914 CS Map	The road in the northern section had been labelled <i>Redwither Lane</i> , and a <i>Tank</i> had been built in the south eastern section.
1938 CS Map	Changes were not recorded at the Study Site.
1961 OS Map	A number of structures apparently associated with <i>ROF Wrexham</i> and previously located on-site had been demolished.
1979 OS Map	The remaining on-site structures were demolished, aside from a structure in the south eastern section. <i>Coed-Aben Woods</i> had been mostly cleared.
1982 OS Map	All remaining structures on-site had been cleared, and the Study Site was now part of <i>Wrexham Industrial Estate</i> . A road had been built which ran through the central and southern sections of the Study Site.
1986 OS Map	A small structure, possibly part of an <i>Electricity Sub-Station</i> was built in the northern section of the Study Site. Two <i>Drains</i> were constructed which partially intersected the south-eastern section of the Study Site.
1989 OS Map	The road running through the Study Site was labelled <i>Clywedog Road North</i>
1994 OS Map	Changes were not recorded at the Study Site.
2006 OS Map	Changes were not recorded at the Study Site.
2020 OS Map	Changes were not recorded at the Study Site.

WWII Bombing of Wrexham

During WWII, *Wrexham* was subjected to few aerial attacks however, a succession of air raids between 28th August and 1st September 1940 inflicted moderate levels of damage to the town and the surrounding area. The raids were attributed to the large-scale attacks on *Liverpool* and *Manchester*, in which the town of *Chester* was subjected to multiple air raids. The *Ruabon Mountain* range (located to the west of *Wrexham*) was extensively bombed during this period, with an estimated 2,000 bomb strikes recorded within the area, which caused fires that enveloped twenty eight square miles (7,251ha) of moorland.

Following these attacks, a defensive group was established to protect the northwest region from *Luftwaffe* attacks. The defences involved extensive reconstruction and development of *Wrexham Airfield* between December 1940 and June 1941, which included the construction of concrete runways and all-weather lighting. The primary role for the fighter squadrons based at *Wrexham Airfield* was to defend *Liverpool* and *Manchester*, as well as *Royal Ordnance Factory Wrexham* located to the southeast of the town. Despite these sporadic attacks on the town, *Wrexham* was considered relatively safe, with many evacuees having been relocated to the area.

WWII Luftwaffe Bombing Targets (Figure 4)

Prior to WWII, the *Luftwaffe* conducted numerous aerial photographic reconnaissance missions over *Britain*, recording key military, industrial and commercial facilities for attack, in the event of war. In addition, logistics infrastructure and public services, such as railways, canals, power stations, reservoirs, water and gas works were also considered viable bombing targets.

Luftwaffe aerial reconnaissance photography associated with the Study Site identified the *ROF Wrexham* complex (located on-site) as a primary bombing target.

WWII HE Bomb Strikes

During WWII, ARP wardens compiled detailed logs of bomb strikes across their respective districts. However, ARP records associated with the Study Site did not note any HE bomb strikes within it. Nonetheless, further research did not identify any bomb strikes on-site, or within 1,000m of the Study Site boundary. Furthermore, whilst IBs may have fallen within the Study Site, they fell in such large numbers that accurate record keeping was either non-existent or perfunctory therefore, their prospective presence cannot be either corroborated or discounted.

In addition to IBs and HE bomb strikes, during the latter part of the war when aerial bombing had significantly declined, the main threat came from V type weapons. V1 and V2 rockets were thin-skinned, unmanned and inaccurate weapons. Despite this, there is no evidence to suggest that the Study Site (or its immediate vicinity) was subjected to rockets strikes during WWII.

The potential penetration depth of an UXB was dependent on a number of factors including but not restricted to those prior to striking the ground e.g. velocity and orientation of the UXB which in turn will be influenced on factors such as the release altitude from the aircraft and encounters with infrastructure during its fall; those encountered at the point of impact i.e. was the impact on concrete, grass, water etc and finally, the below ground level conditions which were encountered such as infrastructure e.g. services, basements, foundations, and geology e.g. made ground, clay, sand, etc. Further, as the UXB penetrated the ground, it's velocity naturally slowed where, it either came to an abrupt stop e.g. against foundations or would continue for 10's of feet along a route of least resistance which often resulted in a curving of the trajectory back towards the surface. This is known as the "J Curve" effect and often resulted in a considerable horizontal off-set from the point of entry. This is often the reason why UXBs have been discovered against or under the foundations of buildings, which were present during WWII, or many meters from the point of impact.

WWII Bomb Damage

Official bomb damage mapping associated with the Study Site was not available. It should be noted that it is likely that bomb damage records associated with *ROF Wrexham* were recorded privately and not released into the public domain as a matter of national security. Nonetheless, an analysis of post-war mapping and further research of historical records did not identify any potential bomb damage on-site or in close proximity to it.

WWII HE Bomb Density (Figure 5)

The Study Site was located within the *Wrexham Rural District*, which recorded one HE bomb per 100 hectares, a very low level of bombing.

Abandoned Bombs

An examination of the official abandoned bomb records did not identify any abandoned bombs on-site, nor within 1,000m of the Study Site boundary.

Records of WWII UXB Disposal Tasks

Civil defence records did not identify any UXB disposal tasks in *Wrexham Rural District* within 1,000m of the Study Site from 1940-45. However, it is known that these records are incomplete, some having been destroyed by *Luftwaffe* action during WWII.

Records of Post-WWII UXB Disposal Tasks

An examination of the post-WWII BDO tasks associated with the area has not identified any BDO operations within the Study Site itself, nor within 1,000m of its boundary.

WWII Site Use

Pre-WWII mapping (1938) associated with the Study Site shows that it was located within an undeveloped rural area during WWII, with the Study Site itself consisting of mainly undeveloped ground, although *Redwither Lane* was located in the northern section, *Coed-Aben Woods* in the central and southern sections. However, an analysis of *Luftwaffe* aerial photography suggests that explosives warehouses and other structures were located on part of the Study Site – or in very close proximity to it – during WWII that were associated with the *ROF Wrexham*. As a result, it is considered plausible that the Study Site may have been inspected for UXB entry holes following any raids.

Military Activity

The Study Site comprised *ROF Wrexham* during WWII, which was approved for construction in 1939. During WWII, it primarily produced *cordite*, an explosive propellant used in shells and ammunition, though other munitions/chemical agents may also have been produced or stored there. When post-war production ceased, *ROF Wrexham* was no longer needed and was subsequently shut down once hostilities ceased in 1945.

The site for *ROF Wrexham* was chosen for a number of reasons, including its rural location and distance from mainland *Europe* – which largely placed it outside the range of the *Luftwaffe* bombers. The site of *ROF Wrexham* also possessed impressive railway links to other munitions facilities in *South Wales* and a good supply of labour was available in the local area.

The site itself comprised approximately 1,730 acres (700ha), with the complex spread over large area to minimise any damage from aerial attacks. The structures themselves were built to withstand incendiary and high explosive blasts, although there is no evidence that *ROF Wrexham* was ever hit by any bomb strikes during WWII. The site was also defended by numerous pillboxes, as well as by *RAF Wrexham*.

Because the Study Site was located within the former grounds of the *ROF Wrexham* complex, it is considered possible that munitions, and materials involved in munitions production, were manufactured, located, or stored on or near the Study Site during WWII. It was common that munitions were buried at former military facilities and were often abandoned at the end of the war, known as Abandoned Explosive Ordnance (AXO).

In addition, four pillboxes were identified, 805m to the south-east, 935m to the south-east, 995m to the east and 995m to the south-east.

Sources of UXO Contamination

The most probable UXO threat items are AXO/LSA/SAA and munitions materials associated with *ROF Wrexham* which, if present, are likely to be encountered in previously undisturbed ground to depths of circa 2.0m. *German* HE bombs, IBs and *British* AAA projectiles pose a residual threat. The consequences of initiating *German* HE bombs are more severe than initiating IBs or AAA projectiles, and thus they pose the greatest prospective risk to intrusive works.

STAGE THREE – DATA ANALYSIS

Variable	Result	Comment
Was the area considered to be a primary bombing target?	✓	The <i>ROF Wrexham</i> complex (located on-site) was identified as a primary bombing target.
Was the Study Site or the immediate area bombed during WWII?	✗	ARP records were not available.
Did the Study Site or the immediate area experience bomb damage?	✗	There is no evidence of bomb damage on-site.
Was the ground undeveloped during WWII?	✓	The Study Site consisted of <i>ROF Wrexham</i> , although some undeveloped ground was located on-site.
Would the footfall have been high in the area?	✓	Given that <i>ROF Wrexham</i> was located on-site and in the immediate vicinity, it is likely that footfall would have been high.
Would a UXB entry hole have been observed during WWII?	✓	Given <i>ROF Wrexham</i> was located on-site, it is considered likely that the Study Site would have been subjected to inspections for UXB entry holes following any raids.
Have military personnel ever occupied the Study Site?	✓	The Study Site comprised <i>ROF Wrexham</i> during WWII – it appears that explosives warehouses were located on-site.
Would munitions have been manufactured, stored and/or fired from the Study Site?	✓	Given that explosives warehouses were located on-site, it is likely that munitions, or materials involved in munitions production, were manufactured or stored from the Study Site. Munitions were often buried and abandoned near former <i>ROF</i> sites.
Would previous intrusive works have removed the potential for UXO to be present?	✗	The Study Site has been subjected to some redevelopment post-WWII; therefore, it is likely that any UXO within post-war disturbed and developed ground would potentially have been discovered and removed, whilst the surrounding areas remain extant.
Are proposed intrusive works likely to extend into previously undisturbed ground?	✓	Some areas of the Study Site have remained undeveloped since WWII and therefore some proposed works will likely extend into previously undisturbed ground.
Is there potential for an unplanned encounter with UXO to occur during proposed intrusive works?	✓	Given that <i>ROF Wrexham</i> was located on-site during WWII, it is considered possible for an unplanned encounter with UXO to occur.
Does the probability of UXO vary across the Study Site?	✓	The probability of discovering UXO within post-war disturbed and developed ground is considered to be remote, however, the probability of UXO discovery within all previously undisturbed areas of the Study Site is extant.

N.B. The ✓ / ✗ symbology is intended to act only as a succinct visual indicator as to whether the data analysis has returned a positive (i.e. ✓) or negative (✗) answer to each question concerning the potential for UXO contamination at the Study Site.

STAGE FOUR – RISK ASSESSMENT

Threat Items

The most probable UXO threat items are AXO/LSA/SAA and munitions materials associated with *ROF Wrexham* which, if present, are likely to be encountered in previously undisturbed ground to depths of circa 2.0m. *German* HE bombs, IBs and *British* AAA projectiles pose a residual threat. The consequences of initiating *German* HE bombs are more severe than initiating IBs or AAA projectiles, and thus they pose the greatest prospective risk to intrusive works.

Bomb Penetration Depth

Considering the ground conditions (highlighted in Stage 1), the average BPD for a 250kg *German* HE bomb is assessed to be approximately 6m bgl, with the maximum BPD considered to be approximately 15m bgl. Although it is possible that the *Luftwaffe* deployed larger bombs in the area, their deployment was infrequent, and to use such larger (or the largest) bombs for BPD calculations are not justifiable on either technical or risk management grounds.

WWII *German* bombs have a greater penetration depth when compared to IBs and AAA projectiles, which are unlikely to be encountered at depths greater than 1m bgl. However, due to the "J Curve" and the potential for structures to impede the penetration into the ground, HE bombs have been discovered at much shallower depths than the average.

Risk Pathway

Given the types of UXO that might be present on-site, all types of aggressive intrusive engineering activities (i.e. investigative groundworks) may generate a significant risk pathway. Whilst not all UXO encountered aggressively will initiate upon contact, such a discovery could lead to serious impact on the project especially in terms of critical injury to personnel, damage to equipment and project delay.

Prospective Consequences

Consequences of UXO initiation include:

1. Fatally injure personnel;
2. Severe damage to plant and equipment;
3. Deliver blast and fragmentation damage to nearby buildings;
4. Rupture and damage underground utilities/services.

Consequences of UXO discovery include:

1. Delay to the project and blight;
2. Disruption to local community/infrastructure;
3. The expenditure of additional risk mitigation resources and EOD clearance;
4. Incurring additional time and cost.

UXO RISK CALCULATION

Site Activities

Although there is some variation in the probability of encountering and initiating items of UXO when conducting different types of intrusive activities, a number of investigative methodologies have been described for analysis at this Site. The consequences of initiating UXO vary greatly, depending upon, *inter alia* the mass of HE in the UXO and how aggressively it might be encountered. For this reason, *6 Alpha* has conducted separate risk rating calculations for each investigative methodology that might be employed.

Risk Rating Calculation

6 Alpha's Semi-Quantitative Risk Assessment assesses and rates the risks posed by the most probable threat items when conducting a number of different activities on the Site. Risk Rating is determined by calculating the probability of encountering UXO and the consequences of initiating it.

UXO Risk Calculation Table – All Areas

Activity	Threat Item	Probability (SH+EM=P)	Consequence (D+PSR=C)	Risk Rating (PXC=RR)
Trial Pits (to 5m bgl)	HE Bombs	0+2=2	3+3=6	2x6=12
	AAA Projectiles	0+2=2	3+1=4	2x4=8
	IBs	0+2=2	3+1=4	2x4=8
	AXO/LSA/SAA	3+2=5	3+2=5	5x5=25
Window Sampling (~5 m bgl)	HE Bombs	0+3=3	3+2=5	3x5=15
	AAA Projectiles	0+3=3	3+1=4	3x4=12
	IBs	0+3=3	3+1=4	3x4=12
	AXO/LSA/SAA	3+3=6	3+2=5	6x5=30
Boreholes (~5 m bgl)	HE Bombs	0+3=3	3+2=5	3x5=15
	AAA Projectiles	0+3=3	3+1=4	3x4=12
	IBs	0+3=3	3+1=4	3x4=12
	AXO/LSA/SAA	3+3=6	3+2=5	6x5=30
Abbreviations – Site History (SH), Engineering Methodology (EM), Probability (P), Depth (D), Consequence (C), Proximity to Sensitive Receptors (PSR) and Risk Rating (RR).				

STAGE FIVE – RECOMMENDED RISK MITIGATION MEASURES

Do the ground conditions support a geophysical UXO survey?

Non-Intrusive Methods of Mitigation – Magnetometer results may be affected by ferro-magnetic contamination due to previous construction activities and made ground within the Site.

Intrusive Methods of Mitigation – Intrusive magnetometry may be effective on this Site, prior to boreholing especially. However, any ferrous metal/red brick contamination in made ground/old foundations may affect the detection capability of the UXB survey equipment, as it passes through the contaminated layer especially. Nonetheless, beyond the contaminated strata such a survey should prove effective.

Mitigation Measures to Reduce Risk to 'ALARP'

Activity	Risk Mitigation Measures	Final Risk Rating
All Activities in All Areas	1. Operational UXO Emergency Response Plan; appropriate site management documentation should be held on-site to guide and plan for the actions which should be undertaken in the event of a suspected or real UXO discovery (this plan can be supplied by <i>6 Alpha</i>); 2. UXO Safety & Awareness Briefings; the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement. All personnel working on the site should receive a briefing on the identification of a UXB, what actions they should take to keep people and equipment away from such a hazard and to alert site management. Information concerning the nature of the UXB threat should be held in the site office and displayed for general information on notice boards, both for reference and as a reminder for ground workers. The safety awareness briefing is an essential part of the <i>Health & Safety Plan</i> for the site and helps to evidence conformity with the principles laid down in the <i>CDM regulations 2015</i> (this brief can be delivered directly, or in some cases remotely, by <i>6 Alpha</i>).	ALARP
Trial Pits into Previously Undisturbed Ground	3. Non-intrusive UXO Survey and/or EOD Engineer in the Watching Brief Role; Where 'open' intrusive works into previously undisturbed ground are proposed and where the extent is considered to be within the capabilities of non-intrusive UXO survey equipment and implementation of this is assessed as likely to prove effective, a non-intrusive geophysical UXO survey should be trialed and, if it proves successful, should be employed to survey site-wide, or in specific areas where 'open' intrusive works are to be implemented to identify for signs of sub-surface anomalies which may model as the target UXO in advance of said works. If the survey proves partially or wholly ineffective, an EOD Engineer should be present in the UXO Watching Brief role to monitor ongoing 'open' intrusive works to identify any suspicious items that may be UXB or UXO related (this service can be provided by <i>6 Alpha</i>).	
Window Sampling and Boreholing into Previously Undisturbed Ground	4. Intrusive UXO Survey; Where 'blind' intrusive works into previously undisturbed ground are proposed, an intrusive UXO survey (employing down-hole magnetometer or MagCone techniques) is strongly recommended. Such a survey should extend to the <i>assessed average bomb penetration depth</i> or to the maximum depth of the works, whichever is encountered first, or until geology is encountered through which it is assessed a UXB would not penetrate, to identify for signs of sub-surface anomalies which may model as the target UXO in advance of said works. (this service can be provided by <i>6 Alpha</i>).	

This assessment has been conducted based on the information provided by the Client; should the proposed works change then *6 Alpha* should be re-engaged to refine this risk assessment.

Report Figures

Figure One - Study Site Location

TRITECH, UNIT 69, CLYWEDOG ROAD EAST,
WREXHAM INDUSTRIAL ESTATE, WREXHAM, LL13 9XE

Site Location



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PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
8004	1	CC	LS	23 June 2020

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Figure Two - Study Site Boundary

TRITECH, UNIT 69, CLYWEDOG ROAD EAST,
WREXHAM INDUSTRIAL ESTATE, WREXHAM, LL13 9XE

Site Boundary



LEGEND
Site_Boundary

PROJECT NO: 8004
SCALE: 2
DRAWN: CC
CHECKED: LB
DATE: 03 June 2020

Geographic Information Systems ©
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Reviewed by and Copyright for B. Alpha Associates
and shown working map to the above details B. Alpha

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Figure Three - Aerial Photography (2018)

TRITECH, UNIT 69, CLYWEDOG ROAD EAST,
WREXHAM INDUSTRIAL ESTATE, WREXHAM, LL13 9XE

Aerial Photography (2018)



PROJECT NO	ISSUE	DRAWN	CHECKED	DATE
0001	3	CC	LG	03 June 2020

Map data Google

Produced by and for copyright to Alpha Associates
and others holding the aerial photography to Alpha

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Figure Four - WWII *Luftwaffe* Bombing Targets

WWII Luftwaffe Bombing Targets

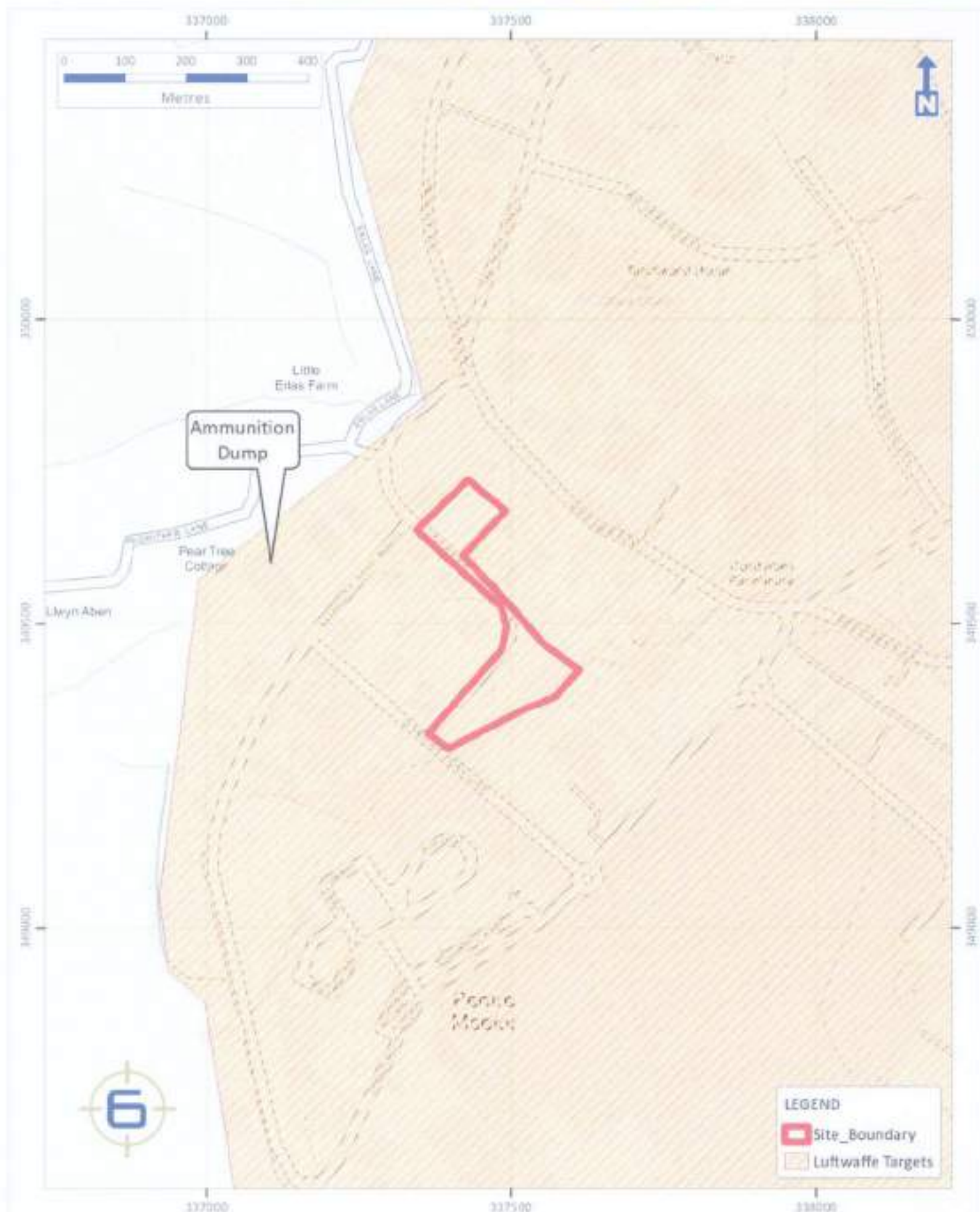


Figure Five - WWII High Explosive Bomb Density

TRITECH, UNIT 69, CLYWEDOG ROAD EAST,
WREXHAM INDUSTRIAL ESTATE, WREXHAM, LL13 9XE

WWII High Explosive Bomb Density



APPENDIX C

Historical Site Features

Legend

- Approximate Site Boundary
- ▨ Approximate Location of ROF Drying Houses
- ▤ Approximate Location of Wooded Area
- ▧ Approximate Location of ROF Cuttings
- ▩ Approximate Location of ROF Mound
- 🏠 Approximate Location of Tank
- Approximate Location of Pipework
- ⚡ Approximate Location of Electrical Substation
- Site Former ROF Infrastructure (e.g. paths)
- Site Approximate Location of Repetitive Lane
- 🚰 Approximate Location of Hydrant
- Approximate Location of Ponds
- Approximate Location of Possible Stream / Drain



APPENDIX D

Borehole and Trial Pit Logs

CLIENT <u>F1 Real Estate Management</u>	PROJECT NAME <u>Wrexham Industrial Estate - Site 2</u>
PROJECT NUMBER <u>S1671 - 2</u>	PROJECT LOCATION <u>Wrexham</u>
DATE STARTED <u>5/3/20</u> COMPLETED <u>5/5/20</u>	GROUND ELEVATION _____ HOLE SIZE _____
DRILLING CONTRACTOR _____	GROUND WATER LEVELS:
DRILLING METHOD <u>Window Sampler</u>	AT TIME OF DRILLING <u>---</u>
LOGGED BY <u>PVC</u> CHECKED BY _____	AT END OF DRILLING <u>---</u>
NOTES <u>Standpipe installed to 6m, 1m plain, 5m slotted.</u>	AFTER DRILLING <u>---</u>

DEPTH (m)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0.00	UD 1			Soft, brown, silty CLAY with occasional roots (Topsoil)
0.30				Firm to stiff, brown CLAY (Glacial Till)
1.00				
1.00	UD 2	SPT N @ 1m = 13		Firm to stiff, brown and grey mottled CLAY (Glacial Till)
2.00				
2.00	UD 3	SPT N @ 2m = 19		
3.00				
3.00	UD 4	SPT N @ 3m = 29		
4.00				
4.00	SPT 5	SPT N @ 4m = 32		
4.40				

Bottom of borehole at 4.45 meters.

CLIENT F1 Real Estate Management PROJECT NAME Wrexham Industrial Estate - Site 2
 PROJECT NUMBER S1671 - 2 PROJECT LOCATION Wrexham
 DATE STARTED 5/3/20 COMPLETED 5/3/20 GROUND ELEVATION _____ HOLE SIZE _____
 DRILLING CONTRACTOR _____ GROUND WATER LEVELS:
 DRILLING METHOD Window Sampler AT TIME OF DRILLING _____
 LOGGED BY PVC CHECKED BY _____ AT END OF DRILLING _____
 NOTES Borehole remained dry AFTER DRILLING _____

DEPTH (m)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0.20	UD 1			Soft, dark brown, sandy CLAY with roots (Topsoil)
1.00	UD 2	SPT N @ 1m = 20		Firm to stiff, brown CLAY (Glacial Till)
2.40	UD 3	SPT N @ 2m = 22		Firm, brown CLAY (Glacial Till)
	UD 4	SPT N @ 3m = 16		
	UD 5	SPT N @ 4m = 17		
	UD 6	SPT N @ 5m = 14		
6.00	SPT 7	SPT N @ 6m = 21		Firm to stiff, brown CLAY (Glacial Till)
6.45				Bottom of borehole at 6.45 meters.



PAGE 1 OF 1

CLIENT	F1 Real Estate Management	PROJECT NAME	Wrexham Industrial Estate - Site 2
PROJECT NUMBER	S1671 - 2	PROJECT LOCATION	Wrexham
DATE STARTED	5/3/20	COMPLETED	5/5/20
DRILLING CONTRACTOR		GROUND ELEVATION	
DRILLING METHOD	Window Sampler	HOLE SIZE	
LOGGED BY	PVC	CHECKED BY	
NOTES	Standpipe installed to 5m, 1m plain, 4m slotted.		
	GROUND WATER LEVELS:		
	AT TIME OF DRILLING		
	AT END OF DRILLING		
	AFTER DRILLING		

DEPTH (m)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0.00				Soft, brown CLAY with roots (Topsoil)
0.20	UD 1			Firm to stiff, brown CLAY with occasional shale fragments (Glacial Till)
1.00	UD 2	SPT N @ 1m = 18		Firm to stiff, brown and grey mottled CLAY (Glacial Till)
2.00	UD 3	SPT N @ 2m = 23		
3.00	UD 4	SPT N @ 3m = 23		Firm, brown CLAY (Glacial Till)
4.00	UD 5	SPT N @ 4m = 11		
5.00	SPT 6	SPT N @ 5m = 12		

Bottom of borehole at 5.45 meters.

SP Associates

CLIENT F1 Real Estate ManagementPROJECT NAME Wrexham Industrial Estate - Site 2PROJECT NUMBER S1671 - 2PROJECT LOCATION WrexhamDATE STARTED 5/3/20COMPLETED 5/3/20

GROUND ELEVATION _____

HOLE SIZE _____

DRILLING CONTRACTOR _____

GROUND WATER LEVELS:

DRILLING METHOD Window Sampler

AT TIME OF DRILLING _____

LOGGED BY PVC

CHECKED BY _____

AT END OF DRILLING _____

NOTES Borehole remained dry

AFTER DRILLING _____

DEPTH (m)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
	UD 1			Soft, dark brown, sandy SILT with occasional roots (Topsoil)
1				Firm, brown CLAY with occasional fine shale fragments (Glacial Till)
	UD 2	SPT N @ 1m = 18		
2				
	UD 3	SPT N @ 2m = 15		
3				
	UD 4	SPT N @ 3m = 20		
4				
	UD 5	SPT N @ 4m = 11		
5				
	SPT 6	SPT N @ 5m = 26		

Bottom of borehole at 5.45 meters.

SP Associates

CLIENT F1 Real Estate Management PROJECT NAME Wrexham Industrial Estate - Site 2
 PROJECT NUMBER S1671-2 PROJECT LOCATION Wrexham
 DATE STARTED 5/3/20 COMPLETED 5/3/20 GROUND ELEVATION _____ HOLE SIZE _____
 DRILLING CONTRACTOR _____ GROUND WATER LEVELS:
 DRILLING METHOD Window Sampler AT TIME OF DRILLING _____
 LOGGED BY PVC CHECKED BY _____ AT END OF DRILLING _____
 NOTES Borehole remained dry AFTER DRILLING _____

DEPTH (m)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
				Soft brown CLAY with occasional roots (Topsoil)
	UD 1			Soft to firm, brown CLAY (Glacial Till)
1				
	UD 2	SPT N @ 1m = 13		Firm to stiff, brown and grey mottled CLAY (Glacial Till)
2				
	UD 3	SPT N @ 2m = 15		
3				
	UD 4	SPT N @ 3m = 18		Firm, brown CLAY (Glacial Till)
4				
	UD 5	SPT N @ 4m = 18		
5				
	SPT 6	SPT N @ 5m = 20		
				Bottom of borehole at 5.45 meters.

TEST PIT NUMBER TP1

PAGE 1 OF 1

SP Associates

CLIENT F1 Real Estate Management PROJECT NAME Wrexham Industrial Estate - Site 2
 PROJECT NUMBER 51671-2 PROJECT LOCATION Wrexham
 DATE STARTED 12/3/20 COMPLETED 12/3/20 GROUND ELEVATION _____ TEST PIT SIZE _____
 EXCAVATION CONTRACTOR _____ GROUND WATER LEVELS:
 EXCAVATION METHOD Trial Pit AT TIME OF EXCAVATION _____
 LOGGED BY PVC CHECKED BY _____ AT END OF EXCAVATION _____
 NOTES Trial Pit remained dry. AFTER EXCAVATION _____

DEPTH (m)	SAMPLE TYPE NUMBER	GRAPHIC LOG	MATERIAL DESCRIPTION
0.10			Soft, dark brown CLAY with occasional roots (Made Ground)
			Firm to stiff, brown CLAY with occasional pockets of brown, ashy sand with some boulders of concrete (Made Ground)
0.70			
			Firm to stiff, brown and grey mottled CLAY (Glacial Till)
1			
2			
2.20			

Bottom of test pit at 2.20 meters.

TEST PIT NUMBER TP2

PAGE 1 OF 1

SP Associates

CLIENT F1 Real Estate Management PROJECT NAME Wrexham Industrial Estate - Site 2
 PROJECT NUMBER S1671-2 PROJECT LOCATION Wrexham
 DATE STARTED 12/3/20 COMPLETED 12/3/20 GROUND ELEVATION _____ TEST PIT SIZE _____
 EXCAVATION CONTRACTOR _____ GROUND WATER LEVELS:
 EXCAVATION METHOD Trial Pit AT TIME OF EXCAVATION ---
 LOGGED BY PVC CHECKED BY _____ AT END OF EXCAVATION ---
 NOTES Trial Pit remained dry. AFTER EXCAVATION ---

DEPTH (m)	SAMPLE TYPE NUMBER	GRAPHIC LOG	MATERIAL DESCRIPTION
			0.10 Soft, dark brown CLAY with occasional roots (Made Ground)
			Firm to stiff, brown CLAY with some brick and concrete fragments (Made Ground)
			0.90
1			Firm to stiff, brown mottled grey CLAY (Glacial Till)
2			
			2.20

Bottom of test pit at 2.20 meters.

CLIENT F1 Real Estate Management PROJECT NAME Wrexham Industrial Estate - Site 2
 PROJECT NUMBER S1671-2 PROJECT LOCATION Wrexham
 DATE STARTED 12/3/20 COMPLETED 12/3/20 GROUND ELEVATION _____ TEST PIT SIZE _____
 EXCAVATION CONTRACTOR _____ GROUND WATER LEVELS: _____
 EXCAVATION METHOD Trial Pit AT TIME OF EXCAVATION ---
 LOGGED BY PVC CHECKED BY _____ AT END OF EXCAVATION ---
 NOTES Trial Pit remained dry. AFTER EXCAVATION ---

DEPTH (m)	SAMPLE TYPE NUMBER	GRAPHIC LOG	MATERIAL DESCRIPTION
			0.10 Soft, dark brown CLAY with occasional roots (Made Ground)
	GB 1		Soft to firm, brown CLAY with some boulders of concrete, some brick fragments and occasional shale and fine coal fragments (Made Ground)
			0.40 Firm to stiff, brown mottled grey CLAY (Glacial Till)
1	GB 2		
2			
			2.20

Bottom of test pit at 2.20 meters.

TEST PIT NUMBER TP4

PAGE 1 OF 1

SP Associates

CLIENT F1 Real Estate Management PROJECT NAME Wrexham Industrial Estate - Site 2
 PROJECT NUMBER S1671-2 PROJECT LOCATION Wrexham
 DATE STARTED 12/3/20 COMPLETED 12/3/20 GROUND ELEVATION _____ TEST PIT SIZE _____
 EXCAVATION CONTRACTOR _____ GROUND WATER LEVELS:
 EXCAVATION METHOD Trial Pit AT TIME OF EXCAVATION ---
 LOGGED BY PVC CHECKED BY _____ AT END OF EXCAVATION ---
 NOTES Trial Pit remained dry. AFTER EXCAVATION ---

DEPTH (m)	SAMPLE TYPE NUMBER	GRAPHIC LOG	MATERIAL DESCRIPTION
	GB		Soft, dark brown CLAY with occasional roots (Made Ground)
		0.20	Soft to firm, brown CLAY with occasional brick fragments (Made Ground)
		0.40	Firm to stiff, brown and grey mottled CLAY (Glacial Till)
1			
2		2.00	

Bottom of test pit at 2.00 meters.

APPENDIX E

Chemical Test Results



Amended Report

Report No.:	20-09021-2	Date of Re-issue:	28-Apr-2020
Initial Date of Issue:	21-Apr-2020		
Client:	SP Associates Ltd		
Client Address:	1 Market Place Warwick Warwickshire CV34 4SA		
Contact(s):	Steven Peters		
Project:	S1671-2 Wrexham Industrial Estate Site 2		
Quotation No.:	Q19-18628	Date Received:	20-Mar-2020
Order No.:		Date Instructed:	22-Apr-2020
No. of Samples:	6		
Turnaround (Wkdays):	5	Results Due:	28-Apr-2020
Date Approved:	28-Apr-2020	Subcon Results Due:	15-Apr-2020
Approved By:			

Details: Glynn Harvey, Technical Manager

Deviations

In accordance with UKAS Policy on Deviating Samples (TR6-EX), Chemtest have a procedure to ensure representation of each sample & comment on laboratory results that states whether the sample is suitable with regard to the requested results. This policy and the respective finding levels against, can be supplied upon request. The reason a sample is declared as deviating is detailed below. Where applicable for analysis on-site UKAS ISO/IEC 17025 accreditation the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sample Date:	Deviation Code(s):	Containers Received:
000011			TR1	12-Mar-2020	0	Amber Glass 250ml
000014			TR1	12-Mar-2020	0	Plastic Bag
000013			TR2	12-Mar-2020	0	Amber Glass 250ml
000015			TR3	12-Mar-2020	0	Plastic Bag
000016			TR4	12-Mar-2020	0	Amber Glass 250ml
000018			TR4	12-Mar-2020	0	Plastic Bag
000017			TR4	12-Mar-2020	0	Amber Glass 250ml
000017			TR4	12-Mar-2020	0	Plastic Bag
000018			DR2	12-Mar-2020	0	Amber Glass 250ml
000019			DR2	12-Mar-2020	0	Plastic Tub 100g
000019			DR5	12-Mar-2020	0	Amber Glass 250ml
000019			DR6	12-Mar-2020	0	Plastic Tub 100g

ICP	Title	Parameters included	Method summary
2010	pH Value of Soil	pH	pH Value
2030	Moisture and Stone Content of Soil/Resistant of AGGRTS	Moisture content	Determination of moisture content of soil as a percentage of its as received state obtained at 100°C
2120	Water Soluble Borne, Sulphate Magnesium & Calcium	Borne, Sulphate, Magnesium, Calcium	Aqueous extraction / ICP-OES
2150	Acidities	Acidities	Proximate light microscopy / Gravimetry
2450	Acid Soluble Metals in Soil	Alkali, including Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Mercury, Molybdenum, Nickel, Selenium, Vanadium, Zinc	Acid digestion followed by determination of metals in solution by ICP-MS
3000	TPH by GC	Alkanes: C15-C19, C20-C24, C25-C29, C30-C34, C35-C39, C40-C44, C45-C49, C50-C54, C55-C59, C60-C64, C65-C69, C70-C74, C75-C79, C80-C84, C85-C89, C90-C94, C95-C99, C100-C104	Octadecane extraction / GC-MS (MS detection)
3700	Speciated Polynuclear Aromatic Hydrocarbons (PAHs) in Soil by GC-MS	Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[e]pyrene, Dibenzo[a,h]anthracene, Dibenzo[a,h]fluoranthene, Fluoranthene, Fluorene, Indeno[1,2,3-cd]pyrene, Naphthalene, Phenanthrene, Pyrene	Octadecane extraction / GC-MS (GC-MS detection is non-selective and can be subject to interference from co-eluting compounds)
3700	Volatile Organic Compounds (VOCs) in Soil by HeadSpace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic Aromatics (if HSEVA method 5260/please refer to UNAS website)	Automated headspace gas chromatography (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds
5000	Phenols in Soil by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 2-Naphthol and 1-naphthol (phenols are excluded)	60-40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection

Report Information**Key**

-
- U - UKAS accredited
 - M - MCERTS and UKAS accredited
 - N - Unaccredited
 - S - This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
 - SN - This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
 - T - This analysis has been subcontracted to an unaccredited laboratory
 - IS - Insufficient Sample
 - US - Unsuitable Sample
 - NE - not evaluated
 - < - "less than"
 - > - "greater than"

Comments or Interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis: TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

-
- A - Date of sampling not supplied
 - B - Sample age exceeds stability time (sampling to extraction)
 - C - Sample not received in appropriate container
 - D - Broken Container
 - E - Insufficient Sample (Applies to LOI in Treated Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com



Final Report

Report No.: 20-06877-1
Initial Date of Issue: 19-Mar-2020
Client SP Associates Ltd
Client Address: 1 Market Place
Warwick
Warwickshire
CV34 4SA
Contact(s): Steven Peters
Project Wrexham Industrial Estate, Wrexham

Quotation No.:	Q20-19849	Date Received:	04-Mar-2020
Order No.:		Date Instructed:	11-Mar-2020
No. of Samples:	6		
Turnaround (Wkdays):	5	Results Due:	17-Mar-2020
Date Approved:	17-Mar-2020		

Approved By:

Details: Darrell Hall, Director

Results - Water

Client: SP Associates Ltd	Chemtest Job No.	20-06677	20-06677	20-06677	20-06677	20-06677	20-06677
Quotation No.: Q20-19848	Chemtest Sample ID	980043	980041	980042	980043	980044	980045
Order No.:	Client Sample Ref.	BN1	BN2	BN1	BN4	BN1	BN3
	Sample Location	Site 2	Site 2	Site 3	Site 4	Site 5B	Site 5B
	Sample Type	WATER	WATER	WATER	WATER	WATER	WATER
	Date Sampled	02-Mar-2020	02-Mar-2020	02-Mar-2020	02-Mar-2020	02-Mar-2020	02-Mar-2020
Determinand	Assted	SDP	Units	LOD			
pH	U	1050	N/A	8.2	8.4	8.4	8.1
Electrical Conductivity	U	1020	µS/cm	1.0	2250	1180	1820
Chloride	U	1220	mg/l	1.0	360	33	85
Fluoride	U	1220	mg/l	0.050	0.16	0.27	0.29
Ammonium	U	1220	mg/l	0.050	0.76	0.067	0.055
Nitrite	U	1220	mg/l	0.020	< 0.020	< 0.020	< 0.020
Nitrate	U	1220	mg/l	0.50	< 0.50	< 0.50	< 0.50
Sulphate	U	1220	mg/l	1.0	3000	64	110
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050
Sodium	U	1410	mg/l	0.50	360	38	140
Aluminium (Dissolved)	N	1490	µg/l	1.0	210	< 1.0	360
Arsenic (Dissolved)	U	1490	µg/l	1.0	1.1	< 1.0	< 1.0
Boron (Dissolved)	U	1490	µg/l	2.0	270	63	38
Cadmium (Dissolved)	U	1490	µg/l	0.080	0.16	< 0.080	< 0.080
Chromium (Dissolved)	U	1490	µg/l	1.0	2.4	< 1.0	< 1.0
Copper (Dissolved)	U	1490	µg/l	1.0	4.2	5.4	3.1
Cobalt (Dissolved)	N	1490	µg/l	2.0	600	210	340
Mercury (Dissolved)	U	1490	µg/l	0.50	< 0.50	< 0.50	< 0.50
Manganese (Dissolved)	U	1490	µg/l	1.0	63	3.0	1200
Nickel (Dissolved)	U	1490	µg/l	1.0	3.5	3.3	< 1.0
Lead (Dissolved)	U	1490	µg/l	1.0	< 1.0	< 1.0	< 1.0
Antimony (Dissolved)	U	1490	µg/l	1.0	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1490	µg/l	1.0	6.4	1.3	< 1.0
Zinc (Dissolved)	U	1490	µg/l	1.0	140	11	7.4
Total TPH (C8-C40)	U	1870	µg/l	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Benz[a]anthracene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	N	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Benz[b]fluoranthene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Benz[a]pyrene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Indeno[1,2,3-cd]pyrene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz[a,h]anthracene	U	1700	µg/l	< 0.10	< 0.10	< 0.10	< 0.10

Results - Water

Client: SP Associates Ltd	Chemtest Job No.	20-05877	20-05877	20-05877	20-05877	20-05877	20-05877
Quotation No.: Q30-18849	Chemtest Sample ID	980040	980041	980042	980043	980044	980045
Order No.	Client Sample Ref.	BH1	BH2	BH3	BH4	BH5	BH6
	Sample Location	Site 2	Site 2	Site 3	Site 4	Site 5B	Site 5B
	Sample Type	WATER	WATER	WATER	WATER	WATER	WATER
	Date Sampled	03-Mar-2020	03-Mar-2020	03-Mar-2020	03-Mar-2020	03-Mar-2020	03-Mar-2020
Determinand	Assted	SOP	Units	LOD			
Benz[a]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAHs	N	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0
Dibenzofuran	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	N	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromobenzene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Chloroethane	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0
Trichloroethene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Trans-1,2-Dichloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromochloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Trichloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1,1-Trichloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tetrachloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloropropane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Benzene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dichloroethane	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0
Trichloroethane	N	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dichloropropane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Dibromomethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromochloromethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
cis-1,3-Dichloropropene	N	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Toluene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Trans-1,3-Dichloropropene	N	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1,2-Trichloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tetrachloroethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3-Dichloropropene	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0
Dibromochloromethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dibromomethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	N	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1,1,2-Tetrachloroethane	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
o-Xylene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Styrene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Trichloromethane	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromobenzene	U	1700	µg/l	1.0	< 1.0	< 1.0	< 1.0

Results - Water

Client: SP Associates Ltd	Chemtest Job No.	20-06877	20-06877	20-06877	20-06877	20-06877	20-06877
Quotation No.: Q20-19849	Chemtest Sample ID.	860040	860041	860042	860043	860044	860045
Order No.	Client Sample Ref.	BH1	BH2	BH3	BH4	BH5	BH6
	Sample Location	Site 2	Site 2	Site 3	Site 4	Site 5B	Site 5B
	Sample Type	WATER	WATER	WATER	WATER	WATER	WATER
	Date Sampled	03-Mar-2020	03-Mar-2020	03-Mar-2020	03-Mar-2020	03-Mar-2020	03-Mar-2020
Determinand	Accred.	SOP	Units	LOD			
1,2,3-Trichlorobenzene	N	1760	µg/l	50	< 50	< 50	< 50
N-Propylbenzidine	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
2-Chlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trinitrobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
4-Chlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tert-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trinitrobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Sec-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3-Dichlorobenzene	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
4-Isopropyltoluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
N-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dibromo-3-Chlorobenzene	U	1760	µg/l	50	< 50	< 50	< 50
1,2,4-Trinitrobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Hexachlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,3-Trinitrobenzene	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Methyl Tert-Butyl Ether	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Epichlorohydrin	N	1760	µg/l	10	< 10	< 10	< 10
Acybenzide	N	1760	mg/l	0.55	< 0.55	< 0.55	< 0.55
Total Phenols	U	1920	mg/l	0.030	(B) < 0.030	(B) < 0.030	(B) < 0.030

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63, Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request. The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
980040	BH1		Site 2	02-Mar-2020	B	Coloured Winchester 1000ml
980040	BH1		Site 2	02-Mar-2020	B	EPA Vial 40ml
980040	BH1		Site 2	02-Mar-2020	B	Plastic Bottle 1000ml
980041	BH3		Site 2	02-Mar-2020	B	Coloured Winchester 1000ml
980041	BH3		Site 2	02-Mar-2020	B	EPA Vial 40ml
980041	BH3		Site 2	02-Mar-2020	B	Plastic Bottle 1000ml
980042	BH1		Site 3	02-Mar-2020	B	Coloured Winchester 1000ml
980042	BH1		Site 3	02-Mar-2020	B	EPA Vial 40ml
980042	BH1		Site 3	02-Mar-2020	B	Plastic Bottle 1000ml
980043	BH4		Site 4	02-Mar-2020	B	Coloured Winchester 1000ml
980043	BH4		Site 4	02-Mar-2020	B	EPA Vial 40ml
980043	BH4		Site 4	02-Mar-2020	B	Plastic Bottle 1000ml
980044	BH1		Site 5B	02-Mar-2020	B	Coloured Winchester 1000ml
980044	BH1		Site 5B	02-Mar-2020	B	EPA Vial 40ml
980044	BH1		Site 5B	02-Mar-2020	B	Plastic Bottle 1000ml
980045	BH3		Site 5B	02-Mar-2020	B	Coloured Winchester 1000ml
980045	BH3		Site 5B	02-Mar-2020	B	EPA Vial 40ml
980045	BH3		Site 5B	02-Mar-2020	B	Plastic Bottle 1000ml

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1300	Cyanides & Thiocyanate in Waters	Free (or easily liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6-C40); optional carbon banding, e.g. 3-band - GRO, DRO & LRO	Pentane extraction / GC FID detection
1700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID (GC-FID detection is non-selective and can be subject to interference from co-eluting compounds)
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds
1790	Semi-Volatile Organic Compounds (SVOCs) in Waters by GC-MS	Semi-volatile organic compounds	Solvent extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

- U UKAS accredited
- M MCERTS and UKAS accredited
- N Unaccredited
- S This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
- SN This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
- T This analysis has been subcontracted to an unaccredited laboratory
- I/S Insufficient Sample
- U/S Unsuitable Sample
- N/E not evaluated
- < "less than"
- > "greater than"

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com



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Final Report

Report No.: 20-08553-1
 Initial Date of Issue: 24-Mar-2020
 Client: SP Associates Ltd
 Client Address: 1 Market Place
 Warwick
 Warwickshire
 CV34 4SA

Contact(s): Steven Peters

Project: Water Analysis

Quotation No.: Q20-19849

Date Received: 18-Mar-2020

Order No.:

Date Instructed: 18-Mar-2020

No. of Samples: 6

Turnaround (Wkdays): 5

Results Due: 24-Mar-2020

Date Approved: 24-Mar-2020

Approved By:

Details: Glynn Harvey, Technical Manager

Results - Water

Client: SP Associates Ltd	Chemtest Job No.	30-08553	30-08553	30-08553	30-08553	30-08553	30-08553
Question No.: Q20-19849	Chemtest Sample ID:	867614	867615	867616	867617	867618	867619
	Client Sample ID:	BT5	BT4	BT3	BT1	BT5	BT6
	Sample Location:	Site 2	Site 3	Site 3	Site 4	Site 4	Site 50
	Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER
Determinand	Accred.	DDP	Units	LOD			
pH	U	1010	NA	[A] 8.4	[A] 8.5	[A] 9.4	[A] 8.1
Electrical Conductivity	U	1020	µS/cm	[A] 3000	[A] 980	[A] 1000	[A] 2200
Chloride	U	1220	mg/l	[A] 130	[A] 23	[A] 54	[A] 280
Fluoride	U	1220	mg/l	[A] 0.16	[A] 0.13	[A] 0.25	[A] 0.15
Antimony	U	1220	mg/l	[A] < 0.050	[A] 0.050	[A] 0.11	[A] < 0.050
Nitrite	U	1220	mg/l	[A] < 0.020	[A] < 0.020	[A] < 0.020	[A] < 0.020
Nitrate	U	1220	mg/l	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50
Sulphate	U	1220	mg/l	[A] 1.0	[A] 670	[A] 99	[A] 270
Cyanide (Total)	U	1300	mg/l	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Sodium	U	1415	mg/l	[A] 0.80	[A] 140	[A] 24	[A] 55
Aluminium (Dissolved)	N	1450	µg/l	[A] 15	[A] 8.10	[A] 206	[A] 10
Arsenic (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 1.7	[A] < 1.0	[A] 2.2
Boron (Dissolved)	U	1450	µg/l	[A] 20	[A] 1460	[A] 204	[A] 990
Cadmium (Dissolved)	U	1450	µg/l	[A] 0.080	[A] 0.11	[A] < 0.080	[A] 0.15
Chromium (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 2.1	[A] < 1.0	[A] 10
Copper (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 15	[A] 7.4	[A] 3.6
Iron (Dissolved)	N	1450	µg/l	[A] 20	[A] 370	[A] 420	[A] 510
Mercury (Dissolved)	U	1450	µg/l	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50
Manganese (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 1.5	[A] 215	[A] 1.5
Nickel (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 3.7	[A] 5.3	[A] 1.4
Lead (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 1.5	[A] < 1.0	[A] < 1.0
Antimony (Dissolved)	U	1450	µg/l	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Selenium (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 3.3	[A] 1.4	[A] 2.8
Zinc (Dissolved)	U	1450	µg/l	[A] 1.0	[A] 32	[A] 14	[A] 5.7
Mineral Oil	N	1670	µg/l	[A] 10	[A] < 10	[A] < 10	[A] < 10
Total TPH > C10-C40	U	1670	µg/l	[A] 10	[A] < 10	[A] < 10	[A] < 10
Naphthalene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Acenaphthylene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Acenaphthene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Fluorene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Phenanthrene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Anthracene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Fluoranthene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Pyrene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Benzo[a]anthracene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Chrysene	N	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Benzo[b]fluoranthene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Benzo[k]fluoranthene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Indeno[1,2,3-c,d]pyrene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Dibenz[a,h]anthracene	U	1700	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10

Project: Water Analysis

Client: SP Associates Ltd

Quotation No.: Q36-19849

Chemtest Job No.	20-00933	20-08853	20-08853	20-08853	20-08853	20-08853	20-08853
Chemtest Sample ID	867614	867615	867616	867617	867618	867619	867620
Client Sample ID	SP-0	SP-1	SP-2	SP-3	SP-4	SP-5	SP-6
Sample Location	Site 2	Site 3	Site 3	Site 4	Site 4	Site 5	Site 5
Sample Type	WATER	WATER	WATER	WATER	WATER	WATER	WATER
Determinand	Across	BDP	Units	LOD			
Benzol h/phenyl	U	1700	µg/l	0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Total Of 16 PAHs	N	1700	µg/l	2.0	[A] < 2.0	[A] < 2.0	[A] < 2.0
Dibenzodioxinmethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Chloromethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Vinyl Chloride	N	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Bromomethane	U	1760	µg/l	5.0	[A] < 5.0	[A] < 5.0	[A] < 5.0
Chloroethane	U	1760	µg/l	2.0	[A] < 2.0	[A] < 2.0	[A] < 2.0
Trichloromethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,1-Dichloroethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Trans 1,2-Dichloroethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,1-Dichloroethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
cis-1,2-Dichloroethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Bromochloromethane	U	1760	µg/l	5.0	[A] < 5.0	[A] < 5.0	[A] < 5.0
Trichloromethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,1,1-Trichloroethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Trichloromethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,1-Dichloropropene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Benzene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,2-Dichloroethane	U	1760	µg/l	2.0	[A] < 2.0	[A] < 2.0	[A] < 2.0
Trichloroethane	N	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,2-Dichloropropene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Dibromomethane	U	1760	µg/l	10	[A] < 10	[A] < 10	[A] < 10
Bromodichloromethane	U	1760	µg/l	5.0	[A] < 5.0	[A] < 5.0	[A] < 5.0
cis-1,3-Dichloropropene	N	1760	µg/l	10	[A] < 10	[A] < 10	[A] < 10
Toluene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Trans-1,3-Dichloropropene	N	1760	µg/l	10	[A] < 10	[A] < 10	[A] < 10
1,1,1-Trichloroethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Tetrachloroethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,3-Dichloropropene	U	1760	µg/l	2.0	[A] < 2.0	[A] < 2.0	[A] < 2.0
Dibromodichloromethane	U	1760	µg/l	10	[A] < 10	[A] < 10	[A] < 10
1,2-Dibromochloroethane	U	1760	µg/l	5.0	[A] < 5.0	[A] < 5.0	[A] < 5.0
Chlorobenzene	N	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,1,1,2-Tetrachloroethane	U	1760	µg/l	2.0	[A] < 2.0	[A] < 2.0	[A] < 2.0
Styrene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
m & p-Xylene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
o-Xylene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Benzene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Dibromomethane	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Isopropylbenzene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Bromobenzene	U	1760	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,2,3-Trichloropropene	N	1760	µg/l	50	[A] < 50	[A] < 50	[A] < 50

Results - Water

Client: SP Associates Ltd	Chemtest Job No.	20-08553	20-08553	20-08553	20-08553	20-08553	20-08553
Quotation No.: Q20-19949	Chemtest Sample ID:	987614	987615	987616	987617	987618	987619
	Client Sample ID:	SHC	SH4	SH5	SH1	SH6	SH0
	Sample Location:	Site 2	Site 3	Site 3	Site 4	Site 4	Site 5b
	Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER
Determinand	Accepted	SPC	Units	LOD			
N-Propylbenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
2-Chlorotoluene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,3,5-Trimethylbenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
4-Chlorotoluene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
tert-Butylbenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,2,4-Trimethylbenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
sec-Butylbenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,3-Dichlorobenzene	N	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
4-Isopropyltoluene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,4-Dichlorobenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
n-Butylbenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,2-Dichlorobenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,3-Dinitro-5-Chloropropane	U	1750	µg/l	90	[A] < 90	[A] < 90	[A] < 90
1,2,4-Trichlorobenzene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Hexachlorobutadiene	U	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
1,3,3-Trichlorobenzene	U	1750	µg/l	2.0	[A] < 2.0	[A] < 2.0	[A] < 2.0
Methyl tert-Butyl Ether	N	1750	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Epichlorohydrin	N	1750	µg/l	10	< 10	< 10	< 10
Acrylamide	N	1750	mg/l	0.50	< 0.50	< 0.50	< 0.50
Total Phenols	U	1920	mg/l	0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63, Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request. The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
987614		BH5	Site 2		A	Coloured Winchester 1000ml
987614		BH5	Site 2		A	EPA Vial 40ml
987614		BH5	Site 2		A	Plastic Bottle 1000ml
987615		BH4	Site 3		A	Coloured Winchester 1000ml
987615		BH4	Site 3		A	EPA Vial 40ml
987615		BH4	Site 3		A	Plastic Bottle 1000ml
987616		BH5	Site 3		A	Coloured Winchester 1000ml
987616		BH5	Site 3		A	EPA Vial 40ml
987616		BH5	Site 3		A	Plastic Bottle 1000ml
987617		BH1	Site 4		A	Coloured Winchester 1000ml
987617		BH1	Site 4		A	EPA Vial 40ml
987617		BH1	Site 4		A	Plastic Bottle 1000ml
987618		BH5	Site 4		A	Coloured Winchester 1000ml
987618		BH5	Site 4		A	EPA Vial 40ml
987619		BH6	Site 5b		A	Coloured Winchester 1000ml
987619		BH6	Site 5b		A	EPA Vial 40ml
987619		BH6	Site 5b		A	Plastic Bottle 1000ml

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 800' Discrete Analyser.
1300	Cyanides & Thiocyanate in Waters	Free (or easily liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6-C40); optional carbon banding, e.g. 3-band - GRO, DRO & LRO	Pentane extraction / GC FID detection
1700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenzo[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID (GC-FID detection is non-selective and can be subject to interference from co-eluting compounds)
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds.
1790	Semi-Volatile Organic Compounds (SVOCs) in Waters by GC-MS	Semi-volatile organic compounds	Solvent extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

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- < "less than"
- > "greater than"

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

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All Asbestos testing is performed at the indicated laboratory

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Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
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Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com



Final Report

Report No.: 20-09021-1
Initial Date of Issue: 21-Apr-2020
Client SP Associates Ltd
Client Address: 1 Market Place
Warwick
Warwickshire
CV34 4SA
Contact(s): Steven Peters
Project S1671-2 Wrexham industrial Estate Site
2

Quotation No.:		Date Received:	20-Mar-2020
Order No.:		Date Instructed:	23-Mar-2020
No. of Samples:	6		
Turnaround (Wkdays):	15	Results Due:	14-Apr-2020
Date Approved:	21-Apr-2020	Subcon Results Due:	15-Apr-2020
Approved By:			

Details: Glynn Harvey, Technical Manager

Results - Soil

Client: SP Associates Ltd	Chemtest Job No.:	20-09021	20-09021	20-09021	20-09021	20-09021	20-09021
Quotation No.:	Chemtest Sample ID.:	985614	985615	985616	985617	985618	985619
	Sample Location:	TP1	TP2	TP3	TP4	BH2	BH5
	Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Top Depth (m):	0.10	0.10	0.10	0.00	0.08	0.00
	Bottom Depth (m):	0.70	0.80	0.40	0.20	0.58	0.30
	Date Sampled:	12-Mar-2020	12-Mar-2020	12-Mar-2020	12-Mar-2020	12-Mar-2020	12-Mar-2020
Determinant	Appcat.	SOP	Units	LOD			
2,4,6-Trinitrobenzene (TNT)	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
2,4-Dinitrobenzene	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
2,6-Dinitrobenzene	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
Ethylene Glycol Dimethyl Ether (EGDM)	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
Cyclohexanemethylenedinitrobenzene (HMX)	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
Hexanitrobenzene (HNB)	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
Nitrocellulose (NC)	S		mg/kg	5000.00	< 5000	< 5000	< 5000
Nitroglycerine (NG)	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
Pentaerythritol tetranitrate (PETN)	SN		mg/kg	5.00	< 5.0	< 5.0	< 5.0
Plastic	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
Cyclotrimethylenetrinitramine (RDX)	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
2,4,6-Trinitrophenol	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0
N-methyl-N,2,4,6-tetranitroaniline	S		mg/kg	5.00	< 5.0	< 5.0	< 5.0

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APPENDIX F

Geotechnical Test Results



0001

Determination of Moisture Content and Atterberg Limits

Client: SP Associates Ltd
 Client Address: 1 Market Place
 Warwick
 Warwickshire
 CV34 4SA
 Contact: Steve Peters
 Site: LL13 9XE, Wrexham

Report No: 51055776
 Batch Number: DAM0078289

Client Reference: See Below
 Sampled by: Client
 Date Sampled: Not Advised
 Date Received: 20.03.2020
 Tested From: 27.03.2020
 Sample Type: BULK BAG

Test Results:

Laboratory Reference	Location	Depth (m)	Description	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	% Passing 425µm (Estimated)
45366514	Site 2, BH1	1.0 - 2.0	Firm Slightly Sandy, Brown / Grey CLAY	24	51	22	29	N/R
45366515	Site 2, BH2	1.0 - 2.0	Firm Slightly Sandy, Brown / Grey CLAY	21	49	24	25	N/R
45366516	Site 2, BH4	1.0 - 2.0	Firm Slightly Sandy, Brown / Grey CLAY	26	52	24	28	N/R
45366517	Site 2, BH5	1.0 - 2.0	Firm Slightly Sandy, Brown / Grey CLAY	24	53	26	27	N/R
45366518	Site 3, BH1	0.7 - 1.0	Firm Brown / Grey CLAY	26	49	23	26	N/R
45366519	Site 3, BH2	1.0 - 2.0	Firm Brown / Grey CLAY	24	50	25	25	N/R
45366520	Site 2, BH3	1.0 - 2.0	Firm Brown / Grey CLAY	26	53	25	28	N/R
45366521	Site 3, BH4	1.0 - 2.0	Firm Slightly Sandy, Brown / Grey CLAY	21	48	25	23	N/R
45366522	Site 4, BH1	1.0 - 2.0	Firm Brown / Grey CLAY	21	56	26	30	N/R
45366523	Site 4, BH4	1.0 - 2.0	Very Soft Slightly Silty Sandy Brown CLAY	27	59	24	35	N/R

Sample Preparation: As Received
 Certified that the laboratory testing was carried out in accordance with BS 1377-2: 1990: Method 3.2, 4.4 and 5

Page: 1 of 2
 Date Reported: 01.05.2020

Signed

[] J.J. Caiger - Materials Section Manager
 [X] S. Bourton - Laboratory Manager

For and on behalf of SOCOTEC UK Limited

Opinions and interpretations expressed herein are restricted to scope of UKAS accreditation

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APPENDIX G

Dynamic Probe Results

Wrexham Industrial Estate – Site 2

Dynamic Probing Results

DP1

DEPTH (m)	GL -1	1 - 2	2 -3
BLOWS	19	28	45

DP2

DEPTH (m)	GL -1	1 - 2	2 -3
BLOWS	23	29	45

DP3

DEPTH (m)	GL -1	1 - 2	2 -3
BLOWS	22	26	38

DP4

DEPTH (m)	GL -1	1 - 2	2 -3
BLOWS	21	27	36

DP5

DEPTH (m)	GL -1	1 - 2	2 -3
BLOWS	24	29	38

DP6

DEPTH (m)	GL -1	1 - 2	2 -3
BLOWS	20	29	41

APPENDIX H

Amended CSM

Wrexham Industrial Estate – Site 52

Amended Conceptual Site Model

Source	Pathway	Receptor	Risk Matrix Assessment	Assessment of Linkage Significance/Potential Mitigation Measures
Contaminated Soils and Groundwater from historical and current on-site sources.	Direct Ingestion, direct contact and inhalation of dust, vapours and liquids	Future site users	Low	Some Made Ground materials are present associated with historical site structures; however, concentrations of potential contaminants of concern are below threshold levels for an industrial site use. Acetone and explosives testing have failed to detect these materials at concentrations above laboratory detection limits. No soil remedial measures are proposed to protect human health.
		Construction workers	Moderate	Some shallow and laterally discontinuous perched water is present within the natural formation; however, most measured determinants conform to UK Drinking Water Standards. A controlled-waters quantified risk assessment is not proposed and nor are controlled waters remedial measures.
	Leaching and vertical and lateral migration	Controlled waters	Low	Site workers to wear appropriate PPE and adopt appropriate hygiene and safe working practices including a 'hotspot' protocol to be established. It is recommended that an explosives testing protocol is established and this should form part of the H and S file.
	Direct infiltration in water supply pipes	Service Conduits	Low	Leaching through near surface Made Ground materials could impact controlled waters. However, it is unlikely that any significant contamination would migrate to sensitive surface water receptors through the Glacial Till formation that contains significant horizons of low permeability cohesive soils. In addition, the Secondary Undifferentiated Aquifer is not considered to be overly sensitive.
				Shallow contaminated groundwater could potentially infiltrate service conduits; however, most of the groundwater determinants conform to UK Drinking Water Standards.
				Requirement for upgraded pipework considered to be low.

	Plant uptake	Vegetation within soft landscape areas	Low	Some phytotoxic contamination possible in near surface soils. Clean sub-soil and imported topsoil cover unlikely to be required.
	Lateral migration through groundwater	Off-site neighbouring properties	Low	Significant lateral migration unlikely due to the laterally discontinuous and perched nature of the shallow groundwater system.
Potentially contaminated groundwater: migration from off-site sources onto site	Direct contact or ingestion and inhalation of dust and vapours	Future site users	Very low	No significant upstream sources in terms of groundwater flow.
	Vertical and lateral migration	Controlled waters	Low	Geology not conducive to migration.
Ground gases generated on-site	Vertical and lateral migration	Buildings and human occupiers	Very Low	The ground gas regime conforms to Characteristic Situation 1 whereby no gas mitigation measures are required.
Ground gas migration onto site from off-site sources	Lateral migration	Buildings and human occupiers	Low	No apparent nearby source.
High sulphate and low pH in site soils	Direct contact and within shallow groundwater	Below ground concrete	Very Low	pH and soluble sulphate conditions conform to the most benign category.