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**ESL GROUP UK**

**ASH ROAD SOUTH  
WREXHAM**

**GROUND INVESTIGATION REPORT**

**Contract: 2230428**

**Date: April 2021**

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## **GROUND INVESTIGATION REPORT**

Carried out at

**Ash Road South,  
Wrexham**

Prepared for

**ESL GROUP UK  
6-8 Salisbury Road,  
Wrexham.  
LL13 7AS**

Contract No: 2230428

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## Document Control

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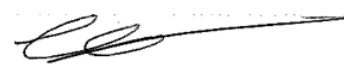
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## **EXECUTIVE SUMMARY**

On the instructions of ESL Group UK, an investigation was undertaken to determine ground conditions and review gas emissions.

This report should be read in conjunction with the Preliminary Investigation (Desk Study Report), which was reported under reference W07/40026-1 in February 2007; and the Ground Investigation Report which was reported under reference 42370 V01 in October 2019.

It is understood that the proposed development comprises commercial unit with associated car parking areas and access roads.

The site is located adjacent to Ash Road South, Wrexham Industrial Estate.

The geological map indicates the site to be underlain by superficial deposits of Made Ground as part of the Wrexham Industrial Estate, however the surrounding geology indicated Glacial Till. The superficial deposits are underlain by the Erbistock Formation of Westphalian age.

Site work comprised of eleven windowless sample boreholes, the installation of six gas and groundwater monitoring wells and their subsequent monitoring.

Ground conditions comprised Made Ground overlying firm to very stiff Glacial Till. A thin layer of Peat was identified at the base of the Made Ground in WS01A.

Made Ground extended to depths of between 2.50 m and 4.20 m in the southwest of the site, reducing to a maximum thickness of 0.30 m in the northeast.

Six monitoring visits have been undertaken over a period of a seven weeks.

Maximum carbon dioxide concentrations of 11.5%v/v and 8.7%v/v have been recorded in WS02A and WS03 respectively.

Methane concentrations of between 27.7%v/v and 46.8%v/v were recorded in WS02A on monitoring visits 4, 5 and 6. Methane concentration of 9.1%v/v was recorded in the same hole on visit 2.

Methane concentrations below the Level of Detection (LoD) have been recorded in WS04, WS05 and WS06. The maximum carbon dioxide concentration recorded in these holes was 0.2%v/v.

Steady state flow rates of 0.0 litres/hour were found on all monitoring visits. Peak flow rates of between -6.0 litres/hour and 4.0 litres/hour were found in WS01A and WS02A.

A carbon dioxide Gas Screening Value (GSV) of 0.69 l/h and a methane GSV of 2.81 l/h have been calculated, which would place the site within Characteristic Situation 3 (moderate risk), for which protection measures are required.

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## **1.0 INTRODUCTION**

- 1.1 On the instructions of ESL Group UK, an investigation was undertaken to determine ground conditions and review gas emissions.
- 1.2 It is understood that the proposed development comprises a commercial unit with associated car parking areas and access roads.
- 1.3 This report should be read in conjunction with the Preliminary Investigation (Desk Study Report), which was reported under reference W07/40026-1 in February 2007; and the Ground Investigation Report which was reported under reference 42370 V01 in October 2019.
- 1.4 It is recommended that copy of these reports be submitted to the relevant authorities to enable them to carry out their own site assessments and provide any comments.
- 1.5 This report has been prepared for the sole use of the Client for the purpose described and no extended duty of care to any third party is implied or offered. Third parties using any information contained within this report do so at their own risk.
- 1.6 The comments given in this report and the opinions expressed herein are based on the information received, the conditions encountered during site works, and on the results of tests made in the field and laboratory. However, there may be conditions prevailing at the site which have not been disclosed by the investigation and which have not been taken into account in the report.
- 1.7 The comments on groundwater conditions are based on observations made at the time the site work was carried out. It should be noted that groundwater levels vary owing to seasonal or other effects.

## **2.0 SITE SETTING**

### **2.1 Site Location**

2.1.1 The site is situated within Wrexham Industrial Estate, approximately 4.5 km to the east of the town centre of Wrexham and may be located by National Grid Reference SJ 382 499.

2.1.2 A site location plan is included in Appendix 1, Figure A1.1.

### **2.2 Site Description**

2.2.1 At the time of the ground investigation the site was an undeveloped plot of level grass covered land with approximate dimensions of 120 m by 110 m.

2.2.2 The site was bounded to the north by a fence line and a row of trees, and to the south by commercial properties. The western boundary was formed by Ash Road South and the eastern boundary by disused land.

2.2.3 Portacabins were located in the southwest corner of the site.

2.2.4 Since the previous 2007 investigation took place, the levels in the northeast of the site have been reduced and a wildlife habitat area established beyond.

### **2.2 Geological Setting**

2.2.1 Details of the geology underlying the site have been obtained from the British Geological Survey map, Sheet No. 121, 'Wrexham', solid and drift edition, 1:50,000 scale, published 1994.

2.2.2 The geological map indicates the site to be underlain by superficial deposits of Made Ground as part of the Wrexham Industrial Estate, however the surrounding geology is indicated to be Glacial Till.

2.2.3 The superficial deposits are underlain by the Erbistock Formation of Westphalian age.

### 3.0 SITE WORK

- 3.1 The site work was carried out on the 10<sup>th</sup> and 11<sup>th</sup> February 2021. The locations of the exploratory holes have been positioned with respect to the most up to date development proposals and to better delineate the areas of the site affected by ground gas.
- 3.2 The site work has been carried out on the basis of the practices set out in BS 10175:2011+A2:2017, ref. 6.2, BS 5930:2015+A1:2020 ref. 6.3 and BS EN 1997-2:2007, ref 6.4.

| Exploratory Hole Type           | Quantity | Hole Reference                          | Depths           | Notes                                                                                                                                      |
|---------------------------------|----------|-----------------------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Windowless sample boreholes     | 11       | WS01 to WS09                            | 0.80 m to 6.00 m | WS01 terminated at 0.80 m due to water in inspection pit; relocated as WS01A. WS02 terminated at 2.10 m on obstruction; relocated as WS02A |
| Slotted standpipe installations | 6        | WS01A, WS02A, WS03, WS04, WS05 and WS06 | 1.50 m to 6.00 m | Installed into the Made Ground and Glacial Till to monitor groundwater and gas levels, each with gas valve and flush cover fitted.         |

- 3.3 The positions of the above are shown on the exploratory hole location plan, Appendix 1, Figure A1.2. Also included on this plan are the locations of the exploratory holes undertaken as part of the previous investigation.
- 3.4 The depths of the exploratory holes, descriptions of strata encountered and comments on groundwater conditions are given in the site work records in Appendix 2.
- 3.5 Representative disturbed samples were taken, ref. 6.5, at the depths shown on the exploratory hole records. Samples for environmental purposes were collected in appropriate containers and retained in cool boxes.
- 3.6 The coordinates and ground levels at the exploratory hole locations, reported on the records, were surveyed in based on OS National Grid.
- 3.7 Upon completion of the siteworks, the boreholes instrumented with standpipes were monitored at intervals specified by IFA for groundwater and gas levels. The gas levels monitored were oxygen, carbon dioxide, methane, carbon monoxide and hydrogen sulphide. The flow rate of each borehole was also monitored. The results are given in Appendix 3.

## 4.0 GROUND CONDITIONS ENCOUNTERED

### 4.1 Sequence

- 4.1.1 The sequence of the strata encountered during the investigation generally confirms the anticipated geology as interpreted from the geological map.
- 4.1.2 Interpolation of strata depths between locations should be undertaken with caution, particularly for depths of Made Ground.
- 4.1.3 The sequence and indicative thicknesses of strata are provided below:

| Strata Encountered                              | Depth Encountered (m) |              | Strata Thickness (m)                            |
|-------------------------------------------------|-----------------------|--------------|-------------------------------------------------|
|                                                 | From                  | To           |                                                 |
| Made Ground (not encountered in WS05 and WS07)  | 0.00                  | 0.30 to 4.20 | 0.30 to 4.20 (base not proven in WS01 and WS02) |
| Glacial Till (not encountered in WS01 and WS02) | 0.00 to 2.55          | 3.00 to 6.00 | 1.60 to 3.45 (base not proven)                  |
| No Recovery (WS02A)                             | 4.20                  | 5.85         | 1.65 (cobble advanced with barrel)              |
| Peat (WS01A only)                               | 2.50                  | 2.55         | 0.05                                            |

### 4.2 Made Ground

- 4.2.1 Deposits considered to represent Made Ground were found in all exploratory hole locations with the exception of WS05 and WS07.
- 4.2.2 The Made Ground was composed generally of firm, slightly sandy, slightly gravelly clay. Low cobble content was noted locally together with rootlets.
- 4.2.3 Brown and black, slightly sandy, slightly clayey gravel was noted in WS03 and WS04.
- 4.2.4 Partially decomposed plant matter and organic odour was noted in WS01, WS01A and WS03. In addition, the Made Ground between 1.30 m and 2.00 m in WS01A was recorded as “peaty” by the engineer.
- 4.2.5 The thickness of the Made Ground deposits varied between 0.80 m and 4.20 m.
- 4.2.6 The largest thickness of Made Ground was present in the exploratory holes located along the southwest part of the site. Specifically, WS01A (2.50 m thick), WS02 (2.10 m thick), WS02A (4.20 m thick) and WS03 (1.40 m thick).
- 4.2.7 Made Ground thickness reduced to 0.30 m along the northeast of the site.

4.2.8 No Made Ground was found in WS05 and WS07 with possible reworked Made Ground being identified in WS04 and WS08, with thicknesses of 1.40 m and 0.40 m respectively.

4.2.9 It should be noted that a cobble was advanced with the barrel in WS02A between 4.20 m and 5.85 m resulting in no sample recovery. In addition, the boundary between Made Ground and underlying Glacial Till could not be firmly established in this borehole.

### **4.3 Glacial Till**

4.3.1 Deposits considered to represent Glacial Till were found in all exploratory holes with the exception of WS01 and WS02.

4.3.2 The deposits comprised generally of firm to very stiff, brown and dark brown mottled grey and bluish grey, slightly sandy, slightly gravelly clay. Rare rootlets were noted locally.

4.3.3 Minimum thicknesses were found to be between 1.60 m and 3.45 m. The base of the Glacial Till was not established.

4.3.4 The barrel of the Windowless Sampler refused at 4.00 m in WS03 and at 3.00 m in WS04 to WS09.

### **4.4 Peat**

4.4.1 A layer of peat was found in WS01A between 2.50 m and 2.55 m.

4.4.2 This was described as firm, black, pseudofibrous peat with partially decomposed plant matter and an organic odour.

### **4.5 Groundwater**

4.5.1 Groundwater was encountered at depths generally ranging from 0.30 m to 2.08 m all within the Made Ground.

4.5.2 Subsequent groundwater monitoring has indicated groundwater levels to range from 0.17 m to 3.32 m.

## **5.0 GEOENVIRONMENTAL RISK ASSESSMENT**

### **5.1 Gas Generation**

- 5.1.1 The previous Ground Investigation Report, carried out in 2007 (ref. 42370 V01, dated October 2019), identified the potential for sources of ground gas on site in the form of Made Ground.
- 5.1.2 The findings of the Ground Investigation Report relating to gas generation are summarised below:
- Gas monitoring determined the presence of methane at a concentration of up to 37.5%v/v and carbon dioxide up to 3.7%v/v with a flow rate of up to 2.1 litres/hour.
  - Highest methane concentration was recorded in BH08. This borehole was located towards the southeast corner of the site and encountered made ground to a depth of 3.90 m. The monitoring well was installed in this made ground.
  - A low concentration of methane was also recorded in BH07, also towards the southern end of the site and installed in Made Ground.
- 5.1.3 The results of the gas monitoring visits carried out as part of the previous investigation are presented in Appendix 3 together with the results of the gas monitoring visits carried out as part of the current work.
- 5.1.4 Taking into consideration the likely potential source of ground gases, limited to the presence of Made Ground, six monitoring visits have been undertaken over a period of a seven weeks, in accordance with current guidance, as summarised in Appendix 3.
- 5.1.5 Maximum carbon dioxide concentrations of 11.5%v/v and 8.7%v/v have been recorded in WS02A and WS03 respectively.
- 5.1.6 Methane concentrations of between 27.7%v/v and 46.8%v/v were recorded in WS02A on monitoring visits 4, 5 and 6. Methane concentration of 9.1%v/v was recorded in the same hole on visit 2.
- 5.1.7 No methane concentrations have been recorded above the Level of Detection (LoD) in WS04, WS05 and WS06. The maximum carbon dioxide concentration recorded in these holes was 0.2%v/v. Approximately atmospheric oxygen levels were also detected.
- 5.1.8 Gas readings could not be obtained from WS01A on visits 2 and 3 due to the water within the well flooding the gas monitor hose 15 seconds after the pump had been switched on.

- 5.1.9 Steady state flow rates of 0.0 litres/hour were found on all monitoring visits. Peak flow rates of between -6.0 litres/hour and 4.0 litres/hour were found in WS01A and WS02A.
- 5.1.10 Using these worst-case values for peak flow (-6.0 litres/hour), a carbon dioxide Gas Screening Value (GSV) of 0.69 l/h and a methane GSV of 2.81 l/h have been calculated, which would place the site within Characteristic Situation 3 (moderate risk) (Appendix 3, Table A3.2), for which protection measures are required. Recommended gas protection measures appropriate to Characteristic Situation 3 are given in, Appendix 3 section A3.7.
- 5.1.11 Based on the exploratory hole records, it is likely that the source of the ground gases is the Made Ground present in the southwest part of the site which was recorded to be up to 4.10 m thick.
- 5.1.12 This is further indicated by the absence of elevated methane or carbon dioxide levels in WS04, WS05 and WS06 where the maximum thickness of Made Ground is 0.30 m.

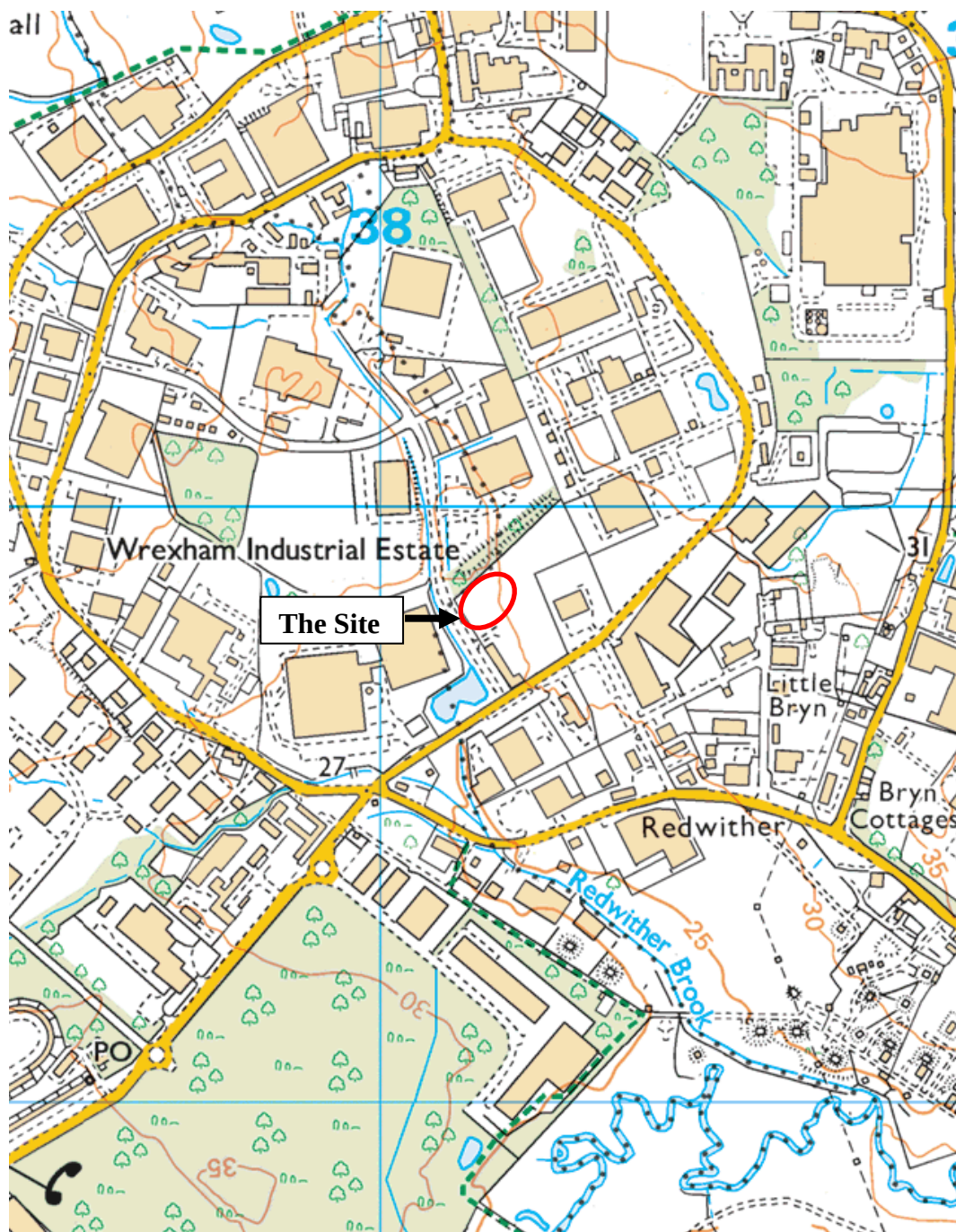
## **5.2 Summary of Risk Evaluation**

- 5.2.1 The proposed development does require the installation of gas protection measures due to the presence of methane and carbon dioxide.
- 5.2.2 The findings of this investigation agree with those of the previous investigation for the site which placed the site within Characteristic Situation 3.

## 6.0 REFERENCES

- 6.1 BGS Sheet No. 121, 'Wrexham', solid and drift edition, 1:50,000 scale. British Geological Survey, 1994.
- 6.2 BS 10175: 2011+A2:2017 '*Investigation of potentially contaminated sites. Code of practice*', British Standards Institute, 2017
- 6.3 BS 5930: 2015+A1:2020 '*Code of practice for ground investigations*', British Standards Institute, 2020
- 6.4 BS EN 1997, Part 2:2007, '*Eurocode 7 – Geotechnical Design – Part 2, Ground Investigation and Design*' British Standards Institute, 2007
- 6.5 BS EN ISO 22475-1:2006, '*Geotechnical Investigation and Testing – Sampling Methods and Groundwater Measurements*' Part 1: *Technical Principles for Execution*', British Standards Institute, 2006
- 6.6 BS EN ISO 14688 Part 1:2018 and Part 2:2018, '*Geotechnical Investigation and Testing – Identification and Classification of Soil*', British Standards Institute, 2018
- 6.7 The Environmental Protection Act, Part IIA, Section 78, DoE 1990.
- 6.8 CIRIA Reports 149 to 152, '*Methane and Associated Hazards to Construction*', 1995.
- 6.9 CIRIA C665, '*Assessing Risks Posed by Hazardous Ground Gases in Buildings*', 2007.
- 6.10 British Standard 8485:2015, '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*' British Standards Institute, 2015
- 6.11 Office of the Deputy Prime Minister, '*The Building Regulations 2000, Approved Document C, Site Preparation and Resistance to Contaminants and Moisture*', 2004.
- 6.12 BR 414, '*Protective Measures for Housing on Gas Contaminated Land*', Building Research Establishment, 2004
- 6.13 Wilson, S.A and Haines, S, '*Site Investigation and Monitoring for Soil Gas Assessment – Back to Basics*', Land Contamination and Reclamation, 2005
- 6.14 Wilson S A and Card G B, '*Reliability and Risk in Gas Protection Design*', Ground Engineering, 1999.
- 6.15 Report Edition No.4, '*Guidance on Evaluation on Development Proposals on Sites where Methane and Carbon Dioxide are present*'. NHBC, 2007.

**APPENDIX 1**  
**DRAWINGS**



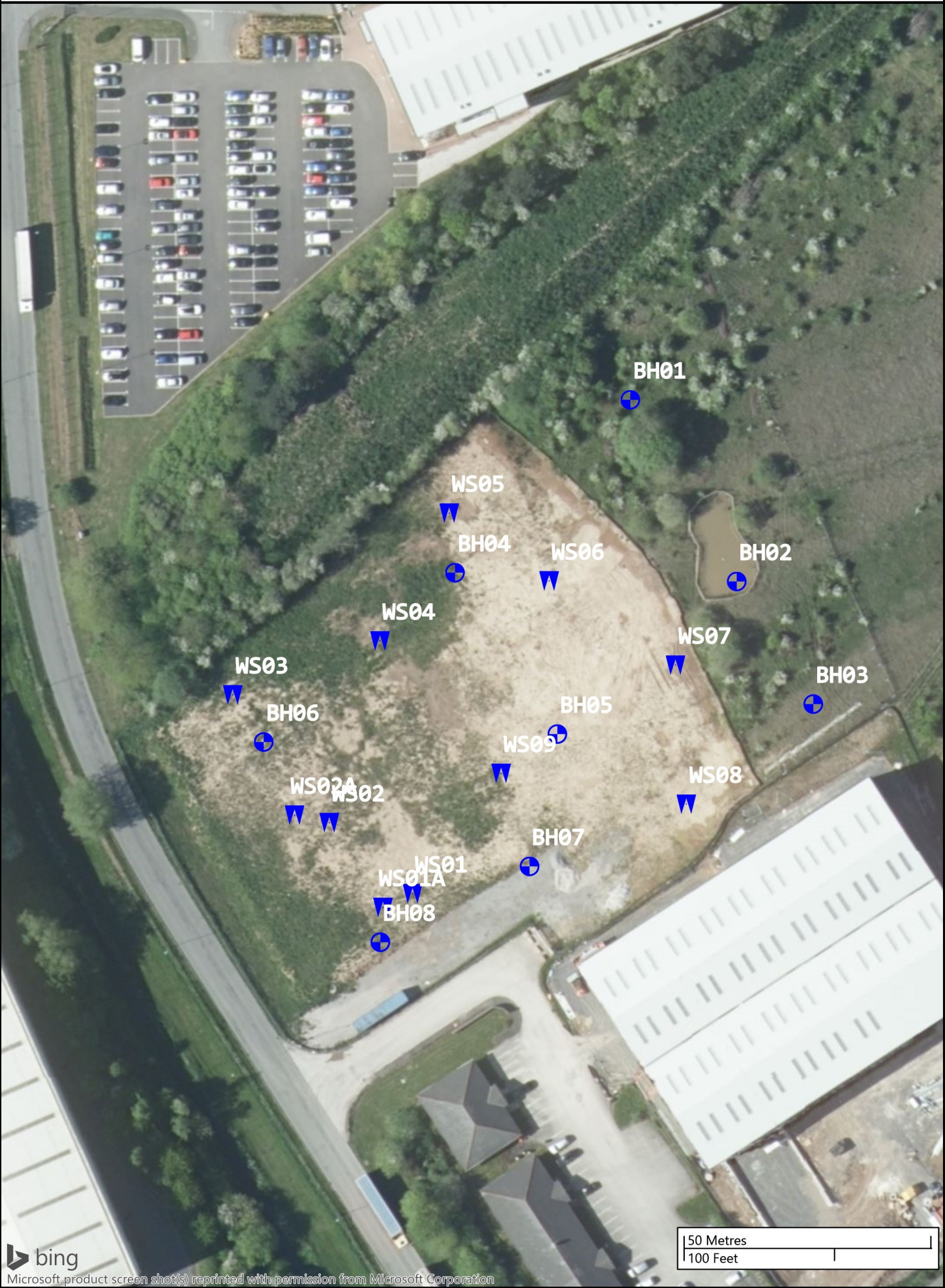
**PROJECT:** 2230428 – Ash Road South,

**FIGURE No.** A1.1

**SCALE:** Not to scale

**TITLE:** Site Location Plan





## **APPENDIX 2**

### **SITE WORK**

## **APPENDIX 2**

### **GENERAL NOTES ON SITE WORKS**

#### **A2.1 SITE WORK**

##### **A2.1.1 General**

Site work is carried out in general accordance with the guidelines given in BS EN 1997, ref. 6.4 and BS 5930, ref. 6.3, and BS 10175, ref.6.2.

##### **A2.1.2 Drive-in Window Sampler**

The dynamic sampler, ref 6.5, consists generally of a track mounted window sampler and a series of cylindrical sample tubes, generally varying in diameter from 98mm to 35mm. A cutting shoe is fitted to the bottom of each tube, while samples are collected in plastic liners fitted inside the sample tube.

The borehole is extended by using progressively smaller diameter tubes.

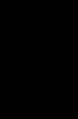
## **A2.2 SAMPLES / TESTS**

- B represents large bulk disturbed samples
- D represents small disturbed sample
- ES represents environmental soil sample, consisting of amber jar, vial and plastic tub
- ∇ represents water strike
- ▼ represents level to which water rose

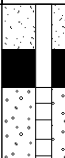
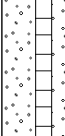
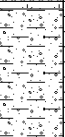
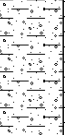
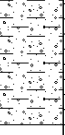
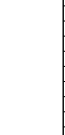
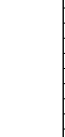
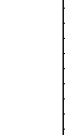
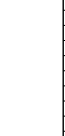
## **A2.3 DESCRIPTION OF SOILS**

### **A2.3.1 General**

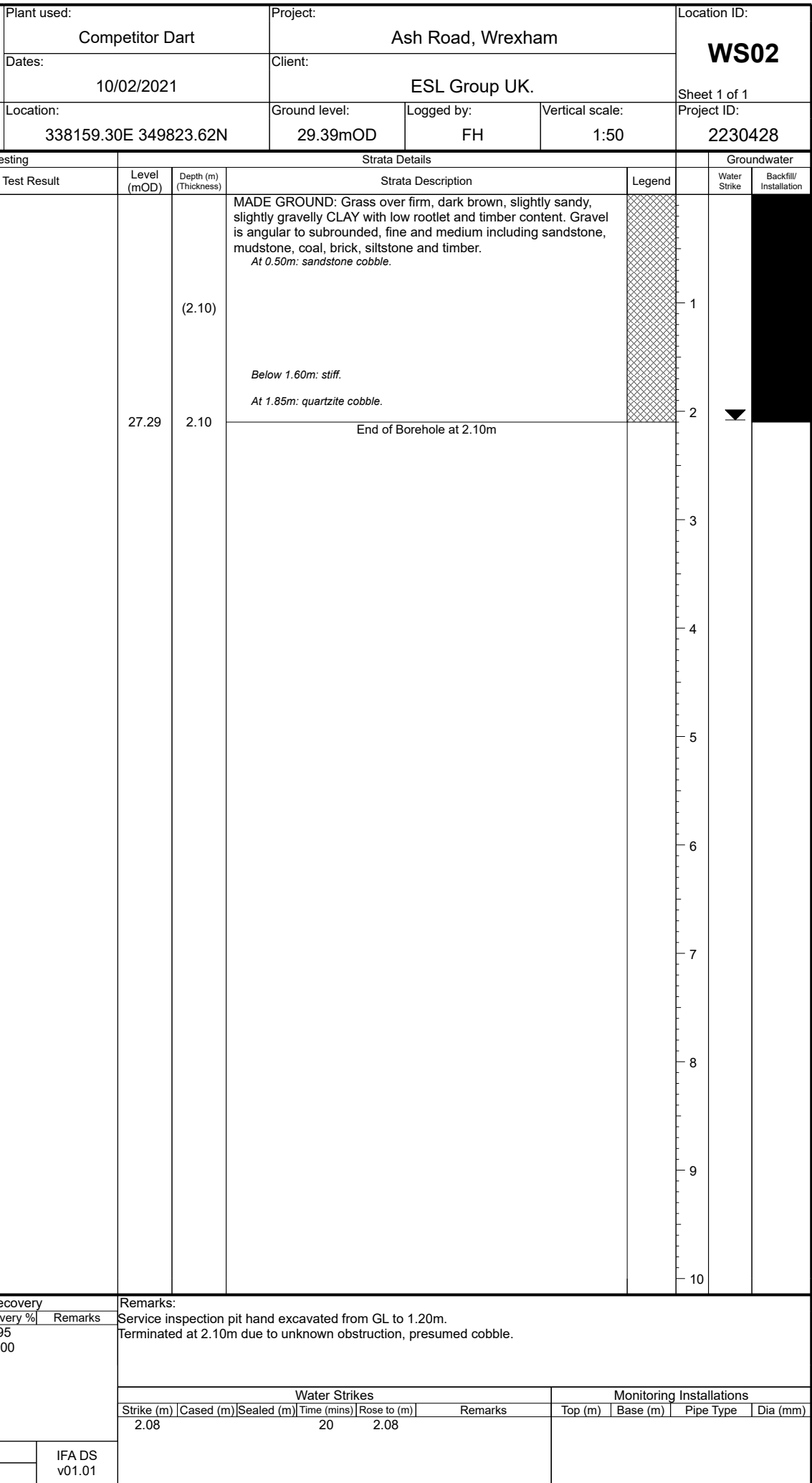
The procedures and principles given in BS EN ISO 14688 Parts 1 and 2, ref 6.6, supplemented by section 6 of BS 5930+A1:2020, ref. 6.3 have been used in the soil descriptions contained within this report.

|                                                                                  |           |                                    |             |                               |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     |                                                                                     |                                                                                     |             |         |         |          |           |
|----------------------------------------------------------------------------------|-----------|------------------------------------|-------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------|---------|---------|----------|-----------|
|  |           | Plant used:<br>Competitor Dart     |             | Project:<br>Ash Road, Wrexham |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     | Location ID:<br><b>WS01</b>                                                         |                                                                                     |             |         |         |          |           |
|                                                                                  |           | Dates:<br>10/02/2021               |             | Client:<br>ESL Group UK.      |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     |                                                                                     |                                                                                     |             |         |         |          |           |
| Dynamic Sample Borehole Log                                                      |           | Location:<br>338176.03E 349808.95N |             | Ground level:<br>29.33mOD     | Logged by:<br>FH                                                                                                                                                                                                                                                                                                                                      | Vertical scale:<br>1:50                                                             | Sheet 1 of 1<br>Project ID:<br>2230428                                              |                                                                                     |             |         |         |          |           |
| Samples & In Situ Testing                                                        |           | Strata Details                     |             |                               |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     |                                                                                     | Groundwater                                                                         |             |         |         |          |           |
| Depth                                                                            | Sample ID | Test Result                        | Level (mOD) | Depth (m) (Thickness)         | Strata Description                                                                                                                                                                                                                                                                                                                                    | Legend                                                                              | Water Strike                                                                        | Backfill/ Installation                                                              |             |         |         |          |           |
| 0.50                                                                             | D1        |                                    | 28.53       | (0.80)<br>0.80                | MADE GROUND: Grass over firm, dark brown, slightly sandy, slightly gravelly CLAY with occasional rootlets and slight organic odour. Gravel is angular to subrounded, fine and medium including quartz, brick and clinker.<br><i>Below 0.30m: no rootlets.</i><br><i>Between 0.40m and 0.70m: decomposed plant matter.</i><br>End of Borehole at 0.80m |  |  |  |             |         |         |          |           |
|                                                                                  |           |                                    |             |                               |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     | 1                                                                                   |                                                                                     |             |         |         |          |           |
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|                                                                                  |           |                                    |             |                               |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     | 10                                                                                  |                                                                                     |             |         |         |          |           |
| Dynamic Sample Recovery                                                          |           |                                    |             |                               | Remarks:                                                                                                                                                                                                                                                                                                                                              |                                                                                     |                                                                                     |                                                                                     |             |         |         |          |           |
| Top (m)                                                                          | Base (m)  | Dia (mm)                           | Recovery %  | Remarks                       | Service inspection pit hand excavated from GL to 0.80m.<br>Terminated at 0.80m due to water.                                                                                                                                                                                                                                                          |                                                                                     |                                                                                     |                                                                                     |             |         |         |          |           |
|                                                                                  |           |                                    |             |                               | Water Strikes                                                                                                                                                                                                                                                                                                                                         |                                                                                     |                                                                                     | Monitoring Installations                                                            |             |         |         |          |           |
|                                                                                  |           |                                    |             |                               | Strike (m)                                                                                                                                                                                                                                                                                                                                            | Cased (m)                                                                           | Sealed (m)                                                                          | Time (mins)                                                                         | Rose to (m) | Remarks | Top (m) | Base (m) | Pipe Type |
|                                                                                  |           |                                    |             |                               | 0.60                                                                                                                                                                                                                                                                                                                                                  |                                                                                     |                                                                                     | 20                                                                                  | 0.60        |         |         |          |           |
| Checked by:                                                                      |           | JT                                 |             | IFA DS<br>v01.01              |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     |                                                                                     |                                                                                     |             |         |         |          |           |
| Log status:                                                                      |           | DRAFT                              |             |                               |                                                                                                                                                                                                                                                                                                                                                       |                                                                                     |                                                                                     |                                                                                     |             |         |         |          |           |

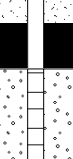
|                                       |                                           |                                  |
|---------------------------------------|-------------------------------------------|----------------------------------|
| Plant used:<br><b>Competitor Dart</b> | Project:<br><b>Ash Road, Wrexham</b>      | Location ID:<br><b>WS01A</b>     |
| Dates:<br><b>11/02/2021</b>           | Client:<br><b>ESL Group UK.</b>           | Sheet 1 of 1                     |
| Dynamic Sample Borehole Log           | Location:<br><b>338170.02E 349806.26N</b> | Ground level:<br><b>29.40mOD</b> |
|                                       | Logged by:<br><b>FH</b>                   | Vertical scale:<br><b>1:50</b>   |
|                                       |                                           | Project ID:<br><b>2230428</b>    |

| Samples & In Situ Testing |           |             | Strata Details |                       |                                                                                                                                                                                                                                                                                                                                                |                                                                                       | Groundwater  |                                                                                       |
|---------------------------|-----------|-------------|----------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------|
| Depth                     | Sample ID | Test Result | Level (mOD)    | Depth (m) (Thickness) | Strata Description                                                                                                                                                                                                                                                                                                                             | Legend                                                                                | Water Strike | Backfill/ Installation                                                                |
| 0.20                      | D1        |             |                | (1.30)                | MADE GROUND: Grass over firm, dark brown, slightly sandy, slightly gravelly CLAY with low cobble content and rare rootlets. Gravel is angular to subangular, fine and medium including brick and concrete. Cobbles are angular to subangular including concrete.<br><i>Below 0.50m: rootlets absent.</i><br><i>At 0.80m: concrete boulder.</i> |    | 1            |    |
| 1.00                      | D2        |             | 28.10          | 1.30                  | MADE GROUND: Firm, dark brown, peaty, slightly sandy, slightly gravelly CLAY with some partially decomposed plant matter and slight organic odour and rare rootlets. Gravel is subrounded to angular including brick and mudstone.<br><i>Between 1.60m and 2.00m: firm and slightly peaty.</i>                                                 |    | 2            |    |
| 1.35                      | D3        |             |                | (0.70)                | MADE GROUND: Firm, dark brown, slightly sandy, slightly gravelly CLAY with occasional partially decomposed plant matter. Gravel is rounded to angular, fine and medium including mixed igneous lithologies and brick.                                                                                                                          |    | 3            |    |
| 1.45                      | D4        |             | 27.40          | 2.00                  | Firm, black, pseudofibrous PEAT with partially decomposed plant matter and organic odour.                                                                                                                                                                                                                                                      |    | 4            |    |
| 1.70                      | D5        |             |                | (0.50)                | Stiff, brown mottled blueish grey, slightly sandy, slightly gravelly CLAY with rare silt and sand laminations and partially decomposed plant matter. Gravel is subrounded to rounded, fine and medium including mixed igneous lithologies.                                                                                                     |    | 5            |    |
| 1.90                      | D6        |             | 26.90          | 2.50                  |                                                                                                                                                                                                                                                                                                                                                |   | 6            |   |
| 2.40 - 2.52               | D7        |             | 26.85          | 2.50                  |                                                                                                                                                                                                                                                                                                                                                |  | 7            |  |
| 2.52 - 2.60               | D8        |             |                | (3.45)                |                                                                                                                                                                                                                                                                                                                                                |  | 8            |  |
| 3.50                      | D9        |             |                |                       |                                                                                                                                                                                                                                                                                                                                                |  | 9            |  |
| 4.50                      | D10       |             |                |                       |                                                                                                                                                                                                                                                                                                                                                |  | 10           |  |
| 5.50                      | D11       |             | 23.40          | 6.00                  | End of Borehole at 6.00m                                                                                                                                                                                                                                                                                                                       |  | 11           |  |

| Dynamic Sample Recovery |           |            |             |             | Remarks:                 |
|-------------------------|-----------|------------|-------------|-------------|--------------------------|
| Top (m)                 | Base (m)  | Dia (mm)   | Recovery %  | Remarks     |                          |
| 1.20                    | 2.00      |            | 100         |             |                          |
| 2.00                    | 3.00      |            | 100         |             |                          |
| 3.00                    | 4.00      |            | 100         |             |                          |
| 4.00                    | 5.00      |            | 100         |             |                          |
| 5.00                    | 6.00      |            | 100         |             |                          |
| Water Strikes           |           |            |             |             | Monitoring Installations |
| Strike (m)              | Cased (m) | Sealed (m) | Time (mins) | Rose to (m) | Remarks                  |
| 0.00                    | 0.55      |            |             |             |                          |
| 0.55                    | 2.55      |            |             |             |                          |
| Checked by:             |           |            |             |             | Log status:              |
| JT                      |           |            |             |             | DRAFT                    |
| IFA DS v01.01           |           |            |             |             |                          |



| Dynamic Sample Recovery |           |            |             |                  | Remarks:                                                |         |          |           |          |                          |  |  |  |  |
|-------------------------|-----------|------------|-------------|------------------|---------------------------------------------------------|---------|----------|-----------|----------|--------------------------|--|--|--|--|
| Top (m)                 | Base (m)  | Dia (mm)   | Recovery %  | Remarks          | Service inspection pit hand excavated from GL to 1.20m. |         |          |           |          |                          |  |  |  |  |
| 1.20                    | 2.00      |            | 80          |                  |                                                         |         |          |           |          |                          |  |  |  |  |
| 2.00                    | 3.00      |            | 100         |                  |                                                         |         |          |           |          |                          |  |  |  |  |
| 3.00                    | 4.00      |            | 100         |                  |                                                         |         |          |           |          |                          |  |  |  |  |
| 4.00                    | 5.00      |            | 10          |                  |                                                         |         |          |           |          |                          |  |  |  |  |
| 5.00                    | 6.00      |            | 15          |                  |                                                         |         |          |           |          |                          |  |  |  |  |
|                         |           |            |             |                  | Water Strikes                                           |         |          |           |          | Monitoring Installations |  |  |  |  |
| Strike (m)              | Cased (m) | Sealed (m) | Time (mins) | Rose to (m)      | Remarks                                                 | Top (m) | Base (m) | Pipe Type | Dia (mm) |                          |  |  |  |  |
|                         |           |            |             |                  |                                                         | 0.00    | 1.00     | Plain     | 38       |                          |  |  |  |  |
|                         |           |            |             |                  |                                                         | 1.00    | 6.00     | Slotted   | 38       |                          |  |  |  |  |
| Checked by:             |           | JT         |             | IFA DS<br>v01.01 |                                                         |         |          |           |          |                          |  |  |  |  |
| Log status:             |           | DRAFT      |             |                  |                                                         |         |          |           |          |                          |  |  |  |  |

|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
|-----------------------------------------------------------------------------------|------------------------------------|-------------|-------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------|---------|----------|-----------|----------|
|  | Plant used:<br>Competitor Dart     |             | Project:<br>Ash Road, Wrexham |                                                         |                                                                                                                                                                                                                                                                                                                                 | Location ID:<br><b>WS03</b>                                                           |              |                                                                                       |         |          |           |          |
|                                                                                   | Dates:<br>10/02/2021               |             | Client:<br>ESL Group UK.      |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| Dynamic Sample Borehole Log                                                       | Location:<br>338139.98E 349849.89N |             | Ground level:<br>29.37mOD     | Logged by:<br>FH                                        | Vertical scale:<br>1:50                                                                                                                                                                                                                                                                                                         | Sheet 1 of 1<br>Project ID:<br>2230428                                                |              |                                                                                       |         |          |           |          |
|                                                                                   | Samples & In Situ Testing          |             | Strata Details                |                                                         |                                                                                                                                                                                                                                                                                                                                 | Groundwater                                                                           |              |                                                                                       |         |          |           |          |
| Depth                                                                             | Sample ID                          | Test Result | Level (mOD)                   | Depth (m) (Thickness)                                   | Strata Description                                                                                                                                                                                                                                                                                                              | Legend                                                                                | Water Strike | Backfill/Installation                                                                 |         |          |           |          |
| 0.50                                                                              | D1                                 |             |                               | (1.20)                                                  | MADE GROUND: Grass over firm, dark brown, slightly sandy, slightly gravelly CLAY with low cobble content, occasional rootlets and rare partially decomposed plant matter. Gravel is angular to subrounded, fine to coarse including brick, clinker, sandstone, siltstone and quartzite.<br><i>Below 0.75m: rootlets absent.</i> |    |              |    |         |          |           |          |
| 1.25                                                                              | D2                                 |             | 28.17                         | 1.20                                                    | MADE GROUND: Brown, red and black, slightly sandy, slightly clayey, angular to subangular, fine to coarse GRAVEL including clinker, mudstone, brick and coal. With organic odour.                                                                                                                                               |    |              |    |         |          |           |          |
| 1.35                                                                              | D3                                 |             | 28.07                         | 1.30                                                    |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| 1.50                                                                              | D4                                 |             | 27.97                         | 1.40                                                    |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
|                                                                                   |                                    |             |                               | (0.40)                                                  | MADE GROUND: Firm, dark brown mottled black, slightly sandy, gravelly CLAY with organic odour. Gravel is angular to subangular, fine to coarse including brick, coal and clinker.                                                                                                                                               |    |              |    |         |          |           |          |
| 2.00                                                                              | D5                                 |             | 27.57                         | 1.80                                                    | Firm, dark brown, slightly sandy, slightly gravelly CLAY with rare rootlets. Gravel is fine, subrounded to rounded including quartz.                                                                                                                                                                                            |                                                                                       |              |                                                                                       |         |          |           |          |
| 2.50                                                                              | D6                                 |             |                               | (2.20)                                                  | Stiff, brown mottled blueish grey, slightly sandy, slightly gravelly CLAY. Gravel is subangular to rounded, fine and medium including sandstone and siltstone.                                                                                                                                                                  |    |              |    |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| 3.50                                                                              | D7                                 |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |    |              |    |         |          |           |          |
|                                                                                   |                                    |             | 25.37                         | 4.00                                                    | End of Borehole at 4.00m                                                                                                                                                                                                                                                                                                        |    |              |    |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |   |              |   |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |  |              |  |         |          |           |          |
| Dynamic Sample Recovery                                                           |                                    |             | Remarks:                      |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| Top (m)                                                                           | Base (m)                           | Dia (mm)    | Recovery %                    | Remarks                                                 |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| 1.20                                                                              | 2.00                               |             | 100                           | Service inspection pit hand excavated from GL to 1.20m. |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| 2.00                                                                              | 3.00                               |             | 100                           | Terminated at 4.00m due to barrel refusal.              |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| 3.00                                                                              | 4.00                               |             | 100                           |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
|                                                                                   |                                    |             | Water Strikes                 |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
|                                                                                   |                                    |             | Monitoring Installations      |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
|                                                                                   |                                    |             | Strike (m)                    | Cased (m)                                               | Sealed (m)                                                                                                                                                                                                                                                                                                                      | Time (mins)                                                                           | Rose to (m)  | Remarks                                                                               | Top (m) | Base (m) | Pipe Type | Dia (mm) |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       | 0.00    | 0.50     | Plain     | 38       |
|                                                                                   |                                    |             |                               |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       | 0.50    | 1.50     | Slotted   | 38       |
| Checked by:                                                                       |                                    | JT          | IFA DS                        |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |
| Log status:                                                                       |                                    | DRAFT       | v01.01                        |                                                         |                                                                                                                                                                                                                                                                                                                                 |                                                                                       |              |                                                                                       |         |          |           |          |

| Dynamic Sample Recovery |           |            |             |                  | Remarks:                                                |         |          |           |          |                          |  |  |  |  |
|-------------------------|-----------|------------|-------------|------------------|---------------------------------------------------------|---------|----------|-----------|----------|--------------------------|--|--|--|--|
| Top (m)                 | Base (m)  | Dia (mm)   | Recovery %  | Remarks          | Service inspection pit hand excavated from GL to 1.20m. |         |          |           |          |                          |  |  |  |  |
| 1.20                    | 2.00      |            | 100         |                  | Terminated at 3.00m due to barrel refusal.              |         |          |           |          |                          |  |  |  |  |
| 2.00                    | 3.00      |            | 100         |                  |                                                         |         |          |           |          |                          |  |  |  |  |
|                         |           |            |             |                  | Water Strikes                                           |         |          |           |          | Monitoring Installations |  |  |  |  |
| Strike (m)              | Cased (m) | Sealed (m) | Time (mins) | Rose to (m)      | Remarks                                                 | Top (m) | Base (m) | Pipe Type | Dia (mm) |                          |  |  |  |  |
| 0.30                    |           |            | 20          | 0.30             | Seepage                                                 | 0.00    | 0.50     | Plain     | 38       |                          |  |  |  |  |
|                         |           |            |             |                  |                                                         | 0.50    | 3.00     | Slotted   | 38       |                          |  |  |  |  |
| Checked by:             |           | JT         |             | IFA DS<br>v01.01 |                                                         |         |          |           |          |                          |  |  |  |  |
| Log status:             |           | DRAFT      |             |                  |                                                         |         |          |           |          |                          |  |  |  |  |

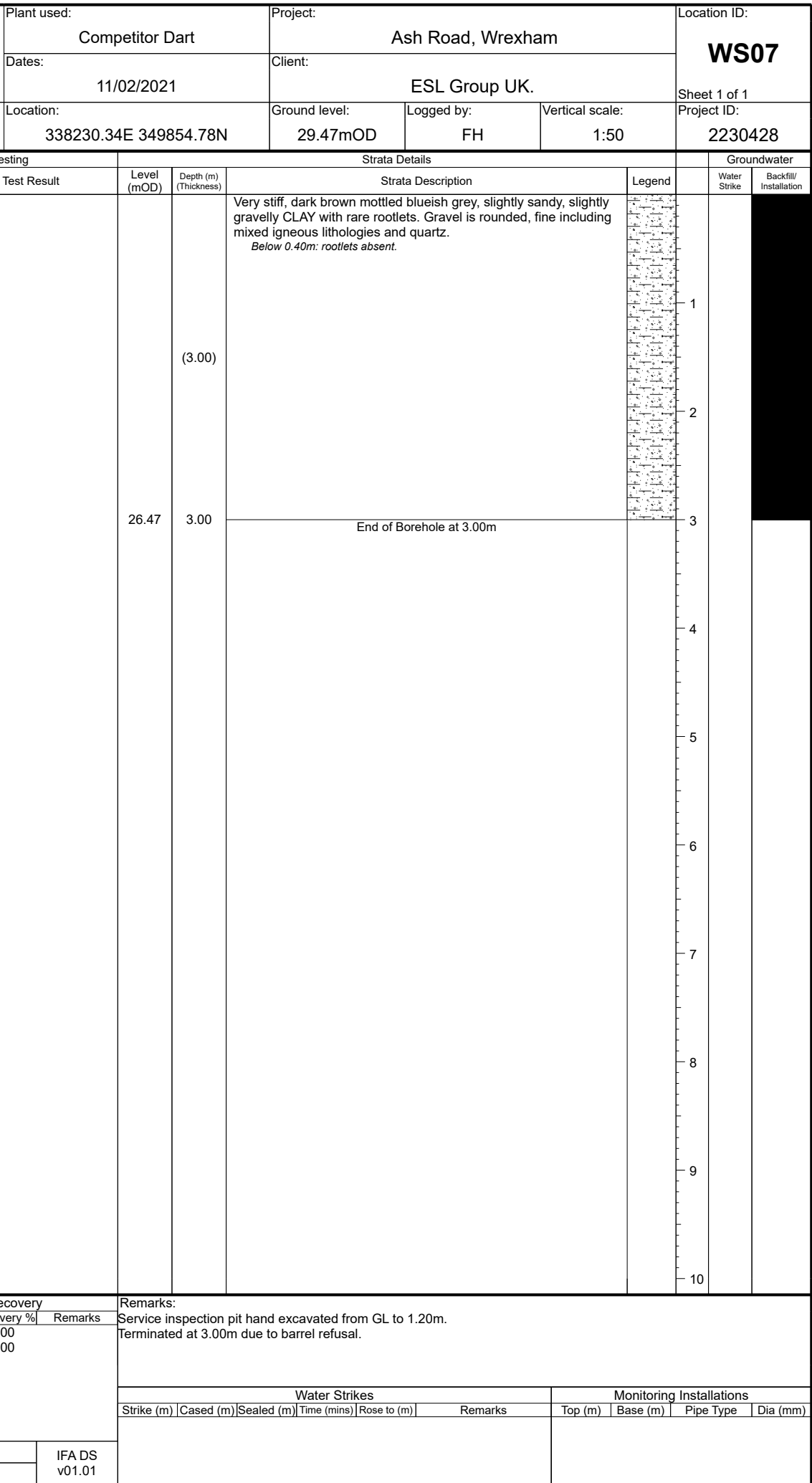


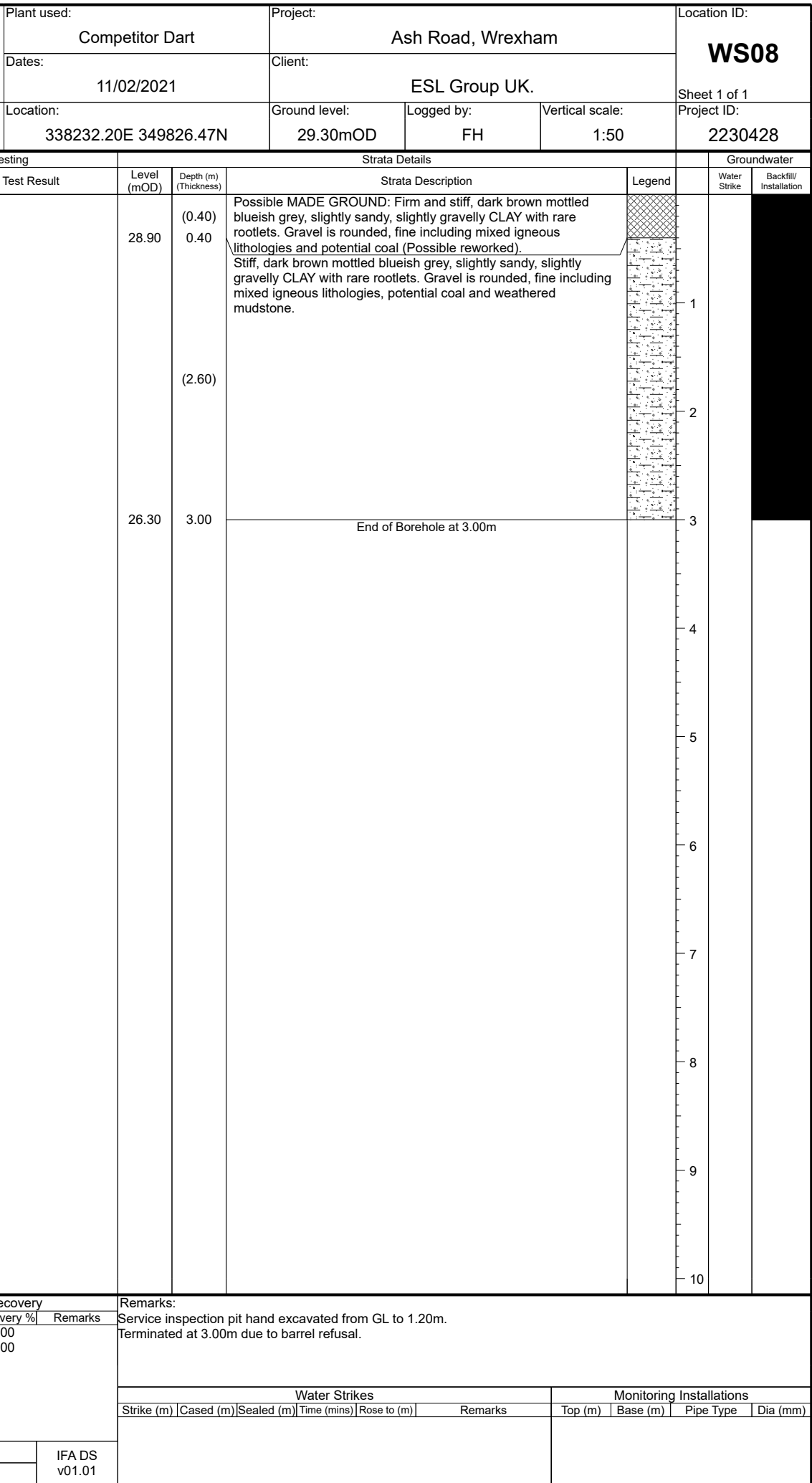
|                                    |                               |                  |                         |                                        |
|------------------------------------|-------------------------------|------------------|-------------------------|----------------------------------------|
| Plant used:<br>Competitor Dart     | Project:<br>Ash Road, Wrexham |                  |                         | Location ID:<br><br><b>WS05</b>        |
| Dates:<br>11/02/2021               | Client:<br>ESL Group UK.      |                  |                         |                                        |
| Location:<br>338184.55E 349886.29N | Ground level:<br>29.47mOD     | Logged by:<br>FH | Vertical scale:<br>1:50 | Sheet 1 of 1<br>Project ID:<br>2230428 |

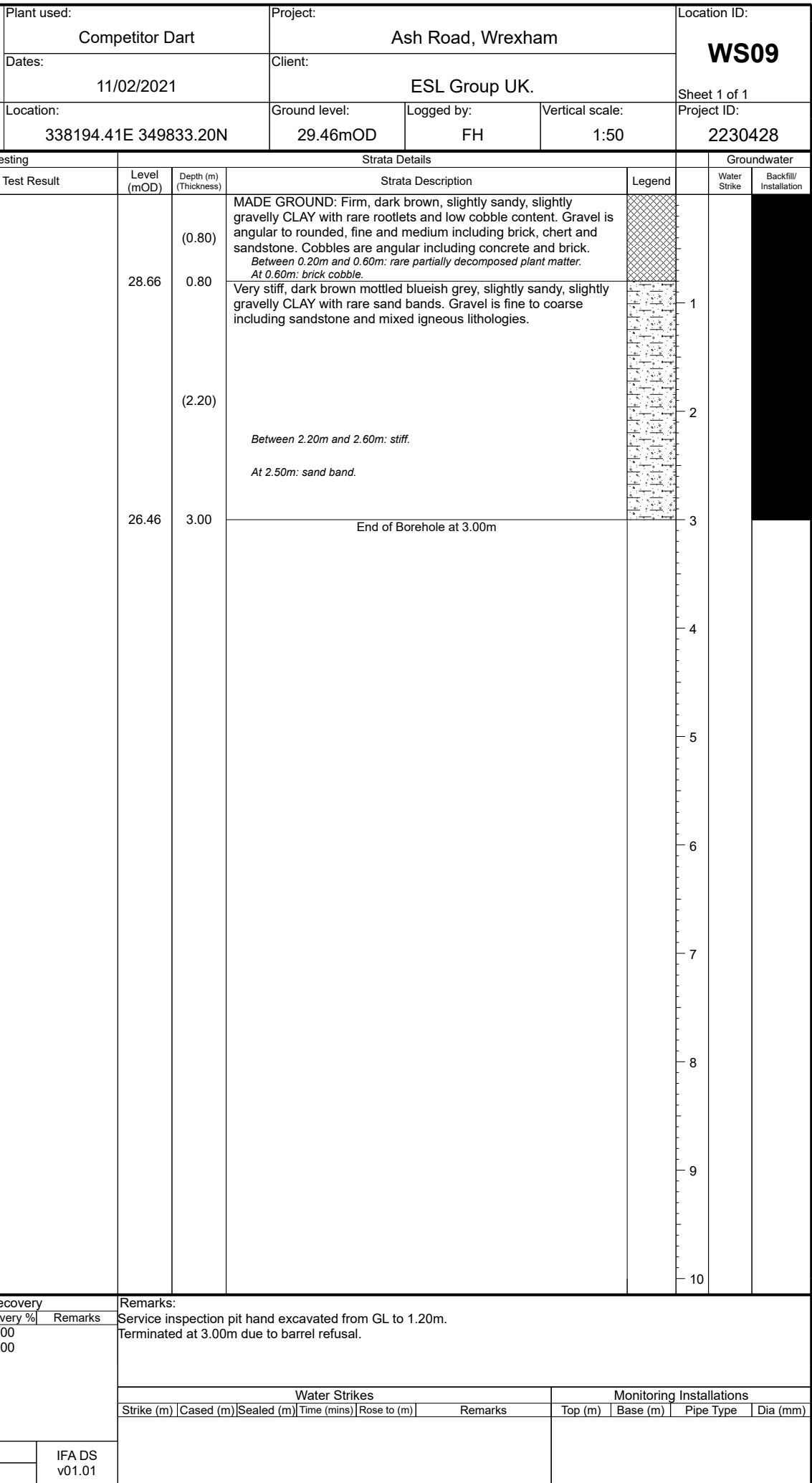
| Samples & In Situ Testing |           |             | Strata Details |                       |                                                                                                                                                                                                                                                                                                          |        | Groundwater  |                        |
|---------------------------|-----------|-------------|----------------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------|------------------------|
| Depth                     | Sample ID | Test Result | Level (mOD)    | Depth (m) (Thickness) | Strata Description                                                                                                                                                                                                                                                                                       | Legend | Water Strike | Backfill/ Installation |
| 0.20                      | D1        |             |                |                       | Grass over firm, dark brown, slightly sandy, slightly gravelly CLAY with rare rootlets. Gravel is subrounded to rounded, fine including mixed igneous lithologies, quartz, siltstone and weathered mudstone.<br><i>Below 0.40m: rootlets absent.</i><br><i>Below 0.70m: stiff and mottled blue grey.</i> |        |              |                        |
| 1.00                      | D2        |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 1            |                        |
| 1.50                      | D3        |             |                | (3.00)                |                                                                                                                                                                                                                                                                                                          |        |              |                        |
| 1.60                      | D5        |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 2            |                        |
| 2.50                      | D4        |             |                |                       |                                                                                                                                                                                                                                                                                                          |        |              |                        |
|                           |           |             | 26.47          | 3.00                  | End of Borehole at 3.00m                                                                                                                                                                                                                                                                                 |        | 3            |                        |
|                           |           |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 4            |                        |
|                           |           |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 5            |                        |
|                           |           |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 6            |                        |
|                           |           |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 7            |                        |
|                           |           |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 8            |                        |
|                           |           |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 9            |                        |
|                           |           |             |                |                       |                                                                                                                                                                                                                                                                                                          |        | 10           |                        |

| Dynamic Sample Recovery |           |            |             |                  | Remarks:<br>Service inspection pit hand excavated from GL to 1.20m.<br>Terminated at 3.00m due to barrel refusal. |  |  |  |  |                          |          |           |          |  |
|-------------------------|-----------|------------|-------------|------------------|-------------------------------------------------------------------------------------------------------------------|--|--|--|--|--------------------------|----------|-----------|----------|--|
| Top (m)                 | Base (m)  | Dia (mm)   | Recovery %  | Remarks          |                                                                                                                   |  |  |  |  |                          |          |           |          |  |
| 1.20                    | 2.00      |            | 100         |                  |                                                                                                                   |  |  |  |  |                          |          |           |          |  |
| 2.00                    | 3.00      |            | 100         |                  |                                                                                                                   |  |  |  |  |                          |          |           |          |  |
|                         |           |            |             |                  | Water Strikes                                                                                                     |  |  |  |  | Monitoring Installations |          |           |          |  |
| Strike (m)              | Cased (m) | Sealed (m) | Time (mins) | Rose to (m)      | Remarks                                                                                                           |  |  |  |  | Top (m)                  | Base (m) | Pipe Type | Dia (mm) |  |
|                         |           |            |             |                  |                                                                                                                   |  |  |  |  | 0.00                     | 0.50     | Plain     | 38       |  |
|                         |           |            |             |                  |                                                                                                                   |  |  |  |  | 0.50                     | 3.00     | Slotted   | 38       |  |
| Checked by:             |           | JT         |             | IFA DS<br>v01.01 |                                                                                                                   |  |  |  |  |                          |          |           |          |  |
| Log status:             |           | DRAFT      |             |                  |                                                                                                                   |  |  |  |  |                          |          |           |          |  |

| Dynamic Sample Recovery |          |          |            |                  | Remarks:                                                                                              |           |            |             |             |                          |         |          |           |          |
|-------------------------|----------|----------|------------|------------------|-------------------------------------------------------------------------------------------------------|-----------|------------|-------------|-------------|--------------------------|---------|----------|-----------|----------|
| Top (m)                 | Base (m) | Dia (mm) | Recovery % | Remarks          | Service inspection pit hand excavated from GL to 1.20m.<br>Terminated at 3.00m due to barrel refusal. |           |            |             |             |                          |         |          |           |          |
| 1.20                    | 2.00     |          | 100        |                  |                                                                                                       |           |            |             |             |                          |         |          |           |          |
| 2.00                    | 3.00     |          | 100        |                  |                                                                                                       |           |            |             |             |                          |         |          |           |          |
|                         |          |          |            |                  | Water Strikes                                                                                         |           |            |             |             | Monitoring Installations |         |          |           |          |
|                         |          |          |            |                  | Strike (m)                                                                                            | Cased (m) | Sealed (m) | Time (mins) | Rose to (m) | Remarks                  | Top (m) | Base (m) | Pipe Type | Dia (mm) |
|                         |          |          |            |                  |                                                                                                       |           |            |             |             | 0.00                     | 0.50    | Plain    | 38        |          |
| Checked by:             |          | JT       |            | IFA DS<br>v01.01 |                                                                                                       |           |            |             |             | 0.50                     | 3.00    | Slotted  | 38        |          |
| Log status:             |          | DRAFT    |            |                  |                                                                                                       |           |            |             |             |                          |         |          |           |          |







**APPENDIX 3**  
**GAS GENERATION**

## **APPENDIX 3**

### **GENERAL NOTES ON GAS GENERATION**

#### **A3.1 GENERAL**

- A3.1.1 In the past, a series of guidance documents were published by CIRIA, ref. 6.8, providing advice on hazards associated with methane. This earlier guidance was consolidated in CIRIA Document C659 to provide a risk based approach to gas contaminated land. This was subsequently re-issued as CIRIA Document C665, ref 6.9. In 2007, British Standard, BS8485, ref 6.10, dealing with ground gas was published. It is recommended that guidance in C665 and BS8485 is adopted to provide a consistent approach in dealing with ground gas contamination, the principal details being as follows.
- A3.1.2 This guidance is based on a similar approach to that for dealing with contaminated soil. The presence of hazardous gases could be deemed to be the 'source' in a 'pollutant linkage' that could lead to the conclusion that significant harm is or could be caused to people, buildings or the environment. In such circumstances the land could be deemed 'contaminated', ref. 6.7.
- A3.1.3 Should a potential source of gas be identified in the conceptual model, a gas risk assessment should be carried out, sufficient to demonstrate to the local authority that the proposals mitigate any hazards associated with ground gas. The authority enforces compliance with Approved Document Part C of the Building Regulations, ref. 6.11.

#### **A3.2 APPROACH**

- A3.2.1 A flow chart detailing the approach to assessing a site is given in CIRIA document C665, Figure 1.1. This may be summarised as follows.
- Carry out Phase 1 desk study, including initial conceptual model
  - Assess site, potential presence of gas / potential unacceptable risk / identify further action, if necessary
  - Monitor gas concentrations
  - Assessment of Risk
  - Recommendations / remediation
  - Validation

#### **A3.3 POLLUTANT LINKAGE ASSESSMENT**

- A3.3.1 A pollutant linkage assessment is presented in Appendix 3 of the Phase 1 Desk Study Report.
- A3.3.2 Using the risk model in the desk study, the pollutant linkage can be identified and a preliminary estimate of risk undertaken. If there is no relevant pollutant linkage identified there is likely to be negligible risk. If there is a very low risk, it is likely that no further assessment is required. If further assessment is necessary, then gas monitoring is required.

## A3.4 SITE MONITORING

A3.4.1 For sites with low generation potential, giving consistently low concentrations of soil gas under the worst-case conditions, a limited programme of monitoring would be appropriate. Where high or variable concentrations are anticipated or recorded, an extended programme of monitoring would be appropriate. The following guidance has been proposed, ref. 6.13.

**Table A3.1**

| Sensitivity of development | Generation potential of source  |          |     |          |       |           |
|----------------------------|---------------------------------|----------|-----|----------|-------|-----------|
|                            |                                 | Very low | Low | Moderate | High  | Very high |
|                            | Low (Commercial)                | 4/1      | 6/2 | 6/3      | 12/6  | 12/12     |
|                            | Moderate (Flats)                | 6/2      | 6/3 | 9/6      | 12/12 | 24/24     |
|                            | High (Residential with gardens) | 6/3*     | 9/6 | 12/6     | 24/12 | 24/24     |

### Notes

1. First number is minimum number of readings and second number is minimum period in months, for example 4/1 – Four sets of readings over 1 month.
2. At least two sets of readings must be at low and falling atmospheric pressure (but not restricted to periods below <1000mb) known as worst case conditions (see NHBC, ref 6.15).
3. The frequency and period stated are considered to represent typical minimum requirements. Depending on specific circumstances fewer or additional readings may be required (e.g. any such variation subject to site specific justification). The NHBC guidance is also recommending these periods/frequency of monitoring.
4. Historical data can be used as part of the data set.
5. Not all sites will require gas monitoring however, this would need to be confirmed with demonstrable evidence.
6. Placing high sensitivity end use on a high hazard site is not normally acceptable unless the source is removed or treated to reduce its gassing potential. Under such circumstances long-term monitoring may not be appropriate or required.

A3.4.2 Before taking any readings, zero the instrument, record atmospheric pressure and temperature.

A3.4.3 Gas flow should be recorded, giving the range of pressures, ensuring positive or negative flow is recorded.

A3.4.4 Record gas levels, recording peak and steady. Where steady state not obtained within 3 minutes, record change in concentration, where concentrations are decreasing, always record peak value. For very high concentrations, record for longer period of up to 10 minutes.

## A3.5 ASSESSMENT OF RISK AND RECOMMENDATIONS

A3.5.1 The main method of characterising a site is the method described by Wilson and Card, ref. 6.14 and is termed Situation A. This can be used for all types of development except conventional low-rise housing with suspended ground floor and ventilated underfloor void.

A3.5.2 Low rise housing, Situation B, was developed by Boyle and Witherington for the NHBC, ref. 6.15, for classifying gassing sites for houses with suspended ground floor slab with ventilated void.

A3.5.3 Although the Code of Practice, ref 6.10, assesses the characteristic gas situation as CIRIA recommend for Situation A, see Table A3.2 below, their solution for gas protection systems is different, see section A3.8.

### A3.6 SITUATION A - ASSESSMENT

A3.6.1 This system proposed by Wilson and Card was originally developed in CIRIA Report 149, ref. 6.8.

A3.6.2 The method uses both gas concentrations and borehole flow rate for methane and carbon dioxide to define a Characteristic Situation for a site.

A3.6.3 Gas Screening Value (litre/hr) = borehole flow rate (litre/hr) x gas concentration (%). The GSV is determined for methane and carbon dioxide and the worst case adopted. The Characteristic Situation can then be determined from the table below. The GSV can be exceeded if the conceptual model indicates it is safe to do so, and other factors may lead to a change in the Characteristic Situation.

**Table A3.2**

| Characteristic Situation | Risk Classification   | Gas screening value (CH <sub>4</sub> or CO <sub>2</sub> (1/hr) <sup>1</sup> | Additional factors                                                                                     | Typical source of generation                                                 |
|--------------------------|-----------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| 1                        | Very low risk         | <0.07                                                                       | Typically methane ≤1% and/or carbon dioxide ≤5%. Otherwise consider increase to Situation 2            | Natural soils with low organic content<br>“Typical” Made Ground              |
| 2                        | Low risk              | <0.7                                                                        | Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to Characteristic Situation 3 | Natural soil, high peat/organic content.<br>“Typical” Made Ground            |
| 3                        | Moderate risk         | <3.5                                                                        |                                                                                                        | Old landfill, inert waste, mineworking flooded                               |
| 4                        | Moderate to high risk | <15                                                                         | Quantitative risk assessment required to evaluate scope of protective measures                         | Mineworking – susceptible to flooding, completed landfill (WMP 26B criteria) |
| 5                        | High risk             | <70                                                                         |                                                                                                        | Mineworking unflooded inactive with shallow workings near surface            |
| 6                        | Very high risk        | >70                                                                         |                                                                                                        | Recent landfill site                                                         |

1. Site characterisation should be based on gas monitoring of concentrations and borehole flow rates for the minimum periods defined in Table A7.1
2. Source of gas and generation potential/performance must be identified.
3. If there is no detectable flow use the limit of detection of the instrument.

### A3.7 SITUATION A – SOLUTION

A3.7.1 The Characteristic Situation can be used to define the scope of gas protective measures required.

A3.7.2 The CIRIA approach uses the characteristic situation to define the level of gas protection as follows:

**Table A3.3**

| Characteristic situation | Residential building (Not low-rise traditional housing) |                                                                                                                                                                                                                                                                                        | Office/commercial/industrial development |                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          | Number of levels of protection                          | Typical scope of protective measures                                                                                                                                                                                                                                                   | Number of levels of protection           | Typical scope of protective measures                                                                                                                                                                                                                                                                                                                       |
| 1                        | None                                                    | No special precautions                                                                                                                                                                                                                                                                 | None                                     | No special precautions                                                                                                                                                                                                                                                                                                                                     |
| 2                        | 2                                                       | a) Reinforced concrete cast in situ floor slab (suspended non-suspended or raft) with at least 1200g DPM and underfloor venting<br><br>b) Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane and underfloor venting<br><br>All joints and penetrations sealed | 1 to 2                                   | a) Reinforced concrete cast in-situ floor slab (suspended non-suspended or raft) with at least 1200g DPM<br><br>b) Beam and block or pre cast concrete slab and minimum 2000g DPM/reinforced gas membrane<br><br>c) Possibly underfloor venting or pressurisation in combination with a) and b) depending on use<br><br>All joints and penetrations sealed |
| 3                        | 2                                                       | All types of floor slab as above.<br>All joints and penetrations sealed.<br>Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space                                                                                                 | 1 to 2                                   | All types of floor slab as above.<br><br>All joints and penetrations sealed.<br>Minimum 2000g/reinforced gas proof membrane and passively ventilated underfloor sub-space or positively pressurised underfloor sub-space                                                                                                                                   |
| 4                        | 3                                                       | All types of floor slab as above.                                                                                                                                                                                                                                                      | 2 to 3                                   | All types of floor slab as above.                                                                                                                                                                                                                                                                                                                          |

| Characteristic situation | Residential building (Not low-rise traditional housing) |                                                                                                                                                                                                                                                                                                     | Office/commercial/industrial development |                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          |                                                         | <p>All joints and penetrations sealed.</p> <p>Proprietary gas resistant membrane and passively ventilated underfloor subspace or positively pressurised underfloor sub-space, oversite capping or blinding and in ground venting layer</p>                                                          |                                          | <p>All joints and penetration sealed.</p> <p>Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space with monitoring facility</p>                                                                                                                                                               |
| 5                        | 4                                                       | <p>Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft).</p> <p>All joints and penetrations sealed.</p> <p>Proprietary gas resistant membrane and ventilated or positively pressurised underfloor sub-space, oversite capping and in ground venting wells or barriers</p> | 3 to 4                                   | <p>Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft).</p> <p>All joints and penetrations sealed.</p> <p>Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space with monitoring facility.</p> <p>In ground venting wells or barriers</p>                           |
| 6                        | 5                                                       | <p>Not suitable unless gas regime is reduced first and quantitative risk assessment carried out to assess design of protection measures in conjunction with foundation design</p>                                                                                                                   | 4 to 5                                   | <p>Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft).</p> <p>All joints and penetrations sealed.</p> <p>Proprietary gas resistant membrane and actively ventilated or positively pressurised underfloor sub-space with monitoring facility, with monitoring. In ground venting wells and reduction of gas regime.</p> |

1. Typical scope of protective measures may be rationalised for specific developments on the basis of quantitative risk assessments.
2. Note the type of protection is given for illustration purposes only. Information on the detailing and construction of passive protection measures is given in BR414, ref. 6.12.
3. In all cases there should be minimum penetration of ground slabs by services and minimum number of confined spaces such as cupboards above the ground slab. Any confined spaces should be ventilated.

4. Foundation design must minimise differential settlement particularly between structural elements and ground-bearing slabs.
5. Commercial buildings with basement car parks, provided with ventilation in accordance with the Building Regulations, may not require gas protection for characteristic situations 3 and 4.
6. Floor slabs should provide an acceptable formation on which to lay the gas membrane. If a block and beam floor is used it should be well detailed so it has no voids in it that membranes have to span, and all holes for service penetrations should be filled. The minimum density of the blocks should be 600kg/m<sup>3</sup> and the top surface should have a 4:1 sand cement grout brushed into all joints before placing any membrane (this is also good practice to stabilise the floor and should be carried out regardless of the need for gas membrane).
7. The gas-resistant membrane can also act as the damp-proof membrane.

### **A3.8 CODE OF PRACTICE – SOLUTIONS**

- |        |                                                                                                                                                                                                                                     |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A3.8.1 | The Characteristic Gas Situation is determine in a similar manner to that recommended by CIRIA, see Table A3.2 above.                                                                                                               |
| A3.8.2 | Having selected the Characteristic Gas Situation, the appropriate gas protection could be selected for the building. The tables below give a guide as to the relative performance of the various designs and systems.               |
| A3.8.3 | A guidance value for the required gas protection, in the range 0 to 7 should be obtained from Table A3.4 below. Then, a combination of ventilation and/or barrier system should be chosen from Table A3.5 to meet that requirement. |

Table A3.4

| Characteristic gas situation, CS | NHBC traffic light | Required gas protection                    |                               |                      |                                    |
|----------------------------------|--------------------|--------------------------------------------|-------------------------------|----------------------|------------------------------------|
|                                  |                    | Non-managed property, e.g. private housing | Public building <sup>A)</sup> | Commercial buildings | Industrial buildings <sup>B)</sup> |
| 1                                | Green              | 0                                          | 0                             | 0                    | 0                                  |
| 2                                | Amber 1            | 3                                          | 3                             | 2                    | 1 <sup>C)</sup>                    |
| 3                                | Amber 2            | 4                                          | 3                             | 2                    | 2                                  |
| 4                                | Red                | 6 <sup>D)</sup>                            | 5 <sup>D)</sup>               | 4                    | 3                                  |
|                                  |                    |                                            | 6 <sup>E)</sup>               | 5                    | 4                                  |
|                                  |                    |                                            |                               | 7                    | 6                                  |

*NOTE: Traffic light indications are taken from NHBC Report no.: 10627-R01 (04) [3] and are mainly applicable to low-rise residential housing. These are for comparative purposes but the boundaries between the traffic light indications and CS values do not coincide.*

- A) Public buildings include, for example, managed apartments, schools and hospitals.  
 B) Industrial buildings are generally open and well ventilated. However, areas such as office pods might require a separate assessment and may be classified as commercial buildings and require a different scope of gas protection to the main building.  
 C) Maximum methane concentration 20% otherwise consider an increase to CS3.  
 D) Residential building on higher traffic light/CS sites is not recommended unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations.  
 E) Consideration of issues such as ease of evacuation and how false alarms will be handled are needed when completing the design specification of any protection scheme.

A3.8.4 Having determined the appropriate guidance value from Table A3.4, an element or combination of elements from a), b), c) or d) in Table A3.5, should be chosen to achieve the required level of protection.

Table A3.5

| PROTECTION ELEMENT/SYSTEM                                                                                                                             |                       | SCORE | COMMENTS                                                                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------|---------------------------------------------------------------------------------------------------------------|
| <b>a) Venting/dilution</b>                                                                                                                            |                       |       |                                                                                                               |
| Passive sub floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) <sup>A)</sup> | Very good performance | 2.5   | Ventilation performance in accordance with Annex A, ref. 6.10                                                 |
|                                                                                                                                                       | Good performance      | 1     | If passive ventilation is poor this is generally unacceptable and some form of active system will be required |

| PROTECTION ELEMENT/SYSTEM                                                                                                                                                           |                                                      | SCORE | COMMENTS                                                                                                                                                                                                                                                                                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Subfloor ventilation with active abstraction/pressurization (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) <sup>A)</sup> |                                                      | 2.5   | <i>There have to be robust management systems in place to ensure the continued maintenance of any ventilation system.</i><br><i>Active ventilation can always be designed to meet good performance.</i><br><i>Mechanically assisted systems come in two main forms: extraction and positive pressurization.</i> |
| Ventilated car park (basement or undercroft)                                                                                                                                        |                                                      | 4     | <i>Assumes car park is vented to deal with car exhaust fumes, designed to Building Regulations Document F and IstructE guidance</i>                                                                                                                                                                             |
| b) Barriers                                                                                                                                                                         |                                                      |       |                                                                                                                                                                                                                                                                                                                 |
| Floor slabs                                                                                                                                                                         |                                                      |       |                                                                                                                                                                                                                                                                                                                 |
| Block and beam floor slab                                                                                                                                                           |                                                      | 0     | <i>It is good practice to install ventilation in all foundation systems to effect pressure relief as a minimum.</i><br><i>Breached in floor slabs such as joints have to be effectively sealed against gas ingress in order to maintain these performances</i>                                                  |
| Reinforced concrete ground bearing floor slab                                                                                                                                       |                                                      | 0.5   |                                                                                                                                                                                                                                                                                                                 |
| Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into slab                                                                        |                                                      | 1.5   |                                                                                                                                                                                                                                                                                                                 |
| Reinforced concrete cast in situ suspended slab with minimal service penetrations and water bars around all slab penetrations and at joints                                         |                                                      | 1.5   |                                                                                                                                                                                                                                                                                                                 |
| Fully tanked basement                                                                                                                                                               |                                                      | 2     |                                                                                                                                                                                                                                                                                                                 |
| c) Membranes                                                                                                                                                                        |                                                      |       |                                                                                                                                                                                                                                                                                                                 |
| Taped and sealed membrane to reasonable levels of workmanship/in line with current good practice with validation <sup>B), C)</sup>                                                  |                                                      | 0.5   | <i>The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation, and the integrity of joints</i>                                                                                                                                    |
| Proprietary gas resistant membrane to reasonable levels of workmanship/in line with current good practice under independent inspection (CQA) <sup>B), C)</sup>                      |                                                      | 1     |                                                                                                                                                                                                                                                                                                                 |
| Proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practice under CQA with integrity testing and independent validation     |                                                      | 2     |                                                                                                                                                                                                                                                                                                                 |
| d) Monitoring and detection (not applicable to non-managed property, or in isolation)                                                                                               |                                                      |       |                                                                                                                                                                                                                                                                                                                 |
| Intermittent monitoring using hand held equipment                                                                                                                                   |                                                      | 0.5   | <i>Where fitted, permanent monitoring systems ought to be installed in the underfloor venting/dilution system in the first instance but can also be provided within the occupied space as a fail safe.</i>                                                                                                      |
| Permanent monitoring and alarm system <sup>A)</sup>                                                                                                                                 | Installed in the underfloor venting/ dilution system | 2     |                                                                                                                                                                                                                                                                                                                 |
|                                                                                                                                                                                     | Installed in the building                            | 1     |                                                                                                                                                                                                                                                                                                                 |
| e) Pathway intervention                                                                                                                                                             |                                                      |       |                                                                                                                                                                                                                                                                                                                 |

| PROTECTION ELEMENT/SYSTEM                                                                                                                                                                                                                         | SCORE | COMMENTS                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------------------------------------------------------------------------------------------------------------|
| Pathway intervention                                                                                                                                                                                                                              | -     | <i>This can consist of site protection measures for off-site or on-site sources (see Annex A, ref. 6.10)</i> |
| <i>NOTE: In practice the choice of materials might well rely on factors such as construction method and the risk of damage after installation. It is important to ensure that the chosen combination gives an appropriate level of protection</i> |       |                                                                                                              |

- A) It is possible to test ventilation systems by installing monitoring probes for post installation validation.
- B) If a 1200 g DPM material is to function as a gas barrier it should be installed according to BRE 414, ref. 6.12 being taped and sealed to all penetrations.
- C) Polymeric Materials >1200g can be used to improve confidence in the barrier. Remember that their gas resistance is little more than the standard 1200g (proportional to thickness) but their physical properties mean that they are more robust and resistant to site damage.



>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.



>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.



>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.

## Gas and Groundwater Monitoring

|                                                                                                                                                                                                                                                                                                                 |         |                                         |                       |                       |        |                              |                      |                   |                      |                       |      |                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-----------------------------------------|-----------------------|-----------------------|--------|------------------------------|----------------------|-------------------|----------------------|-----------------------|------|------------------|
| <b>Contract Number:</b> 2230428                                                                                                                                                                                                                                                                                 |         |                                         |                       |                       |        | <b>Gas Monitor:</b> GA5000   |                      |                   |                      |                       |      |                  |
| <b>Contract Name:</b> Ash Road South                                                                                                                                                                                                                                                                            |         |                                         |                       |                       |        | <b>Readings Taken By:</b> LW |                      |                   |                      |                       |      |                  |
| <b>Date:</b> 30th March 2021                                                                                                                                                                                                                                                                                    |         |                                         |                       |                       |        | <b>Checked By:</b> JT        |                      |                   |                      |                       |      |                  |
| <b>Background Readings:</b>                                                                                                                                                                                                                                                                                     |         | Weather Conditions:                     |                       |                       |        | Clear, Sunny, Warm           |                      | O <sub>2</sub> %  | CO <sub>2</sub> %    | CH <sub>4</sub> %     | CO   | H <sub>2</sub> S |
|                                                                                                                                                                                                                                                                                                                 |         | Ground Conditions (dry / wet etc):      |                       |                       |        | Dry                          |                      | v/v               | v/v                  | v/v                   | ppm  | ppm              |
|                                                                                                                                                                                                                                                                                                                 |         | Atmospheric Pressure (Start):           |                       |                       |        | 1022mb                       |                      | 20.1              | 0.0                  | 0.0                   | 0.0  | 0.0              |
|                                                                                                                                                                                                                                                                                                                 |         | Atmospheric Pressure (Finish):          |                       |                       |        | 1022mb                       |                      |                   |                      |                       |      |                  |
|                                                                                                                                                                                                                                                                                                                 |         | Time (Start): 13:40      Time (Finish): |                       |                       |        | 15:30                        |                      |                   |                      |                       |      |                  |
| Location                                                                                                                                                                                                                                                                                                        | VOC ppm | O <sub>2</sub> % v/v                    | CO <sub>2</sub> % v/v | CH <sub>4</sub> % v/v |        | CO ppm                       | H <sub>2</sub> S ppm | Rel Pressure (mb) | Gas flow Rate (l/hr) | Depth to base of well | SWL  | LNAPL or DNAPL   |
|                                                                                                                                                                                                                                                                                                                 | Steady  | Steady                                  | Steady                | Peak                  | Steady | Steady                       | Steady               | Steady            | Steady               | mBGL                  | mBGL | mBGL             |
| WS01A                                                                                                                                                                                                                                                                                                           | 0.0     | 19.5                                    | 0.0                   | 0.0                   | 0.0    | 0                            | 0                    | -0.17             | 0.0                  | 2.72                  | 0.43 | NR               |
| WS02A (13:50)                                                                                                                                                                                                                                                                                                   | 0.0     | 10.2                                    | 0.1                   | 31.5                  | ND     | 1                            | 1                    | -0.17             | 0.0                  | NR                    | NR   | NR               |
| WS02A (14:00)                                                                                                                                                                                                                                                                                                   | 0.0     | 7.8                                     | 5.0                   | 27.7                  | NR     | 2                            | 1                    | -0.17             | 0.0                  | NR                    | NR   | NR               |
| WS02A (15:22)                                                                                                                                                                                                                                                                                                   | 0.0     | 6.6                                     | 7.4                   | 32.4                  | NR     | 2                            | 1                    | -0.17             | 0.0                  | 5.80                  | 2.00 | NR               |
| WS03                                                                                                                                                                                                                                                                                                            | 0.0     | 8.0                                     | 5.5                   | 0.0                   | 0.0    | 0                            | 0                    | -0.17             | 0.0                  | 1.60                  | 1.28 | NR               |
| WS04                                                                                                                                                                                                                                                                                                            | 0.0     | 20.0                                    | 0.1                   | 0.0                   | 0.0    | 0                            | 0                    | -0.17             | 0.0                  | 2.97                  | 0.54 | NR               |
| WS05                                                                                                                                                                                                                                                                                                            | 0.0     | 19.1                                    | 0.0                   | 0.0                   | 0.0    | 1                            | 0                    | -0.17             | 0.0                  | 2.60                  | 0.32 | NR               |
| WS06                                                                                                                                                                                                                                                                                                            | 0.0     | 19.5                                    | 0.1                   | 0.0                   | 0.0    | 0                            | 0                    | -0.17             | 0.0                  | 3.02                  | 0.43 | NR               |
|                                                                                                                                                                                                                                                                                                                 |         |                                         |                       |                       |        |                              |                      |                   |                      |                       |      |                  |
|                                                                                                                                                                                                                                                                                                                 |         |                                         |                       |                       |        |                              |                      |                   |                      |                       |      |                  |
| >>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.                                                                                                                                                                             |         |                                         |                       |                       |        |                              |                      |                   |                      |                       |      |                  |
| Remarks:      WS01A: VOC peak at 0.6 ppm. Pipe flooded after 45 s.      WS05: VOC peak at 2.6 ppm.<br>WS02A: VOC peak at 2.8 ppm. Flow peak at -5.4 l/hr. Pump failed between 210 s and 260 s.      WS06: 3.1 VOC peak<br>WS03: VOC peak at 2.7 ppm.      Pipe flooded after 40 s<br>WS04: VOC peak at 2.0 ppm. |         |                                         |                       |                       |        |                              |                      |                   |                      |                       |      |                  |



>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.



>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.

## Gas and Groundwater Monitoring Results

|                                                                                           |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
|-------------------------------------------------------------------------------------------|------------|-------------------------|-----------------------------------|-----------------------|--------------------------|-------------------------|-------------------------------|-----------------------------|-------------------------|------|--|
| <b>Contract Number:</b>                                                                   |            | W07 40026               |                                   |                       |                          |                         |                               |                             |                         |      |  |
| <b>Contract Name:</b>                                                                     |            | Ash Road, Wrexham       |                                   |                       |                          |                         |                               |                             |                         |      |  |
| <b>Date:</b>                                                                              |            | 2nd February 2007       |                                   |                       |                          |                         |                               |                             |                         |      |  |
| Background Readings:                                                                      |            |                         | O <sub>2</sub> %<br>v/v           | 21.0                  | CO <sub>2</sub> %<br>v/v | 0.0                     | CH <sub>4</sub> %<br>v/v      | 0.0                         | H <sub>2</sub> S<br>ppm |      |  |
|                                                                                           |            |                         | Weather Conditions:               |                       |                          |                         | Clear/Dry                     |                             |                         |      |  |
|                                                                                           |            |                         | Ground Conditions (dry / wet etc) |                       |                          |                         | Wet                           |                             |                         |      |  |
|                                                                                           |            |                         | Atmospheric Pressure (Start)      |                       |                          |                         | 1031mb                        |                             |                         |      |  |
|                                                                                           |            |                         | Atmospheric Pressure (Finish)     |                       |                          |                         | 1031mb                        |                             |                         |      |  |
| Hole No:                                                                                  | VOC<br>ppm | O <sub>2</sub> %<br>v/v | CO <sub>2</sub> %v/v              | CH <sub>4</sub> % v/v | LEL                      | H <sub>2</sub> S<br>ppm | Gas<br>flow<br>Rate<br>(l/hr) | Depth<br>to base<br>of well | SWL                     |      |  |
|                                                                                           |            | Steady                  | Steady                            | Peak                  | Steady                   | Steady                  | Steady                        | Range                       | mBGL                    | mBGL |  |
| BH01                                                                                      |            | 20.9                    | 0.0                               | 0.0                   | 0.0                      | 0.0                     | 0.0                           | <<<<                        | 9.73                    | 1.36 |  |
| BH03                                                                                      |            | 20.4                    | 0.0                               | 0.0                   | 0.0                      | 0.0                     | 0.0                           | <<<<                        | 4.70                    | DRY  |  |
| BH04                                                                                      |            | 21.1                    | 0.0                               | 0.0                   | 0.0                      | 0.0                     | 0.0                           | -10.4                       | 9.60                    | 1.25 |  |
| BH05                                                                                      |            | 20.6                    | 0.0                               | 0.0                   | 0.0                      | 0.0                     | 0.0                           | -0.1                        | 4.39                    | 0.10 |  |
| BH07                                                                                      |            | 20.7                    | 0.0                               | 0.0                   | 0.0                      | 0.0                     | 0.0                           | <<<<                        | 8.95                    | 0.60 |  |
| BH08                                                                                      |            | 17.6                    | 0.4                               | 11.5                  | 11.5                     | >>>>                    | 0.0                           | <<<<                        | 4.10                    | 2.16 |  |
|                                                                                           |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
|                                                                                           |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
|                                                                                           |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
|                                                                                           |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
|                                                                                           |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
|                                                                                           |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
| Remarks:                                                                                  |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
| >>>> = Flow above detection limit of 30 l/hr, <<<< = Negative flow greater than -10 l/hr. |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |
| Readings Taken By:                                                                        |            | JT                      |                                   |                       |                          |                         |                               |                             |                         |      |  |
| Checked By:                                                                               |            |                         |                                   |                       |                          |                         |                               |                             |                         |      |  |

## Gas and Groundwater Monitoring Results

|                                                                                          |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
|------------------------------------------------------------------------------------------|------------|-----------------------------------|--------------------------------|-----------------------------------------|---------------|-----------------------------------|----------------------------------------|-------------------------------------|-------------|--|--|
| <b>Contract Number:</b>                                                                  |            | W07 40026                         |                                |                                         |               |                                   |                                        |                                     |             |  |  |
| <b>Contract Name:</b>                                                                    |            | Ash Road, Wrexham                 |                                |                                         |               |                                   |                                        |                                     |             |  |  |
| <b>Date:</b>                                                                             |            | 28th February 2007                |                                |                                         |               |                                   |                                        |                                     |             |  |  |
| Background Readings:                                                                     |            | O <sub>2</sub> %<br>v/v           | 20.9                           | CO <sub>2</sub> %<br>v/v                | 0.0           | CH <sub>4</sub> %<br>v/v          | 0.0                                    | H <sub>2</sub> S<br>ppm             |             |  |  |
|                                                                                          |            | Weather Conditions:               |                                |                                         |               |                                   | Overcast/Dry                           |                                     |             |  |  |
|                                                                                          |            | Ground Conditions (dry / wet etc) |                                |                                         |               |                                   | Wet/Flooded                            |                                     |             |  |  |
|                                                                                          |            | Atmospheric Pressure (Start)      |                                |                                         |               |                                   | 983mb                                  |                                     |             |  |  |
|                                                                                          |            | Atmospheric Pressure (Finish)     |                                |                                         |               |                                   | 983mb                                  |                                     |             |  |  |
| Hole No:                                                                                 | VOC<br>ppm | O <sub>2</sub> %<br>v/v<br>Steady | CO <sub>2</sub> %v/v<br>Steady | CH <sub>4</sub> % v/v<br>Peak<br>Steady | LEL<br>Steady | H <sub>2</sub> S<br>ppm<br>Steady | Gas<br>flow<br>Rate<br>(l/hr)<br>Range | Depth<br>to base<br>of well<br>mBGL | SWL<br>mBGL |  |  |
| BH01                                                                                     |            | 20.7                              | 0.0                            | 0.0<br>0.0                              | 0.0           | 0.0                               | -1.9                                   | 9.73                                | 0.66        |  |  |
| BH03                                                                                     |            | 12.2                              | 4.7                            | 4.7<br>0.0                              | 0.0           | 0.0                               | <<<<                                   | 4.73                                | 4.60        |  |  |
| BH04                                                                                     |            | 20.6                              | 0.0                            | 0.0<br>0.0                              | 0.0           | 0.0                               | 0.5                                    | 9.60                                | 0.90        |  |  |
| BH05                                                                                     |            | 20.6                              | 0.0                            | 0.0<br>0.0                              | 0.0           | 0.0                               | 0.3                                    | 4.38                                | 0.10        |  |  |
| BH07                                                                                     |            | 20.4                              | 0.0                            | 0.0<br>0.0                              | 0.0           | 0.0                               | <<<<                                   | 8.92                                | 0.86        |  |  |
| BH08                                                                                     |            | 18.4                              | 0.1                            | 7.0<br>7.0                              | >>>>          | 0.0                               | 2.1                                    | 4.09                                | 1.96        |  |  |
|                                                                                          |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
|                                                                                          |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
|                                                                                          |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
|                                                                                          |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
|                                                                                          |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
|                                                                                          |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
| Remarks:                                                                                 |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
| >>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |
| Readings Taken By:                                                                       |            | JT                                |                                |                                         |               |                                   |                                        |                                     |             |  |  |
| Checked By:                                                                              |            |                                   |                                |                                         |               |                                   |                                        |                                     |             |  |  |

## Gas and Groundwater Monitoring Results

|                                                                                           |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
|-------------------------------------------------------------------------------------------|------------|-------------------------|-----------------------------------|-----------------------|--------------------------|--------|--------------------------|-------------------------------|-----------------------------|------|--|--|
| <b>Contract Number:</b>                                                                   |            | W07 40026               |                                   |                       |                          |        |                          |                               |                             |      |  |  |
| <b>Contract Name:</b>                                                                     |            | Ash Road, Wrexham       |                                   |                       |                          |        |                          |                               |                             |      |  |  |
| <b>Date:</b>                                                                              |            | 8th May 2007            |                                   |                       |                          |        |                          |                               |                             |      |  |  |
| Background Readings:                                                                      |            |                         | O <sub>2</sub> %<br>v/v           | 21.0                  | CO <sub>2</sub> %<br>v/v | 0.0    | CH <sub>4</sub> %<br>v/v | 0.0                           | H <sub>2</sub> S<br>ppm     | 0.0  |  |  |
|                                                                                           |            |                         | Weather Conditions:               |                       |                          |        |                          | Sunny/Cloudy                  |                             |      |  |  |
|                                                                                           |            |                         | Ground Conditions (dry / wet etc) |                       |                          |        |                          | Dry                           |                             |      |  |  |
|                                                                                           |            |                         | Atmospheric Pressure (Start)      |                       |                          |        |                          | 1010mb                        |                             |      |  |  |
|                                                                                           |            |                         | Atmospheric Pressure (Finish)     |                       |                          |        |                          | 1011mb                        |                             |      |  |  |
| Hole No:                                                                                  | VOC<br>ppm | O <sub>2</sub> %<br>v/v | CO <sub>2</sub> %v/v              | CH <sub>4</sub> % v/v |                          | LEL    | H <sub>2</sub> S<br>ppm  | Gas<br>flow<br>Rate<br>(l/hr) | Depth<br>to base<br>of well | SWL  |  |  |
|                                                                                           |            | Steady                  | Steady                            | Peak                  | Steady                   | Steady | Steady                   | Range                         | mBGL                        | mBGL |  |  |
| BH01                                                                                      |            | 20.9                    | 0.0                               | 0.0                   | 0.0                      | 0.0    | 0.0                      | 0.01                          | 9.76                        | 1.38 |  |  |
| BH03                                                                                      |            | 18.3                    | 0.8                               | 0.0                   | 0.0                      | 0.0    | 0.0                      | 0.01                          | 4.74                        | 3.66 |  |  |
| BH04                                                                                      |            | 21.0                    | 0.0                               | 0.0                   | 0.0                      | 0.0    | 0.0                      | 0.01                          | 9.64                        | 1.29 |  |  |
| BH05                                                                                      |            | 20.9                    | 0.0                               | 0.0                   | 0.0                      | 0.0    | 0.0                      | 0.01                          | 4.40                        | 0.85 |  |  |
| BH07                                                                                      |            | 13.4                    | 2.0                               | 0.5                   | 0.1                      | 0.0    | 0.0                      | 1.61                          | 8.97                        | 0.80 |  |  |
| BH08                                                                                      |            | 4.00                    | 3.7                               | 37.5                  | 37.5                     | >>>>   | 0.0                      | 0.01                          | 4.10                        | 1.86 |  |  |
|                                                                                           |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
|                                                                                           |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
|                                                                                           |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
|                                                                                           |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
|                                                                                           |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
|                                                                                           |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
| Remarks:                                                                                  |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
| >>>> = Flow above detection limit of 30 l/hr, <<<< = Negative flow greater than -10 l/hr. |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |
| Readings Taken By:                                                                        |            | DM                      |                                   |                       |                          |        |                          |                               |                             |      |  |  |
| Checked By:                                                                               |            |                         |                                   |                       |                          |        |                          |                               |                             |      |  |  |