

Mr C. IVES

**BLUE HILLS FARM,
BIRKENSHAW, BD11 2DU**

GROUND INVESTIGATION REPORT

Contract: 2230244

Date: March 2021

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GROUND INVESTIGATION REPORT

carried out at

**BLUE HILLS FARM,
BIRKENSHAW, BD11 2DU**

Prepared for

**MR C. IVES
Blue Hills Farm
Birkenshaw
West Yorkshire
BD11 2DU**

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EXECUTIVE SUMMARY

On the instructions of Mr C. Ives, a ground investigation was undertaken to assess ground conditions at Blue Hills Farm.

It is understood that the site use will be changed from agricultural to residential.

The site comprised an area of agricultural land with adjacent gravel car parking extending in total to about 3.5Ha.

Geological records indicated bedrock of the Pennine Lower Coal Measures beneath the site. Coal seams and a fault are mapped across the site.

Site work comprised ten dynamic sample boreholes, six rotary open hole boreholes and five machine excavated trial pits. Monitoring wells were installed at four locations.

Ground conditions across most of the site comprised a thin layer of made ground and clay over bedrock of mudstone. An area of raised ground on the northern part of the site corresponded to an increased thickness of made ground to about 2m.

Bedrock of mudstone and sandstone was proved to 30m in rotary boreholes. Coal seams or evidence of historic coal mining was not encountered.

Based on the coal seams and the fault the site area has been subdivided into four zones referenced A to D, clockwise from north.

Zone A and Zone B are located on the northern and eastern site areas. The possibility of small-scale historic coal workings to exploit seams at shallow depths below these zones cannot be eliminated. A low risk from historic coal workings is considered appropriate. When preparing Zone A and Zone B for development the topsoil and made ground should be stripped and a watching brief by a suitably experienced professional maintained for any evidence of unrecorded historic mine entries.

Zone C and Zone D are not considered to be at risk from historic coal workings.

Foundation options will be dependent on the proposed development levels, any proposals for cut and fill earthworks to achieve those levels and the watching brief for any unrecorded historic coal mining.

Across most of the site the use of traditional spread foundations is anticipated. Foundations of widths about 1m may be designed based on a lower bound allowable bearing pressure about 80kN/m².

If the higher ground levels about the northern part of the site are to be retained, then in this area it may be more economical to adopt piled foundations.

The Design Sulphate Class for concrete may be taken as DS-1. An ACEC class for the site of AC-1 would be appropriate.

Contamination in the form of slightly elevated concentrations of PAH was encountered in made ground beneath the western, car parking, area of the site. To isolate these materials from end users and mitigate any potential risks it is recommended that they are removed and stockpiled separately either for re-use beneath areas of roadways and hardstanding or removed from site.

All other contamination test results were below guidance values. On this basis it is considered that the risks to end users from soils, excluding car park construction layers, are negligible.

Gas monitoring indicates a Gas Screening Value (GSV) consistent with Characteristic Situation 1. The maximum concentration of CO₂ for Characteristic Situation 1 was slightly exceeded in one borehole (WS06) on two visits. This indicates that consideration may be given to an increase to Characteristic Situation 2 on part of the site. In which case basic gas protection measures may locally be required.

The final design decisions on the use of gas protection measures would require information including development layout, earthworks and development levels and foundation types. When design details are available then further work to delineate any areas affected by ground gas would enable targeted use of protection measures.

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1.0 INTRODUCTION

- 1.1 It is understood that the site use will be changed from agricultural to residential.
- 1.2 On the instructions of Mr C. Ives, a ground investigation was undertaken to assess ground conditions, potential contamination and potential ground gas to inform any future development.
- 1.3 This report should be read in conjunction with the Preliminary Assessment report, which was reported under reference 42251 in September 2018.
- 1.4 A copy of this report may 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 at Blue Hills Farm, approximately 1.20km to the southwest of the village centre of Birkenshaw.
- 2.1.2 The site may be located by National Grid Reference SE 199 277.
- 2.1.3 A site location plan is included in Appendix 1, Figure A1.1.

2.2 Site Description

- 2.1.1 The site is approximately rectangular, tapering to the south with an area about 3.5Ha.
- 2.1.2 At the time of the investigation, the site predominantly comprised of agricultural land with gravelled car parking to the west.
- 2.1.3 The site sloped gently towards the south.
- 2.1.4 The site was defined by the following boundaries:
 - Northwest – adjacent pasture and farm buildings including farm shop and play barn
 - Southwest – fence defining crest of cutting that carries M62 motorway
 - Southeast – Whitehall Road West
 - Northeast – Wall, fencing and mature trees to adjacent agricultural grazing with parking area to northern part
- 2.1.5 The majority of the site was grazing pasture. The southwest part of the site comprised gravel covered parking areas, access road and fenced animal pens.
- 2.1.6 The agricultural land was subdivided north to south by a line of trees and bushes. The western part of the agricultural land was further subdivided by a west to east trending break of slope with occasional trees and a height up to about 2m.
- 2.1.7 The break of slope defined a flat-topped area of ground that occupied the north central part of the site. Material exposed on the southern slope of this raised area comprised of mudstone gravel.
- 2.1.8 A disused refrigerated container was on the southern edge of the car park. Stockpiles of old telegraph poles were located within the southern part of the site.

- 2.1.9 Access to the site was off Whitehall Road West located to the southeast of the site.
- 2.1.10 Along the eastern edge of the site, animal burrowing was evident. The spoil from the disturbance comprised grey angular gravel of mudstone.
- 2.1.11 Overhead services were present on site. Electricity pylon and associated overhead cables was located on the northern part of the site. The cabling was trending north to south. Telegraph poles and wiring were observed crossing the site.

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. 77, 'Huddersfield', solid and drift edition, 1:50,000 scale, published 2003.
- 2.2.2 The geological map indicates superficial deposits to be absent beneath the site.
- 2.2.3 The bedrock beneath the site is recorded as mudstone, siltstone, sandstone and Coal of the Pennine Lower Coal Measures Formation (Westphalian A) of Carboniferous Age.
- 2.2.4 Although not indicated as present on the site from the geological maps, made ground, in the form of colliery spoil, is anticipated across the northern part of the site.
- 2.2.5 The generalized vertical sequence of strata about the site is recorded as mudstone with coal seams and subordinate sandstone.
- 2.2.6 The bedrock strata beneath the site undulate gently at low angles about horizontal.
- 2.2.7 A fault trending northeast-southwest bisects the site. The fault is downthrown to the southeast. Coal seams are indicated at outcrop either side of the fault.

3.0 SITE WORK

- 3.1 The site work was carried out between the 4th and 13th November 2020.
- 3.2 The locations of exploratory holes were determined to provide an appropriate sampling regime across the site.
- 3.3 The site works were carried out on the basis of the practices set out in CLR 4, (ref. 9.1), BS 5930:2015 (ref. 9.2), BS EN ISO 14688-1:2002+A1:2013 (ref. 9.3), BS EN ISO 14689-1:2003 (ref. 9.4) and BS 10175:2011, (ref. 9.5).
- 3.4 Exploratory holes were undertaken as follows:
- WS 01 to WS 10: Dynamic sample boreholes
 - RO 01 to RO 06: Open hole rotary boreholes
 - TP 01 to TP 05: Machine excavated trial pits
- 3.5 A site plan showing the positions of the Exploratory Holes is presented in Appendix 1 as Figure A1.2.
- 3.6 The depths of exploratory holes, descriptions of strata encountered and comments on groundwater conditions are given in the records presented in Appendix 2.
- 3.7 A GPR survey and Cable Avoidance Tool (CAT) survey was undertaken at each exploratory hole location prior to excavation. At the location of boreholes an inspection pit was excavated by hand to a depth of 1.20m below ground level to check for buried services.
- 3.8 Representative disturbed samples were taken at the depths shown on the records. Samples for environmental analysis were collected in appropriate containers and kept in cool boxes for daily despatch to the analytical laboratory.
- 3.9 A photographic record of trial pits is given in Appendix 2.
- 3.10 Standard penetration tests (SPT), ref. 9.3 were carried out in dynamic sample boreholes in the various strata to assess the relative density or consistency. The values of penetration resistance are given in the borehole records. An energy ratio calibration certification for the SPT hammer used on site are presented in Appendix 2.
- 3.11 Perforated standpipes, surrounded by pea shingle and protected by a stopcock cover were installed in boreholes WS 02, WS 03, WS 06 and WS 10. The details of the installations are presented on the borehole records in Appendix 2.
- 3.12 The ground levels and co-ordinates reported on the records were determined by survey to OS datum and National Grid by GPS methods.
- 3.13 Monitoring of wells for water levels and ground gas concentrations has been carried out on six occasions. Monitoring results are presented in Appendix 2.

4.0 LABORATORY TESTS

4.1 Geotechnical Testing

4.1.1 Soil samples for testing were prepared in accordance with BS1377: Part One: 1990 ref. 9.11 and representative sub-samples were taken for testing. The following tests were carried out:

- 4 No. Moisture contents
- 4 No. Plasticity indices
- 3 No. Particle size distribution by wet sieving
- 2 No. Compaction
- 10 No. BRE suite B

4.1.2 The results of the soil tests are presented in Appendix 3, Test Report 2230244/1.

4.1.3 The results of the sulphate and pH tests are presented in Appendix 4, within Test Reports 20/09718 and 20/09917.

4.2 Chemical Testing

4.2.1 Chemical analysis was carried out on fifteen samples of soil for a range of commonly occurring contaminants. The nature of the analysis is detailed below:

4.2.2 **Metals screen** - arsenic, cadmium, chromium, chromium VI, lead, mercury, selenium, boron (water soluble), copper, nickel, vanadium and zinc

4.2.3 **Organic Screen** - polycyclic aromatic hydrocarbons (PAH) – USEPA 16 suite, total phenols

4.2.4 **Inorganics Screen** - cyanide (total), sulphide, sulphur

4.2.5 **Others** - pH, organic matter, asbestos

4.2.6 The results of chemical analysis on soil samples are presented in Appendix 4, Test Reports 20/09718 and 20/09917.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Sequence

- 5.1.1 The sequence of the strata encountered during the investigation generally confirms the anticipated geology as interpreted from the geological map.
- 5.1.2 The sequence encountered may be summarised as topsoil and made ground over clay that in turn overlies bedrock. The clay generally comprised weathered bedrock.

5.2 Topsoil and Made Ground

- 5.2.1 A thin layer of topsoil was encountered at all locations, except WS01 and WS04. Topsoil varied in thickness from 0.20 to 0.40m and generally comprised sandy gravelly clay. Anthropogenic fragments included brick and plastic.
- 5.2.2 Made ground extended to depths up to 2.00m beneath the northern part of the site in RO01, RO03 and RO05. TP01, TP02 and TP04 were also located on the northern part of the site and encountered made ground to depths in the range 1.50 to 1.80m. WS02 encountered made ground and possible made ground to depths about 1.40 to 2.00m.
- 5.2.3 Made ground beneath the northern part of the site generally comprised gravelly clay. This is considered to represent re-worked colliery spoil and is consistent with the raised area of ground created by tipping from the historic colliery to the north of the site.
- 5.2.4 The remaining exploratory holes, on the southeast part of the site, encountered made ground to depths in the range 0.30 to 0.90m. This material generally comprised gravelly clay consistent with re-worked weathered mudstone.
- 5.2.5 WS01 and WS04 were located within the car parking area on the western part of the site and encountered gravel at surface extending to depths of 0.60 and 0.30m respectively. This was underlain by clay to depths of 1.20 and 0.50m respectively. Anthropogenic ash, brick and asphalt were present within the made ground beneath the car park.

5.3 Superficial Strata

- 5.3.1 Clay was encountered across the site at depths with an overall range from 0.30 to 2.00m.
- 5.3.2 Clay was typically sandy and gravelly with colouring varying from brown to grey.
- 5.3.3 The majority of the clay is considered to represent the weathering profile of the underlying coal measures bedrock. Variable consistencies from soft to stiff were noted generally increasing with depth.
- 5.3.4 The base of the clay was proved at depths in the range 4.00 to 6.00m in rotary open holes. These depths are based on flush returns and are likely to indicate the transition from weathered to unweathered bedrock.
- 5.3.5 All trial pits and windowless sample boreholes were terminated within clay at depths in the range 2.20 to 5.45m. Boreholes were terminated due to the stiffness of the strata probably indicating a decrease in weathering of the underlying bedrock and corresponding transition from soil to rock.
- 5.3.6 Gravel was noted between 0.30 and 1.30m in WS03. This may represent re-worked mudstone.

5.4 Bedrock

- 5.4.1 Bedrock was encountered in rotary boreholes at depths in the range 2.50 to 6.00m.
- 5.4.2 Bedrock was described as mudstone and sandstone based on flush returns.
- 5.4.3 Boreholes RO01, RO03 and RO05, located on the northern part of the site, encountered bedrock of mudstone proved to the base of the boreholes at depths of 30m.
- 5.4.4 Boreholes RO02, RO04 and RO06, located on the eastern part of the site, encountered mudstone to depths of 12.00, 11.80 and 13.00m respectively. This stratum overlay sandstone, proved to the base of the boreholes at depths of 30.00m.

5.5 Groundwater

- 5.5.1 Groundwater was encountered as seepages in TP02, TP03 and WS10 at depths of 1.60, 2.10 and 1.20m respectively.
- 5.5.2 Groundwater was not noted in the remaining exploratory holes.
- 5.5.3 Rotary open hole drilling was carried out using water flush so may have obscured water strikes.

6.0 GEOTECHNICAL ASSESSMENT

6.1 Proposed Development

- 6.1.1 It is understood that the site use will be changed from agricultural to residential.
- 6.1.2 Development proposals and layouts have not been presented.
- 6.1.3 It has been assumed for the purposes of this report that development will be traditional two or three storey housing with associated loads in the region of 50kN per linear metre beneath load bearing walls.
- 6.1.4 The comments and discussion below do not fall within the requirements of EC7 (ref. 9.7) and are offered for guidance. The comments and recommendations below should be reviewed as development details become available.

6.2 Assessment of Strata Condition

Made Ground

- 6.2.1 The materials encountered on site were principally cohesive in nature with varying proportions of sand, gravel and, locally, cobbles.
- 6.2.2 The made ground is generally consistent with re-worked mudstone generally present as gravelly clay or, locally clayey gravel. The greatest thickness of made ground was beneath the elevated northern part of the site. Historical mapping indicated that this area received spoil from the Oakroyd Colliery, located a short distance to the north of the site about the end of the nineteenth century.
- 6.2.3 Made ground of gravel and gravelly clay was present at shallow depths on the western part of the site beneath the car parking areas.
- 6.2.4 One SPT 'N' value of 5 was recorded in made ground in WS02 at 1.20m.
- 6.2.5 One Atterberg limit test in made ground recorded a plastic limit of 34% with a plastic index value of 27. A water content of 32% was also recorded.
- 6.2.6 Three particle size distribution tests within made ground indicated sandy and very sandy gravel with fines of 1, 7 and 16%.
- 6.2.7 Compaction tests on made ground recorded maximum dry densities of 1.88 and 1.95Mg/m³ with corresponding optimum moisture contents of 11 and 8.5%.

Superficial Strata

- 6.2.8 Natural clay was encountered beneath made ground across much of the site. The clay strata were considered to be a product of the weathering of the underlying mudstone. Consistency of the clay varied from soft to very stiff, generally increasing with depth.
- 6.2.9 Three Atterberg limits tests in clay recorded plastic limits from 29 to 32% with plastic index values between 14 and 21. Water contents between 12 and 43% were also recorded.
- 6.2.10 On this basis the material may be classified as intermediate and high plasticity silt of low and medium volume change potential.
- 6.2.11 Thirty-three SPT 'N' values were recorded in clay ranging from 3 to >50. These values generally increase with penetration into the strata. This is considered to reflect the decrease in weathering of the mudstone with depth.
- 6.2.12 Soil boreholes were terminated due to the stiffness of the strata probably indicating a decrease in weathering of the underlying bedrock and corresponding transition from soil to rock.
- 6.2.13 The undrained shear strength of clay may be approximated from SPT 'N' values using the approximate relationship $C_u = 5 \times 'N'$.
- 6.2.14 On this basis undrained shear strength in the range 15 to >250kN/m² may be approximated indicating a wide range of strengths from very low to very high.
- 6.2.15 Undrained shear strength generally increased with depth. Softening at the top of clay strata is likely to be due to increase in water content due to perching of water.
- 6.2.16 One SPT 'N' value of 4 was recorded in gravel indicating very loose to loose material.

Bedrock

- 6.2.17 Bedrock of mudstone and sandstone was encountered in all rotary boreholes at depths between 2.50 and 6.00m.
- 6.2.18 The unconfined compressive strength of bedrock may be approximated from SPT 'N' values based on the following relationship:

$$\sigma_c > 10N \text{ (kN/m}^2\text{)}$$

where σ_c = unconfined compressive strength (UCS) and

N = SPT 'N' value

- 6.2.19 This approach is presented in CIRIA Report 143 and is considered to represent a lower bound value of UCS.
- 6.2.20 On the assumption that SPT's where full penetration was not achieved indicate the transition from clay to mudstone a range of 'N' values, extrapolated to 300mm, between 53 and 500 may be derived. From these values lower bound values of the UCS of mudstone about 0.5 to 5MPa may be derived.
- 6.2.21 These values of UCS are consistent with extremely weak and very weak rock at or about the top of the bedrock.

6.3 Coal Mining Risks

- 6.3.1 Geological records indicate the inferred outcrop of two coal seams beneath the site.
- 6.3.2 Neither of the coal seams extends across the whole site due to a northeast to southwest trending fault.
- 6.3.3 The coal seam outcrop to the west of the fault is orientated northwest to southeast beneath the northwest part of the site. This recorded as the Wheatley Lime Coal on the geological mapping.
- 6.3.4 The coal seam outcrop to the east of the fault is orientated west to east beneath the eastern part of the site. Based on the regional sequence of coal seam outcrops this seam appears to lie in the sequence between the Flockton Thin Coal and Wheatley Lime Coal.
- 6.3.5 The locations of these two coal seams and intervening fault, as recorded by British Geological Survey web mapping services are presented on Figure A1.3.
- 6.3.6 Based on the coal seams and the fault the site area has been subdivided into four zones referenced A to D, clockwise from north, as indicated on Figure A1.3.
- 6.3.7 Dips of strata in the area are at very low angles towards the northeast.
- 6.3.8 Reference to the Coal Authority interactive mapping indicates probable shallow mine workings extending to the northeast of the inferred seam outcrops. This is consistent with the mapped location of the seams and dip of strata towards the northeast.
- 6.3.9 Risks from shallow mine workings are also recorded by the Coal Authority along the southwest boundary of the site, about the top of the motorway embankment, extending towards the southwest. As these extend away from the site, they are not considered to present a risk to development of the site.

- 6.3.10 Rotary drilling was carried out at six locations to depths of 30m. Locations were selected on the basis of the positions of the coal seams and fault.
- 6.3.11 Rotary drilling did not encounter any significant coal seams or evidence of coal mining.
- 6.3.12 A slight loss of flush was noted about 13m in RO 04 on entering sandstone. This is considered to be due to fracturing about the top of the sandstone.
- 6.3.13 TP04 and TP05 were located to target the locations of the coal seams. Coal was not encountered in these trial pits.
- 6.3.14 Based on the geological records, Coal Authority records and ground investigation Zone C and Zone D on Figure 3 are not considered to be at risk from historic coal workings.
- 6.3.15 The possibility of small-scale historic coal workings to exploit seams at shallow depths below Zone A and Zone B on Figure A1.3 cannot be eliminated. On this basis a low risk from historic coal workings is considered appropriate. It is recommended that when preparing Zone A and Zone B for development the topsoil and made ground is stripped and a watching brief by a suitably experienced professional is maintained for any evidence of unrecorded historic mine entries. If any unrecorded mine entries are encountered these should be appropriately investigated and treated prior to development.
- 6.3.16 The CMRA previously presented in Report 42251 has been reviewed and amended as follows:

Coal Mining Risk	Yes	No	Risk Assessment
Underground coal mining recorded at shallow depths	X		Zones A & B – low risk. Watching brief required during site preparation. Zones C & D – no risk
Workable coal seams at shallow depths	X		Zones A & B – low risk. Watching brief required during site preparation. Zones C & D – no risk
Mine entries (shafts & adits)	X		Zones A & B – low risk. Watching brief required during site preparation. Zones C & D – no risk
Coal mining geology (fissures)		X	No further investigation required
Record of past mine gas emissions		X	None recorded
Recorded coal mining surface hazard		X	No further investigation required
Surface mining (opencast workings)		X	No further investigation required

6.4 Foundations

- 6.4.1 The results of laboratory tests indicate the made ground and natural clay at shallow depths are of low and medium volume change potential as defined by the National House Building Council, ref 9.14 and other published data, refs 9.15 and 9.16. Changes in moisture content may result in moderate changes in volume, seasonal changes being exacerbated by the presence of trees. It is recommended that for design purposes, medium volume change potential should be adopted.
- 6.4.2 Foundation options will be dependent on the proposed development levels, any proposals for cut and fill earthworks to achieve those levels and the watching brief for any unrecorded historic coal mining.
- 6.4.3 Current site levels on the raised northern part of the site would require foundations to be extended through made ground to depths greater than 2m to bear on competent natural ground. This may be achieved either by extending excavations for traditional spread foundations and backfilling with mass concrete or by use of piles.
- 6.4.4 Assuming development levels about existing levels across the central and southern parts of the site shallow spread foundations bearing on competent natural ground are anticipated. Competent natural strata of clay or weathered mudstone is anticipated at depths in the order of 1m across these areas. Localised soft areas, as evidenced by low SPT 'N' values to about 2.50m in WS07 may be mitigated by excavation and replacement with mass concrete or the use of reinforcement.
- 6.4.5 Outside the zone of influence of existing and proposed trees, it is recommended that conventional shallow spread footings should be taken through any Made Ground and placed in the underlying natural strata at a minimum depth of 0.90m.
- 6.4.6 On this basis foundations of widths about 1m may be designed based on a lower bound allowable bearing pressure about 80kN/m² which would provide an adequate factor of safety against shear failure and limit settlements to the order of 10mm.
- 6.4.7 If the higher ground levels about the northern part of the site are to be retained, then in this area it may be more economical to adopt piled foundations. Guidelines for the design of piles are given in Appendix 5.
- 6.4.8 The carrying capacity of piles depends not only on their size and the ground conditions but also on their method of installation. Pile design and installation are continuously evolving processes and state-of-the-art techniques are often employed before they reach the public domain, perhaps several years down the line. Therefore, it is recommended that specialist Piling Contractors be contacted as to the suitability and carrying capacity of their piles in the ground conditions pertaining to the site.

6.5 Ground Floor Slabs

- 6.5.1 Options for ground floor slabs will be dependent on the proposed development levels and any proposals for cut and fill earthworks to achieve those levels.
- 6.5.2 Within the zone of influence of trees or hedgerows, the floor slabs should be suspended over a void, in accordance with NHBC guidelines.
- 6.5.3 Where the final levels dictate that the depth of sub floor fill exceeds 600mm, ground floor slabs should be suspended in accordance with NHBC requirements.
- 6.5.4 In areas where only a thin veneer of made ground was encountered overlying natural strata, generally through the central and southern parts of the site, ground bearing floor slabs on formations prepared in natural ground may be considered.
- 6.5.5 Formations should be considered frost susceptible and should not be within 450mm of ground level. Formations should be inspected, and any soft or otherwise deleterious material removed and replaced with suitable compacted fill.

6.6 Excavations

- 6.6.1 Excavations for shallow foundations and services should be achievable with conventional plant.
- 6.6.2 On the basis of observations on site, together with the results of in-situ and laboratory tests, it is considered that excavations to less than 1.00m should stand unsupported in the short term. Side support for safety purposes should of course be provided to all excavations which appear unstable, and those in excess of 1.20m deep, in accordance with Health and Safety Regulations.
- 6.6.3 Significant groundwater inflows are not anticipated in shallow excavations for foundations or services. It is possible that perched groundwater could be locally present over clay strata. It is considered that this could be dealt with by pumping from sumps.

6.7 Chemical Attack on Buried Concrete

- 6.7.1 The site has been classified in accordance with BRE Special Digest 1, ref. 9.19, natural ground that contains pyrite and laboratory testing undertaken accordingly. It is recommended that the guidelines given in BRE Special Digest 1, ref. 9.19, be adopted.
- 6.7.2 The results of chemical tests in the strata at shallow depths, indicate a sulphate concentration in the soil of between <10 to 56mg/l as a 2:1 water/soil extract, a total sulphate concentration of between <0.02 and 0.05% and total sulphur of between <0.01 and 0.04%, with pH values in the range of 6.98 to 7.53.
- 6.7.3 It is recommended that for conventional shallow foundations the groundwater should be regarded as mobile.
- 6.7.4 Values for Total Potential Sulphate (TPS) and Oxidisable Sulphate (OS) have been derived from laboratory results where the values of Sulphur and Sulphate (acid soluble) were above detection limit.
- 6.7.5 Calculated values for TPS ranged from 0.03 to 0.12% and for OS ranged from 0.01 to 0.07%.
- 6.7.6 Values for OS greater than 0.30% indicate that pyrite is present and may be oxidised to sulphate where the ground is disturbed.
- 6.7.7 On the basis of the laboratory test results it is considered that a Design Sulphate Class for concrete may be taken as DS-1. The site conditions would suggest that an ACEC class for the site of AC-1 would be appropriate.

7.0 ENVIRONMENTAL RISK ASSESSMENT IN RELATION TO PROPOSED DEVELOPMENT

7.1 Contaminated Land

7.1.1 The statutory definition of contaminated land is defined in the Environmental Protection Act 1990, ref 9.21, which was introduced by the Environment Act 1995, ref 9.22, as:

- ‘Land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –
- significant harm is being caused or there is a significant possibility of such harm being caused; or
- significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused.’

7.2 Risk Assessment

7.2.1 The definition of contaminated land is based on the principles of risk assessment. Risk is defined as a combination of:

- The probability, or frequency of exposure to a substance with the potential to cause harm, and:
- The seriousness of the consequence.

7.3 Pollutant Linkage

7.3.1 The basis of an environmental risk assessment involves identifying a ‘source’ of contamination, a ‘pathway’ along which the contamination may migrate and a ‘receptor’ at risk from the contamination.

7.3.2 Current legislation defines the various elements of the pollution linkage as:

- A contaminant is a substance which is in or under the ground and which has the potential to cause harm or to cause pollution of controlled waters.
- A pathway is one or more routes through which a receptor is being exposed to, or affected by, a contaminant, or could be so affected.
- A receptor is either a living organism, an ecological system, a piece of land or property, or controlled water.

7.3.3 A pollutant linkage indicates that all three elements have been identified. The site can only be defined as ‘Contaminated Land’ if a pollutant linkage exists and the contamination meets the criteria in Section 7.1 above.

7.3.4 The guidance proposes a four-stage approach for the assessment of contamination and the associated risks. The four stages are listed below:

- Hazard Identification
- Hazard Assessment
- Risk Assessment
- Risk Evaluation

7.3.5 The hazard identification and hazard assessment have been based upon the Phase 1 Desk Study and formed the conceptual site model, detailed in our report, reference 42251, dated September 2018.

7.3.6 The risk assessment and evaluation stages are presented in this phase 2 interpretive report, after an intrusive ground investigation has taken place.

7.4 Risk Assessment – Human Health

7.4.1 Proposals for the site are a change of use from agricultural to residential. In the absence of any specific development proposals the risk assessment has been based on the most sensitive guidelines for a residential end use with homegrown produce. Should the proposed development be changed in the future then further risk assessment may be required.

7.4.2 The results of the soil analyses from the current investigation have been compared to CLEA SGVs published in Environment Agency Science Reports SC050021/SR3, ref 9.24 and SC050021, ref 9.25, where available, Generic Assessment Criteria (GAC), determined by LQM and CIEH, ref 9.26, DEFRA C4SL, ref. 9.27 as well as Assessment Criteria (AC) derived in-house using the CLEA Software Version 1.06, ref 9.27. The CLEA AC have been derived by Ian Farmer Associates in accordance with current legislation and guidance.

7.4.3 The guidance values used within this contamination assessment have been tabulated and are detailed within Appendix 6.

7.4.4 The results of chemical analyses have been processed in accordance with recommendations set out in the CIEH and CL:AIRE document ‘Guidance on Comparing Soil Contamination Data with a Critical Concentration’, ref 9.29. Where the concentrations determined on site are at or below the respective Guidance Level, they are considered not to pose a risk and are removed from further consideration, unless otherwise stated. Those contaminants with observed concentrations above the Guidance Level are detailed below:

Location	Depth (m)	Contaminant	Concentration (mg/kg)	Guidance Level (mg/kg) ⁽¹⁾
WS 01	0.00	Benzo(a)pyrene	4.36	2.7
WS 01	0.00	Benzo(b)fluoranthene	5.38	3.3
WS 01	0.00	Dibenzo(ah)anthracene	0.33	0.28
WS 01	0.70	Benzo(a)pyrene	6.32	2.7
WS 01	0.70	Benzo(b)fluoranthene	7.76	3.3
WS 01	0.70	Dibenzo(ah)anthracene	0.52	0.28

Note (1) Guidance at 2.5% soil organic matter

7.4.5 These exceedances were recorded on samples of made ground from shallow depths within the car parking area. This material was described as gravel or gravelly clay with included ash, asphalt and brick. In order to isolate these materials from end users and mitigate any potential risks it is recommended that they are removed and stockpiled separately either for re-use beneath areas of roadways and hardstanding or removed from site.

7.4.6 All other contamination test results were below guidance values. On this basis it is considered that the risks to end users from soils, excluding car park construction layers, are negligible.

7.5 Risk Assessment – Asbestos

7.5.1 Asbestos including Asbestos Containing Soils (ACS) only presents a risk to health if fibres are released into the air. It is generally assumed that only near surface ACS would contribute airborne fibres. However, in instances where gardens are proposed, then there is a risk that ACS could be exposed to the atmosphere through the action of digging.

7.5.2 Although no assessment criteria (AC) have been proposed in the new CIRIA C733, Ian Farmer Associates have adopted the view that if asbestos is identified within soil then further sampling and testing will be required; specifically, to quantify the amount and type of asbestos present. This information should then be used in Detailed Quantitative Risk Assessment (DQRA) as outlined in CIRIA C733.

7.5.3 Testing of six soil samples from a variety of materials reported that no asbestos was detected.

7.5.4 On this basis risks from asbestos are considered to be very low.

7.6 Risk Assessment - Controlled Waters

- 7.6.1 The site is located on a Secondary A aquifer, is not within groundwater source protection zone and there are no groundwater abstractions within 1km of the site.
- 7.6.2 The nearest surface watercourse is Lodge Beck, located approximately 291m to the northwest of the site.
- 7.6.3 Given the ground conditions encountered at the site and the results of this contamination assessment, it is considered unlikely that further assessment of the risks to controlled waters may be required.

7.7 Gas Generation

- 7.7.1 Gas monitoring visits have been undertaken on six visits after fieldwork, the results of which are included within Appendix 2.
- 7.7.2 The results of gas monitoring to date determined the presence of carbon dioxide up to 6.1%v/v with flow rates below machine detection limit. Methane was not detected. Based on these readings, remedial measures may be required, see section 8.0.

7.8 Protection of Services

- 7.8.1 Guidance from the UKWIR, ref 9.34, sets out the material requirements for newly laid water supply pipes within brownfield sites. However, the exact requirements should be clarified with the relevant local water utility supplier for the site.

7.9 Risk Evaluation

- 7.9.1 The conceptual model formed within the Phase 1 Desk Study has been updated to reflect the findings of the contamination risk assessment and the revised conceptual model, detailing the relevant pollutant linkages, is tabulated below:

Source	Potential Pathways	Receptor Group
PAH in made ground (car park area only)	• Ingestion of contaminated soil by direct contact. • Ingestion of contaminants through vegetables. • Entry of contaminants by skin or eye contact with contaminated soils or dust. • Inhalation of contaminated dust. • Inhalation or migration of toxic / explosives gases	Humans • Site occupants¹ • Site users¹ • Construction workers² • Maintenance workers¹ • Neighbouring site users²
Ground gas	• Migration • Ingression	Humans and buildings • Gas ingress into building/s • Site occupants
¹ – Assumes no remediation is undertaken. ² – Pathway exists only during the construction period		

7.10 Summary of Risk Evaluation

7.10.1 The above assessment identifies that the ‘source – pathway – receptor’ linkage potentially occurs PAH from made ground in the car parking area impacting upon the identified receptors. Therefore, it would be necessary to manage the risk at this location by either eliminating one of the links or by minimising the potential effects.

7.10.2 The elevated PAH is likely to be due anthropogenic material within made ground including ash. This material was not encountered elsewhere on site.

7.10.3 A ‘source – pathway – receptor’ linkage may potentially occur from slightly elevated CO₂ soil gas.

8.0 MANAGEMENT OF CONTAMINATION

8.1 Remediation and Verification

- 8.1.1 The risk management framework set out in the Model Procedures for the Management of Land Contamination, CLR 11, ref. 9.35, is applicable to the redevelopment of sites that may be affected by contamination.
- 8.1.2 The risk management process set out in the Model Procedures has three main components:
- Risk assessment
 - Options appraisal
 - Implementation
- 8.1.3 This initial risk assessment has identified the presence of elevated PAH concentrations within the Made Ground in the car park area. Relevant pollutant linkages have been identified, as demonstrated in the updated conceptual model.
- 8.1.4 The remediation strategy will need to review methods of reducing or controlling the identified unacceptable risks. This could be done by removing or treating the sources of contamination, removing or modifying the pathways or removing or modifying the behaviour of the receptors, to ensure there is no significant risk of significant harm to either human health or controlled waters from the identified contamination, in relation to the proposed end use.
- 8.1.5 An important part of the risk management process is identifying and informing all stakeholders with an interest in the outcome of the risk management project. To this end, if the regulators have not yet been contacted regarding the redevelopment of this site, it is recommended that they be supplied with a copy of both the Phase 1 Desk Study and this Phase 2 Site Investigation report in order to enable liaison to be undertaken with them.
- 8.1.6 Following liaison with the relevant regulatory bodies, a remediation strategy could be formulated, which should incorporate an options appraisal and summarise in detail the chosen remedial approach, along with the verification proposals. The remediation strategy should then be approved by the relevant regulatory authorities prior to implementation.
- 8.1.7 Where remediation is required, a verification report will need to be formulated following implementation of the remediation strategy, which should provide a complete record of all remedial activities conducted on site and include all the data obtained to support the remedial objectives and demonstrate that the remediation has been effective. Any unexpected conditions encountered during the remedial works should also be detailed within the verification report.

- 8.1.8 A number of potential remedial options for dealing with the contamination identified at this site, by removing the contamination sources or treating the contamination source, are detailed below:
- 8.1.9 In areas that are to be covered by buildings or hard standing, no pathway is likely to exist between any source of contamination and the human receptors by ingestion or dermal contact. Consideration should therefore be given to re-use of the made ground, where elevated PAH was encountered in the car parking area, beneath the buildings or roadways / hardstanding. Alternatively, if cut and fill earthworks are proposed to create development levels then the affected material may be placed at a suitable depth within earthworks. The re-use of this material in earthworks or capping layers beneath hardstanding would be subject to suitability assessment for the intended purpose.
- 8.1.10 The results of initial gas monitoring determined the presence of carbon dioxide of up to 6.1%v/v with negligible gas flow. Methane was not detected. Reduced oxygen concentration down to 8.8%v/v was also noted.
- 8.1.11 The slightly elevated concentrations of CO₂ and reduced oxygen were encountered in WS06, located towards the southwest side of the site adjacent to the edge of the car park. This borehole generally encountered topsoil over natural strata. Natural soils with a low degradable organic content have a very low gas generation potential.
- 8.1.12 The recorded gas concentrations indicate Gas Screening Values (GSV) consistent with Characteristic Situation 1, Table A7.2. The maximum concentration of CO₂ recorded indicates that consideration may be given to an increase to Characteristic Situation 2 for development about the affected area. In this area basic gas protection measures may be required.
- 8.1.13 If development proceeds with suspended floor slabs and ventilated void, then the NHBC Traffic Lights system may be used for gas assessment. Based on the Gas Screening value for carbon dioxide, an initial screening puts the Traffic Light into green. However, the threshold concentration for this class was exceeded in one borehole on two monitoring visits indicating that an increase to “Amber 1” may be required in the affected area. Recommended protective measures are given in Appendix 7, section A7.9.
- 8.1.14 The final design decisions on the use of gas protection measures would require information including development layout, earthworks and development levels and foundation types. When design details are available then further work to delineate any areas affected by ground gas would enable targeted use of protection measures.

8.2 Management of Unidentified Sources of Contamination

8.2.1 There is the possibility that other sources of contamination may be present on the site, which were not detected during the investigation. Should such contamination be identified or suspected during the site clearance or ground works, these should be dealt with accordingly. A number of options are available for handling this material, which include:

- The removal from site and disposal to a suitably licensed tip of all material suspected of being contaminated. The material would need to be classified prior to disposal.
- Short-term storage of the suspected material while undertaking verification testing for potential contamination. The storage area should be a contained area to ensure that contamination does not migrate and affect other areas of the site. Depending upon the amounts of material under consideration, this could be either a skip or a lined area.
- Having a suitably experienced environmental engineer either on-call or with a watching brief for the visual and olfactory assessment of the material, and sampling for verification purposes.

8.3 Consultation

8.3.1 During the development of a contaminated site, consultation may be required for a number of reasons with a number of regulatory Authorities. The following provides an indication as to the most likely Authorities with which consultation may be required.

- **Local Authority.** There may be a planning condition regarding contamination and consultation will be required with a designated Contaminated Land Officer within the Environmental Health Department. The Local Authority is generally concerned with human health risks. Some Authorities now require 'Completion Certificates' to be signed off following remediation works.
- **Environment Agency.** Where a site is within a groundwater protection zone or has been designated as a special site, the Environment Agency is likely to be involved to ensure that controlled waters are protected.
- **National House Building Council, NHBC.** Section 4.1 of the NHBC Standards requires land management to be addressed. For a new housing development to be approved by the NHBC, any remediation will require a validation report.

8.3.2 Based on the results of any consultation, there may be specific remediation requirements imposed by one or more of the Authorities.

8.4 Risk Management During Site Works

8.4.1 During ground works, some simple measures may have to be put in place to mitigate the risk of contamination affecting the site workers and the environs. The majority of the proposed measures represent good practice for the construction industry and include:

- Informing the site workers of the contamination on site and the potential health effects from exposure.
- Where appropriate, the provision of suitable Personal Protective Equipment (PPE) for workers who may be potentially impacted by working in areas of the contamination.
- Ensuring good hygiene is enforced on site and washing facilities are maintained on the site. Workers are discouraged from smoking, eating or drinking without washing their hands first.
- Dust monitoring, and if necessary, suppression measures should be put into practice where contamination is becoming airborne.

8.4.2 Where contaminated materials are being removed from the site they should be disposed of at a suitably licensed landfill, with a 'duty of care' system in place and maintained throughout the disposal operations.

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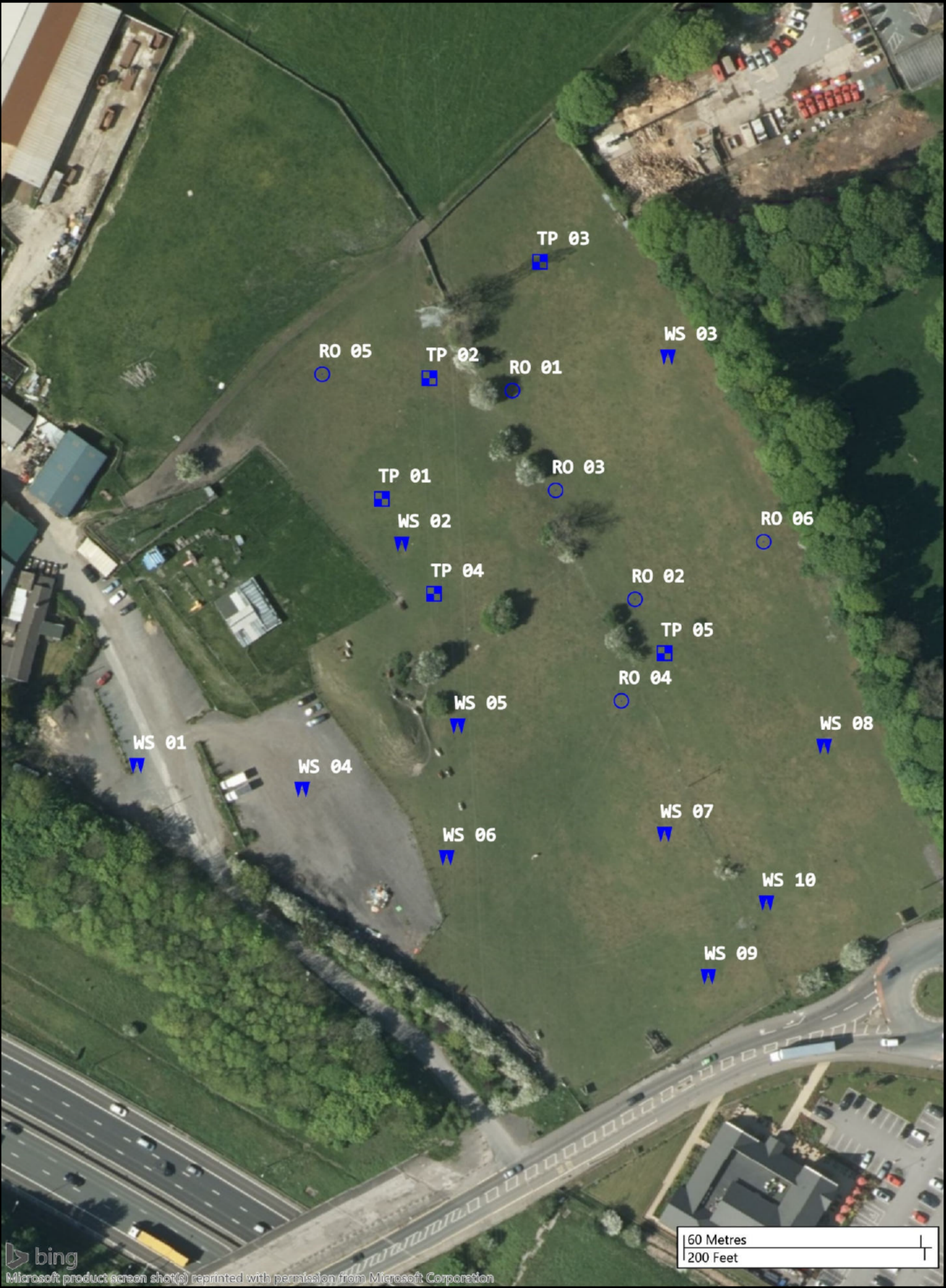
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APPENDIX 1
DRAWINGS







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 ISO 1997, 9.3 and BS 5930, ref 9.2.

A2.1.2 Trial Pits

Shallow trial pits are generally dug by mechanical excavator, however, in difficult access locations or adjacent to structures, such pits may be hand dug. Pits are best used where the ground will stand unsupported and generally, the maximum depth of machine dug pits is 4m to 5m. Where personnel are required to enter pits, it is essential that side support is provided. Entry by personnel into unsupported pits deeper than 1.2m is not allowed for health and safety reasons.

Trial pits allow the in-situ condition of the ground to be examined both laterally and vertically and also allow discontinuities to be recorded. The field record should give the orientation of the pit with details of which face was logged, assessment of stability of sides of pit and groundwater as well as the strata encountered. Photographs of the pit should also be taken.

In-situ testing, such as hand penetrometer, hand vane, Macintosh probe, or similar, can be undertaken in the sides or base of pits while both disturbed and undisturbed samples recovered.

It is generally advisable to backfill the pits as soon as possible, open pits should not be left unattended.

A2.1.3 Drive-in Window Sampler

The drive-in window sampler, ref 9.10, 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 a window, representing about a quarter of the circumference, is cut along the length of the tube. Soil samples are extracted through the window of the tube.

The borehole is extended by using progressively smaller diameter tubes.

Alternatively, undisturbed samples may be collected in plastic liners, known as *windowless sampling*.

A2.2 IN-SITU TESTS

A2.2.1 Standard Penetration Test

The Standard Penetration Test is carried out in accordance with the proposals recommended by ISO 1997, ref 9.3, BS 1377, Part 9, 1990 ref 9.11 and ISO 22476 ref 9.8.

The standard penetration test, **SPT**, covers the determination of the resistance of soils to the penetration of a split barrel sampler. A 50mm diameter split barrel sampler is driven 450mm into the soil using a 63.5kg hammer with a 760mm drop. The penetration resistance is expressed as the number of blows required to obtain 300mm penetration below an initial seating drive of 150mm through any disturbed ground at the bottom of the borehole. The number of blows to achieve the standard penetration of 300mm is reported as the 'N' value.

The test is generally carried out in fine soils, however, it may also be carried out in coarse granular soils, weak rocks and glacial tills using the same procedure as for the SPT but with a 50mm diameter, 60° apex solid cone replacing the split spoon sampler, **CPT**.

When attempting the standard penetration test in very dense material or weathered rocks it may be necessary to terminate the test before completion to prevent damage to the equipment. In these circumstances it is important to distinguish how the blow count relates to the penetration of the sampler. This may be achieved in the following manner:

- Where the seating drive has been completed, the test drive is terminated if 50 blows are reached before the full penetration of 300mm is achieved. The penetration for 50 blows is recorded and an approximate N value obtained by linear extrapolation of the number of blows for the partial test drive.
- If the seating drive of 150mm is not achieved within the first 25 blows, the penetration after 25 blows is recorded and the test drive then commenced.
- For tests in soft rocks, the test drive should be terminated after 100 blows where the penetration of 300mm has not been achieved.

The N-value obtained from the Standard Penetration Test may be used to assess the relative density of sands and gravels as follows:

Term	SPT N-Value : Blows/300mm Penetration
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	Over 50

A2.3 SAMPLES

U	represents undisturbed 100mm diameter sample, the number of blows to obtain the sample also recorded.
U fail	indicates undisturbed sample not recovered
HV	represents Hand Vane test with equivalent undrained shear strength in kN/m ² .
PP	represents Pocket Penetrometer test with equivalent undrained shear strength in kN/m ² .
CBR	represents California Bearing Ratio test
B	represents large bulk disturbed samples
D	represents small disturbed sample
A	represents amber jar contamination sample
V	represents vial contamination sample
W	represents water sample
	represents water strike
	represents level to which water rose

A2.4 DESCRIPTION OF SOILS

A2.4.1 General

The procedures and principles given in ISO 14688 Parts 1 and 2, ref 9.3, supplemented by section 6 of BS 5930, ref. 9.2 have been used in the soil descriptions contained within this report.

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2001

ARCHWAY ENGINEERING (UK) LTD
AINLEYS INDUSTRIAL ESTATE
ELLAND
WEST YORKSHIRE
HX5 9JP

SPT Hammer Ref: PM01
Test Date: 03/02/2020
Report Date: 03/02/2020
File Name: PM01.spt
Test Operator: JL

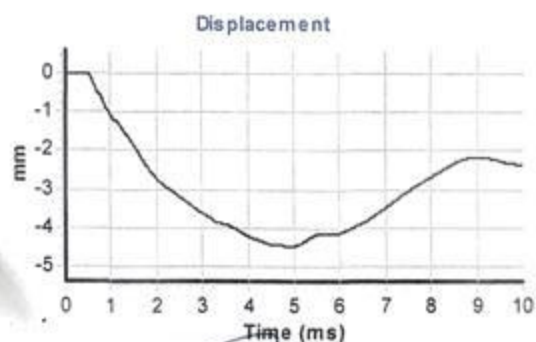
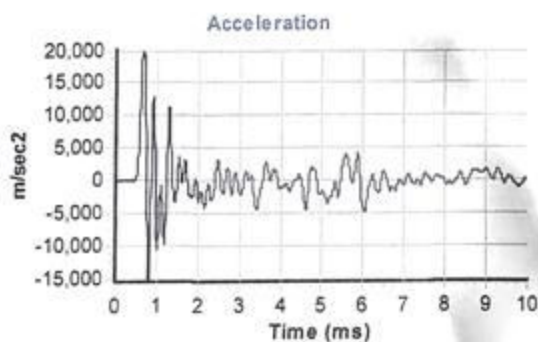
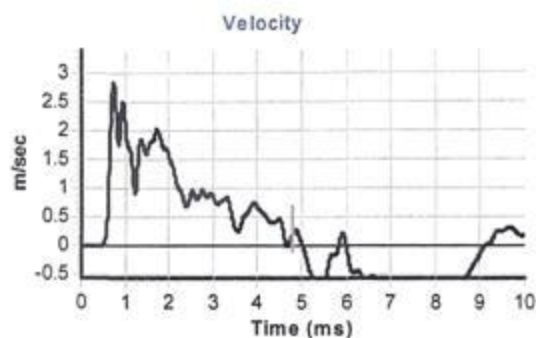
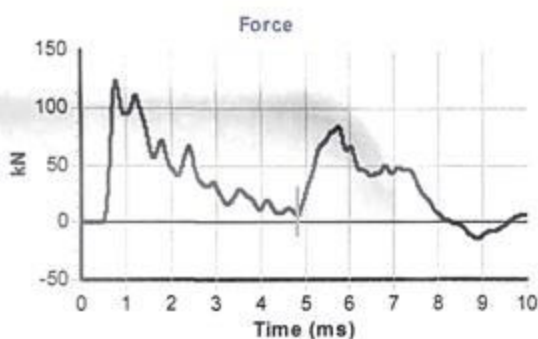
Instrumented Rod Data

Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.5
Assumed Modulus E_a (GPa): 208
Accelerometer No.1: 7080
Accelerometer No.2: 11609

SPT Hammer Information

Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 10.0

Comments / Location



Calculations

Area of Rod A (mm²): 970
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 287

Energy Ratio E_r (%): **61**

Signed: S. HOWARTH
Title: FITTER

The recommended calibration interval is 12 months



Plant used: Competitor Dart	Project: Blue Hills Farm			Location ID: WS 01	
Dates: 11/11/2020	Client: Mr. C. Ives				
Dynamic Sample Borehole Log	Location: 419864.18E 427727.15N	Ground level: 158.96mOD	Logged by: JS	Vertical scale: 1:50	Sheet 1 of 1
	Project ID: 2230244				

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
0.00 - 0.10	D2		158.36	(0.60)	MADE GROUND: Dark brown, sandy, slightly clayey GRAVEL including mudstone, limestone, ash, asphalt and mixed igneous lithologies.		1	
0.00 - 0.10	ES1							
0.30 - 0.60	B3							
0.70 - 0.80	D5							
0.70 - 0.80	ES4			(0.60)	MADE GROUND: Soft, dark brown, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including brick, asphalt and mudstone.			
1.20		SPT(S) N=9 (2,2/3,2,2,2)	157.76	1.20	Soft to firm, orange mottled grey and brown, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal <i>At 1.60m: becoming friable and firm.</i>			
1.50 - 1.70	D7	SPT(S) N=21 (5,4/4,5,6,6)	(1.97)	<i>At 2.20m: becoming stiff.</i>				
1.50 - 1.70	ES6							
2.00						<i>At 2.65m: becoming very stiff.</i>		
2.50 - 2.70	D8							
3.00		SPT(S) 50 (25 for 50mm/50 for 120mm)	155.79	3.17	End of Borehole at 3.17m			
							4	
							5	
							6	
							7	
							8	
							9	
							10	

Dynamic Sample Recovery					Remarks:									
Top (m)	Base (m)	Dia (mm)	Recovery %	Remarks	Hand excavated pit from ground level to 1.20m. Pit was stable. No groundwater encountered.									
					SPT Hammer: N/R, Energy Ratio: N/R									
					Water Strikes					Monitoring Installations				
					Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD		IFA DS v01.01											
Log status:	DRAFT													



Plant used: Competitor Dart	Project: Blue Hills Farm			Location ID: WS 02	
Dates: 11/11/2020	Client: Mr. C. Ives				
Dynamic Sample Borehole Log	Location: 419931.32E 427783.69N	Ground level: 164.95mOD	Logged by: JS	Vertical scale: 1:50	Sheet 1 of 1 Project ID: 2230244

Samples & In Situ Testing				Strata Details			Groundwater	
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
0.10 - 0.30	D2	SPT(S) N=5 (1,1/2,1,1,1)	164.65	(0.30)	MADE GROUND: Grass over, soft, dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine to coarse including mudstone, coal and brick (Topsoil)			
0.10 - 0.30	ES1			0.30				
0.40 - 0.60	D4							
0.40 - 0.60	ES3			(0.60)	Soft, orange mottled grey and brown, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal (Possible made ground)			
0.90 - 1.10	D6			0.90				
0.90 - 1.10	ES5	SPT(S) N=4 (1,2/2,1,0,1)	164.05	(0.40)	Soft, blueish grey, friable, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone (Possible made ground)		1	
1.20								
1.30 - 1.40	D7			1.30				
1.50 - 1.70	ES8			1.40	Blueish grey, slightly sandy, clayey, subangular to subrounded, fine to coarse GRAVEL including mudstone and coal (Possible made ground)			
1.70 - 1.90	D8							
2.00		SPT(S) N=9 (2,3/2,2,2,3)			Soft, blueish grey, friable, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal. (Possibly reworked in upper part)		2	
2.50 - 2.70	D9							
3.00				(3.20)	At 3.00m: becoming firm.			
3.60 - 3.80	D10							
4.00					Below 4.00m: becoming stiff			
4.60 - 4.80	D11	SPT(S) N=18 (3,5/4,4,5,5)	160.35	4.60	Stiff, orange mottled grey and brown, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.		4	
5.00				(0.85)				
		SPT(S) 50 (7,8/50 for 285mm)	159.50	5.45	End of Borehole at 5.43m		5	
							6	
							7	
							8	
							9	
							10	

Dynamic Sample Recovery					Remarks:									
Top (m)	Base (m)	Dia (mm)	Recovery %	Remarks	Hand excavated pit from ground level to 1.20m. Pit was stable. No groundwater encountered.									
					SPT Hammer: N/R, Energy Ratio: N/R									
					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	
Checked by:	TD		IFA DS v01.01						0.50	3.50	Slotted			
Log status:	DRAFT													

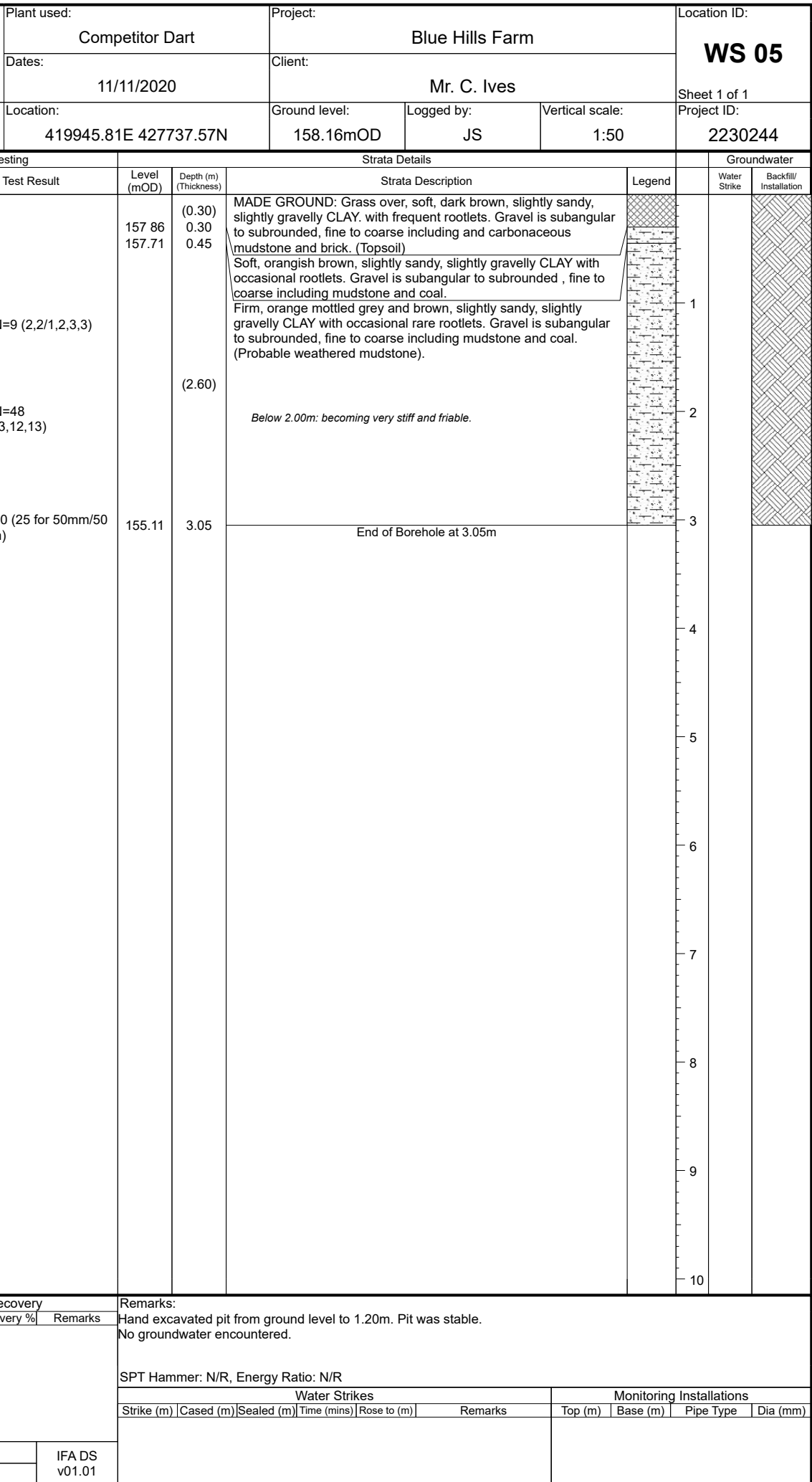


Plant used: Competitor Dart	Project: Blue Hills Farm			Location ID: WS 03	
Dates: 12/11/2020	Client: Mr. C. Ives				
Dynamic Sample Borehole Log	Location: 419998.88E 427831.55N	Ground level: 168.77mOD	Logged by: JS	Vertical scale: 1:50	Sheet 1 of 1 Project ID: 2230244

Samples & In Situ Testing			Strata Details				Groundwater		
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation	
0.10 - 0.30	D4		168.47	(0.30)	MADE GROUND: Soft, dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine to coarse including mudstone and coal. (Topsoil) Blueish grey, slightly sandy, clayey, subangular to subrounded, fine to coarse GRAVEL including mudstone and coal. With low-medium cobble content. Cobbles are subangular to subrounded up to 120mm including mudstone. (Possible made ground).				
0.10 - 0.30	ES1			0.30					
0.40 - 0.50	ES3			(1.00)					
0.50 - 0.70	B5								
1.20	D6	SPT(S) N=4 (1,1/1,1,1,1)	167.47	1.30	Soft, grey, friable, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.				
1.30 - 1.50				ES6					(0.60)
2.00	D7	SPT(S) N=15 (2,3/3,4,4,4)	166.87	1.90	Firm orange mottled grey and brown, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine and medium including mudstone and coal. Between 2.45m and 2.60m; dark grey At 2.80m: becoming friable.				
2.45 - 2.60									
3.00									
3.50 - 3.70									
4.00	D8	SPT(S) N=39 (5,5/6,8,11,14)		(3.47)	Below 4.00m: becoming very stiff				
4.50 - 4.70	D9								
5.00									
			163.40	5.37	End of Borehole at 5.37m				
								</	

Dynamic Sample Recovery					Remarks:									
Top (m)	Base (m)	Dia (mm)	Recovery %	Remarks	Hand excavated pit from ground level to 1.20m. Pit was stable.									
					SPT Hammer: N/R, Energy Ratio: N/R									
					Water Strikes					Monitoring Installations				
					Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
					4.00			0	0.00	Seepage	0.00	0.30	Plain	
Checked by: TD					IFA DS									
Log status: DRAFT					v01.01									

Dynamic Sample Recovery					Remarks:									
Top (m)	Base (m)	Dia (mm)	Recovery %	Remarks	Hand excavated pit from ground level to 1.20m. Pit was stable. No groundwater encountered.									
					SPT Hammer: N/R, Energy Ratio: N/R									
					Water Strikes					Monitoring Installations				
					Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD		IFA DS v01.01										
Log status:		DRAFT												



	Plant used:		Competitor Dart		Project:		Blue Hills Farm		Location ID:				
			Dates: 11/11/2020		Client:		Mr. C. Ives		WS 06				
Dynamic Sample Borehole Log			Location: 419943.10E 427704.04N		Ground level: 155.58mOD		Logged by: JS		Vertical scale: 1:50				
									Sheet 1 of 1 Project ID: 2230244				
Samples & In Situ Testing			Strata Details					Groundwater					
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend		Water Strike	Backfill/ Installation				
0.10 - 0.20	D4	SPT(S) N=17 (3,4/4,4,5,4)	155.28	(0.30)	MADE GROUND: Grass over, soft, dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine and medium including mudstone, brick and plastic. (Topsoil) Soft, blueish grey, friable, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone Soft, orangish brown, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine and medium including mudstone and coal. Stiff, orange mottled grey and brown, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal. (Probable weathered mudstone). <i>Below 1.90m: becoming friable.</i> <i>Below 2.80m: becoming very stiff.</i> End of Borehole at 2.96m	 	1						
0.10 - 0.20	ES1			0.30									
0.30 - 0.50	D5			0.30									
0.30 - 0.50	ES3	SPT(S) N=22 (6,5/5,6,6,5)	154.68	(0.60)			2						
0.90 - 1.10	D6			0.90									
0.90 - 1.10	ES5			0.40									
1.20		SPT(S) 50 (25 for 60mm/50 for 105mm)	154.28	1.30			3						
1.70 - 1.90	D7												
2.00													
2.50 - 2.70	D8		152.61	2.97			4						
2.80													
							5						
							6						
							7						
							8						
							9						
							10						
Dynamic Sample Recovery			Remarks:										
Top (m)	Base (m)	Dia (mm)	Recovery %	Hand excavated pit from ground level to 1.20m. Pit was stable. No groundwater encountered.									
				SPT Hammer: N/R, Energy Ratio: N/R									
				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	
										0.50	1.50	Slotted	
Checked by:		TD		IFA DS v01.01									
Log status:		DRAFT											

Dynamic Sample Recovery					Remarks:									
Top (m)	Base (m)	Dia (mm)	Recovery %	Remarks	Hand excavated pit from ground level to 1.20m. Pit was stable. No groundwater encountered.									
					SPT Hammer: N/R, Energy Ratio: N/R									
					Water Strikes					Monitoring Installations				
					Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD		IFA DS v01.01										
Log status:		DRAFT												



Plant used:	Competitor Dart		Project:		Blue Hills Farm		Location ID: WS 08
Dates:	12/11/2020		Client:		Mr. C. Ives		
Dynamic Sample Borehole Log		Location: 420039.04E 427732.76N		Ground level: 156.71mOD	Logged by: JS	Vertical scale: 1:50	Sheet 1 of 1 Project ID: 2230244

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
0.10 - 0.30	D4	SPT(S) N=11 (2,2/2,3,3,3)	156.41	(0.30)	MADE GROUND: soft, brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine to coarse including mudstone, coal and brick. (Topsoil)		1	
0.10 - 0.30	ES1			0.30				
0.40 - 0.60	D5							
0.40 - 0.60	ES3			(0.60)	Soft, blueish grey, friable, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.			
0.90 - 1.10	ES5	SPT(S) N=19 (3,4/4,5,6,4)	155.81	0.90	Firm, orange mottled grey and brown, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.		2	
1.00 - 1.20	D6							
1.20								
1.80 - 2.00	D7				Below 1.80m: becomes stiff			
2.00		SPT(S) 50 (25 for 70mm/50 for 100mm)	153.54	(2.27)			3	
2.50 - 2.70	D8							
3.00					Below 2.90m: becomes very stiff			
				3.17	End of Borehole at 3.17m			
							4	
							5	
							6	
							7	
							8	
							9	
							10	

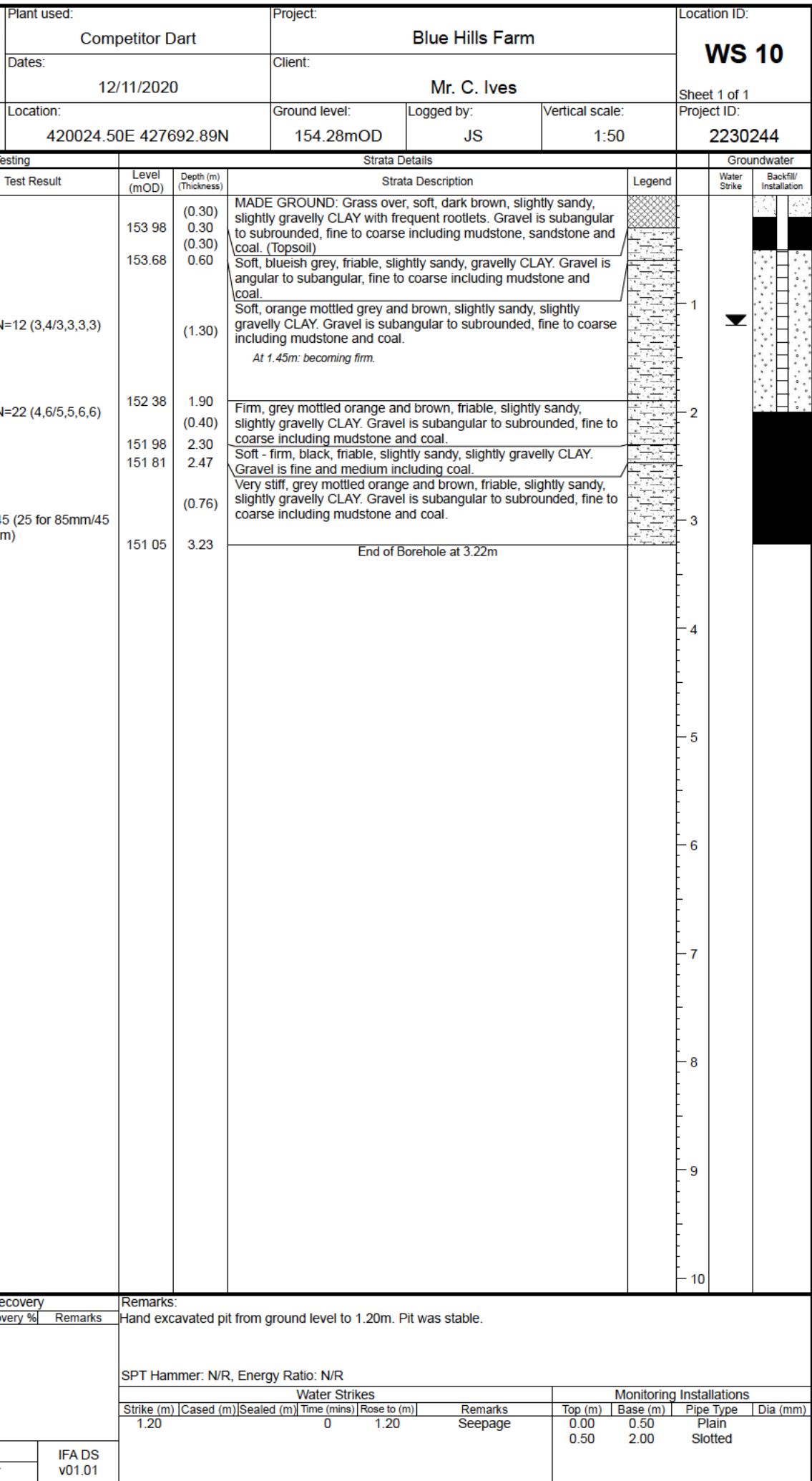
Dynamic Sample Recovery					Remarks:									
Top (m)	Base (m)	Dia (mm)	Recovery %	Remarks	Hand excavated pit from ground level to 1.20m. Pit was stable.									
					SPT Hammer: N/R, Energy Ratio: N/R									
					Water Strikes					Monitoring Installations				
					Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
					2.00			0	0.00	Seepage				
Checked by:	TD		IFA DS v01.01											
Log status:	DRAFT													



Plant used: Competitor Dart	Project: Blue Hills Farm		Location ID: WS 09		
Dates: 12/11/2020	Client: Mr. C. Ives				
Dynamic Sample Borehole Log	Location: 420009.79E 427674.16N	Ground level: 153.59mOD	Logged by: JS	Vertical scale: 1:50	Sheet 1 of 1 Project ID: 2230244

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
0.10 - 0.30	D4		153.19	(0.40)	MADE GROUND: Soft, dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. gravel is subangular to subrounded, fine to coarse including mudstone, sandstone and coal and brick. (Topsoil)			
0.10 - 0.30	ES1			0.40				
0.50 - 0.70	D5			(0.85)				
0.50 - 0.70	ES3	SPT(S) N=10 (2,2/1,3,3,3)	152.34	1.25	Soft, blueish grey, slightly sandy, gravelly CLAY. Gravel is angular to subrounded, fine to coarse including mudstone and coal.		1	
1.20								
1.50 - 1.60	ES6							
1.50 - 1.80	D6	SPT(S) N=20 (3,3/4,4,5,7)		(2.08)	Firm, orange and mottled grey and brown, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.		2	
2.00								
2.60 - 2.80	D7							
3.00		SPT(S) 50 (10,14/50 for 175mm)	150.27	3.33	Below 1.90m; becoming firm		3	
					End of Borehole at 3.32m			
							4	
							5	
							6	
							7	
							8	
							9	
							10	

Dynamic Sample Recovery					Remarks: Hand excavated pit from ground level to 1.20m. Pit was stable. No groundwater encountered. SPT Hammer: N/R, Energy Ratio: N/R				
Top (m)	Base (m)	Dia (mm)	Recovery %	Remarks					
Water Strikes					Monitoring Installations				
Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD		IFA DS v01.01					
Log status:		DRAFT							



Flush Details				Borehole Diameter		Boring Progress					Remarks:				
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)	Hand excavated pit from ground level to 1.20m. Descriptions based on flush returns from open hole drilling. Borehole backfilled with bentonite.				
0.00	30.00	Water				04/11	16 00	30.00	5.00						
				Casing Diameter		Water Strikes					Monitoring Installations				
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD	IFA RC v01.01												
Log status:		DRAFT													



Plant used: Mazenza M13	Project: Blue Hills Farm		Location ID: RO 01		
Dates: 04/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 419959.40E 427822.88N	Ground level: 167.52mOD	Logged by: JS	Vertical scale: 1:50	Sheet 2 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
		OH			(25.50)	Hard, grey MUDSTONE with sandstone.			
								11	
								12	
								13	
								14	
								15	
								16	
								17	
								18	
								19	
								20	

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													



Plant used: Mazenza M13	Project: Blue Hills Farm		Location ID: RO 01		
Dates: 04/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 419959.40E 427822.88N	Ground level: 167.52mOD	Logged by: JS	Vertical scale: 1:50	Sheet 3 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
						Hard, grey MUDSTONE with sandstone.			
								21	
								22	
								23	
								24	
								25	
								26	
								27	
								28	
								29	
								30	
				137 52	30.00	End of Borehole at 30.00m			

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													

Flush Details				Borehole Diameter		Boring Progress					Remarks:				
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)	Hand excavated pit from ground level to 1.20m. Descriptions based on flush returns from open hole drilling. Borehole backfilled with bentonite.				
0.00	30.00	Water				06/11	16 00	30.00	15.00						
				Casing Diameter		Water Strikes					Monitoring Installations				
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD	IFA RC v01.01												
Log status:		DRAFT													

Flush Details				Borehole Diameter		Boring Progress					Remarks:			
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)				
				Casing Diameter		Water Strikes					Monitoring Installations			
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type
Checked by:		TD	IFA RC v01.01											
Log status:		DRAFT												



Plant used: Mazenza M13	Project: Blue Hills Farm			Location ID: RO 02	
Dates: 06/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 419990.77E 427769.96N	Ground level: 160.29mOD	Logged by: JS	Vertical scale: 1:50	Sheet 3 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
						Brown SANDSTONE with mudstone bands.			
								21	
								22	
								23	
								24	
		OH			(13.00)			25	
								26	
								27	
								28	
								29	
				130 29	30.00	End of Borehole at 30.00m		30	

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													

Flush Details				Borehole Diameter		Boring Progress					Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)	Hand excavated pit from ground level to 1.20m. Descriptions based on flush returns from open hole drilling. Borehole backfilled with bentonite.					
0.00	30.00	Water				05/11	16 00	30.00	10.00							
				Casing Diameter		Water Strikes					Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks		Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD	IFA RC v01.01													
Log status:		DRAFT														

Flush Details				Borehole Diameter		Boring Progress					Remarks:			
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)				
				Casing Diameter		Water Strikes					Monitoring Installations			
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type
Checked by:		TD	IFA RC v01.01											
Log status:		DRAFT												



Plant used: Mazenza M13	Project: Blue Hills Farm		Location ID: RO 03		
Dates: 05/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 419970.41E 427797.57N	Ground level: 163.49mOD	Logged by: JS	Vertical scale: 1:50	Sheet 3 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
						Hard, grey, MUDSTONE with sandstone.			
								21	
								22	
								23	
								24	
								25	
								26	
								27	
								28	
								29	
								30	
				133.49	30.00	End of Borehole at 30.00m			

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													

Flush Details				Borehole Diameter		Boring Progress					Remarks:				
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)	Hand excavated pit from ground level to 1.20m. Descriptions based on flush returns from open hole drilling.				
0.00	30.00	Water				09/11	16 00	30.00	20.00						
				Casing Diameter		Water Strikes					Monitoring Installations				
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD	IFA RC v01.01												
Log status:		DRAFT													

Flush Details				Borehole Diameter		Boring Progress						Remarks:			
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)					
				Casing Diameter		Water Strikes						Monitoring Installations			
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD	IFARC v01.01												
Log status:		DRAFT													



Plant used: Mazenza M13	Project: Blue Hills Farm		Location ID: RO 04		
Dates: 09/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 419987.54E 427744.19N	Ground level: 158.21mOD	Logged by: JS	Vertical scale: 1:50	Sheet 3 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
		OH			(18.20)	Brown SANDSTONE and MUDSTONE with fragments of coal.			
								21	
								22	
								23	
								24	
								25	
								26	
								27	
								28	
								29	
				128 21	30.00	End of Borehole at 30.00m		30	

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													

Flush Details				Borehole Diameter		Boring Progress						Remarks: Hand excavated pit from ground level to 1.20m. Descriptions based on flush returns from open hole drilling. Borehole backfilled with bentonite.			
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)	Water (m)					
0.00	30.00	Water				13/11	16 00	1.20							
						16/11	16 00	30.00	10.00						
				Casing Diameter		Water Strikes						Monitoring Installations			
				Depth (m) Dia (mm)		Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD	IFA RC v01.01												
Log status:		DRAFT													



Plant used: Mazenza M13	Project: Blue Hills Farm		Location ID: RO 05		
Dates: 13/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 419910.93E 427826.83N	Ground level: 166.62mOD	Logged by: JS	Vertical scale: 1:50	Sheet 2 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
		OH			(24.50)	Grey MUDSTONE with orange sandstone and occasional coal fragments.			
								11	
								12	
								13	
								14	
								15	
								16	
								17	
								18	
								19	
								20	

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													



Plant used: Mazenza M13	Project: Blue Hills Farm			Location ID: RO 05	
Dates: 13/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 419910.93E 427826.83N	Ground level: 166.62mOD	Logged by: JS	Vertical scale: 1:50	Sheet 3 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ROD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/Installation
		OH				Grey MUDSTONE with orange sandstone and occasional coal fragments.			
								21	
								22	
								23	
								24	
								25	
								26	
								27	
								28	
								29	
				136.62	30.00	End of Borehole at 30.00m		30	

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													



Plant used: Mazenza M13	Project: Blue Hills Farm			Location ID: RO 06	
Dates: 12/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 420023.56E 427784.73N	Ground level: 161.14mOD	Logged by: JS	Vertical scale: 1:50	Sheet 1 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
			0.10m - B3 0.10m - ES1 0.40m - D4 0.40m - ES3	160.84	(0.30) 0.30	MADE GROUND: Soft dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine to coarse of mudstone and coal. (Topsoil)			
					(0.95)	Soft, blueish grey, slightly sandy, slightly gravelly CLAY with low cobble content. Gravel is subangular to subrounded, fine to coarse of mudstone and coal. Cobbles are angular to subangular, up to 120mm of mudstone.		1	
				159.89	1.25	Soft, orange mottled grey and brownish, slightly sandy, slightly gravelly, fine to coarse of mudstone and coal.		2	
					(1.25)				
				158.64	2.50	Brown CLAY with gravel of mudstone and coal.		3	
					(2.50)			4	
				156.14	5.00	Grey MUDSTONE.		5	
					(8.00)			6	
								7	
								8	
								9	
								10	

Flush Details				Borehole Diameter		Boring Progress				Remarks: Hand excavated pit from ground level to 1.20m. Descriptions based on flush returns from open hole drilling. Borehole backfilled with bentonite.					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
0.00	30.00	Water				12/11	16 00	1.20							
						13/11	16 00	30.00	12.00						
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:		TD	IFA RC												
Log status:		DRAFT	v01.01												



Plant used: Mazenza M13	Project: Blue Hills Farm			Location ID: RO 06	
Dates: 12/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 420023.56E 427784.73N	Ground level: 161.14mOD	Logged by: JS	Vertical scale: 1:50	Sheet 2 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
						Grey MUDSTONE.			
								11	
								12	
								13	
				148.14	13.00	Brown SANDSTONE with mudstone and coal fragments.		14	
								15	
								16	
								17	
								18	
								19	
								20	
						Continued next sheet			

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													



Plant used: Mazenza M13	Project: Blue Hills Farm			Location ID: RO 06	
Dates: 12/11/2020	Client: Mr. C. Ives				
Rotary Borehole Log	Location: 420023.56E 427784.73N	Ground level: 161.14mOD	Logged by: JS	Vertical scale: 1:50	Sheet 3 of 3 Project ID: 2230244

Coring, Samples & In Situ Testing				Strata Details				Groundwater	
Depth	TCR/SCR/ RQD	FI	Samples & Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Water Strike	Backfill/ Installation
		OH			(17.00)	Brown SANDSTONE with mudstone and coal fragments.			
								21	
								22	
								23	
								24	
								25	
								26	
								27	
								28	
								29	
				131.14	30.00	End of Borehole at 30.00m		30	

Flush Details				Borehole Diameter		Boring Progress				Remarks:					
Top (m)	Base (m)	Flush Type	Flush Return %	Depth (m)	Dia (mm)	Date	Time	Depth (m)	Cased (m)		Water (m)				
				Casing Diameter		Water Strikes				Monitoring Installations					
				Depth (m)	Dia (mm)	Strike (m)	Cased (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks	Top (m)	Base (m)	Pipe Type	Dia (mm)
Checked by:	TD	IFA RC													
Log status:	DRAFT	v01.01													



Plant used:	JCB 3CX	Project:	Blue Hills Farm		Location ID: TP 01
Dates:	09/11/2020	Client:	Mr. C. Ives		
Trial Pit Log	Location: 419926.14E 427795.18N	Ground level: 165.38mOD	Logged by: JS	Vertical scale: 1:25	Sheet 1 of 1 Contract ID: 2230244

Samples & In Situ Testing			Strata Details						
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Scale	Water Strike	Backfill/ Installation
0.10 - 0.20 0.10 - 0.20	D2 ES1		165.18	0.20	MADE GROUND: Grass over, soft, dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine to coarse including coal, brick, mudstone and sandstone. (Topsoil).				
0.30 - 0.50 0.30 - 0.50	B4 ES3				MADE GROUND: Blue grey, subangular to subrounded, fine to coarse slightly sandy, clayey GRAVEL including mudstone and, coal. Low to medium cobble content. Cobbles are subangular to subrounded up to 200mm including mudstone.				
				(1.60)			1		
1.80 - 2.00 1.80 - 2.00	D6 ES5		163.58	1.80	Soft to firm, brown, friable, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.				
			163.38	2.00	Firm, orange mottled grey, friable, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine and medium including mudstone and coal.		2		
2.40 - 2.60 2.40 - 2.60	D8 ES7								
				(1.20)			3		
			162.18	3.20	End of Trial Pit at 3.20m				
							4		
							5		

Termination:	Stability: Pit collapsed	Remarks: No groundwater encountered		
Dimensions (Length m x Width m): 3.00 x 0.90				
Water Strikes				
Strike (m)	Time (mins)		Rose to (m)	Remarks
Checked by:		TD	IFA TP v01 01	
Status:		DRAFT		



Plant used:	JCB 3CX	Project:	Blue Hills Farm		Location ID: TP 02
Dates:	09/11/2020	Client:	Mr. C. Ives		
Trial Pit Log	Location: 419938.15E 427825.96N	Ground level: 166.99mOD	Logged by: JS	Vertical scale: 1:25	Sheet 1 of 1 Contract ID: 2230244

Samples & In Situ Testing			Strata Details							
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Scale	Water Strike	Backfill/ Installation	
0.10 - 0.20 0.10 - 0.20	D2 ES1		166.59	(0.40)	MADE GROUND: Grass over, soft, dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine to coarse including coal, brick, mudstone and sandstone. (Topsoil).		1			
0.50 - 0.70 0.50 - 0.70	D4 ES3			0.40	MADE GROUND: Soft - firm, orange brown, friable, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including coal and mudstone.					
			(0.90)							
1.30 - 1.50 1.30 - 1.50	D6 ES5		165.69	1.30	MADE GROUND: Firm, orange brown, friable, slightly sandy, gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.					
1.60 - 1.80 1.60 - 1.80	D8 ES7		165.49	1.50	Firm, orangish brown, friable, slightly sandy, gravelly CLAY with low cobble content. Gravel is subangular to subrounded, fine to coarse including mudstone, carbonaceous mudstone and coal. Cobbles are angular to subangular up to 150mm including mudstone.					
				(0.70)			2			
			164.79	2.20	End of Trial Pit at 2.20m					
							3			
							4			
							5			

Termination:	Stability: Walls remained vertical	Remarks:		
Dimensions (Length m x Width m): 3.00 x 0.90				
Water Strikes				
Strike (m)	Time (mins)		Rose to (m)	Remarks
1.60	0		1.60	Seepage
Checked by:		TD	IFA TP v01 01	
Status:		DRAFT		



Plant used:	JCB 3CX	Project:		Blue Hills Farm		Location ID: TP 03	
Dates:	09/11/2020	Client:		Mr. C. Ives			
Trial Pit Log		Location:		Ground level:	Logged by:	Vertical scale:	Contract ID:
		419966.31E 427855.60N		170.23mOD	JS	1:25	2230244

Samples & In Situ Testing			Strata Details						
Depth	Sample ID	Test Result	Level (mOD)	Depth (m) (Thickness)	Strata Description	Legend	Scale	Water Strike	Backfill/ Installation
0.10 - 0.20	D2		170.03	0.20	MADE GROUND: Grass over, soft, dark brown, slightly sandy, slightly gravelly CLAY with frequent rootlets. Gravel is subangular to subrounded, fine and medium including coal, brick, mudstone and sandstone. (Topsoil).		1		
0.10 - 0.20	ES1			(0.30)	MADE GROUND: Soft to firm, orange brown, friable, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.				
0.30 - 0.50	D4		169.73	0.50	MADE GROUND: Soft to firm, orange brown, friable, slightly sandy, very gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone and coal.				
0.30 - 0.50	ES3			(0.40)	MADE GROUND: Soft to firm, orange brown, friable, slightly sandy, very gravelly CLAY. Gravel is subangular to subrounded, fine to coarse including mudstone, carbonaceous mudstone and coal.				
0.70 - 0.90	D6		169.33	0.90	MADE GROUND: Orangish brown, subangular to subrounded, fine to coarse slightly sandy, clayey GRAVEL including mudstone, carbonaceous mudstone and coal.				
0.70 - 0.90	ES5			1.10	Stiff, orangish brown, friable, slightly sandy, gravelly CLAY with low to medium cobble content. Gravel is subangular to subrounded, fine to coarse including mudstone, carbonaceous mudstone and coal. Cobbles are angular to subangular up to 200mm including mudstone. (Possibly re-worked in upper part)				
0.95 - 1.10	D8		169.13	(1.40)			2	▼	
0.95 - 1.10	ES7								
1.20 - 1.50	D10		167.73	2.50			3		
1.20 - 1.50	ES9								
					End of Trial Pit at 2.50m				
							4		
							5		

Termination:			Stability:		Remarks:		
			Walls remained vertical				
Dimensions (Length m x Width m):							
3.00 x 0.90							
Water Strikes							
Strike (m)	Time (mins)	Rose to (m)	Remarks				
2.10	0	2.10	Seepage				
Checked by:			TD		IFA TP v01 01		
Status:			DRAFT				

Plant used: JCB 3CX	Project: Blue Hills Farm			Location ID: TP 04
Dates: 09/11/2020	Client: Mr. C. Ives			
Location: 419939.60E 427771.13N	Ground level: 164.72mOD	Logged by: JS	Vertical scale: 1:25	Sheet 1 of 1 Contract ID: 2230244

Plant used: JCB 3CX	Project: Blue Hills Farm			Location ID: TP 05
Dates: 09/11/2020	Client: Mr. C. Ives			
Location: 419998.28E 427756.34N	Ground level: 159.08mOD	Logged by: JS	Vertical scale: 1:25	Sheet 1 of 1 Contract ID: 2230244

Trial Pit 1



Trial Pit 1



Trial Pit 2



Trial Pit 3



Trial Pit 4



Trial Pit 5



Gas and Groundwater Monitoring

Contract Number: 2230244						Gas Monitor: GA2000						
Contract Name: Blue Hills Farm						Readings Taken By: FH						
Date: 24th November 2020						Checked By: TD						
Background Readings:		Weather Conditions:				Cool, overcast, dry		O ₂ %	CO ₂ %	CH ₄ %	CO	H ₂ S
		Ground Conditions (dry / wet etc):				Damp		v/v	v/v	v/v	ppm	ppm
		Atmospheric Pressure (Start):				998mb		20.9	0.0	0.0	0.0	0.0
		Atmospheric Pressure (Finish):				998mb						
		Time (Start): 09:00 Time (Finish): 10:00										
Location	VOC ppm	O ₂ % v/v	CO ₂ % v/v	CH ₄ % v/v		CO ppm	H ₂ 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
WS02	0.0	15.1	3.4	0.0	0.0	0	0	-0.59	0.0	3.13	Dry	NA
WS03	0.0	19.6	1.2	0.0	0.0	0	0	-0.59	0.0	1.64	Dry	NA
WS06	0.0	8.8	6.0	0.0	0.0	0	0	-0.59	0.0	1.57	0.87	ND
WS10	0.0	20.5	0.7	0.0	0.0	0	0	-0.59	0.0	2.64	0.57	ND
>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit. Remarks: WS06: VOC Peak = 0.4ppm. WS10 = flow peak = 0.3l/h. Water in tube at 70 seconds, stopped monitoring.												

Gas and Groundwater Monitoring

Contract Number: 2230244						Gas Monitor: GA2000								
Contract Name: Blue Hills Farm						Readings Taken By: FH + LW								
Date: 4th January 2021						Checked By: TD								
Background Readings:						Weather Conditions:		Cold, overcast, dry		O ₂ %	CO ₂ %	CH ₄ %	CO	H ₂ S
						Ground Conditions (dry / wet etc):		Damp		v/v	v/v	v/v	ppm	ppm
						Atmospheric Pressure (Start):		1013 mb		21.0	0.0	0.0	0.0	0.0
						Atmospheric Pressure (Finish):		1013 mb						
						Time (Start): 1.00pm Time (Finish):		2.20pm						
Location	VOC ppm	O ₂ % v/v	CO ₂ % v/v	CH ₄ % v/v		CO ppm	H ₂ 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		
WS02	0.0	16.3	3.3	0.0	0.0	0	0	0.09	0.0	3.14	DRY	NA		
WS03	0.0	19.5	2.5	0.0	0.0	0	0	0.15	0.0	1.62	ND	NA		
WS06	0.0	11.5	4.2	0.0	0.0	42	0	0.09	0.0	1.57	ND	NA		
WS10	0.0	21.4	0.0	0.0	0.0	0	0	0.09	0.0	2.73	ND	NA		
>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.														
Remarks: WS10: stopped monitoring at 200s due to water in tubing Water depth not recorded due to equipment failure														

Gas and Groundwater Monitoring

Contract Number: 2230244						Gas Monitor: GA2000								
Contract Name: Blue Hills Farm						Readings Taken By: LW								
Date: 18th January 2021						Checked By: TD								
Background Readings:						Weather Conditions:		Dry, overcast, cool		O ₂ %	CO ₂ %	CH ₄ %	CO	H ₂ S
						Ground Conditions (dry / wet etc):		Wet		v/v	v/v	v/v	ppm	ppm
						Atmospheric Pressure (Start):		1006mb		21.3	0.0	0.0	0.0	0.0
						Atmospheric Pressure (Finish):		1003mb						
						Time (Start): 11:40 Time (Finish): 12:45								
Location	VOC ppm	O ₂ % v/v	CO ₂ % v/v	CH ₄ % v/v		CO ppm	H ₂ 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		
WS02	NR	17.5	2.7	0.0	0.0	0	0	-0.43	0.0	3.12	Dry	NR		
WS03	NR	21.5	0.0	0.0	0.0	0	0	-0.43	0.0	1.64	1.60	NR		
WS06	NR	6.0	4.6	0.0	0.0	0	0	-0.62	0.0	1.56	0.90	NR		
WS10	NR	21.4	0.2	0.0	0.0	0	0	-0.62	0.0	2.59	0.24	NR		
>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.														
Remarks: WS10: Stopped monitoring at 120s, water in tube.														

Gas and Groundwater Monitoring

Contract Number:		2230244				Gas Monitor:		GA2000				
Contract Name:		Blue Hills Farm				Readings Taken By:		LW				
Date:		1st February 2021				Checked By:		TD				
Background Readings:		Weather Conditions:				Cool, Clear, Breezy		O ₂ %	CO ₂ %	CH ₄ %	CO	H ₂ S
		Ground Conditions (dry / wet etc):				Frozen		v/v	v/v	v/v	ppm	ppm
		Atmospheric Pressure (Start):				984 mb		22.1	0.0	0.0	0.0	0.0
		Atmospheric Pressure (Finish):				984 mb						
		Time (Start): 9:15am		Time (Finish):		10:21am						
Location	VOC ppm	O ₂ % v/v	CO ₂ % v/v	CH ₄ % v/v		CO ppm	H ₂ 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
WS02	0.0	22.1	0.0	0.0	0.0	0	0	-0.41	0.0	3.12	ND	NA
WS03	0.0	21.6	1.7	0.0	0.0	0	0	-0.41	0.0	1.62	1.60	NA
WS06	0.0	12.4	3.9	0.0	0.0	0	0	-0.41	0.0	1.54	0.85	NA
WS10	0.0	22.4	0.0	0.0	0.0	0	0	-0.41	0.0	2.67	1.30	NA
>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.												
Remarks: WS10: Bung was removed on arrival (9:31). Bung was replaced & sampled at 10:12.												

Gas and Groundwater Monitoring

Contract Number:		2230244				Gas Monitor:		GA2000				
Contract Name:		Blue Hills Farm				Readings Taken By:		LW				
Date:		15th February 2021				Checked By:		TD				
Background Readings:		Weather Conditions:				Cool, Overcast, dry		O ₂ %	CO ₂ %	CH ₄ %	CO	H ₂ S
		Ground Conditions (dry / wet etc):				Damp		v/v	v/v	v/v	ppm	ppm
		Atmospheric Pressure (Start):				999 mb		20.8	0.0	0.0	0.0	0.0
		Atmospheric Pressure (Finish):				999 mb						
		Time (Start): 12:10am (Finish): 13:20										
Location	VOC ppm	O ₂ % v/v	CO ₂ % v/v	CH ₄ % v/v		CO ppm	H ₂ 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
WS02	0.0	19.5	2.0	0.0	0.0	0	0	-0.38	0.0	3.16	Dry	NA
WS03	0.0	20.0	3.7	0.0	0.0	0	0	-0.36	0.0	1.66	1.65	NA
WS06	0.0	13.4	3.7	0.0	0.0	0	0	-0.38	0.0	1.58	0.90	NA
WS10	0.0	20.8	0.0	0.0	0.0	0	0	-0.38	0.0	2.67	0.30	NA
>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.												
Remarks: WS10: Water in tube at 100 seconds, monitoring stopped.												

Gas and Groundwater Monitoring

Contract Number: 2230244						Gas Monitor: GA5000						
Contract Name: Blue Hills Farm						Readings Taken By: LW						
Date: 1st March 2021						Checked By: TD						
Background Readings:		Weather Conditions:				Grey, cloud, drizzle		O ₂ %	CO ₂ %	CH ₄ %	CO	H ₂ S
		Ground Conditions (dry / wet etc):				Wet		v/v	v/v	v/v	ppm	ppm
		Atmospheric Pressure (Start):				1014mb		21.2	0.2	0.0	0.0	0.0
		Atmospheric Pressure (Finish):				1013mb						
		Time (Start):12:30pm (Finish): 13:50pm										
Location	VOC ppm	O ₂ % v/v	CO ₂ % v/v	CH ₄ % v/v		CO ppm	H ₂ 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
WS02	0.0	16.5	3.6	0.0	0.0	0	0	-0.02	0.0	3.14	3.12	ND
WS03	0.0	19.2	2.6	0.0	0.0	0	0	0.00	0.0	1.65	Dry	ND
WS06	0.0	13.4	6.1	0.0	0.0	0	0	-0.02	0.0	1.58	1.24	ND
WS10	0.0	19.6	2.0	0.0	0.0	0	0	0.00	0.0	2.64	Dry	ND
>>>> = Flow above detection limit of 30 l/hr, <<< = Negative flow greater than -10 l/hr. >Max = In excess of lower explosive limit.												
Remarks: Bung was not found at WS10. New one fitted at 12:40.												

APPENDIX 3
GEOTECHNICAL TEST RESULTS

F.A.O.

Final Test Report - 2230244 / 1

Site: Blue Hills Farm
Job Number: 2230244
Originating Client: Mr C. Ives
Originating Reference: 2230244
Date Sampled: 09/11/2020
Date Scheduled: 23/11/2020
Date Testing Started: 23/11/2020
Date Testing Finished: 04/12/2020

Previous Reports		Amendments	Date Issued

Amendments:

Authorised By:



Tim Robinson
Quality Supervisor

Report Issue Date: 04/12/2020

Page: 2

Results reported relate only to the samples tested.

Site: Blue Hills Farm

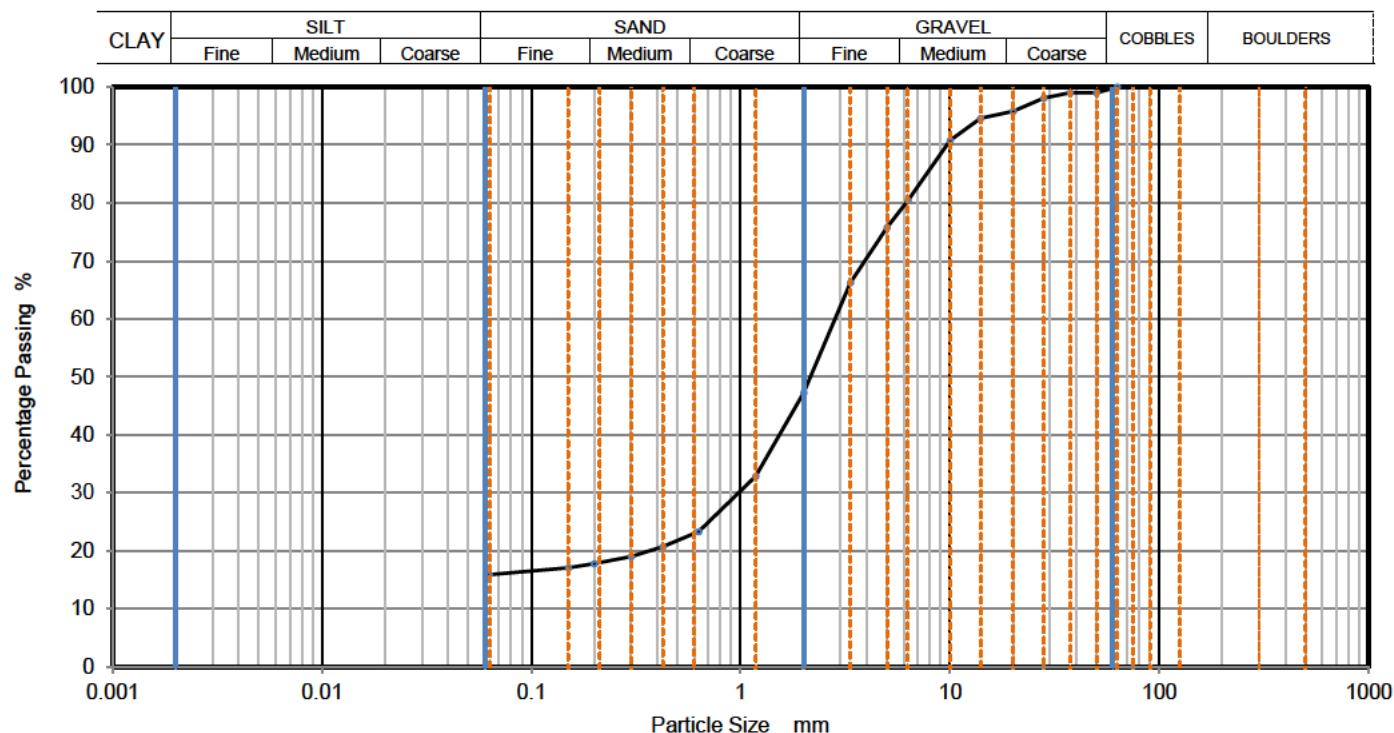
Job Number: 2230244

Client: Mr C. Ives

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DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
RO 03	0.50	B5	Wet Sieve	Grey silty, sandy GRAVEL (Siltstone)



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
63	100		
50	99		
37.5	99		
28	98		
20	96		
14	95		
10	91		
6.3	81		
5	76		
3.35	66		
2	47		
1.18	33		
0.63	23		
0.425	21		
0.3	19		
0.2	18		
0.15	17		
0.063	16		

Dry Mass of sample, g
4807

Sample Proportions	% dry mass
Very coarse	0
Gravel	53
Sand	31
Fines <0.063mm	16

Grading Analysis		
D100	mm	63
D60	mm	2.82
D30	mm	0.977
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

Preparation and testing in accordance with BS17892 unless noted below

Method of Preparation: BS EN 17892:Part4:2016, clause 5.2.2 Preparation of samples for wet sieving test

Method of Test: BS EN 17892:Part4:2016, clause 5.2.3 Determination of particle size distribution by wet sieving method

Site: Blue Hills Farm

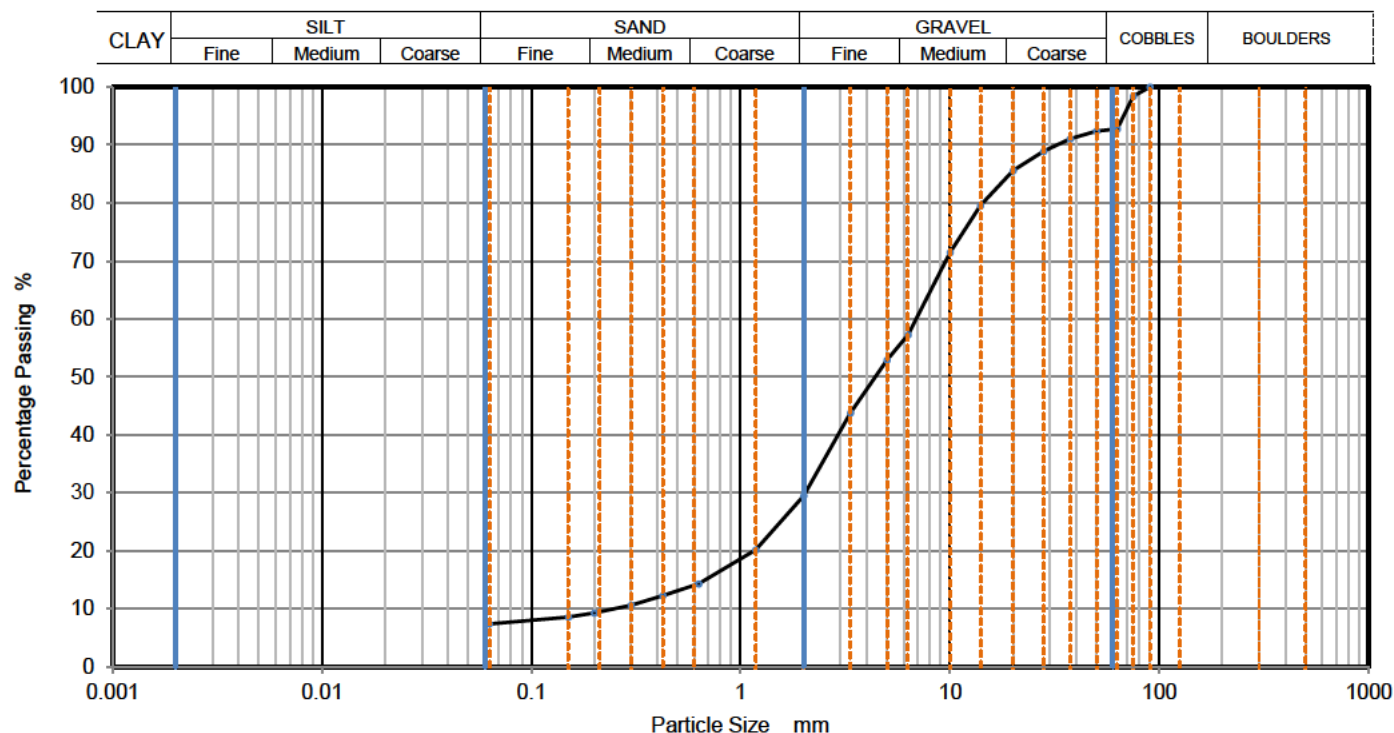
Job Number: 2230244

Client: Mr C. Ives

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DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
TP 05	0.70	B7	Wet Sieve	Grey slightly silty, sandy GRAVEL



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
90	100		
75	98		
63	93		
50	92		
37.5	91		
28	89		
20	86		
14	80		
10	72		
6.3	57		
5	53		
3.35	44		
2	30		
1.18	20		
0.63	14		
0.425	12		
0.3	11		
0.2	9		
0.15	9		
0.063	7		

Dry Mass of sample, g
11527

Sample Proportions	% dry mass
Very coarse	7
Gravel	63
Sand	22
Fines <0.063mm	7

Grading Analysis		
D100	mm	90
D60	mm	6.87
D30	mm	2.03
D10	mm	0.248
Uniformity Coefficient		28
Curvature Coefficient		2.4

Remarks

Preparation and testing in accordance with BS17892 unless noted below

Method of Preparation: BS EN 17892:Part4:2016, clause 5.2.2 Preparation of samples for wet sieving test

Method of Test: BS EN 17892:Part4:2016, clause 5.2.3 Determination of particle size distribution by wet sieving method

Site: Blue Hills Farm

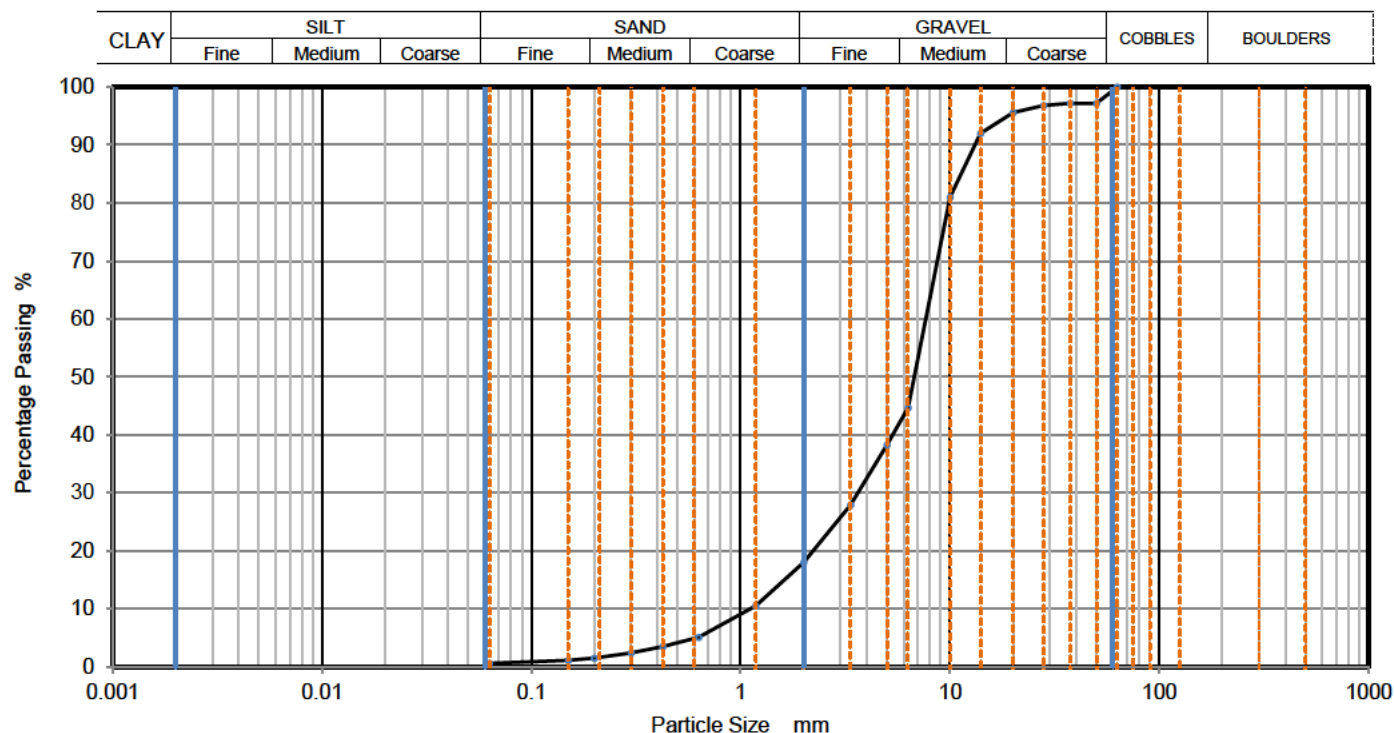
Job Number: 2230244

Client: Mr C. Ives

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DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
WS 01	0.30	B3	Wet Sieve	Grey/Black sandy GRAVEL



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
63	100		
50	97		
37.5	97		
28	97		
20	96		
14	92		
10	81		
6.3	45		
5	38		
3.35	28		
2	18		
1.18	11		
0.63	5		
0.425	4		
0.3	2		
0.2	2		
0.15	1		
0.063	1		

Dry Mass of sample, g
3795

Sample Proportions	% dry mass
Very coarse	0
Gravel	82
Sand	17
Fines <0.063mm	1

Grading Analysis		
D100	mm	63
D60	mm	7.65
D30	mm	3.63
D10	mm	1.12
Uniformity Coefficient		6.8
Curvature Coefficient		1.5

Remarks

Preparation and testing in accordance with BS17892 unless noted below

Method of Preparation: BS EN 17892:Part4:2016, clause 5.2.2 Preparation of samples for wet sieving test

Method of Test: BS EN 17892:Part4:2016, clause 5.2.3 Determination of particle size distribution by wet sieving method

Site: Blue Hills Farm

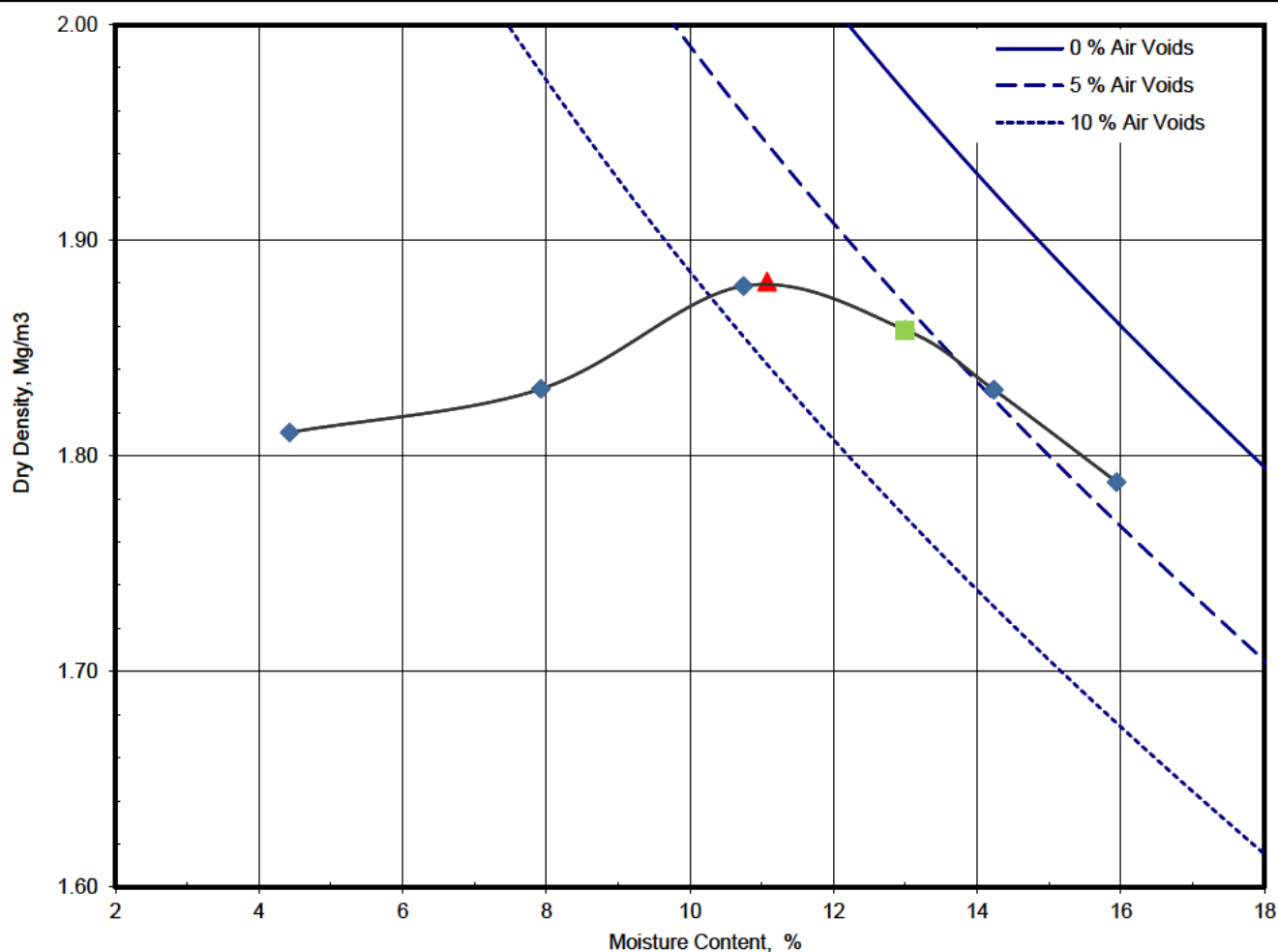
Job Number: 2230244

Client: Mr C. Ives

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DETERMINATION OF DRY DENSITY/MOISTURE CONTENT RELATIONSHIP

Borehole / Trial Pit	Depth (m)	Sample	Description
RO 02	0.60	B5	Grey silty GRAVEL
Percentage Retained 37.5mm		0 %	
Percentage Retained 20.0mm		48 %	
Grading Zone		X	Particle Density 2.65 Mg/m ³ Assumed
Mould Type		CBR	Method of compaction Compaction using 2.5kg rammer
Maximum Dry Density		1.88 Mg/m ³	Optimum Moisture Content 11 %



▲ : Maximum Dry Density vs. Optimum Water Content
 ■ : Point at Natural Moisture Content

Remarks:

Method of Preparation: BS 1377:PART 1:1990:7.6 Preparation of samples for compaction related test
 BS 1377:PART 4:1990:3.2 Preparation of samples for compaction tests

Preparation Details: Material used was oven dried at 50°C. Single sample tested

Method of Test: BS1377:Part 4:1990, clause 3.4, 2.5kg rammer



Result reported relates only to the sample tested.



Site: Blue Hills Farm

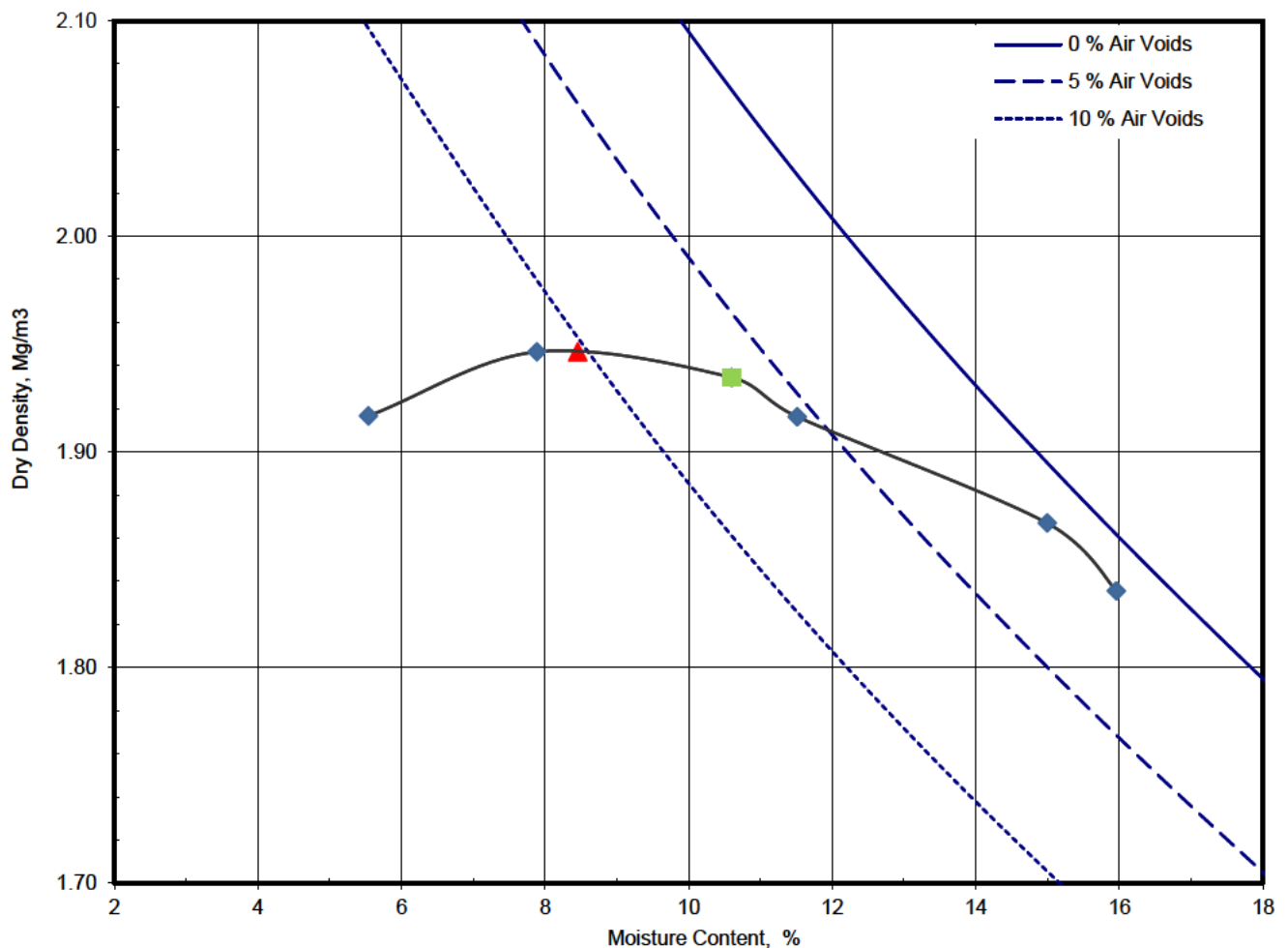
Job Number: 2230244

Client: Mr C. Ives

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DETERMINATION OF DRY DENSITY/MOISTURE CONTENT RELATIONSHIP

Borehole / Trial Pit	Depth (m)	Sample	Description
TP 01	0.30	B4	Grey SILTSTONE
Percentage Retained 37.5mm		0 %	
Percentage Retained 20.0mm		48 %	Samples Used Single sample tested
Grading Zone		X	Particle Density 2.65 Mg/m ³ Assumed
Mould Type		CBR	Method of compaction Compaction using 2.5kg rammer
Maximum Dry Density		1.95 Mg/m ³	Optimum Moisture Content 8.5 %



▲ : Maximum Dry Density vs. Optimum Water Content
■ : Point at Natural Moisture Content

Remarks:

Method of Preparation: BS 1377:PART 1:1990:7.6 Preparation of samples for compaction related test
BS 1377:PART 4:1990:3.2 Preparation of samples for compaction tests

Preparation Details: Material used was oven dried at 50°C. Single sample tested

Method of Test: BS1377:Part 4:1990, clause 3.4, 2.5kg rammer



Result reported relates only to the sample tested.



Final Test Report - 2230244 / 1

Site: Blue Hills Farm

Job Number: 2230244

Originating Client: Mr C. Ives

All opinions and interpretations contained within this report are outside of our Scope of Accreditation.

This test report shall not be reproduced, except in full and only with the written permission of Ian Farmer Associates Ltd.

Samples will be retained for 28 days from date of issue of the final test report before being disposed of, unless we receive written instruction to the contrary.

Report Issue Date: 04/12/2020

APPENDIX 4
CHEMICAL TEST RESULTS

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 20/09718
Issue Number: 1

Date: 26 November, 2020

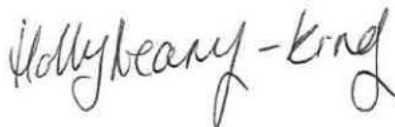
Client: Ian Farmer Associates (Warrington)
14/15 Rufford Court
Hardwick Grange
Warrington
WA1 4RF

Project Manager: Tim Downes
Project Name: Blue Hills Farm
Project Ref: 2230244
Order No: P7524644
Date Samples Received: 10/11/20
Date Instructions Received: 13/11/20
Date Analysis Completed: 26/11/20

Prepared by:


Melanie Marshall
Laboratory Coordinator

Approved by:


Holly Neary-King
Client Services Supervisor

Envirolab Job Number: 20/09718

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09718/2	20/09718/4	20/09718/7	20/09718/9	20/09718/11	20/09718/15	20/09718/18	Units	Limit of Detection	Method ref
Client Sample No	3	3	3	3	3	3	3			
Client Sample ID	RO 01	RO 02	RO 03	RO 04	TP 01	TP 04	TP 05			
Depth to Top	0.40	0.50	0.30	0.50	0.30	0.40	0.30			
Depth To Bottom										
Date Sampled	04-Nov-20	06-Nov-20	05-Nov-20	09-Nov-20	09-Nov-20	09-Nov-20	09-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES			
Sample Matrix Code	5A	6A	6A	5A	3	6AE	6E			
% Stones >10mm _A	<0.1	22.8	12.6	<0.1	<0.1	6.7	<0.1	% w/w	0.1	A T 044
pH _D ^{M#}	-	-	-	-	8.07	7.14	7.12	pH	0.01	A T 031s
pH BRE _D ^{M#}	7.32	7.17	7.14	7.23	-	-	-	pH	0.01	A T 031s
Sulphate BRE (water sol 2 1) _D ^{M#}	<10	10	<10	11	-	-	-	mg/l	10	A T 026s
Sulphate BRE (acid sol) _D ^{M#}	<0.02	<0.02	<0.02	<0.02	-	-	-	% w/w	0.02	A T 028s
Sulphur BRE (total) _D	<0.01	0.02	0.03	<0.01	-	-	-	% w/w	0.01	A T 024s
Cyanide (total) _A ^{M#}	-	-	-	-	<1	<1	<1	mg/kg	1	A T 042sTCN
Phenols - Total by HPLC _A	-	-	-	-	<0.2	<0.2	<0.2	mg/kg	0.2	A T 050s
Organic matter _D ^{M#}	-	-	-	-	2.5	4.7	5.3	% w/w	0.1	A T 032 OM
Arsenic _D ^{M#}	-	-	-	-	2	7	15	mg/kg	1	A T 024s
Boron (water soluble) _D	-	-	-	-	<1.0	<1.0	1.1	mg/kg	1	A T 027s
Cadmium _D ^{M#}	-	-	-	-	0.5	<0.5	0.6	mg/kg	0.5	A T 024s
Copper _D ^{M#}	-	-	-	-	61	39	30	mg/kg	1	A T 024s
Chromium _D ^{M#}	-	-	-	-	24	21	22	mg/kg	1	A T 024s
Chromium (hexavalent) _D	-	-	-	-	<1	<1	<1	mg/kg	1	A T 040s
Lead _D ^{M#}	-	-	-	-	27	24	37	mg/kg	1	A T 024s
Mercury _D	-	-	-	-	<0.17	<0.17	<0.17	mg/kg	0.17	A T 024s
Nickel _D ^{M#}	-	-	-	-	50	32	21	mg/kg	1	A T 024s
Selenium _D ^{M#}	-	-	-	-	1	<1	2	mg/kg	1	A T 024s
Vanadium _D ^{M#}	-	-	-	-	20	20	36	mg/kg	1	A T 024s
Zinc _D ^{M#}	-	-	-	-	128	78	71	mg/kg	5	A T 024s

Envirolab Job Number: 20/09718

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09718/2	20/09718/4	20/09718/7	20/09718/9	20/09718/11	20/09718/15	20/09718/18	Units	Limit of Detection	Method ref
Client Sample No	3	3	3	3	3	3	3			
Client Sample ID	RO 01	RO 02	RO 03	RO 04	TP 01	TP 04	TP 05			
Depth to Top	0.40	0.50	0.30	0.50	0.30	0.40	0.30			
Depth To Bottom										
Date Sampled	04-Nov-20	06-Nov-20	05-Nov-20	09-Nov-20	09-Nov-20	09-Nov-20	09-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES			
Sample Matrix Code	5A	6A	6A	5A	3	6AE	6E			
Asbestos in Soil (inc. matrix)										
Asbestos in soil [#]	-	-	-	-	NAD	NAD	-			A T 045
Asbestos ACM - Suitable for Water Absorption Test? _D	-	-	-	-	N/A	N/A	-			A T 045

Envirolab Job Number: 20/09718

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09718/2	20/09718/4	20/09718/7	20/09718/9	20/09718/11	20/09718/15	20/09718/18	Units	Limit of Detection	Method ref
Client Sample No	3	3	3	3	3	3	3			
Client Sample ID	RO 01	RO 02	RO 03	RO 04	TP 01	TP 04	TP 05			
Depth to Top	0.40	0.50	0.30	0.50	0.30	0.40	0.30			
Depth To Bottom										
Date Sampled	04-Nov-20	06-Nov-20	05-Nov-20	09-Nov-20	09-Nov-20	09-Nov-20	09-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES			
Sample Matrix Code	5A	6A	6A	5A	3	6AE	6E			
PAH-16MS										
Acenaphthene _A ^{M#}	-	-	-	-	<0.01	<0.01	0.04	mg/kg	0.01	A T 019s
Acenaphthylene _A ^{M#}	-	-	-	-	<0.01	<0.01	<0.01	mg/kg	0.01	A T 019s
Anthracene _A ^{M#}	-	-	-	-	<0.02	<0.02	0.04	mg/kg	0.02	A T 019s
Benzo(a)anthracene _A ^{M#}	-	-	-	-	<0.04	<0.04	0.12	mg/kg	0.04	A T 019s
Benzo(a)pyrene _A ^{M#}	-	-	-	-	<0.04	<0.04	0.10	mg/kg	0.04	A T 019s
Benzo(b)fluoranthene _A ^{M#}	-	-	-	-	<0.05	<0.05	0.14	mg/kg	0.05	A T 019s
Benzo(ghi)perylene _A ^{M#}	-	-	-	-	<0.05	<0.05	<0.05	mg/kg	0.05	A T 019s
Benzo(k)fluoranthene _A ^{M#}	-	-	-	-	<0.07	<0.07	<0.07	mg/kg	0.07	A T 019s
Chrysene _A ^{M#}	-	-	-	-	<0.06	<0.06	0.15	mg/kg	0.06	A T 019s
Dibenzo(ah)anthracene _A ^{M#}	-	-	-	-	<0.04	<0.04	<0.04	mg/kg	0.04	A T 019s
Fluoranthene _A ^{M#}	-	-	-	-	<0.08	<0.08	0.24	mg/kg	0.08	A T 019s
Fluorene _A ^{M#}	-	-	-	-	<0.01	<0.01	0.03	mg/kg	0.01	A T 019s
Indeno(123-cd)pyrene _A ^{M#}	-	-	-	-	<0.03	<0.03	0.06	mg/kg	0.03	A T 019s
Naphthalene _A ^{M#}	-	-	-	-	<0.03	<0.03	<0.03	mg/kg	0.03	A T 019s
Phenanthrene _A ^{M#}	-	-	-	-	0.03	0.10	0.21	mg/kg	0.03	A T 019s
Pyrene _A ^{M#}	-	-	-	-	<0.07	<0.07	0.21	mg/kg	0.07	A T 019s
Total PAH-16MS _A ^{M#}	-	-	-	-	<0.08	0.10	1.34	mg/kg	0.01	A T 019s

Envirolab Job Number: 20/09718

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09718/23	20/09718/28						Units	Limit of Detection	Method ref
Client Sample No	3	5								
Client Sample ID	TP 02	TP 03								
Depth to Top	0.30	0.70								
Depth To Bottom										
Date Sampled	09-Nov-20	09-Nov-20								
Sample Type	Soil - ES	Soil - ES								
Sample Matrix Code	6	6								
% Stones >10mm _A	<0.1	<0.1						% w/w	0.1	A T 044
pH _D ^{M#}	6.22	6.88						pH	0.01	A T 031s
Cyanide (total) _A ^{M#}	<1	<1						mg/kg	1	A T 042sTCN
Phenols - Total by HPLC _A	<0.2	<0.2						mg/kg	0.2	A T 050s
Organic matter _D ^{M#}	30.0	1.7						% w/w	0.1	A T 032 OM
Arsenic _D ^{M#}	24	3						mg/kg	1	A T 024s
Boron (water soluble) _D	<1.0	<1.0						mg/kg	1	A T 027s
Cadmium _D ^{M#}	<0.5	0.5						mg/kg	0.5	A T 024s
Copper _D ^{M#}	45	27						mg/kg	1	A T 024s
Chromium _D ^{M#}	25	21						mg/kg	1	A T 024s
Chromium (hexavalent) _D	<1	<1						mg/kg	1	A T 040s
Lead _D ^{M#}	34	18						mg/kg	1	A T 024s
Mercury _D	<0.17	<0.17						mg/kg	0.17	A T 024s
Nickel _D ^{M#}	42	34						mg/kg	1	A T 024s
Selenium _D ^{M#}	1	<1						mg/kg	1	A T 024s
Vanadium _D ^{M#}	43	22						mg/kg	1	A T 024s
Zinc _D ^{M#}	108	103						mg/kg	5	A T 024s

Envirolab Job Number: 20/09718

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09718/23	20/09718/28						Units	Limit of Detection	Method ref
Client Sample No	3	5								
Client Sample ID	TP 02	TP 03								
Depth to Top	0.30	0.70								
Depth To Bottom										
Date Sampled	09-Nov-20	09-Nov-20								
Sample Type	Soil - ES	Soil - ES								
Sample Matrix Code	6	6								
PAH-16MS										
Acenaphthene _A ^{M#}	<0.01	<0.01						mg/kg	0.01	A T 019s
Acenaphthylene _A ^{M#}	<0.01	<0.01						mg/kg	0.01	A T 019s
Anthracene _A ^{M#}	<0.02	<0.02						mg/kg	0.02	A T 019s
Benzo(a)anthracene _A ^{M#}	<0.04	<0.04						mg/kg	0.04	A T 019s
Benzo(a)pyrene _A ^{M#}	<0.04	<0.04						mg/kg	0.04	A T 019s
Benzo(b)fluoranthene _A ^{M#}	<0.05	<0.05						mg/kg	0.05	A T 019s
Benzo(ghi)perylene _A ^{M#}	<0.05	<0.05						mg/kg	0.05	A T 019s
Benzo(k)fluoranthene _A ^{M#}	<0.07	<0.07						mg/kg	0.07	A T 019s
Chrysene _A ^{M#}	<0.06	<0.06						mg/kg	0.06	A T 019s
Dibenzo(ah)anthracene _A ^{M#}	<0.04	<0.04						mg/kg	0.04	A T 019s
Fluoranthene _A ^{M#}	<0.08	<0.08						mg/kg	0.08	A T 019s
Fluorene _A ^{M#}	<0.01	<0.01						mg/kg	0.01	A T 019s
Indeno(123-cd)pyrene _A ^{M#}	<0.03	<0.03						mg/kg	0.03	A T 019s
Naphthalene _A ^{M#}	<0.03	<0.03						mg/kg	0.03	A T 019s
Phenanthrene _A ^{M#}	0.14	<0.03						mg/kg	0.03	A T 019s
Pyrene _A ^{M#}	<0.07	<0.07						mg/kg	0.07	A T 019s
Total PAH-16MS _A ^{M#}	0.14	<0.08						mg/kg	0.01	A T 019s

REPORT NOTES

General

This report shall not be reproduced, except in full, without written approval from Envirolab.

The results reported herein relate only to the material supplied to the laboratory.

The residue of any samples contained within this report, and any received with the same delivery, will be disposed of six weeks after initial scheduling. For samples tested for Asbestos we will retain a portion of the dried sample for a minimum of six months after the initial Asbestos testing is completed.

Analytical results reflect the quality of the sample at the time of analysis only.

Opinions and interpretations expressed are outside the scope of our accreditation.

If results are in italic font they are associated with an AQC failure, these are not accredited and are unreliable.

A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

The Client Sample No, Client Sample ID, Depth to Top, Depth to Bottom and Date Sampled were all provided by the client.

Soil chemical analysis:

All results are reported as dry weight (<40°C).

For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.

For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any "A" subscripts.

All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

TPH analysis of water by method A-T-007:

Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

Electrical Conductivity of water by Method A-T-037:

Results greater than 12900µS/cm @ 25°C / 11550µS/cm @ 20°C fall outside the calibration range and as such are unaccredited.

Asbestos:

Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.

Stones etc. are not removed from the sample prior to analysis.

Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

Predominant Matrix Codes:

1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample.

Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.

Secondary Matrix Codes:

A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal,

E = contains roots/twigs.

Key:

IS indicates Insufficient Sample for analysis.

US indicates Unsuitable Sample for analysis.

NDP indicates No Determination Possible.

NAD indicates No Asbestos Detected.

N/A indicates Not Applicable.

Superscript # indicates method accredited to ISO 17025.

Superscript "M" indicates method accredited to MCERTS.

Subscript "A" indicates analysis performed on the sample as received.

Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve.

Please contact us if you need any further information.

Envirolab Deviating Samples Report

Units 7&8 Sandpits Business Park, Mottram Road, Hyde, SK14 3AR
Tel. 0161 368 4921 email. ask@envlab.co.uk

Client:	Ian Farmer Associates (Warrington), 14/15 Rufford Court, Hardwick Grange, Warrington, WA1 4RF	Project No:	20/09718
Project:	Blue Hills Farm	Date Received:	13/11/2020 (am)
Clients Project No:	2230244	Cool Box Temperatures (°C):	13.3 - 16.4

NO DEVIATIONS IDENTIFIED

If, at any point before reaching the laboratory, the temperature of the samples has breached those set in published standards, e.g. BS-EN 5667-3, ISO 18400-102:2017, then the concentration of any affected analytes may differ from that at the time of sampling.

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 20/09917
Issue Number: 1

Date: 27 November, 2020

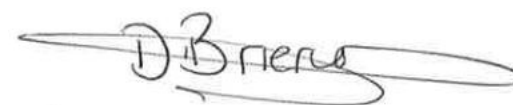
Client: Ian Farmer Associates (Warrington)
14/15 Rufford Court
Hardwick Grange
Warrington
WA1 4RF

Project Manager: Tim Downes
Project Name: Blue Hills Farm
Project Ref: 2230244
Order No: P7524674
Date Samples Received: 16/11/20
Date Instructions Received: 19/11/20
Date Analysis Completed: 27/11/20

Prepared by:


Melanie Marshall
Laboratory Coordinator

Approved by:


Danielle Brierley
Client Manager

Envirolab Job Number: 20/09917

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09917/2	20/09917/5	20/09917/6	20/09917/7	20/09917/10	20/09917/11	20/09917/14	Units	Limit of Detection	Method ref
Client Sample No	3	3	1	4	3	5	3			
Client Sample ID	RO 05	RO 06	WS 01	WS 01	WS 02	WS 02	WS 03			
Depth to Top	0.4	0.4	0.00	0.70	0.40	0.90	0.40			
Depth To Bottom	0.6	0.6	0.10	0.80	0.60	1.10	0.50			
Date Sampled	13-Nov-20	12-Nov-20	11-Nov-20	11-Nov-20	12-Nov-20	12-Nov-20	12-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Solid	Solid			
Sample Matrix Code	6A	6AE	4A	2AB	5AB	7	7			
% Stones >10mm _A	1.9	27.0	5.2	38.0	30.7	<0.1	<0.1	% w/w	0.1	A T 044
pH _D ^{M#}	-	-	9.74	8.53	7.90	7.99	7.38	pH	0.01	A T 031s
pH BRE _D ^{M#}	7.42	7.44	-	-	-	-	-	pH	0.01	A T 031s
Sulphate BRE (water sol 2 1) _D ^{M#}	<10	<10	-	-	-	-	-	mg/l	10	A T 026s
Sulphate BRE (acid sol) _D ^{M#}	0.04	<0.02	-	-	-	-	-	% w/w	0.02	A T 028s
Sulphur BRE (total) _D	0.02	0.01	-	-	-	-	-	% w/w	0.01	A T 024s
Cyanide (total) _A ^{M#}	-	-	<1	<1	<1	<1	<1	mg/kg	1	A T 042sTCN
Phenols - Total by HPLC _A	-	-	<0.2	<0.2	<0.2	<0.2	<0.2	mg/kg	0.2	A T 050s
Organic matter _D ^{M#}	-	-	5.9	3.5	0.8	1.8	3.8	% w/w	0.1	A T 032 OM
Arsenic _D ^{M#}	-	-	2	16	3	32	6	mg/kg	1	A T 024s
Boron (water soluble) _D	-	-	<1.0	1.5	<1.0	<1.0	<1.0	mg/kg	1	A T 027s
Cadmium _D ^{M#}	-	-	1.1	1.2	1.0	1.6	2.4	mg/kg	0.5	A T 024s
Copper _D ^{M#}	-	-	17	25	12	30	30	mg/kg	1	A T 024s
Chromium _D ^{M#}	-	-	135	120	17	27	25	mg/kg	1	A T 024s
Chromium (hexavalent) _D	-	-	<1	<1	<1	<1	<1	mg/kg	1	A T 040s
Lead _D ^{M#}	-	-	36	29	10	25	23	mg/kg	1	A T 024s
Mercury _D	-	-	0.25	<0.17	<0.17	<0.17	<0.17	mg/kg	0.17	A T 024s
Nickel _D ^{M#}	-	-	21	18	23	45	67	mg/kg	1	A T 024s
Selenium _D ^{M#}	-	-	<1	1	<1	<1	<1	mg/kg	1	A T 024s
Vanadium _D ^{M#}	-	-	66	34	16	26	29	mg/kg	1	A T 024s
Zinc _D ^{M#}	-	-	64	60	53	114	169	mg/kg	5	A T 024s

Envirolab Job Number: 20/09917

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09917/2	20/09917/5	20/09917/6	20/09917/7	20/09917/10	20/09917/11	20/09917/14	Units	Limit of Detection	Method ref
Client Sample No	3	3	1	4	3	5	3			
Client Sample ID	RO 05	RO 06	WS 01	WS 01	WS 02	WS 02	WS 03			
Depth to Top	0.4	0.4	0.00	0.70	0.40	0.90	0.40			
Depth To Bottom	0.6	0.6	0.10	0.80	0.60	1.10	0.50			
Date Sampled	13-Nov-20	12-Nov-20	11-Nov-20	11-Nov-20	12-Nov-20	12-Nov-20	12-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Solid	Solid			
Sample Matrix Code	6A	6AE	4A	2AB	5AB	7	7			
Asbestos in Soil (inc. matrix)										
Asbestos in soil [#]	-	-	NAD	-	NAD	-	-			A T 045
Asbestos ACM - Suitable for Water Absorption Test? _D	-	-	N/A	-	N/A	-	-			A T 045

Envirolab Job Number: 20/09917

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09917/2	20/09917/5	20/09917/6	20/09917/7	20/09917/10	20/09917/11	20/09917/14	Units	Limit of Detection	Method ref
Client Sample No	3	3	1	4	3	5	3			
Client Sample ID	RO 05	RO 06	WS 01	WS 01	WS 02	WS 02	WS 03			
Depth to Top	0.4	0.4	0.00	0.70	0.40	0.90	0.40			
Depth To Bottom	0.6	0.6	0.10	0.80	0.60	1.10	0.50			
Date Sampled	13-Nov-20	12-Nov-20	11-Nov-20	11-Nov-20	12-Nov-20	12-Nov-20	12-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Solid	Solid			
Sample Matrix Code	6A	6AE	4A	2AB	5AB	7	7			
PAH-16MS										
Acenaphthene _A ^{M#}	-	-	1.21	2.56	0.11	<0.01	<0.01	mg/kg	0.01	A T 019s
Acenaphthylene _A ^{M#}	-	-	0.27	0.14	<0.01	<0.01	<0.01	mg/kg	0.01	A T 019s
Anthracene _A ^{M#}	-	-	4.23	3.99	0.10	<0.02	<0.02	mg/kg	0.02	A T 019s
Benzo(a)anthracene _A ^{M#}	-	-	6.21	7.55	0.15	<0.04	<0.04	mg/kg	0.04	A T 019s
Benzo(a)pyrene _A ^{M#}	-	-	4.36	6.32	0.10	<0.04	<0.04	mg/kg	0.04	A T 019s
Benzo(b)fluoranthene _A ^{M#}	-	-	5.38	7.76	0.14	<0.05	<0.05	mg/kg	0.05	A T 019s
Benzo(ghi)perylene _A ^{M#}	-	-	1.53	2.69	<0.05	<0.05	<0.05	mg/kg	0.05	A T 019s
Benzo(k)fluoranthene _A ^{M#}	-	-	2.27	3.10	<0.07	<0.07	<0.07	mg/kg	0.07	A T 019s
Chrysene _A ^{M#}	-	-	5.04	7.34	0.15	<0.06	<0.06	mg/kg	0.06	A T 019s
Dibenzo(ah)anthracene _A ^{M#}	-	-	0.33	0.52	<0.04	<0.04	<0.04	mg/kg	0.04	A T 019s
Fluoranthene _A ^{M#}	-	-	17.6	16.3	0.45	<0.08	<0.08	mg/kg	0.08	A T 019s
Fluorene _A ^{M#}	-	-	2.34	1.65	0.09	<0.01	<0.01	mg/kg	0.01	A T 019s
Indeno(123-cd)pyrene _A ^{M#}	-	-	2.18	3.51	0.04	<0.03	<0.03	mg/kg	0.03	A T 019s
Naphthalene _A ^{M#}	-	-	0.25	<0.30	0.10	<0.03	0.06	mg/kg	0.03	A T 019s
Phenanthrene _A ^{M#}	-	-	16.6	14.7	0.55	0.08	0.10	mg/kg	0.03	A T 019s
Pyrene _A ^{M#}	-	-	14	14.8	0.34	<0.07	<0.07	mg/kg	0.07	A T 019s
Total PAH-16MS _A ^{M#}	-	-	83.8	92.9	2.32	0.08	0.16	mg/kg	0.01	A T 019s

Envirolab Job Number: 20/09917

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09917/17	20/09917/18	20/09917/20	20/09917/21	20/09917/23	20/09917/25	20/09917/27	Units	Limit of Detection	Method ref
Client Sample No	4	6	3	5	3	1	1			
Client Sample ID	WS 04	WS 04	WS 05	WS 05	WS 06	WS 07	WS 08			
Depth to Top	0.30	0.50	0.30	0.50	0.30	0.10	0.10			
Depth To Bottom	0.50	0.70	0.40	0.70	0.50	0.30	0.30			
Date Sampled	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	12-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Solid	Soil - ES	Soil - ES			
Sample Matrix Code	5A	5A	5AE	5A	7	5AE	6AE			
% Stones >10mm _A	1.0	<0.1	<0.1	<0.1	<0.1	5.7	<0.1	% w/w	0.1	A T 044
pH _D ^{M#}	7.37	7.00	7.19	-	7.75	-	7.24	pH	0.01	A T 031s
pH BRE _D ^{M#}	-	-	-	6.98	-	7.50	-	pH	0.01	A T 031s
Sulphate BRE (water sol 2 1) _D ^{M#}	-	-	-	56	-	<10	-	mg/l	10	A T 026s
Sulphate BRE (acid sol) _D ^{M#}	-	-	-	0.02	-	0.05	-	% w/w	0.02	A T 028s
Sulphur BRE (total) _D	-	-	-	0.01	-	0.04	-	% w/w	0.01	A T 024s
Cyanide (total) _A ^{M#}	<1	<1	<1	-	<1	-	<1	mg/kg	1	A T 042sTCN
Phenols - Total by HPLC _A	<0.2	<0.2	<0.2	-	<0.2	-	<0.2	mg/kg	0.2	A T 050s
Organic matter _D ^{M#}	4.5	0.8	3.0	-	1.1	-	15.7	% w/w	0.1	A T 032 OM
Arsenic _D ^{M#}	12	<1	10	-	<1	-	18	mg/kg	1	A T 024s
Boron (water soluble) _D	<1.0	<1.0	1.0	-	<1.0	-	1.1	mg/kg	1	A T 027s
Cadmium _D ^{M#}	2.5	1.8	2.6	-	1.0	-	2.4	mg/kg	0.5	A T 024s
Copper _D ^{M#}	11	12	7	-	29	-	19	mg/kg	1	A T 024s
Chromium _D ^{M#}	29	28	24	-	22	-	26	mg/kg	1	A T 024s
Chromium (hexavalent) _D	<1	<1	<1	-	<1	-	<1	mg/kg	1	A T 040s
Lead _D ^{M#}	42	12	34	-	23	-	46	mg/kg	1	A T 024s
Mercury _D	<0.17	<0.17	<0.17	-	<0.17	-	<0.17	mg/kg	0.17	A T 024s
Nickel _D ^{M#}	23	29	30	-	44	-	23	mg/kg	1	A T 024s
Selenium _D ^{M#}	3	<1	2	-	<1	-	2	mg/kg	1	A T 024s
Vanadium _D ^{M#}	40	28	32	-	16	-	43	mg/kg	1	A T 024s
Zinc _D ^{M#}	99	61	107	-	102	-	84	mg/kg	5	A T 024s

Envirolab Job Number: 20/09917

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09917/17	20/09917/18	20/09917/20	20/09917/21	20/09917/23	20/09917/25	20/09917/27	Units	Limit of Detection	Method ref
Client Sample No	4	6	3	5	3	1	1			
Client Sample ID	WS 04	WS 04	WS 05	WS 05	WS 06	WS 07	WS 08			
Depth to Top	0.30	0.50	0.30	0.50	0.30	0.10	0.10			
Depth To Bottom	0.50	0.70	0.40	0.70	0.50	0.30	0.30			
Date Sampled	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	12-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Solid	Soil - ES	Soil - ES			
Sample Matrix Code	5A	5A	5AE	5A	7	5AE	6AE			
Asbestos in Soil (inc. matrix)										
Asbestos in soil [#]	NAD	NAD	-	-	-	-	-			A T 045
Asbestos ACM - Suitable for Water Absorption Test? _D	N/A	N/A	-	-	-	-	-			A T 045

Envirolab Job Number: 20/09917

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09917/17	20/09917/18	20/09917/20	20/09917/21	20/09917/23	20/09917/25	20/09917/27	Units	Limit of Detection	Method ref
Client Sample No	4	6	3	5	3	1	1			
Client Sample ID	WS 04	WS 04	WS 05	WS 05	WS 06	WS 07	WS 08			
Depth to Top	0.30	0.50	0.30	0.50	0.30	0.10	0.10			
Depth To Bottom	0.50	0.70	0.40	0.70	0.50	0.30	0.30			
Date Sampled	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	11-Nov-20	12-Nov-20			
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Solid	Soil - ES	Soil - ES			
Sample Matrix Code	5A	5A	5AE	5A	7	5AE	6AE			
PAH-16MS										
Acenaphthene _A ^{M#}	<0.01	<0.01	<0.01	-	<0.01	-	0.01	mg/kg	0.01	A T 019s
Acenaphthylene _A ^{M#}	<0.01	<0.01	<0.01	-	<0.01	-	<0.01	mg/kg	0.01	A T 019s
Anthracene _A ^{M#}	<0.02	<0.02	<0.02	-	<0.02	-	<0.02	mg/kg	0.02	A T 019s
Benzo(a)anthracene _A ^{M#}	<0.04	<0.04	<0.04	-	<0.04	-	0.10	mg/kg	0.04	A T 019s
Benzo(a)pyrene _A ^{M#}	0.06	0.06	<0.04	-	<0.04	-	0.09	mg/kg	0.04	A T 019s
Benzo(b)fluoranthene _A ^{M#}	0.09	0.07	<0.05	-	<0.05	-	0.13	mg/kg	0.05	A T 019s
Benzo(ghi)perylene _A ^{M#}	<0.05	<0.05	<0.05	-	<0.05	-	<0.05	mg/kg	0.05	A T 019s
Benzo(k)fluoranthene _A ^{M#}	<0.07	<0.07	<0.07	-	<0.07	-	<0.07	mg/kg	0.07	A T 019s
Chrysene _A ^{M#}	<0.06	<0.06	<0.06	-	<0.06	-	0.12	mg/kg	0.06	A T 019s
Dibenzo(ah)anthracene _A ^{M#}	<0.04	<0.04	<0.04	-	<0.04	-	<0.04	mg/kg	0.04	A T 019s
Fluoranthene _A ^{M#}	<0.08	<0.08	<0.08	-	<0.08	-	0.23	mg/kg	0.08	A T 019s
Fluorene _A ^{M#}	<0.01	<0.01	<0.01	-	<0.01	-	<0.01	mg/kg	0.01	A T 019s
Indeno(123-cd)pyrene _A ^{M#}	0.04	0.04	<0.03	-	<0.03	-	0.05	mg/kg	0.03	A T 019s
Naphthalene _A ^{M#}	<0.03	<0.03	<0.03	-	<0.03	-	<0.03	mg/kg	0.03	A T 019s
Phenanthrene _A ^{M#}	0.05	<0.03	<0.03	-	0.04	-	0.14	mg/kg	0.03	A T 019s
Pyrene _A ^{M#}	<0.07	<0.07	<0.07	-	<0.07	-	0.19	mg/kg	0.07	A T 019s
Total PAH-16MS _A ^{M#}	0.24	0.17	<0.08	-	<0.08	-	1.06	mg/kg	0.01	A T 019s

Envirolab Job Number: 20/09917

Client Project Name: Blue Hills Farm

Client Project Ref: 2230244

Lab Sample ID	20/09917/31	20/09917/34						Units	Limit of Detection	Method ref
Client Sample No	3	3								
Client Sample ID	WS 09	WS 10								
Depth to Top	0.50	0.40								
Depth To Bottom	0.70	0.55								
Date Sampled	12-Nov-20	12-Nov-20								
Sample Type	Solid	Solid								
Sample Matrix Code	7	7								
% Stones >10mm _A	<0.1	<0.1						% w/w	0.1	A T 044
pH BRE _D ^{M#}	7.71	7.53						pH	0.01	A T 031s
Sulphate BRE (water sol 2 1) _D ^{M#}	<10	<10						mg/l	10	A T 026s
Sulphate BRE (acid sol) _D ^{M#}	<0.02	<0.02						% w/w	0.02	A T 028s
Sulphur BRE (total) _D	<0.01	0.01						% w/w	0.01	A T 024s

REPORT NOTES

General

This report shall not be reproduced, except in full, without written approval from Envirolab.

The results reported herein relate only to the material supplied to the laboratory.

The residue of any samples contained within this report, and any received with the same delivery, will be disposed of six weeks after initial scheduling. For samples tested for Asbestos we will retain a portion of the dried sample for a minimum of six months after the initial Asbestos testing is completed.

Analytical results reflect the quality of the sample at the time of analysis only.

Opinions and interpretations expressed are outside the scope of our accreditation.

If results are in italic font they are associated with an AQC failure, these are not accredited and are unreliable.

A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

The Client Sample No, Client Sample ID, Depth to Top, Depth to Bottom and Date Sampled were all provided by the client.

Soil chemical analysis:

All results are reported as dry weight (<40°C).

For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.

For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any "A" subscripts.

All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

TPH analysis of water by method A-T-007:

Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

Electrical Conductivity of water by Method A-T-037:

Results greater than 12900µS/cm @ 25°C / 11550µS/cm @ 20°C fall outside the calibration range and as such are unaccredited.

Asbestos:

Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.

Stones etc. are not removed from the sample prior to analysis.

Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

Predominant Matrix Codes:

1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample.

Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.

Secondary Matrix Codes:

A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal,

E = contains roots/twigs.

Key:

IS indicates Insufficient Sample for analysis.

US indicates Unsuitable Sample for analysis.

NDP indicates No Determination Possible.

NAD indicates No Asbestos Detected.

N/A indicates Not Applicable.

Superscript # indicates method accredited to ISO 17025.

Superscript "M" indicates method accredited to MCERTS.

Subscript "A" indicates analysis performed on the sample as received.

Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve.

Please contact us if you need any further information.

Envirolab Deviating Samples Report

Units 7&8 Sandpits Business Park, Mottram Road, Hyde, SK14 3AR
Tel. 0161 368 4921 email. ask@envlab.co.uk

Client:	Ian Farmer Associates (Warrington), 14/15 Rufford Court, Hardwick Grange, Warrington, WA1 4RF	Project No:	20/09917
Project:	Blue Hills Farm	Date Received:	19/11/2020 (am)
Clients Project No:	2230244	Cool Box Temperatures (°C):	10.2

NO DEVIATIONS IDENTIFIED

If, at any point before reaching the laboratory, the temperature of the samples has breached those set in published standards, e.g. BS-EN 5667-3, ISO 18400-102:2017, then the concentration of any affected analytes may differ from that at the time of sampling.

APPENDIX 5
DESIGN CONSIDERATIONS

APPENDIX 5

GEOTECHNICAL DESIGN CONSIDERATIONS

A5.1 ASSESSMENT OF GRANULAR SOIL CONDITION

- A5.1.1 SPT 'N' values reported on the borehole logs are as measured in the field with no corrections applied.
- A5.1.2 However for general design in sands the 'N' values should be normalised to 60% by the following equation:-
- A5.1.3 $N_{60} = E_r/60.N$ where:-
N is the blow count and
Er is the energy ratio of the specific test equipment
- A5.1.4 Further corrections for rod length and overburden pressure in sands may be applied in accordance with BS EN ISO 22476-3, ref 9.6.

A5.2 ASSESSMENT OF COHESIVE SOIL CONDITION

- A5.2.1 In accordance with BS EN ISO 22475-1, ref. 9.10, and BS5930, ref.9.2, the thick walled U100 sample is considered as a Class B sampling technique and will only produce Class 3 to 5 quality samples in accordance with EN 1997-2:2007, ref.9.3.
- A5.2.2 Laboratory strength and consolidation testing should only be carried out on Class 1 quality samples, which can be obtained from a Class A sampling technique, ref. 9.5. This is due to possible disturbance during sampling, giving a weaker strength in testing.
- A5.2.3 Therefore laboratory test values for c_u and m_v obtained from thick walled U100 samples should only be used as guidance and not used as absolute values for the shear strength and compressibility properties of the clay and only used to provide guidance to descriptive strength on the borehole records.
- A5.2.4 Work undertaken by Stroud, ref. 9.16 determined a relationship between SPT 'N' values, plasticity undrained shear strength and compressibility of many over-consolidated clays. Further work by Stroud and Butler, ref.9.17, in which data was analysed from sites covering a wide range of glacial deposits, confirmed there to be a correlation between the 'N' value plasticity undrained shear strength and compressibility.
- A5.2.5 The relationship was of the form:

$$C_u = f_1 \times N$$

and $m_v = 1/(f_2 \times N)$

Where c_u = Un-drained shear strength

m_v = Coefficient of compressibility

f_1 and f_2 = Factors

- A5.2.6 It was determined by Stroud that f_1 varied between 4kPa for material of high plasticity and 6kPa for material of low plasticity. Similarly f_2 varied between 400kPa and 600kPa.

A5.3 GUIDELINES FOR THE DESIGN OF PILES FIRST APPROXIMATION OF WORKING LOAD

A5.3.1 PILING PARAMETERS – GENERAL

The ultimate carrying capacity, Q_u , of a particular pile is taken as the sum of the ultimate shaft friction resistance, Q_s , and the ultimate end bearing resistance, Q_b . This may be expressed as follows:-

$$\begin{aligned} Q_u &= Q_s + Q_b \\ &= f.A_s + q.A_b \end{aligned}$$

where f = unit shaft resistance

A_s = embedded surface area of pile

q = unit end bearing resistance

A_b = effective cross-sectional area of pile base

A5.3.2 COHESIVE SOILS

A5.3.2.1 Shaft Resistance

The ultimate shaft resistance, f , for piles in both compression or tension in cohesive soils is determined by applying a factor to the undrained shear strength, C_s , which exists in the soils along the embedded length of the pile, and is given by:-

$$f = \alpha.C_s$$

Where α is an adhesion factor, which for straight-shafted bored piles may be taken as 0.45 to 0.60.

Ultimate unit shaft friction should not exceed 100kN/m².

A5.3.2.2 End Bearing

For piles terminating in cohesive soils, the ultimate unit end bearing resistance q , is given by:-

$$q = N_c.C_b$$

where C_b is the undrained shear strength at the base of the pile

and N_c is a bearing capacity factor

The value of N_c for a cohesive material is variable, depending on the depth of the penetration of the pile into the bearing stratum. Generally, N_c could be taken to have a value of 9, except in the case of large diameter short piles where a lesser value should be used.

A5.3.3 COHESIONLESS SOILS

A5.3.3.1 Shaft Resistance

For piles driven in cohesionless soils the ultimate unit shaft resistance, f , may be calculated using the following method, which gives:-

$$f = 0.5 \gamma' (D+d) K_s \tan \delta$$

where γ' = average effective unit weight of soil surrounding the pile

D = depth to the pile toe or to the base of the granular stratum whichever is the lesser

d = depth to the top of the granular stratum

δ = angle of friction between pile and soil
(see below)

K_s = a coefficient (see below)

TABLE OF VALUES FOR K_s AND δ

Pile Type	δ	K_s		
		Relative Density		Tension Piles
		Low	High	
Steel	20°	0.5	1.5	0.5
Concrete	0.75ϕ	1.0	2.0	0.5

The value of ϕ may be interpreted from standard penetration tests.

For bored and cast-in-place piles, $\delta = 22^\circ$ and $K_s = 1$ should be used to allow for loosening of the soil during boring.

It has been found that the ultimate unit shaft resistance does not exceed 100kN/m^2 and therefore this value should not be exceeded in design.

A5.3.3.2 End Bearing

The unit ultimate end bearing resistance (q) of piles in cohesionless soils may be calculated as follows:-

$$q = \gamma' \cdot D \cdot N_q$$

where γ' = average effective unit weight of soil surrounding the pile

D = depth to pile toe

N_q = bearing capacity factor

Values for N_q , where piles penetrate the bearing stratum by more than five diameters, may be taken from work carried out by Berezantsev, ref.9.28. In addition, the ultimate unit base resistance should not exceed a value of 11,000kN/m². For bored and cast-in-place piles the value of N_q used should correspond to loose soil conditions.

A5.3.4 FACTORS OF SAFETY

A5.3.4.1 Cohesive and Non-cohesive Soils

For cohesive and non-cohesive soils a factor of safety of 3 may be used to obtain the allowable or safe carrying capacity of piles from the ultimate carrying capacity.

APPENDIX 6
CONTAMINATION ASSESSMENT

APPENDIX 6

GENERAL NOTES ON CONTAMINATION ASSESSMENT

A6.1 STATUTORY FRAMEWORK AND DEFINITIONS

- A6.1.1 The statutory definition of contaminated land is defined in the Environmental Protection Act 1990, ref 9.29, which was introduced by the Environment Act 1995, ref 9.30;

'Land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or

(b) pollution of controlled waters is being, or is likely to be, caused.'

- A6.1.2 The UK guidance on the assessment of contaminated has developed as a direct result of the introduction of these two Acts. The technical guidance supporting the legislation was originally summarised in a number of key documents collectively known as the Contaminated Land Reports (CLRs), a proposed series of twelve documents. Seven were originally published in March 1994, four more were published in April 2002, while the final guidance document, CLR 11, ref 9.47 was published in 2004. CLR7 to 10 were withdrawn in 2008, with CLR 9 and 10 effectively replaced by the Environment Agency in the form of Science Reports SR2, ref 9.40 and SR3, ref 9.32. CLR11 remains valid and sets out the framework of the investigation process.

- A6.1.3 In establishing whether a site fulfils the statutory definition of 'contaminated land' it is necessary to identify, whether a pollutant linkage exists in respect of the land in question and whether the pollutant linkage:

- is resulting in significant harm being caused to the receptor in the pollutant linkage,
- presents a significant possibility of significant harm being caused to that receptor,
- is resulting in the pollution of the controlled waters which constitute the receptor, or
- is likely to result in such pollution.

- A6.1.4 A 'pollutant linkage' may be defined as the link between a contaminant 'source' and a 'receptor' by means of a 'pathway'.

A6.2 ASSESSMENT METHODOLOGY

- A6.2.1 The guidance proposes a four-stage assessment process for identifying potential pollutant linkages on a site. These stages are set out in the table below:

No.	Process	Description
1	Hazard Identification	Establishing contaminant sources, pathways and receptors (the conceptual model).
2	Hazard Assessment	Analysing the potential for unacceptable risks (what linkages could be present, what could be the effects).
3	Risk Estimation	Trying to establish the magnitude and probability of the possible consequences (what degree of harm might result and to what receptors, and how likely is it).
4	Risk Evaluation	Deciding whether the risk is unacceptable.

- A6.2.2 Stages 1 and 2 develop a '*conceptual model*' based upon information collated from desk based studies, and frequently a walkover of the site. The walkover survey should be conducted in general accordance with CLR 2, ref 9.51. The formation of a conceptual model is an iterative process and as such, it should be updated and refined throughout each stage of the project to reflect any additional information obtained.
- A6.2.3 The extent of the desk studies and enquiries to be conducted should be in general accordance with CLR 3, ref 9.31. The information from these enquiries is presented in a desk study report with recommendations, if necessary, for further work based upon the conceptual model. In the absence of specific information on contamination anticipated to be encountered, specific DoE 'Industry Profiles' provide guidance on the nature of contaminants relating to a variety of industrial processes and should be used as the basis for determining which contaminants are more likely to be present on a site.
- A6.2.4 If potential pollutant linkages are identified within the conceptual model, a Phase 2 site investigation and report will be recommended. The investigation should be planned in general accordance with CLR 4, ref 9.1. The number of exploratory holes and samples collected for analysis should be consistent with the size of the site and the level of risk envisaged. This will enable a generic quantitative risk assessment (GQRA) to be conducted, at which point the conceptual model can be updated and relevant pollutant linkages can be identified.
- A6.2.5 A two-stage investigation may be more appropriate where time constraints are less of an issue. The first stage investigation being conducted as an initial assessment for the presence of potential sources, a second being a more refined investigation to delineate wherever possible the extent of the identified contamination.
- A6.2.6 All site works should be in general accordance with the British Standards, BS 5930:2010, ref. 9.2, ISO 1997, ref 9.3 and BS 10175:2011, ref 9.5.
- A6.2.7 The GQRA screens the results of the chemical analysis against generic guidance values, appropriate to the end-use of the site. Soils will be compared to Soil Guideline Values (SGV) where published, Generic Assessment Criteria (GAC) developed by LQM/CIEH, ref 9.34, or internal screening values generated using the Contaminated Land Exposure Assessment (CLEA) Software, Version 1.06, ref 9.35. Toxicological and physico-chemical/fate and transport data used to generate the AC has been derived from a hierarchy of data sources as follows:
1. Environment Agency or Department of Environment Food and Rural Affairs
(DEFRA) documents;
 2. Other documents produced by UK Government or state organisations;
 3. European institution documents;
 4. International organisation documents;
 5. Foreign government institutions.
- A6.2.8 For many of the contaminants considered, input data has been drawn from the relevant SGV where available, or existing toxicological reports published by the Environment Agency which have not yet been withdrawn/replaced. Fate and transport data has been derived in the first instance from Environment Agency (2008), ref 9.52.

- A6.2.9 Recommendations for tolerable intakes of lead are based on evaluation of the relationship between exposure and blood lead levels. The existing toxicological report for lead considers a health criteria value based on an uptake dose, whereas the CLEA model estimates exposure in terms of an intake dose. At present, the CLEA model is not considered appropriate for determining a screening value for lead. In the absence of a current published assessment criterion, the SGV for lead reported in R&D Publication CLR 10 ref 9.41 have been used in this assessment. This will be updated in due course in light of any further published information.
- A6.2.10 Chemical laboratory test results are processed as follows. A statistical analysis of the results is conducted, as detailed in CIEH and CL:AIRE ‘Guidance on Comparing Soil Contamination Data with a Critical Concentration’, ref 9.37. Individual concentrations are compared to the selected guideline values to identify concentrations of contaminants that are above the selected screening criteria.
- A6.2.11 Initially the distribution of the data set is tested using the Shapiro-Wilk normality test, ref 9.39 to determine if the data set is, or is not, normally distributed. Where the distribution of the data is shown to be normal, the mean value test is applied to determine whether the mean characteristics of the selected soil unit present a significant possibility of significant harm to human health. Where the data is not normally distributed a method based on the Chebychev Theorem can be applied to test the same hypothesis. The significance of the data is further tested using the maximum value test. This determines whether the highest recorded contaminant concentrations are from the same statistical distribution or whether they may represent a ‘hot spot’.
- A6.2.12 Where the risk estimation identifies significant concentrations of one or more contaminants, a further risk evaluation needs to be undertaken.
- A6.2.13 The risk evaluation will address the potential pollutant linkages between an identified source of contamination and the likely receptors both on and off site.
- A6.2.14 The potential receptors include:
- 1) Humans – current site occupants, construction workers, future site users and neighbouring site users.
 - 2) Controlled Waters – surface water and groundwater resources
 - 3) Plants – current and future site vegetation
 - 4) Building materials
- A6.2.15 The potential hazards to be considered in relation to contamination are:
- a) Ingestion and inhalation.
 - b) Uptake of contaminants via cultivated vegetables.
 - c) Dermal contact
 - d) Phytotoxicity (the prevention or inhibition of plant growth)
 - e) Contamination of water resources
 - f) Chemical attack on building materials and services
 - g) Fire and explosion
- A6.2.16 Dependent on the outcome of the initial, generic contamination risk assessment, further detailed assessment of the identified risks may be required.

A6.3 Generic Guidance Values Used Within Contamination Risk Assessment

Residential End Use with Homegrown Produce

Residential with Homegrown Produce	Determinant	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Primary Data Source
		1% SOM	2.5% SOM	6% SOM	
PAH	Acenaphthene	210	510	1100	LQM/CIEH S4UL
	Acenaphthylene	170	420	920	LQM/CIEH S4UL
	Anthracene	2400	5400	11000	LQM/CIEH S4UL
	Benzo(a)anthracene	7.2	11	13	LQM/CIEH S4UL
	Benzo(a)pyrene	2.2	2.7	3	LQM/CIEH S4UL
	Benzo(b)fluoranthene	2.6	3.3	3.7	LQM/CIEH S4UL
	Benzo(ghi)perylene	320	340	350	LQM/CIEH S4UL
	Benzo(k)fluoranthene	77	93	100	LQM/CIEH S4UL
	Chrysene	15	22	27	LQM/CIEH S4UL
	Dibenzo(ah)anthracene	0.24	0.28	0.30	LQM/CIEH S4UL
	Fluoranthene	280	560	890	LQM/CIEH S4UL
	Fluorene	170	400	860	LQM/CIEH S4UL
	Indeno(123-cd)pyrene	27	36	41	LQM/CIEH S4UL
	Naphthalene	2.3f	5.6f	13f	LQM/CIEH S4UL
	Phenanthrene	95	220	440	LQM/CIEH S4UL
	Pyrene	620	1200	2000	LQM/CIEH S4UL
Other Organics	Phenol	280	550	1100	LQM/CIEH S4UL
Metals	Arsenic	37	37	37	LQM/CIEH S4UL
	Beryllium	1.7	1.7	1.7	LQM/CIEH S4UL
	Boron	290	290	290	LQM/CIEH S4UL
	Cadmium	11	11	11	LQM/CIEH S4UL
	Chromium (III)	910	910	910	LQM/CIEH S4UL
	Chromium (VI)	6	6	6	LQM/CIEH S4UL
	Copper	2400	2400	2400	LQM/CIEH S4UL
	Lead	200	200	200	EA C4SL
	Mercury	40	40	40	LQM/CIEH S4UL
	Nickel	180f	180	180	LQM/CIEH S4UL
	Selenium	250	250	250	LQM/CIEH S4UL
	Vanadium	410e	410	410	LQM/CIEH S4UL
	Zinc	3700	3700	3700	LQM/CIEH S4UL

d = Based on inhalation exposure compared with inhalation ID

e = Based on oral and dermal exposure with oral TDI

f = Based on comparison of exposure from all pathways with TDI oral

Residential with Homegrown Produce	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Primary Data Source
	1% SOM	2.5% SOM	6% SOM	
Aliphatic				
EC 5-6	42	78	160	LQM/CIEH S4UL
EC >6-8	100	230	530	LQM/CIEH S4UL
EC >8-10	27	65	150	LQM/CIEH S4UL
EC >10-12	130 (48)	330 (118)	770 (283)	LQM/CIEH S4UL
EC >12-16	1100 (24)	2400 (59)	4400 (142)	LQM/CIEH S4UL
EC >16-35	65000 (8.48)	92000 (21)	110000	LQM/CIEH S4UL
EC >35-44	65000 (8.48)	92000 (21)	110000	LQM/CIEH S4UL
Aromatic				
EC 5-7 (benzene)	70	140	300	LQM/CIEH S4UL
EC >7-8 (toluene)	130	290	660	LQM/CIEH S4UL
EC >8-10	34	83	190	LQM/CIEH S4UL
EC >10-12	74	180	380	LQM/CIEH S4UL
EC >12-16	140	330	660	LQM/CIEH S4UL
EC >16-21	260f	540f	930f	LQM/CIEH S4UL
EC >21-35	1100f	1500f	1700f	LQM/CIEH S4UL
EC >35-44	1100f	1500f	1700f	LQM/CIEH S4UL
Aliphatic and Aromatic				
EC >44-70	1600f	1800f	1900f	LQM/CIEH S4UL
BTEX				
Benzene	0.087	0.17	0.37	LQM/CIEH S4UL
Toluene	130	290	660	LQM/CIEH S4UL
Ethylbenzene	47	110	260	LQM/CIEH S4UL
p Xylenes	56	130	310	LQM/CIEH S4UL
m Xylenes	59	140	320	LQM/CIEH S4UL
o Xylene	60	140	330	LQM/CIEH S4UL

SOM = Soil Organic Matter

Values in brackets indicate the solubility or vapour saturation limit where this is exceeded by the GAC

APPENDIX 7
GAS GENERATION

APPENDIX 7

GENERAL NOTES ON GAS GENERATION

A7.1 GENERAL

- A7.1.1 In the past, a series of guidance documents were published by CIRIA, ref. 9.53, 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 9.54. In 2007, British Standard, BS8485, ref 9.55, 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.
- A7.1.2 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. 9.29.
- A7.1.3 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. 9.56.

A7.2 APPROACH

- A7.2.1 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

A7.3 POLLUTANT LINKAGE ASSESSMENT

- A7.3.1 A pollutant linkage assessment is presented in Appendix 3 of the Phase 1 Desk Study Report.
- A7.3.2 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 no 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.

A7.4 SITE MONITORING

A7.4.1 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 guideline has been proposed, ref. 9.58.

Table A7.1

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 Boyle and Witherington, 2006).
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 (Boyle and Witherington, 2006)
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.

A7.4.2 Before taking any readings, zero the instrument, record atmospheric pressure and temperature.

A7.4.3 Gas flow should be recorded, giving the range of pressures, ensuring positive or negative flow is recorded.

A7.4.4 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.

A7.5 ASSESSMENT OF RISK AND RECOMMENDATIONS

- A7.5.1 The main method of characterising a site is the method described by Wilson and Card, ref. 9.59 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.
- A7.5.2 Low rise housing, Situation B, was developed by Boyle and Witherington, ref. 9.60 and was developed for the NHBC for classifying gassing sites for houses with suspended ground floor slab with ventilated void.
- A7.5.3 Although the Code of Practice, ref 9.55, assesses the characteristic gas situation as CIRIA recommend for Situation A, see Table A7.2 below, their solution for gas protection systems is different, see section A7.10.

A7.6 SITUATION A - ASSESSMENT

- A7.6.1 This system proposed by Wilson and Card, ref. 9.59 was originally developed in CIRIA Report 149, ref. 9.53.
- A7.6.2 The method uses both gas concentrations and borehole flow rate for methane and carbon dioxide to define a Characteristic Situation for a site.
- A7.6.3 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 A7.2

Characteristic Situation	Risk Classification	Gas screening value (CH ₄ or CO ₂ (l/hr) ¹	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 "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. "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.

A7.7 SITUATION A – SOLUTION

A7.7.1 The Characteristic Situation can be used to define the scope of gas protective measures required.

A7.7.2 The CIRIA approach uses the characteristic situation to define the level of gas protection as follows:

Table A7.3

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 b) Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane and underfloor venting 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 b) Beam and block or pre-cast concrete slab and minimum 2000g DPM/reinforced gas membrane c) Possibly underfloor venting or pressurisation in combination with a) and b) depending on use All joints and penetrations sealed
3	2	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space	1 to 2	All types of floor slab as above. All joints and penetrations sealed. 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. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated underfloor subspace or positively pressurised underfloor sub-space, oversite capping or blinding and in	2 to 3	All types of floor slab as above. All joints and penetration sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space with monitoring facility

Characteristic situation	Residential building (Not low-rise traditional housing)		Office/commercial/industrial development	
		ground venting layer		
5	4	Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and ventilated or positively pressurised underfloor sub-space, oversite capping and in ground venting wells or barriers	3 to 4	Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space with monitoring facility. In ground venting wells or barriers
6	5	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	4 to 5	Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. 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.

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. 9.57.
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/m³ 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.

A7.8 SITUATION B -ASSESSMENT

- A7.8.1 The NHBC has developed a characterisation system that is similar to Situation A but is specific to low-rise housing development with a clear ventilated underfloor void. The gas emission rates are compared to generic 'Traffic Lights'.
- A7.8.2 The Traffic Lights include a Typical Maximum Concentration that is used for initial screening purposes. Where the Typical Maximum Concentration is exceeded the risk-based Gas Screening Value, GSV, should be adopted. The GSVs are determined for the 'model' low rise development and where they differ from this model, the GSV should be reassessed, ref. 9.54.
- A7.8.3 The calculations should be made for both methane and carbon dioxide, and the worst case adopted. The GSV is only a guideline.

Table A7.4

Traffic light	Methane		Carbon dioxide	
	Typical maximum concentration ² (% v/v)	Gas screening value (GSV) ³ (litres per hour)	Typical maximum concentration ² (% v/v)	Gas screening value (GSV) ^{1,2} (litres per hour)
Green	1	0.16	5	0.78
Amber 1				
Amber 2	5	0.63	10	1.56
Red	20	1.56	30	3.13

1. Generic GSVs are based on guidance contained within latest revision of Department of the Environment and the Welsh Office (2004 edition) "The Building Regulations: Approved Document C" and used a sub-floor void of 150mm thickness.
2. The Typical Maximum Concentrations can be exceeded in certain circumstances should the conceptual site model indicate it is safe to do so. This is where professional judgement will be required, based on a thorough understanding of the gas-regime identified at the site where monitoring in the worst temporal conditions has occurred.
3. The GSV thresholds should not generally be exceeded without completion of a detailed gas risk assessment taking into account site-specific conditions.

A7.9 SITUATION B – SOLUTION

A7.9.1 On the basis of this Traffic Light classification the following protection should be applied to low-rise housing.

Table A7.5

Traffic Light Classification	Protection measures required
Green	Negligible gas regime identified and gas protection measures are not considered necessary.
Amber 1	Low to intermediate gas regime identified, which requires low-level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be as prescribed in BRE Report 414. Ventilation of the sub-floor void should facilitate a minimum of one complete volume change per 24 hours.
Amber 2	Intermediate to high gas regime identified, which requires high-level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to prevent the ingress of gas into buildings. Gas protection measures should be as prescribed in BRE Report 414. A specialist contractor should always fit membranes. As with Amber 1, ventilation of the sub-floor void should facilitate a minimum of one complete volume change per 24 hours. Certification that these passive protection measures have been installed correctly should be provided.
Red	High gas regime identified. It is considered that standard residential housing would not normally be acceptable without a further Gas Risk Assessment and/or possible remedial mitigation measures to reduce and/or remove the source of gas.

A7.10 CODE OF PRACTICE – SOLUTIONS

- A7.10.1 The Characteristic Gas Situation is determined in a similar manner to that recommended by CIRIA, see Table A7.2 above.
- A7.10.2 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.
- A7.10.3 A guidance value for the required gas protection, in the range 0 to 7 should be obtained from Table A7.6 below. Then, a combination of ventilation and/or barrier system should be chosen from Table A7.7 to meet that requirement.

Table A7.6

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

A7.10.4 Having determined the appropriate guidance value from Table A7.6, an element or combination of elements from a), b), c) or d) in Table A7.7, should be chosen to achieve the required level of protection.

Table A7.7

PROTECTION ELEMENT/SYSTEM		SCORE	COMMENTS
a) Venting/dilution			
Passive sub floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) ^{A)}	Very good performance	2.5	<i>Ventilation performance in accordance with Annex A, ref. 9.55</i>
	Good performance	1	<i>If passive ventilation is poor this is generally unacceptable and some form of active system will be required</i>
Subfloor ventilation with active abstraction/pressurization (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) ^{A)}		2.5	<i>There have to be robust management systems in place to ensure the continued maintenance of any ventilation system.</i> <i>Active ventilation can always be designed to meet good performance.</i> <i>Mechanically assisted systems come in two main forms: extraction and positive pressurization.</i>

PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
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. 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 ^{B), C)}	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) ^{B), C)}	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 ^{A)}	2	
Installed in the underfloor venting/dilution system	1	
Installed in the building	1	
e) Pathway intervention		
Pathway intervention	-	<i>This can consist of site protection measures for off-site or on-site sources (see Annex A, ref. 9.55)</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. 9.57 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.

