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PHASE 2: GROUND INVESTIGATION REPORT

STRATEGIC TEAM GROUP

PROPOSED RESIDENTIAL DEVELOPMENT

LAIRDS WAY

PENISTONE

SOUTH YORKSHIRE

Project No: 16-384

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Date: 3rd August 2016

Approved By:
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Date: 3rd August 2016

The information and/or advice contained in this Phase 2: Ground Investigation Report is based solely on, and is limited to, the boundaries of the site, the immediate area around the site, and the historical use(s) unless otherwise stated. This 'Report' has been prepared in order to collate information relating to the physical, environmental and industrial setting of the site, and to highlight, where possible, the likely problems that might be encountered when considering the future development of this site for the proposed end use. All comments, opinions, diagrams, cross sections and/or sketches contained within the report, and/or any configuration of the findings is conjectural and given for guidance only and confirmation of the anticipated ground conditions should be considered before development proceeds. Agreement for the use or copying of this report by any Third Party must be obtained in writing from Arc Environmental Limited (ARC). If a change in the proposed land use is envisaged, then a reassessment of the site should be carried out.

CONTENTS

1.0	INTRODUCTION	Page 3
2.0	SITE DETAILS	Page 3
3.0	SCOPE OF WORKS	Page 3
4.0	GROUND CONDITIONS	Page 4
	4.1 – Soil Profile	Page 4
	4.2 – Shallow Coal Mining Assessment	Page 5
	4.3 – Groundwater	Page 5
5.0	INSITU TESTING	Page 6
	5.1 – Insitu Standard Penetration Tests	Page 6
	5.2 – Insitu Hand Shear Vane Tests	Page 6
	5.3 – Insitu Ground Gas & Groundwater Monitoring	Page 6
6.0	LABORATORY TESTING	Page 8
	6.1 – Determination of Liquid & Plastic Limits	Page 8
	6.2 – Determination of Chemical Attack on Buried Concrete	Page 9
	6.3 – Contamination Screening	Page 10
7.0	GROUND CONTAMINATION RISK ASSESSMENT	Page 11
	7.1 - Methodology	Page 11
	7.2 – Conceptual Site Model (CSM)	Page 11
	7.3 – Screening Strategy	Page 13
	7.4 – Level 1 Generic Quantitative Risk Assessment – Human Health	Page 14
	7.5 – Level 2 Generic Quantitative Risk Assessment – Controlled Waters	Page 21
8.0	CONCLUSIONS & RECOMMENDATIONS	Page 23
	8.1 – Ground Conditions	Page 23
	8.2 – Groundwater	Page 23
	8.3 – Hazardous Ground Gas Risk Assessment	Page 24
	8.4 – Foundation Options	Page 24
	8.5 – Ground Contamination	Page 26
	8.6 – General Comments	Page 28
	REFERENCES	Page 29

APPENDICES

Appendix I	Location Plan, Aerial Photograph, Existing & Proposed Site Layout Plans
Appendix II	Trial Pit & Borehole Location Plan and Trial Pit & Borehole Record Sheets
Appendix III	Insitu Testing (Gas & Groundwater Monitoring Certificate)
Appendix IV	Laboratory Testing Results (Geotechnical & Ground Contamination)
Appendix V	Ground Contamination Risk Assessment Data: Methodology, Notes for Off-Site Disposal, Conceptual Site Model (CSM), CL:AIRE Calculation Sheets & Statistical Analysis (Ver. 1)

1.0 Introduction

August 2016

In conjunction with the findings of the Geo-environmental Investigation Report (OPUS International Consultants (UK) Ltd., ref. no. SMD/J-S0099.00(R03), November 2012), Arc Environmental Ltd. has been instructed by Strategic Team Group, to undertake a programme of ground investigation works on a site located adjacent to Lairds Way, within the South Yorkshire Town of Penistone. The site is currently undeveloped and overgrown with trees, and observations of the site's features and history are contained in the OPUS Geo-environmental Investigation Report. The proposed development will comprise the construction of 34 no. semi-detached and detached residential properties with private gardens and incorporating areas of road & car parking infrastructure.

The intrusive investigation works have been designed to provide an assessment of the potential contamination issues associated with the site as a whole, looking at the potential risks to Human Health and Controlled Waters, as well as considering the geotechnical issues associated with the proposed development works, as highlighted from the results of the OPUS Geo-environmental Investigation Report.

The programme of investigation works designed by Arc Environmental comprised the sinking of 7 no. mechanically excavated trial pits, 4 no. cable percussive boreholes and 3 no. rotary openhole boreholes, accompanied by the installation of 3 no. combined ground gas and groundwater monitoring wells. All the investigation positions put down can be seen on the Trial Pit & Borehole Location Plan, a copy of which can be seen in Appendix II. It should be noted that the plan should be used for orientating purposes only, as the location of the positions are approximate.

2.0 Site Details

Table 2.1 N = north, S = south, E = east, W = west

Site Name & Address:	Lairds Way, Penistone, South Yorkshire, S36 6HN.
OS Grid Reference:	425250, 403260 (representative for the central part of the site).
Description of Location	The site is currently an area of undeveloped overgrown land located adjacent to Lairds Way, within the South Yorkshire town of Penistone.
Site Boundaries:	NE = Sheffield Road (B6462), SE = Rear gardens and residential properties, SW = Undeveloped land and railway lines, NW = Lairds Way.
Site Setting:	Mixed residential and commercial setting.

3.0 Scope of Works

Table 3.1

Client:	Strategic Team Group.
Consulting Engineers:	Adept Consulting Engineers Ltd.
Project type:	Construction of 34 no. semi-detached and detached residential properties with private gardens and incorporating areas of road & car parking infrastructure.
Site Location plan:	See Appendix I.
Layout plans (existing):	See Appendix I.
Layout plans (proposed):	See Appendix I.
Investigation Works:	7 no. mechanically excavate trial pits (TP's 01 – 07), 4 no. cable percussive boreholes (BH's 01 – 03 & 03A), 3 no. rotary openhole boreholes (RBH's 01 - 03), accompanied by the installation of 3 no. combined gas and groundwater monitoring wells (BH's 01, 02 & 03A).
Laboratory Testing:	Geotechnical & Ground Contamination.
CLEA End-Use Classification:	Level 1 GQRA – Residential.

3.0 Scope of Works (Cont'd)

Table 3.1 (Cont'd)

Reporting:	Factual & Interpretative including GQRA's for Human Health, Controlled Waters and Hazardous Ground Gas.
Site History Summary:	Historically, the site was undeveloped, likely to be agricultural from as early c.1851. By c.1893 the site is developed with an Iron & Steel works, until c.1931 when the site is partially demolished, with further demolition occurring by c.1938. By c.1955 the site is mainly occupied by railway lines and sidings. These are dismantled by c.1983, and the site is left vacant and undeveloped to the present day. The site has become thickly overgrown with trees.
Other Comments:	There was no obvious evidence noted during the investigation works to indicate the site is currently affected by the presence of Japanese Knotweed.

The information contained in this report is limited to the area of the site, as indicated on the Existing & Proposed Site Layout Plans shown in Appendix I, and to those areas accessible during the ground investigation. When considering the full scope of the development any features and / or issues not specifically mentioned in this report cannot be assumed to have been covered.

4.0 Ground Conditions

For an accurate description of the ground conditions encountered at each investigation position, reference should be made to the trial pit & borehole record sheets in Appendix II, and the depths of strata on the record sheets are recorded from current ground levels.

4.1 Soil Profile:-

A summary of the soil profile for this site can be found in Table 4.1 below.

Table 4.1

Type of Strata	Depths Recorded (BGL)	Description & General Comments
MADE GROUND:	From 0.00m up to c.2.50m and c.6.70m	The site surfacing comprises overgrown grass and trees and a dark brown sandy clayey soil underlain by made ground comprising mixtures of clay, sand and gravel containing predominantly brick, concrete and slag rubble (constitutes approx. c.30%-c.40% of the made ground matrix), ash, cinder, clinker, coal and burnt siltstone.
DRIFT GEOLOGY: None recorded, area of solid outcrop	From c.2.50m to c.3.70m up to c.3.15m and c.4.10m	Limited natural deposits were noted across the site comprising soft silty sandy gravelly CLAY, and firm to stiff (high strength) slightly sandy slightly gravelly CLAY. A dark grey and black mottled slightly sandy gravelly relic topsoil layer was noted in TP02 between c.2.65m and c.2.85m.
SOLID GEOLOGY: Lower Coal Measures	From c.3.15m to c.6.70m up to at least c.30.00m	The solid geology initially comprises yellowish light brown SILTSTONE which is noted to be highly weathered, recovered as silty fine to coarse angular gravels and cobble sized fragments. Within the rotary boreholes the siltstone alternates with the presence of grey MUDSTONE. No coal seams were encountered within the deeper rotary boreholes, and no soft ground indicative of broken ground associated with historic mine workings was encountered across the site. Consistent drilling rates and between 50% and 100% of the flush medium was maintained during the drilling period.

4.0 Ground Conditions (Cont'd)

4.1 Soil Profile (Cont'd):-

During the works there was evidence of 'ashy' materials noted to be incorporated within the matrix of the made ground materials. There was localised visual and olfactory evidence of potential hydrocarbon contamination noted within the soils at three locations (TP's 02, 03 & 04). There was no significant visual evidence of potential asbestos containing materials (ACM's – cemented sheets, lagging, etc.) encountered within any of the exploratory positions.

At the locations of TP's 05 & 06 and BH's 02, intact relic brick walls, concrete slabs and large boulder sized fragments of concrete & fused slag were recorded throughout the made ground encountered, although the relic obstructions and larger boulders of fused slag were generally encountered on the southeastern half of the site.

It should be noted that the northern and southeastern sides of the site are characterised by the presence of slopes, with the southeastern slope ranging between c.0.80m and c.3.30m in height and the northern slope ranging between c.6.30m and c.7.60m in height, with both slopes ranging between a current slope angle of c.15^{o} and c.22^{o}. Note, the slope heights and angles are based on visual observations only and should be taken as approximate. The northern side of the site is heavily vegetated with large trees, and the previous investigation notes that 'a number of tree trunks were bent which indicates the possibility of the slope moving'. The northeastern corner of the site boundary is characterised by the presence of a c.1m to c.7m high brick, concrete and sandstone retaining wall. The southeastern slope is heavily vegetated with overgrown grass and brambles with occasional trees. The southeastern boundary comprises wooden fencing with steeply sloping gardens beyond, associated with the adjacent residential development. Due to the overgrown nature of obvious potential slope instability issues (i.e. tension cracks, slumping, etc.).

4.2 Shallow Coal Mining Assessment:-

The site is in an area where it is believed that coal seams may exist at shallow depth and within which workings may exist. According to the BGS geological plans, a conjectured coal seam is shown to sub-crop on or close to the northeastern boundary of the site, and this is believed to represent the Lower Penistone coal seam. As such, a series of open hole rotary boreholes have been completed in order to determine the level of risk from the Lower Penistone coal seam.

As can be seen from the rotary borehole logs, copies of which can be found in Appendix II, no intact coal seams, or evidence of workings, in the form of broken ground or voids were recorded below the site during the creation of the boreholes. Between 50% and 100% of the flush medium was returned within the deep boreholes, which were taken to a terminal depth of between c.27.80m and c.30.00m. The decrease in flush return is most likely to be attributable to bedding planes and fractures in the solid geology.

In conclusion, it is felt that the site is not at risk from shallow coal workings, nor future subsidence as a direct result of shallow coal workings collapsing, and therefore no remediation or further investigation works are deemed necessary for this site.

4.3 Groundwater:-

During the investigation period, there were no water strikes recorded within any of the investigation positions.

The findings of these fieldworks would suggest that a continuous shallow groundwater surface (water table) is not present below the site. Nonetheless, it would be considered prudent to allow for the introduction of temporary groundwater control measures (i.e. sump pumping equipment) and adequate shoring, in order to take care of any potential future shallow water ingresses within the underlying deposits particularly where open excavations are present and are to remain open to the natural elements.

4.0 Ground Conditions (Cont'd)

4.3 Groundwater (Cont'd):-

Further groundwater monitoring has been undertaken within the combined gas and groundwater monitoring standpipes installed across the site. The results of the monitoring are discussed in Section 5.3.

5.0 Insitu Testing

5.1 Insitu Standard Penetration Tests:-

Insitu standard penetration tests were carried out within the boreholes with the use of either a split spoon sampler or a solid 60° cone, in order to determine the relative density and strength of the made ground and natural drift deposits. The results are shown as uncorrected 'N' values on the graphic borehole record sheets, adjacent to the appropriate sample level.

Where the full penetration depth, including seating blows (450mm), could not be achieved, the bottom sampling depth is indicated as less than 0.45m from the top (start of test), with the actual depth of penetration and number of blows undertaken also being recorded. A summary of the findings is given below:-

- Test completed within the made ground deposits recorded SPT 'N' values ranging between 19 up to 68, as well as blow counts of up to 75 for limited penetration, indicating medium dense, dense and very dense materials. The higher blow counts and refusals are likely to be attributable to the presence of possible obstructions (large cobbles & boulders) within the made ground materials, as observed during the trial pit excavations.
- Only one test was wholly completed within the natural clay deposits, and an 'N' value of 10 was recorded, suggesting the presence of a 'firm' deposit.
- As anticipated, blows counts of up to 75 for limited penetration were recorded for the underlying siltstone deposits, indicating very dense / hard strata.

5.2 Insitu Hand Shear Vane Tests:-

Insitu hand vane tests were carried out using a portable hand vane tester (upper limit 120kN/m^2) on the natural clay deposits encountered in the trial pits. The results obtained can be found adjacent to the appropriate sample level, on the graphic trial pit and borehole record sheets in Appendix II.

From the results of the testing completed within the natural clay deposits, shear strength values of 96kN/m^2 and 100kN/m^2 were recorded, equating to high strength deposits.

5.3 Insitu Ground Gas & Groundwater Monitoring:-

Combined ground gas & water monitoring standpipes were installed within three of the boreholes (BH's 01, 02 & 03A) to assess the potential for hazardous ground gas generation from on-site made ground and volatile vapours from potential hydrocarbon contamination. The risk of potential rising mine gases is not considered to represent a risk for this site when considering the findings of the investigation works. A standard 50mm diameter HDPE standpipe, with gravel and geo-wrap surround, bentonite seal, gas valve cap and security cover, was installed within each borehole, and ground gas and water levels were allowed to reach equilibrium, prior to the first monitoring visit. The bentonite seal was taken to a depth of c.1.00m bgl, to prevent excessive surface water ingress or venting of soil gas, with the resulting response zone covering the remaining depths of the installations. Monitoring was undertaken using a Gas Data GFM series infra red gas analyser, with integral flow meter, and an electronic dipmeter.

5.0 Insitu Testing (Cont'd)

5.3 Insitu Ground Gas & Groundwater Monitoring (Cont'd):-

Based on the findings of the Geo-Environmental Investigation report and these intrusive works, and in accordance with CIRIA Report C665, November 2007, BS8485:2015: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, and BS8576:2013: Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds, the risk assessment for this site would be based on the following limiting factors:

- The proposed residential development has been considered as *high* sensitivity (Tables 5.5a & 5.5b – Typical/Idealised frequency and period of monitoring, after Wilson et al, 2005).
- The risk associated with the generation potential of a source is considered as *very low* (assessment based on the findings of the intrusive works – lack of significant bio-degradable materials noted in the made ground matrix).
- Monitoring over a minimum of *three* months with *six* recorded readings (Tables 5.5a & 5.5b – Typical /idealised frequency and period of monitoring after Wilson et al, 2005).
- No detectable concentrations of Methane or Carbon Dioxide have been recorded exceeding the action trigger levels of 1% & 5% respectively. (Table 8.5 – Modified Wilson & Card classification).
- *Negligible* (<0.1 l/hr.) flow rates have been recorded during the monitoring period to date (Table 8.5 – Modified Wilson & Card classification).
- A targeted and phased programme of gas monitoring will be completed, which will obtain gas monitoring readings during varying atmospheric conditions, which covers the 'worst case' scenario for ground gas emissions to occur, particularly during rapid falls in atmospheric pressure (i.e. from c.1020mb and c.1010mb), and also during low atmospheric pressure events (i.e. c.1000mb and below).

Due to the presence of localised hydrocarbon contamination being encountered within the made ground and perched water samples, as well as the granular nature of the made ground materials, additional monitoring for Hexane, and the use of a Photo Ionisation Detector (PID) meter will be used on subsequent monitoring visits to monitor the installations' 'head space'. A PID meter is unable to detect methane due to the compound's high ionization energy, however, it will detect other volatile organic compounds (VOC's) associated with the evaporation of volatile hydrocarbons.

A summary of the results for the visits undertaken are presented in Table 5.1 below, with a copy of the monitoring results contained in Appendix III.

Table 5.1

Position	Date	Atmospheric Pressure (mbar)	Water (m bgl)	PID (ppm)	CH_4 (%v/v)	LEL (%v/v)	CO_2 (%v/v)	O_2 (%v/v)	Flow Rate (l/hr)
BH01	09/06/2016	990 (trend - falling 1026-1020)	4.10	~	0.0	0.0	0.4	19.7	<0.1
BH02			5.11	~	0.0	0.0	0.3	19.3	<0.1
BH03A			Dry	~	0.0	0.0	0.0	20.3	<0.1
BH01	20/06/2016	980-981 (trend - falling 1022-1008)	Dry	~	0.0	0.0	0.2	20.4	<0.1
BH02			5.06	~	0.0	0.0	2.2	7.2	<0.1
BH03A			5.51	~	0.0	0.0	0.5	19.0	<0.1
BH01	07/07/2016	984-985 (trend - falling 1022-1016)	Dry	~	0.0	0.0	1.1	17.2	<0.1
BH02			5.10	~	0.0	0.0	0.2	20.0	<0.1
BH03A			5.97	~	0.0	0.0	0.0	20.3	<0.1
3 no. outstanding visits to be completed									

Note – Atmospheric trend taken from Wunderground for Leeds/Bradford Airport.

5.0 Insitu Testing (Cont'd)

5.3 Insitu Ground Gas & Groundwater Monitoring (Cont'd):-

As can be seen from the results to date, no concentrations of detectable Methane (CH_4) have been recorded. Concentrations of Carbon Dioxide (CO_2) have currently been recorded up to a maximum of 2.2% *v/v*, with reduced Oxygen (O_2) concentrations (minimum 7.2% *v/v)*. Negligible flow rates (<0.1 l/hr.) have been recorded on all occasions. At this stage, no results are currently available for volatile vapours as this has yet to be carried out. Subsequent monitoring visits (3 no.) will be monitored for Hexane and PID to determine the presence and concentrations of potential volatile vapours in the ground.

For the purposes of the proposed residential development, the site is characterised based on the limiting borehole gas volume flow for Methane and Carbon Dioxide known as the Gas Screening Value (GSV) which inturn determines the level of protection required. Therefore, in order to complete the risk assessment, the maximum GSV (Gas Screening Value) for the CH_4 and CO_2 levels recorded have been determined as follows:

- Methane (CH_4) – Due to the lack of Methane no GSV can be calculated.
- Carbon Dioxide (CO_2) - multiplying the maximum concentration recorded (taken as 2.2%) by the maximum flow rate (taken as 0.1 l/hr.) which gives a GSV of 0.022 l/hr. (calculated from 0.22 x 0.1 l/hr. maximum flow rate).

From the results it can be seen that the presence of hazardous ground gases do not exceed the GSV assessment value of 0.07 l/hr. (Characteristic Situation 1) or 0.78 l/hr. (Green Classification – NHBC Traffic light system), indicating that no gas protection measures would be required for the proposed residential development. However this will need to be reassessed following the 3 no. outstanding gas monitoring visits, with the results issued as an addendum Letter Report.

From the results of the groundwater monitoring carried out in the standpipes, it can be seen that standing water levels have been recorded between depths of c.4.10m and c.5.97m bgl.

When considering the lack of significant shallow water ingresses encountered during the intrusive works, and the standing water recorded during the monitoring visits, it is felt that this water is likely to be representative of perched/trapped surface water drainage within the standpipes. Therefore, some shallow ingresses of water should be anticipated where construction related excavations are taken down near to the depths where standing water has been recorded, and therefore it would be considered prudent to allow for the introduction of groundwater control measures, in order to take care of any future water ingresses within the underlying deposits particularly where excavations are to remain open to the elements for any significant period of time.

6.0 Laboratory Testing

All geotechnical testing was carried out in accordance with BS1377:1990: Parts 1-9 by Professional Soils Laboratory Limited (PSL) of Doncaster, South Yorkshire (UKAS accredited). Ground contamination was undertaken by Chemtech Environmental of Stanley, Co. Durham (UKAS & MCERTS accredited).

6.1 Determination of Liquid & Plastic Limits:-

Representative samples of the natural clay recovered from the trial pits and boreholes were tested in order to determine their liquid and plastic limits, so that these materials could be classified. In addition, the moisture contents of the samples was also derived. The results are summarised in Table 6.1 on the following page and are also contained in the PSL Analytical Report (ref no.: PSL16/3244), a copy of which is contained in Appendix IV. The results of the liquid and plastic limit testing from the previous investigation have also been summarised in Table 6.1 on the following page.

6.0 Laboratory Testing (Cont'd)

6.1 Determination of Liquid & Plastic Limits (Cont'd):-

Table 6.1

Position	Depth (m)	M/C (%)	LL	PL	PI	Class	% Passing 425µm Sieve
BH01	2.50-3.00	30	50	27	23	CI	92
TP01	3.80-3.95	23	34	23	11	CL	87
TP02	3.00	20	38	23	15	CI	90
TP03	2.60-3.15	14	28	20	8	CL	72
TP3*	2.90-3.20	36	52	28	24	CH	80
TP4*	2.10-2.50	12	39	22	17	CI	45
TP6*	1.80-2.20	31	51	24	27	CH	92
TP6*	2.20-2.50	29	55	24	31	CH	93

M/C = Moisture Content, LL = Liquid Limit, PL = Plastic Limit, PI = Plasticity Index, CL = Clay Low, CI = Clay Intermediate, CH = Clay High, * = Results from previous SI works (2009).

From these results it can be seen that the samples tested are inorganic in nature, and when plotted on the plasticity chart fall within the low, intermediate and high plasticity ranges. From the resulting plasticity indices, these clays display negligible, low and moderate volume change (shrinkage or swelling) potential, when taking into account the amount passing the 425µm sieve.

Therefore, it can be seen that some of these materials are likely to undergo significant changes in volume, if large changes in their natural moisture content were to occur due to seasonal variations or the like, and if new foundations were to be based within these clay deposits, they would need to be taken down to a minimum depth of 0.90m below finished ground levels.

However, an increase in the minimum foundation depths may be required to reach competent strata and if foundations are within close proximity to existing or proposed trees. Reference should be made to BS5837: 2012 - 'Trees in relation to design, demolition & construction', along with the NHBC Standards, 'Building near trees'.

6.2 Determination of Chemical Attack on Buried Concrete:-

In total, twelve representative soils samples of the made ground and natural deposits, and two water samples, recovered from this site were tested in order to determine their pH value and soluble sulphate (SO_4) levels. The results are shown in Table 6.2 below and continue on the following page, and are also contained in the Chemtech Environmental Limited analytical reports (ref. nos.: 59995(1) and 60388), copies of which can be seen in Appendix IV. The results of the soluble sulphate and pH value testing from the previous investigation have also been summarised in Table 6.2.

Table 6.2

Position	Depth (m)	Strata	SO_4 (mg/l)	pH value	Design SO_4 Class	ACEC Class
BH01	4.00	NAT	87	4.5	DS-1	AC-2z
BH03A	6.00-6.50	MG	194	8.7	DS-1	AC-1
BH02	3.50-4.00	NAT	97	5.7	DS-1	AC-1
TP01	1.60-2.90	MG	100	7.9	DS-1	AC-1
TP02	1.40-1.90	MG	211	7.3	DS-1	AC-1
TP03	0.80-1.10	MG	1,985	7.6	DS-3	AC-3
TP03	1.25-2.10	MG	139	8.4	DS-1	AC-1
TP04	0.90-1.20	MG	774	7.9	DS-2	AC-2
TP04	1.20-1.85	MG	394	8.0	DS-1	AC-1
TP06	0.00-1.00	MG	65	7.9	DS-1	AC-1
BH02	5.10	W	253	8.1	DS-1	AC-1

MG = Made Ground, NAT = Natural Soils, W = Water, ACEC = Aggressive Chemical Environment for Concrete site classification, * = Results from previous SI works (2009).

6.0 Laboratory Testing (Cont'd)

6.2 Determination of Chemical Attack on Buried Concrete (Cont'd):-

Table 6.2 (Cont'd)

Position	Depth (m)	Strata	SO_4 (mg/l)	pH value	Design SO_4 Class	ACEC Class
BH03A	5.97	W	1,664	7.2	DS-3	AC-3
WS1*	0.50-1.00	MG	58	8.0	DS-1	AC-1
WS3*	0.10-0.50	MG	66	7.9	DS-1	AC-1
WS4*	0.10-0.50	MG	21	8.2	DS-1	AC-1
WS5*	0.50-1.00	MG	350	8.8	DS-1	AC-1
WS6*	0.50-1.00	MG	520	8.7	DS-2	AC-2
WS7*	0.50-1.00	MG	1,800	7.8	DS-3	AC-3

MG = Made Ground, NAT = Natural Soils, W = Water, ACEC = Aggressive Chemical Environment for Concrete site classification, * = Results from previous SI works (2009).

From these results for the samples of soil and water tested, it can be seen that the amount of soluble sulphate present ranges between 21mg/l up to 1,985mg/l, and the pH values range between 4.5 up to 8.8.

Based on the mean value of the highest 20% of the results obtained, the made ground present on this site should be given a classification of Class DS-3, in accordance with BRE Special Digest 1: 2005 (3rd Edition) and the procedures for determining Sulphate Classification for brownfield locations. When considering the pH values of the materials tested, and assuming potentially mobile groundwater, the assessment of the Aggressive Chemical Environment for Concrete (ACEC) for the made ground is AC-3.

For the natural deposits, the site should be given a classification of Class DS-1, in accordance with BRE Special Digest 1: 2005 (3rd Edition). When considering the pH value of the materials tested, and assuming potentially mobile groundwater, the assessment of the Aggressive Chemical Environment for Concrete (ACEC) for the natural soils is AC-2z, due to potentially acidic ground conditions.

6.3 Contamination Screening:-

Representative samples of the made ground materials, hydrocarbon impacted soils and perched water samples recovered from this site were passed onto Chemtech Environmental of Stanley, Co. Durham, so that soil and water screening could be carried out. The catalogue of testing results can be found in the Chemtech Environmental analytical reports (ref nos.: 59995(1) and 60388), copies of which are contained in Appendix IV, and the total analysis carried out is summarised below:

Soils:-

- 8 no. Generic Soils Suites - Suite comprises; Arsenic, Cadmium, Chromium (III & VI), Copper, Lead, Mercury, Nickel, Selenium, Zinc, pH, Soluble Sulphate, free Cyanide, and Total Organic Carbon (TOC).
- 8 no. Speciated Poly-cyclic Aromatic Hydrocarbons (PAH's) – based on the current USEPA 16 PAH's + Benzo(j)fluoranthene, and Speciated Total Petroleum Hydrocarbons (TPH – Aliphatic / Aromatic Equivalent Carbon Banding) including BTEX.
- 8 no. Asbestos screens (presence), and 1 no. Asbestos Quantification

Water:-

- 2 no. Generic Suites – suite comprises; Arsenic, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Zinc, pH, Sulphate and free Cyanide.
- 2 no. Speciated Poly-cyclic Aromatic Hydrocarbons (PAH's), and speciated Total Petroleum Hydrocarbons (TPH – Aliphatic / Aromatic Equivalent Carbon Banding) including BTEX.

6.0 Laboratory Testing (Cont'd)

6.3 Contamination Screening (Cont'd):-

The soil and water screening contamination results have been used to carryout risk assessments for Human Health and Controlled Waters for potential ground contamination present, and these are discussed in Section 7.0 below and continuing on the following pages.

7.0 Ground Contamination Risk Assessment

7.1 Methodology:-

Following completion of the contamination screening undertaken on various samples from this site, a Level 1 quantitative ground contamination risk assessment has been undertaken, generally in accordance with CLR11: Model Procedures for the Management of Land Contamination. A detailed description of the Assessment Framework and Methodology used by ARC for these risk assessments can be found in Appendix V. This quantitative ground contamination risk assessment uses the current UK practice for assessing the risks from land contamination, which is based on the established *source-pathway-receptor* pollutant linkage methodology and 'suitable for use' approach (Part IIA, EPA 1990 - inserted through Section 57 EA 1995).

Based on the Conceptual Site Model (CSM) for this site (described further in the following Section 7.2), a site specific screening strategy for the site has been developed (see Section 7.3) and the risks from potential contaminants has been assessed for human health and Controlled Waters. The results of the risk assessments can be found in Sections 7.4 (Human Health) and 7.5 (Controlled Waters). Comments regarding off-site disposal can also be found in Appendix V.

7.2 Conceptual Site Model (CSM):-

Following the results of the intrusive investigation works, a Conceptual Site Model (CSM) has been developed. The investigation and this model have identified the potential for land contamination to exist on this site, comprising made ground materials and localised hydrocarbon impacted soils and perched water. Table 7.1 below summarises the *source(s)*, *pathways* and potentially sensitive *receptors* for this site, assuming no remediation, additional protection measures and/or removal of the sources contamination takes place, and this is graphically represented in the CSM drawing contained in Appendix V.

Table 7.1

	Sources (S)		***Pathways (P)***		***Receptors (R)***
S1	Made ground associated with historical development and usage of the site (i.e. iron & steel works, railway land, and demolition of historical infrastructure).	P1	Ingestion & Dermal Contact	R1	Human health
		P2	Inhalation of indoor / outdoor air	R2	Deep Groundwater (Secondary A Aquifer - Bedrock)
		P3	Plant Uptake and attached soil		
S2	Hazardous ground gas/vapours generation – made ground deposits and hydrocarbon impacted soils & water	P4	Migration through existing services	R3	River Don – c.60m north
		P5	Direct contact with building materials	R4*	Building materials
S3	Localised hydrocarbon contamination – soil & perched water	P6	Surface runoff & Infiltration	R5*	Flora and fauna

* = Not included in the Human Health & Controlled Waters Risk Assessment

7.0 Ground Contamination Risk Assessment (Cont'd)

7.2 Revised Conceptual Site Model (CSM) (Cont'd):-

7.2.1 Sources:-

The site is covered with a variable thicknesses of made ground, which represents the primary source of ground contamination for this site, recorded between c.2.50m up to c.6.70m and comprises the types of materials described in Section 4.1 of this report. The origin of these materials is most likely to be associated with the historical development and reclamation of the former iron & steel works and railway sidings.

During the investigation there was visual evidence of 'ashy' materials noted to be incorporated within the made ground matrix, and these types of materials can represent a source of potential 'organic' contamination, i.e. PAH's.

Visual and olfactory evidence of hydrocarbon impacted soils was recorded at 3 no. locations (TP's 02, 03 & 04). There was no further evidence of potential hydrocarbon contamination noted elsewhere on the site. During the sampling of perched water from CP02, whilst there was no visual or olfactory evidence of hydrocarbons, laboratory screening has identified elevated levels of Aliphatic fractions of TPH.

There was no visual evidence of potential Asbestos Containing Materials (ACM's - corrugated sheets, tiles, lagging, etc.) recorded within any of the investigation positions.

When considering the thickness of made ground present on this site (up to c.6.70m), these deposits could represent a source of potential on-site generation of hazardous ground gases, although there was no significant quantities of bio-degradable waste (i.e. paper, timber, household debris, etc.), and as such the risk has been considered as very low. However, it should be noted that the presence of hydrocarbon impacted soils/water can influence gas monitoring readings (see Section 5.3).

7.2.2 Pathways:-

When considering the proposed end use (*Residential*), and without considering treatment, removal or protection measures, there are some potential plausible pathways available for direct contact, dermal contact, ingestion, inhalation, wind (dust / particulate), volatilization, and vertical and lateral transportation below the site, both within the existing structure and externally, where there is no hard cover or vapour barriers present.

Within the CLEA Risk Assessment Model for Human Health, there are 3 exposure mediums considered for on site receptors, comprising ingestion of soil containing contaminants, inhalation of contaminated dust/vapours and dermal contact, with up to 10 no. exposure pathways considered, as shown below.

1. Ingestion of soil and indoor dust 2. Consumption of home-grown produce and attached soil 3. Dermal contact (indoor) 4. Dermal contact (outdoor) 5. Inhalation of dust (indoor) 6. Inhalation of dust (outdoor) 7. Inhalation of vapour (indoor) 8. Inhalation of vapour (outdoor) 9. Oral background intake 10. Inhalation background intake.

Where the future site layout has hard cover and below the actual new structures, some of these pathways will not be available, except where building materials / structures and services come into direct contact with the made ground.

In addition, when considering the potential pathways for leachate migration, where either hard cover and/or future surface water drainage systems are present, the potential effects of surface infiltration or contaminated surface water runoff will be greatly reduced.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.2 Revised Conceptual Site Model (CSM) (Cont'd):-

7.2.2 Pathways (Cont'd):-

Similarly, when considering the construction work force, exposure pathways through direct contact, ingestion and dust inhalation will be available during part of the construction process, and therefore adequate PPE should be provided to protect the work force during this period.

7.2.3 Receptors:-

Within the CLEA Risk Assessment Model for Human Health, the potential receptors are assessed initially on site end use, followed by a delineation of age category (i.e. child or adult), with default settings for *Residential, Allotment* and *Public Open Space (Park)* end uses based on a child aged 0 to 6 years, *Public Open Space (Residential)* based on a child aged 3 to 9 and *Commercial* end uses based upon an adult working exposure period of up to 49 years (i.e. 16 to 65).

Key generic assumptions for *Residential* and *Public Open Space (Residential)* are based upon a typical residential property, consisting of a two-storey small terraced house, with private garden, and a *Commercial* end use based upon a typical commercial or light industrial property, consisting of a three-storey office building (pre-1970). No buildings are anticipated for *Allotment* or *Public Open Space (Park)* end uses.

Within the CLEA Risk Assessment Model for Human Health there are 6 no. generic end use categories presently in use, as follows;

1) Residential - with home grown produce, 2) Residential - without home grown produce, 3) Allotments, 4) Commercial
5) Public Open Space – Residential, 6) Public Open Space - Park

When considering the proposed end use of this site (residential development), the Level 1 Risk Assessment has taken the best fit end use category as:

2) Residential - with home grown produce

For Controlled Waters and assuming a worst case scenario, the primary receptor for the Level 1 Risk Assessment is potential deep groundwater within the underlying bedrock (Secondary A Aquifer), and the River Don located c.60m to the north of the site.

The perched water encountered within the underlying made ground materials on the southern portion of the site, is not considered to be a primary receptor as this water is not considered as a potential aquifer or potential potable supply of water. In addition, it is felt that when taking into account the significant industrial heritage of the site and surrounding area, as well as the cessation of these industrial processes, the levels of any potential contaminants are unlikely to pose a significant risk to the underlying Secondary A Aquifer.

7.3 Screening Strategy:-

Representative samples of the made ground were screened using a standard generic contamination suite (metals, metalloids and non-organics), which is used to assess typical made ground (disturbed natural strata mixed with anthropogenic debris) of an unknown source, and these materials have been assessed as a single averaging area.

Due to the presence of 'ashy' materials within the made ground matrix, samples have been screened for speciated PAH's, with these assessed as a single averaging area.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.3 Screening Strategy (Cont'd):-

When considering the visual and olfactory evidence of hydrocarbon impacted soils and water, selected samples have been screened for speciated TPH's, BTEX and MTBE in order to determine any potential risks, and also to enable these materials to be assessed for the purposes of off-site disposal.

In addition, although no potential ACM's were noted within any of the exploratory positions or any of the materials sampled, screening for the presence of asbestos has been undertaken in order to determine any potential risks. Where the presence of asbestos has been detected, further quantitative screening has been carried out so that a detailed risk assessment can be completed.

When considering the findings of the investigation works and the results of the contamination screening, in order to determine if potential contamination on this site represents a potential risk to Controlled Waters and adjacent sites, two perched water samples have been subjected to contamination testing.

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health:-

7.4.1 BH02 'Hot Spot':-

When considering the findings of these investigation works, and on closer examination of the screening results, it can be seen that spatially BH02 appears to represent a potential localised 'hot spot' of metal contamination, due to significantly higher concentrations of some metals, which is markedly different from the remainder of the site. The results of the analysis and risk assessment have been summarised in Table 7.2 below.

Table 7.2

Analyte	Critical Conc. (C_C)	No. of Samples Screened	Max. Conc. (C_M) Recorded
Arsenic	**37[1]**	**1**	**65**
Cadmium	11[1]	1	0.9
Chromium III	910[1]	1	42
Chromium VI	6[1]	1	<1
Copper	**2,400[1]**	**1**	**27,361**
Lead	**200[2]**	**1**	**1,657**
Mercury	40[1]	1	<0.5
Nickel	**130[1]**	**1**	**455**
Selenium	250[1]	1	2.6
Zinc	**3,700[1]**	**1**	**3,901**
Cyanide	34[3]	1	<1

[1] = LQM S4UL's (2014 & 2015) – *Residential with home grown produce*, [2] = CL:AIRE C4SL's – *Residential with home grown produce,* [3] = ATRISK^{SOIL} SSV, **Bold** = result exceeds critical concentration, Note = All units are mg/kg.

The results have identified the following:

- The maximum concentration (C_M) values for Arsenic, Copper, Lead, Nickel and Zinc exceed the critical concentration (C_C) values for this site, and therefore these analytes are considered to represent a risk to future end users on this site.
- Whilst the results of the contamination screening and analysis has identified significantly elevated levels of Arsenic, Copper, Lead, Nickel and Zinc contamination within the made ground which could pose a risk to human health, it can be seen that this sample was taken at a depth of c.3.50m bgl, and therefore at this stage it is felt that there would be no requirement for removal, treatment, protection measures and/or further risk assessment in order to protect future end users, since this material is too deep to represent a risk to human health from either oral, dermal or inhalation pathways.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health (Cont'd):-

7.4.2 Generic Screening Suite:-

The results of the testing carried out on samples of made ground obtained during these additional investigation works, have been combined with the previous testing results completed by OPUS, to provide a larger sample population for the made ground present across the site.

The generic soil screening results have been subjected to statistical analysis utilising the contaminated land statistical analysis sheets developed by CL:AIRE, and a copy of the calculation sheets can be found in Appendix V. The results of the analysis and risk assessment have been summarised in Table 7.3 below.

Table 7.3

Analyte	Critical Conc. (C_C)	No. of Samples Screened	Max. Conc. (C_M) Recorded	Statistical Upper Confidence Limit ($UCL_{0.95}$)	Has $UCL_{0.95}$ exceeded C_C	No. of Samples > C_C	Is C_M a statistical outlier
Arsenic	**37(1)**	**13**	**92**	**54.71**	**Yes**	**6**	**No**
Cadmium	11(1)	13	2.9	1.50	No	0	No
Chromium III	910(1)	13	122	81.99	No	0	No
Chromium VI	6(1)	7	<1	0.50	No	0	No
Copper	2,400(1)	13	778	625.32	No	0	No
Lead	**200(2)**	**13**	**460**	**272.14**	**Yes**	**2**	**No**
Mercury	40(1)	13	0.2	0.28	No	0	No
Nickel	130(1)	13	124	76.55	No	0	No
Selenium	250(1)	13	5.0	2.76	No	0	No
Zinc	3,700(1)	13	445	296.60	No	0	No
Cyanide	34(3)	13	<1	0.57	No	0	No

(1) = LQM S4UL's (2014 & 2015) – *Residential with home grown produce*, (2) = CL:AIRE C4SL's – *Residential with home grown produce,* (3) = ATRISK^{SOIL} SSV, **Bold** = result exceeds critical concentration, Note = All units are mg/kg.

The results have identified the following:

- The maximum concentration (C_M) and upper confidence limit ($UCL_{0.95}$) values for Arsenic and Lead exceed the critical concentration (C_C) values for this site.
- The C_M values for Arsenic & Lead are not recorded as statistical 'hot spots', and therefore the $UCL_{0.95}$ values are considered to be representative of the site as a whole, indicating that elevated Arsenic & Lead is pervasive across the whole of the site, and therefore these are considered to represent a risk to future end users on this site.
- None of the C_M or $UCL_{0.95}$ values for any of the remaining analytes exceed the C_C values for this site.
- None of the C_M values for any of the remaining metals and metalloids are recorded as statistical outliers (i.e. potential 'hot spots').
- The results of the contamination screening and analysis has identified elevated and pervasive Arsenic & Lead contamination within the made ground which could pose a risk to human health where exposure pathways will be available, and therefore there is a requirement for removal, treatment, protection measures and/or further risk assessment in order to protect future end users (i.e. no risk to human health).

7.4.3 Speciated PAH Screening:-

Selected samples of the made ground materials from across the site have been screened for speciated PAH's in order to determine any potential risks to human health. These results have also been combined with the previous testing results completed by OPUS, to provide a larger sample population for the made ground present across the site.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health (Cont'd):-

7.4.3 Speciated PAH Screening (Cont'd):-

Again the sample population has been subjected to statistical analysis utilising the contaminated land statistical analysis sheets, and a copy of the calculation sheet is contained in Appendix V. The results of the analysis and risk assessment have been summarised in Table 7.4 below.

Table 7.4

Analyte	Critical Conc. (C_C)	No. of Samples Screened	Max. Conc. (C_M) Recorded	Statistical Upper Confidence Limit ($UCL_{0.95}$)	Has $UCL_{0.95}$ exceeded C_C	No. of Samples > C_C	Is C_M a statistical outlier
Speciated PAH's							
Acenaphthene	1,100[1]	13	0.29	0.17	No	0	No
Acenaphthylene	920[1]	13	0.30	0.19	No	0	No
Anthracene	11,000[1]	13	1.90	1.05	No	0	No
Benzo(a)anthracene	13[1]	13	7.51	3.93	No	0	No
Benzo(a)pyrene	**3.0[1]**	**13**	**9.59**	**5.13**	**Yes**	**2**	**No**
Benzo(b)fluoranthene	**3.7[1]**	**13**	**8.47**	**4.61**	**Yes**	**2**	**No**
Benzo(ghi)perylene	350[1]	13	5.74	3.04	No	0	No
Benzo(k)fluoranthene	100[1]	13	4.16	2.19	No	0	No
Chrysene	27[1]	13	5.41	2.98	No	0	No
Dibenz(ah)anthracene	**0.30[1]**	**13**	**1.03**	**0.46**	**Yes**	**5**	**No**
Fluoranthene	890[1]	13	14.77	8.44	No	0	No
Fluorene	860[1]	13	0.60	0.29	No	0	No
Indeno(123cd)pyrene	41[1]	13	7.63	3.92	No	0	No
Naphthalene	13[1]	13	0.97	0.51	No	0	No
Phenanthrene	440[1]	13	5.80	3.17	No	0	No
Pyrene	2,000[1]	13	13.92	7.67	No	0	No

[1] = LQM S4UL's (2014) – *Residential with home grown produce* (6% SOM), **Bold** = result exceeds critical concentration, Note = All units are mg/kg.

The results of the Speciated PAH analysis has identified the following:

- The maximum concentration (C_M) and upper confidence limit ($UCL_{0.95}$) values for Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(ah)anthracene exceed the critical concentration (C_C) values for this site.
- The C_M values for Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(ah)anthracene are not recorded as statistical 'hot spots', and therefore the $UCL_{0.95}$ values are considered to be representative of the site as a whole, indicating that elevated Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(ah)anthracene are pervasive across the whole of the site, and therefore these are considered to represent a risk to future end users on this site.
- None of the C_M or $UCL_{0.95}$ values for any of the remaining analytes exceed the C_C values for this site.
- None of the C_M values for any of the remaining PAH' are recorded as statistical outliers (i.e. potential 'hot spots').
- The results of the contamination screening and analysis has identified elevated and pervasive Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(ah)anthracene contamination within the made ground which could pose a risk to human health where exposure pathways will be available, and therefore there is a requirement for removal, treatment, protection measures and/or further risk assessment in order to protect future end users (i.e. no risk to human health).

7.0 Ground Contamination Risk Assessment (Cont'd)

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health (Cont'd):-

7.4.4 Speciated TPH Screening – Made Ground:-

The speciated TPH, BTEX and MTBE results have been assessed as potential 'hot spots' when considering the visual and olfactory evidence identified across the site, and therefore the maximum values recorded for each speciated analyte have been compared to the critical concentration values chosen for this site. The results of the analysis and risk assessment have been summarised in Table 7.5 below.

Table 7.5

Analyte	Critical Conc. (C_C)	No. of Samples Screened	Max. Conc. (C_M) Recorded	No. of Samples > C_C
Speciated TPH's				
Aliphatic EC5-EC6	160(1)	8	<0.01	0
Aliphatic EC6-EC8	530(1)	8	<0.01	0
Aliphatic EC8-EC10	150(1)	8	<0.01	0
Aliphatic EC10-EC12	760(1)	8	193	0
Aliphatic EC12-EC16	4,300(1)	8	1,110	0
Aliphatic EC16-EC35	110,000(1)	8	6,134	0
Aliphatic EC35-EC44	110,000(1)	8	906	0
Aromatic EC5-EC7	300(1)	8	<0.1	0
Aromatic EC7-EC8	660(1)	8	<0.1	0
Aromatic EC8-EC10	190(1)	8	0.90	0
Aromatic EC10-EC12	380(1)	8	<1	0
Aromatic EC12-EC16	660(1)	8	<1	0
Aromatic EC16-EC21	930(1)	8	31	0
Aromatic EC21-EC35	1,700(1)	8	44	0
Aromatic EC35-EC44	1,700(1)	8	6	0
Benzene	0.37(1)	8	<0.01	0
Toluene	660(1)	8	<0.01	0
Ethylbenzene	260(1)	8	<0.01	0
m & p-Xylene	310(1)	8	<0.02	0
o- Xylene	330(1)	8	<0.01	0
MTBE	160(2)	8	<0.02	0

(1) = LQM S4UL's (2014) – Residen*tial with plant uptake* – based on 6.0% SOM, (2) = CL:AIRE GAC's – *Residential with plant uptake* - 6% SOM, **Bold** = result exceeds critical concentration, Note = All units are mg/kg.

The results have identified the following:

- None of the maximum concentration (C_M) values for any of the speciated TPH, BTEX or MTBE analytes exceed the critical concentration (C_C) values taken for this site.
- As such the results of the TPH screening and analysis has confirmed that the made ground is not considered to pose a risk to human health where exposure pathways are available, and therefore there is no requirement for removal, treatment, protection measures and/or further risk assessment.

7.4.5 Asbestos Screening:-

The results of the asbestos screening is summarised in Table 7.6 on the following page, and has identified the following:

- As can be seen from the samples screened, Amosite has been identified at the location of TP02.
- The remaining samples screened have not identified the presence of any ACM's or fibres.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health (Cont'd):-

7.4.5 Asbestos Screening (Cont'd):-

Table 7.6

Position	Depth (m)	Chrysotile (white)	Amosite (brown)	Crocidolite (blue)	Anthophyl-lite	Actinolite	Tremolite
BH02	3.50-4.00	NAD	NAD	NAD	NAD	NAD	NAD
TP01	1.60-2.90	NAD	NAD	NAD	NAD	NAD	NAD
TP02	**1.40-1.90**	**N**	**Y**	**N**	**N**	**N**	**N**
TP03	0.80-1.10	NAD	NAD	NAD	NAD	NAD	NAD
TP03	1.25-2.10	NAD	NAD	NAD	NAD	NAD	NAD
TP04	0.90-1.20	NAD	NAD	NAD	NAD	NAD	NAD
TP04	1.20-1.85	NAD	NAD	NAD	NAD	NAD	NAD
TP06	0.00-1.00	NAD	NAD	NAD	NAD	NAD	NAD

NAD = No Asbestos detected, Y = Yes asbestos present, N = No asbestos present.

Asbestos Quantification & Detailed Risk Assessment:-

Further quantitative screening has been carried out in order to assess the level of risk posed to future end users from the asbestos recorded within the made ground materials at TP02, with the results of this testing recording a concentration of 0.002% *w/w* of Amosite.

At present, whilst there are currently no suitable generic assessment criteria for assessing risks from asbestos within the soil in the UK, further risk assessment can be undertaken based upon the considered fibre release potential, in accordance with current guidance (CIRIA C733 – Asbestos in soil and made ground: a guide to understanding and managing risks (2014)). Currently, there is limited published data relating to the potential release of fibres from asbestos containing soils following physical disturbances (i.e. excavation, vehicle movement, children playing, etc.) either in the UK or elsewhere. However, one of the few empirical studies was conducted by Addison *et al* (1988), which simulated the potential release of three types of Asbestos (Chrysotile, Amosite and Crocidolite) for three soil types (sandy, intermediate and clay), at asbestos concentrations of 0.1%, 0.01% and 0.001% *w/w*. From this study, it was determined that asbestos concentrations as low as 0.001%*w/w* had the potential to give rise to airbourne asbestos concentrations greater than 0.1 f/ml^{-1}, with these results being determined for dry soils with no moisture content. Therefore, further assessment has been undertaken for this site with regards to the positive quantification of Amosite asbestos identified in TP02, and the exposure estimation is summarised in Table 7.7 below and continuing on the following page.

Exposure Estimation:-

Table 7.7

Parameter	TP02 – 1.40-1.90m
Asbestos Type	Amosite
Asbestos Concentration	0.002%
Soil Type[1]	Sand
Predicted normalised fibre concentration[2]	0.06 f ml^{-1} / mg m^{-3}
Airbourne fibre concentration (C_i) during such activities in dry and dusty conditions[3]	0.006 f/ml
End User Justification	Residential end users are likely to conduct activities in outdoor areas under dry and dusty conditions for an average of 90 hours per year (F_i. T_i), as a conservative estimate for the proposed end use (based on the worked example given in Box 13.3 within CIRIA C733 Asbestos in soil and made ground: a guide to understanding and managing risks).

7.0 Ground Contamination Risk Assessment (Cont'd)

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health (Cont'd):-

7.4.5 Asbestos Screening (Cont'd):-

Exposure Estimation (Cont'd):-

Table 7.7 (Cont'd)

Parameter	TP02 – 1.40-1.90m
Annual Exposure (E_i)	0.006 f/ml x 90 hrs/yr = **0.54 f/ml.hours/year**
Receptor(s) Justification	Most sensitive receptor deemed to be child aged from 0 to 6 years (greatest exposure in garden areas).
Cumulative Exposure (CE_i)	0.54 f/ml.hours/year x 6 years = **3.24 fibre/ml.hours**
Cumulative Exposure (CE_i) adjustment for occupational exposure[4]	3.24 fibre/ml.hours / 2000hrs = **0.0016 fibre/ml.years**

[1] = In accordance with Addison *et al.*
[2] = Taken from Figure 6 in the Addison *et al* study.
[3] = In accordance with CIRIA C733 the concentration of soil dust during gardening activities in dry and dusty conditions is estimated at about 100µg/m³ (i.e. 0.1mg/m³), based on ambient urban dust levels and ART modelling of shovelling dry powders.
[4] = Lung cancer and mesothelioma models are based on occupational exposures, the conversion from hours to years has been based on the number of hours in an occupational working year, which is generally taken to be 48 weeks of 40 hours (rounded to 2000 hours).

Mesothelioma Risk:-

The potential lifetime risk for mesothelioma is taken from Table 14.1 in the CIRIA C733 document, and is summarised in Table 7.8 below.

Table 7.8

Parameter	TP02 – 1.40-1.90m
Asbestos Type	Amosite
Cumulative Exposure (CE_i)	**0.0016 fibres/ml.years**
Lifetime risk per 100,000 exposed[1]	<2 per 100,000
Receptor(s) Justification[2]	Child aged 0 to 6
Age adjustment factor[3]	2.8
Cumulative Exposure (CE_i) after Age-adjustment	0.0016 fibres/ml.years x 2.8 = **0.0045 fibres/ml.years**
Lifetime risk per 100,000 exposed	**<2 per 100,000**

[1] = cumulative exposure based on exposure from aged 30 over 5yrs.
[2] = Consideration has also been made by applying an age adjustment factor for the mesothelioma risk dependent on the age at which exposure starts, as there is a potential increased risk where the exposure can commence at a younger age.
[3] = Appropriate age-adjustment factor taken from Table 14.2.

Lung Cancer Risk:-

The Lung Cancer Risk is based on Table 14.3 in the CIRIA C733 document, and is summarised in Table 7.9 below.

Table 7.9

Parameter	TP02 – 1.40-1.90m
Asbestos Type	Amosite
Cumulative Exposure (CE_i)	**0.0016 fibres/ml.years**
Lifetime risk per 100,000 exposed	**Between 1 & 3 per 100,000**

Excess Lifetime Cancer Risk:-

The excess lifetime cancer risk is assessed by combining the mesothelioma and lung cancer risks, and is summarised in Table 7.10 on the following page.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health (Cont'd):-

7.4.5 Asbestos Screening (Cont'd):-

Excess Lifetime Cancer Risk (Cont'd):-

Table 7.10

Parameter	TP02 – 1.40-1.90m
Asbestos Type	Amosite
Mesothelioma Risk	<2 per 100,000
Lung Cancer Risk	Between 1 & 3 per 100,000
Combined Mesothelioma & Lund Cancer Risk - Lifetime risk per 100,000 exposed	**<5 per 100,000**

Further Considerations:-

The release of airbourne asbestos is also strongly influenced by soil moisture content, with the addition of 5% moisture reducing potential airbourne asbestos by 80% to 95%, with no fibres being detected at above 25% moisture content. The moisture content of the made ground sample from TP02 was c.11% therefore reducing the level of potential risk with regards to airbourne release of asbestos.

Conclusions:-

When considering the concentration of potential Amosite asbestos identified within the made ground at the location of TP02 (concentrations 0.002% *w/w* Amosite), this has the potential lifetime risk to affect <5 per 100,000 exposed. In terms of risk estimation, 1 per 100,000 is deemed as a 'probably insignificant' risk, and the generation potential of the asbestos fibres becoming airborne from this assessment suggests this just exceeds the lower threshold and therefore it is felt that this represents a low risk to human health associated with these materials.

The findings of the screening has identified the presence of asbestos fibres within the samples screened, although this does not appear to be present in significant quantities, particularly when considering the lack of visual evidence of asbestos containing materials on site within the made ground. A proportion of the site will comprise hardcover (building footprints, driveways, road & car parking infrastructure) which will further reduce the exposure risk on this site, once the development is completed, therefore the only potential risk areas will be where areas of private gardens and soft landscaping are proposed, although this would represent a low risk. Nonetheless, in order to reduce risks to negligible levels made ground materials should not be exposed at the surface and should be covered by a minimum of 600mm clean topsoil.

Consideration should be given during the construction phase to potential asbestos fibre release whilst groundworkers are constructing foundations and service excavations, and as such the following precautions should be considered to protect the health of construction workers during groundwork preparation:-

- Suitable PPE should be provided to construction workers during groundwork preparation or when entering excavations, typically dust masks, disposal overalls, etc.
- Any excavations left open for a long period of time should be suitably covered to prevent wind-blown particles/fibres escaping from open excavations, so as to provide protection for the public.
- During dry periods of weather, groundwork preparation and where open excavations exist, the made ground materials should be dampened with water to prevent potential wind-blown particles/fibres from becoming airbourne.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.4 Level 1 Generic Quantitative Risk Assessment - Human Health (Cont'd):-

7.4.5 Asbestos Screening (Cont'd):-

Conclusions (Cont'd):-

- Following the formation of any excavations for foundations and drainage runs, the base of the excavation should be blinded with a concrete screed to limit the potential for wind-blown particles/fines to become airbourne.

7.5 Level 2 Generic Quantitative Risk Assessment – Controlled Waters:-

Two samples of perched water obtained from BH's 02 and 03, were subjected to screening for metals, metalloids, non-organics, speciated PAH, speciated TPH, BTEX and MTBE. The results have been used to complete a Level 2 Risk Assessment for the potential impact on Controlled Waters and adjacent sites. The results are summarised in Table 7.11 below and continues on the following page.

Table 7.11

Analyte	Target Conc. (C_T)	Max. Conc. (C_M) Recorded	Has max. C_T Value Been Exceeded	Number of samples >C_T
Arsenic	50(1)	4.38	No	0
Boron	2000(1)	318	No	0
Cadmium	5(1)	0.23	No	0
Chromium	250(1)	0.3	No	0
Copper	**28(1)**	**31.4**	**Yes**	**1 (BH02)**
Lead	250(1)	0.2	No	0
Mercury	1(1)	<0.008	No	0
Nickel	50(1)	18.7	No	0
Selenium	10(2)	3.22	No	0
Zinc	500(1)	32	No	0
Sulphate	**400mg/l(1)**	**1,664mg/l**	**Yes**	**1 (BH03A)**
Cyanide	50(2)	<20	No	0
Speciated PAH's				
Acenaphthene	**0.1(2)**	**1.6**	**Yes**	**1 (BH02)**
Acenaphthylene	0.1(2)	<0.1	No	0
Anthracene	**0.1(2)**	**2.6**	**Yes**	**1 (BH02)**
Benzo(a)anthracene	**0.1(2)**	**1.0**	**Yes**	**1 (BH02)**
Benzo(a)pyrene	**0.01(2)**	**1.0**	**Yes**	**2 (BH's 02 & 03A)**
Benzo(b)fluoranthene	**0.1(2)**	**1.1**	**Yes**	**2 (BH's 02 & 03A)**
Benzo(ghi)perylene	**0.1(2)**	**0.3**	**Yes**	**1 (BH02)**
Benzo(k)fluoranthene	**0.1(2)**	**0.5**	**Yes**	**2 (BH's 02 & 03A)**
Chrysene	**0.1(2)**	**1.1**	**Yes**	**1 (BH02)**
Dibenz(ah)anthracene	0.1(2)	<0.1	No	0
Fluoranthene	**0.1(2)**	**6.7**	**Yes**	**2 (BH's 02 & 03A)**
Fluorene	**0.1(2)**	**1.9**	**Yes**	**1 (BH02)**
Indeno(123cd)pyrene	0.1(2)	<0.1	No	0
Naphthalene	**10(1)**	**1.1**	**Yes**	**2 (BH's 02 & 03A)**
Phenanthrene	**0.1(2)**	**8.9**	**Yes**	**2 (BH's 02 & 03A)**
Pyrene	**0.1(2)**	**5.9**	**Yes**	**2 (BH's 02 & 03A)**

(1) = EQS Freshwater, (2) = UK Drinking Standard, (3) = WHO Health, **Bold** = result exceeds critical concentration, Note = All units are µg/l unless stated.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.5 Level 2 Generic Quantitative Risk Assessment – Controlled Waters (Cont'd):-

Table 7.11 (Cont'd)

Analyte	Target Conc. (C_T)	Max. Conc. (C_M) Recorded	Has max. C_T Value Been Exceeded	Number of samples >C_T
Speciated TPH's				
Aliphatic EC5-EC6	10[2]	7	No	0
Aliphatic EC6-EC8	**10[2]**	**19**	**Yes**	**1 (BH02)**
Aliphatic EC8-EC10	**10[2]**	**68**	**Yes**	**1 (BH02)**
Aliphatic EC10-EC12	**10[2]**	**296**	**Yes**	**1 (BH02)**
Aliphatic EC12-EC16	**10[2]**	**1,131**	**Yes**	**1 (BH02)**
Aliphatic EC16-EC35	**10[2]**	**2,909**	**Yes**	**2 (BH's 02 & 03A)**
Aliphatic EC35-EC44	**10[2]**	**243**	**Yes**	**1 (BH02)**
Aromatic EC5-EC7	10[2]	1	No	0
Aromatic EC7-EC8	10[2]	1	No	0
Aromatic EC8-EC10	10[2]	3	No	0
Aromatic EC10-EC12	10[2]	4	No	0
Aromatic EC12-EC16	10[2]	6	No	0
Aromatic EC16-EC21	**10[2]**	**30**	**Yes**	**1 (BH02)**
Aromatic EC21-EC35	10[2]	8	No	0
Aromatic EC35-EC44	10[2]	1	No	0
Benzene	30[1]	1	No	0
Toluene	30[1]	1	No	0
Ethylbenzene	300[3]	2	No	0
m & p-Xylene	30[1]	<2	No	0
o-Xylene	30[1]	1	No	0
MTBE	15[3]	6	No	0

[1] = EQS Freshwater, [2] = UK Drinking Standard, [3] = WHO Health, **Bold** = result exceeds critical concentration, Note = All units are µg/l unless stated.

The results have identified the following:

- The C_M values for the majority of the speciated PAH's, the Aliphatic fractions of the speciated TPH's and Copper exceed the C_T values taken for this site, associated with perched water at the locations of BH's 02 & 03A.
- The C_M value for Sulphate exceeds the C_T value taken for this site. This elevated sulphate could be attributable to presence of slag within the made ground.
- From these results and the risk assessment completed, it can be seen that impacted water containing elevated concentrations of copper, sulphate, PAH's and TPH's could represent a potential risk to Controlled Waters and adjacent sites.

From these results it can be seen that the levels of TPH recorded would indicate that potential water movement will be impacted with hydrocarbons. However when considering the maximum solubility of TPH's within water, then the maximum values recorded generally far exceed the maximum solubility of the individual TPH fractions. Given that the values of TPH fractions recorded within the water far exceed the maximum feasible solubility, then it is considered that these values must be attributable to an alternative factor. At this stage it is anticipated that the elevated TPH values recorded relate to a film or emulsion on the water as opposed to hydrocarbons dissolved within the water, particularly when considering that no free-phase fraction was noted during the intrusive investigation works. A film or emulsion of hydrocarbon contamination does not behave in the same way as free phase products and has no significant mobility in water as they will be immobilised by adsorption on to the soil framework and pore spaces.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.5 Level 2 Generic Quantitative Risk Assessment – Controlled Waters (Cont'd):-

Therefore, the risk of off-site migration of the TPH contamination to outlying receptors is considered to be reduced since the film or emulsion of hydrocarbons is likely to be attenuated on site or close to the site within the soil frameworks and/or pore spaces.

As such it is felt that there is no plausible risk for these hydrocarbon concentrations to significantly impact Controlled Waters or migrate to adjacent sites.

8.0 Conclusions & Recommendations

8.1 Ground Conditions:-

From the results of the investigation works carried out, the site surfacing comprised grass and soil, which is underlain by clay, sand and gravel containing predominantly brick, concrete and slag rubble (constitutes approx. c.30%-c.40% of the made ground matrix). At some positions the presence of ash, cinder, clinker, coal and burnt siltstone was also recorded. Relic intact brick walls and concrete slabs (BH02 and TP06), along with large boulder sized blocks of concrete and fused slag (TP05) were also recorded within the made ground matrix.

The natural drift comprises soft silty sandy gravelly clay, and firm to stiff (high strength) slightly sandy slightly gravelly clay, before encountering the natural siltstone solid geology at depths of between c.3.15m up to c.6.70m bgl.

There was visual evidence of 'ashy' materials noted within the made ground, as well as localised potential 'hot spots' of hydrocarbon impacted soils (TP's 02, 03 & 04) and perched water (BH02). There was no visual evidence of potential asbestos containing materials (ACM's) noted within the made ground materials at any of the investigation positions.

Within the solid deposits, no coal seams were encountered, nor any voiding or soft ground indicative of broken ground associated with historic mine workings below the site. Consistent drilling rates were maintained during the drilling period. Therefore it is felt that the proposed development can be constructed without the need for incorporating any remedial measures to mitigate against future shallow mining related ground movement.

8.2 Groundwater:-

During the investigation period, no water strikes or significant ingresses were recorded within any of the investigation positions put down.

From the results of the groundwater monitoring carried out in the standpipes, standing water levels have been recorded between depths of c.4.10m and c.5.97m bgl, generally comprising perched water at the base of the monitoring standpipes.

When considering the lack of water ingresses encountered during the intrusive works, and the water recorded during the monitoring visits, this water is likely to be representative of perched surface water drainage within the made ground rather than representing a natural shallow continuous groundwater surface (water table).

However, when considering the nature of the made ground materials (i.e. mixed clay and granular deposits) and the underlying impermeable natural clay drift deposits, there may be potential for some perched surface water migration through these materials, and as such some shallow water ingresses could be problematic for the proposed development particularly during construction related excavations.

8.0 Conclusions & Recommendations

8.2 Groundwater (Cont'd):-

Therefore, it would be prudent to allow for the introduction of temporary groundwater control measures (i.e. pumping equipment, adequate shoring), in order to take care of any localised ingresses of water during the construction period, and especially during the wetter periods of the year.

8.3 Hazardous Ground Gas Risk Assessment:-

From the results of the gas monitoring visits, no detectable concentrations of Methane (CH_4) have been recorded. Concentrations of Carbon Dioxide (CO_2) have currently been recorded up to a maximum level of 2.2%, with negligible flow rates being recorded (<0.1l/hr). Additional monitoring for Hexane, and the use of a Photo Ionisation Detector (PID) meter will be used on the remaining 3 no. monitoring visits to be completed, in order to monitor the installations for potential volatile vapours.

Based on these results, it is felt that the site can be assessed as Characteristic Situation 1 (CS1) and Green (in accordance with the NHBC Traffic light system) indicating that no gas protection would be required for the proposed residential development.

It should be noted that a final risk assessment will be undertaken following the completion of the remaining three gas monitoring visits, and a reassessment of the site characterisation classification made. This will be issued as an addendum to this report.

8.4 Foundation Options:-

Based on the information gained from these intrusive investigation works, the site is recorded to be underlain by between c.3.15m and c.6.70m of made ground, along with the presence of relic structures and large obstructions which will hinder the construction of foundations, as well as the installation of services and drainage infrastructures. In addition, no shallow homogenous bearing medium is apparent, i.e. the upper soils (c.3.00m) vary from sandy gravelly clay and very gravelly sand with anthropogenic debris (brick, concrete, ash, etc.) over the proposed development area and the foundation zones of influence, which may prove significant with regard to differential settlement for conventional shallow strip footings.

The main risk of basing foundations in both cohesive and granular made ground deposits is the rate, rather than the magnitude of settlement. Granular soils tend to settle quickly (i.e. over the construction period), whereas clays can settle over a number of years. This in the short to medium term can lead to differential settlement, with the sand influenced foundations having undergone the expected amount of settlement and the clays essentially "catching up" over a slower time period.

In this instance typical solutions to overcome the geotechnical issues on this site would be:-

1. Support any new structures on a suitably reinforced raft/semi-rafted foundations,
2. Utilise ground improvement techniques to homogenise the founding strata
3. Support the new structures on piles

Solution 1

The proposed residential development could be supported on reinforced rafted/semi-rafted (pseudo-raft) foundations based at a minimum depth of 0.60m below current ground levels, on a minimum 300mm stone sub-base. An allowable bearing pressure of 75kN/m^2 should not be exceeded.

8.0 Conclusions & Recommendations (Cont'd)

8.4 Foundation Options (Cont'd):-

Solution 2

Alternatively, another option may be the use of ground improvement i.e. vibro-stone columns. The introduction of strengthening materials, i.e. clean graded stone can enable cohesive and granular materials to carry increased foundation loads, without the excessive settlements occurring.

The provision of a detailed ground improvement scheme is beyond the scope of this investigation and advice should be sought from an experienced ground improvement contractors. Consideration to this technique will need to take into consideration the presence of obstructions and the like, and therefore local excavation and removal of relic structures and large obstructions may need to be undertaken prior to this technique being utilised.

Following ground improvement, shallow strip and pad foundations should prove acceptable. The resultant bearing pressure should be in the order of 75kN/m^2 to 150kN/m^2, although this would need to be confirmed by the chosen ground improvement contractor, and further load testing may be required to satisfy regulators.

A potential alternative method of ground improvement might be a 'site turnover'. This would involve the full excavation of the deep made ground before replacement in engineered conditions i.e. crushed and screened of any obstructions graded to a specific type and compacted in layers. The obstructions (typically brickwork, concrete and slag) can be crushed to a specified grading and re-used. Following re-engineering of the fill, conventional reinforced shallow foundations could be utilised with the allowable bearing pressure dependent upon the performance of the engineered fill which would be determined by the compaction and validation methods adopted by the ground improvement specialist.

Solution 3

Alternatively a piled foundation solution could be adopted, with the piles taken down to a suitable bearing medium (most likely the underlying solid deposits). In this instance, due to the numerous types of pile and installation methods used, it is recommended that the information contained within this report should be passed onto specialist contractors so that they can design and price a suitable scheme.

It should be noted that potential buried relic structures and other large obstructions are present below the site, particularly when considering the obstructions encountered (TP's 05 and 06) comprising a concrete slab, relic brick walls and large boulders of slag. Therefore some types of piles may not be suitable due to obstructions in the made ground materials and as such the requirement for pre-auguring or local excavation and removal may need to be considered, especially where buried concrete slabs/footings have been noted.

When taking into consideration the estimated slag content identified during these works and the fact this is contained in a matrix of clay and sand, as well as the fact that much of the fill is likely to have undergone full hydration due to perched water or water infiltration, the presence of slag is not felt to be significant in terms of slag expansion. However this will need to be taken into account for any future pile foundations, and the use of sleeved piles through the made ground are recommended.

Steep slopes are evident on the north and east of the site. Based on visual observations these are around c.0.80m up to c.7.60m in height, with slope angles in the order of c15o up to c.22o. Based on the logging of the soils, and insitu testing carried out, the slopes can be characterised as mainly granular, with characteristic SPT 'N' values of around 30, evident for the made ground as a whole. Based on the type and density of the slope makeup, an estimated internal angle of friction for these soils is calculated at 36o. Given the slope angles are significantly less than this angle of repose there is a negligible risk of long term slope instability.

8.0 Conclusions & Recommendations (Cont'd)

8.4 Foundation Options (Cont'd):-

It is recommended that structures are constructed at least 5m from the top of the slope and suitable drainage is installed to ensure the slopes are free draining.

For any shallow foundations constructed across the site, based within the cohesive made ground materials, an increase in the minimum foundation depths may be required if foundations are within close proximity to existing or proposed trees. Reference should be made to BS5837: 2012, "Trees in relation to design, demolition and construction - Recommendations".

From the results of the pH and soluble sulphate testing, it can be seen that future foundations and buried concrete constructed wholly within the made ground materials should be constructed utilising a concrete design class of DS-3 and ACEC class of AC-3. However, where the construction of concrete extends into the underlying natural deposits, the concrete should be designed to DS-1 and an ACEC class of AC2z due to potentially acidic ground conditions.

During the construction phase, it would be beneficial for a suitably qualified Geotechnical Engineer / Engineering Geologist to attend site in order to confirm the correct founding strata has been achieved within all foundation excavations, as variations have been duly noted.

Bearing in mind the nature of the majority of the materials encountered on this site lateral trench support will be required for most excavations, including drainage, service runs, etc., in order to prevent trench wall collapse or over excavation, as well as to provide a safe working environment below a depth of 1.20m. Reference to CIRIA 97 'Trenching Practice' would be beneficial to establish a suitable means of support or battering of excavation sides during construction.

Founding soils are likely to be susceptible to poor weather conditions and therefore it is recommended that excavations remain open for as short a period as possible, since most of these materials will be susceptible to significant deterioration, if left open to the natural elements even for short periods of time. Similarly foundation excavations could be protected further with a layer of blinding concrete.

8.5 Ground Contamination:-

Made Ground:-

From the results of the contamination screening carried out and the Level 1 Risk Assessments (Section 7.0) undertaken, the results have identified pervasive levels of Arsenic, Lead, Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(ah)anthracene within the underlying made ground materials which could represent a potential future risk to end users. The remaining metals, metalloids, non-organics and speciated PAH's screened for do not pose a significant risk to human health.

The results of the speciated TPH contamination screening and risk assessment have concluded that the made ground is not considered to pose a risk to human health where exposure pathways are available (i.e. no risk to human health).

During the investigation works no asbestos containing materials were noted, however the results of the asbestos screening has identified the presence of Amosite at one location only (TP02). Quantitative testing identified that the amount of Amosite present was 0.002% *w/w*, and following detailed risk assessment this is felt to represent a low risk to future end users (<5 per 100,000 people exposed).

8.0 Conclusions & Recommendations (Cont'd)

8.5 Ground Contamination (Cont'd):-

Made Ground (Cont'd):-

Whilst the results of the asbestos screening would generally suggest that the made ground materials are not heavily or grossly contaminated with asbestos fibres, the potential for unforeseen 'hot spots' of ACM's may still exist and as such it would be prudent for the appointed groundworks contractor to undertake a visual inspection of all excavations and arisings to identify that no suspicious materials are present. Should any unforeseen asbestos containing materials (ACM's) be encountered during the construction phase then these should be dealt with accordingly, with appropriate site protocols put in place during any excavation or during transportation (i.e. suppression by water, appropriately covered, etc.), in order to protect the health of construction workers and members of the public.

When considering the above results, it is felt that remedial measures, in the likely form of clean cover of at least 0.60m thick, will be required in order to protect future end users (i.e. no risk to human health) from the contamination identified on this site. Once the final layout has been determined for this site, a Remediation Strategy should be prepared, which will need to be submitted and agreed with the Local Authority.

Controlled Waters:-

From the results of the water screening carried out on, elevated concentrations of sulphate, copper, speciated PAH's and speciated TPH's have been recorded within the perched water encountered in the boreholes to exceed stringent environmental quality target concentration values.

With particular regard to the elevated TPH's, it can be seen that the maximum values recorded generally far exceed the maximum solubility of the individual TPH fractions, and therefore it is felt that the value recorded are likely to be attributable relate to a film or emulsion on the water as opposed to hydrocarbons dissolved within the water, particularly when considering that no free-phase fraction was noted during the intrusive investigation works. The risk of off-site migration of the TPH contamination to outlying receptors is considered to be reduced since the film or emulsion of hydrocarbons is likely to be attenuated on site. In addition, it should be noted that a shallow groundwater table has not been encountered below the site area, and therefore when taking into further consideration potential attenuation and degradation of the contaminants, as well as the dilution factor of deep groundwater, and future hard cover of the site post-development, it is felt that concentrations of contaminants are unlikely to represent a significant risk to Controlled Waters or migrate to adjacent sites.

Off-site Disposal:-

Where made ground materials are to be removed off site as a 'waste', the results of the contamination screening completed can be used to carry out a preliminary waste classification assessment. At this stage, it is felt that the made ground should initially be considered as both Non-Hazardous and Hazardous waste, due to the presence of some elevated levels of metals and TPH's. As such prior to the disposal of these materials, it is recommended that the results of the contamination screening for this site are passed on to waste management operators for their comments. Prior to disposal of these materials, full WAC screening may need to be undertaken, with the number of samples to be screened dependent upon the volume of material to be disposed of.

Where any excavated natural strata is to be removed from site as a waste, then this can be considered as Inert Waste, provided this remains separate from any 'topsoil' or made ground excavated from this site. At this stage, no Waste Acceptance Criteria (WAC) screening is considered necessary for these materials prior to disposal.

8.0 Conclusions & Recommendations (Cont'd)

8.5 Ground Contamination (Cont'd):-

Construction Workforce:-

When considering the risks to any future maintenance or construction workforce, appropriate PPE should be provided to protect against the levels of potential contaminants recorded during these investigation works. Similarly, the results can also be used by the Main Contractor / Project Coordinator, when devising an adequate Site Health & Safety Plan, in accordance with current CDM Regulations. For further guidance reference should be made to the Health and Safety Executive (HSE) document EH40/2005 (2nd Edition, 2011) Workplace exposure limits.

8.6 General Comments:-

When considering the construction, and bearing in mind the nature of the materials encountered on this site as well as the presence of perched water within the made ground, lateral trench support will be required for most excavations, including drainage, service runs, etc., in order to prevent trench wall collapse or over excavation, as well as to provide a safe working environment below a depth of 1.20m.

Reference to CIRIA 97 'Trenching Practice' would be beneficial to establish a suitable means of support or battering of excavation sides during construction.

It is also recommended for any new developments, adequate surface drainage should be designed and installed by a competent contractor, in order to prevent surface water 'ponding' or collection, during and post construction, particularly where existing surface drainage systems are disrupted or damaged.

Furthermore, for deeper excavations, drainage, service runs or the like that may pass close to or beneath any proposed new foundations, these should be undertaken with care and completed prior to the preparation of any new foundations, so as not to allow any loose or granular material to move or 'flow', thus causing settlement to occur to any new foundations based at a higher level.

An "observational technique" can be applied to the design and construction of this site, and where ground conditions seem to vary from that indicated from the conceptual ground model derived from works to date, then advice from a suitably qualified Engineering Geologist/Geotechnical Engineer should be sought.

END OF REPORT

GENERAL REFERENCES

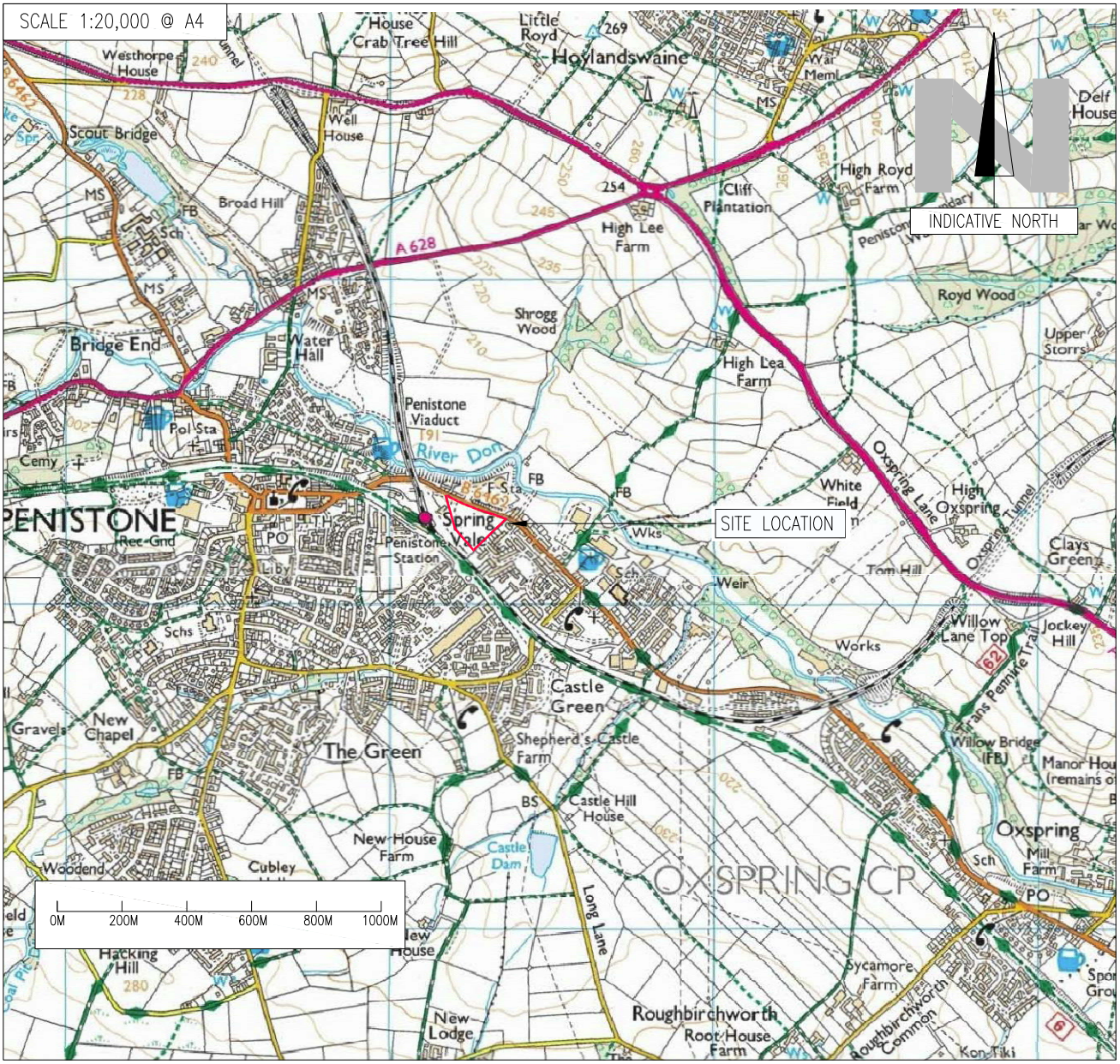
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APPENDIX I

Location Plan
Aerial Photograph
Existing & Proposed Site Layout Plans



Client:

STRATEGIC TEAM GROUP

Project Title:	Drawing Title:
Proposed Residential Development Lairds Way Penistone, South Yorkshire	Location Plan

rev.	date	amendments	drawn	chckd

Job Reference:	Drawing Number:	Revision:
16-384	–	–

Drawn by:	Date:	Scale at A4:
P.D	27.07.16	As Shown

Checked by:	Approved by:	
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LEGEND	
	APPROXIMATE SITE BOUNDARY

rev.	date	amendments	drawn	chckd

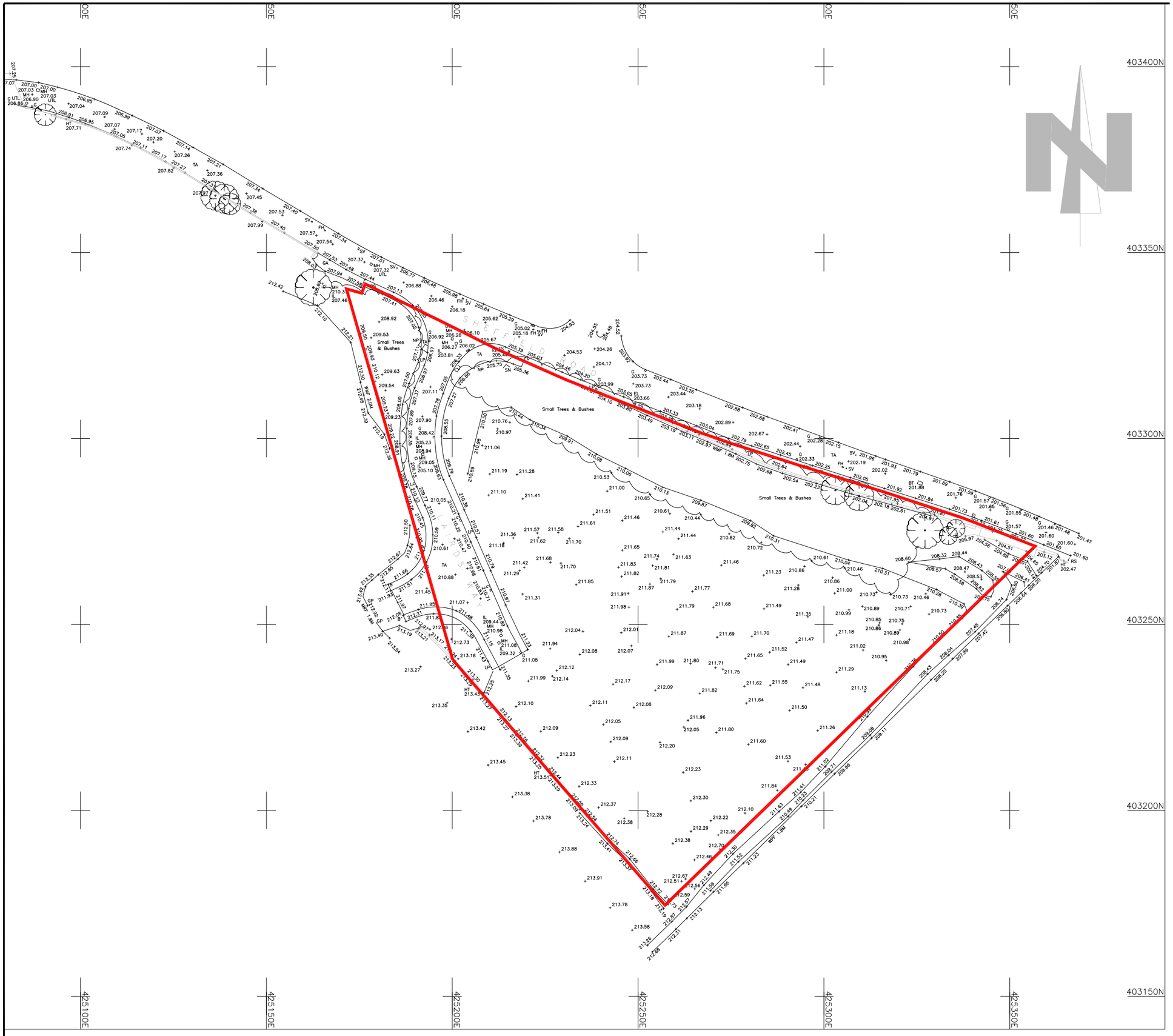
Client:
STRATEGIC TEAM GROUP

Project Title:
Proposed Residential Development
Lairds Way
Penistone, South Yorkshire

Drawing Title:
Aerial Photograph

Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	27.10.16	P.D	R.S

Job Ref:	Drg no:	Rev:
16-384	–	–



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Fax: (0191) 378 0494
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web: www.arc-environmental.com

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LEGEND

	APPROXIMATE SITE BOUNDARY

rev.	date	amendments	drawn	chckd

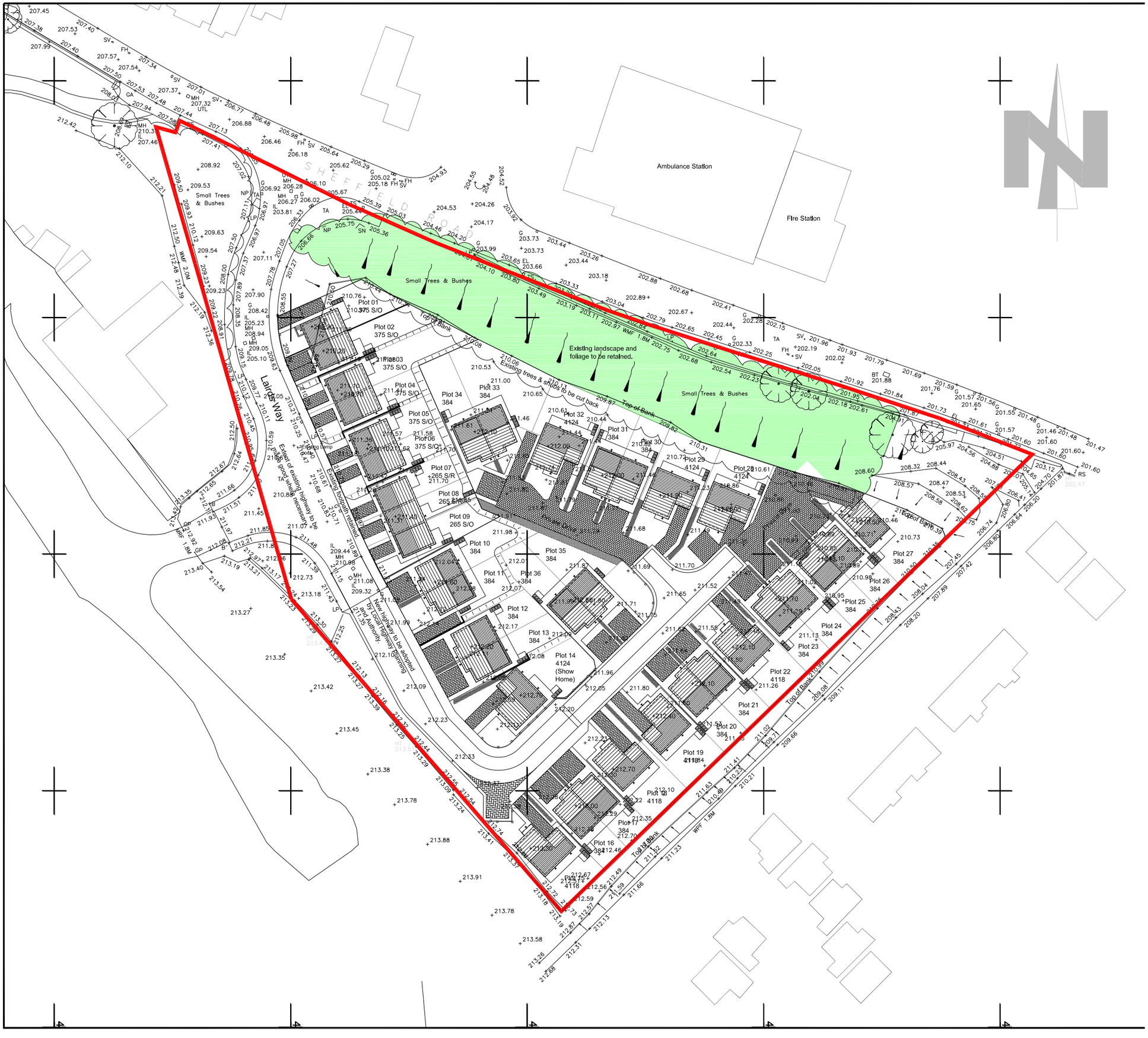
Client:
STRATEGIC TEAM GROUP

Project Title:
Proposed Residential Development
Lairds Way
Penistone, South Yorkshire

Drawing Title:
Existing Site Layout Plan

Scale at A3:	Date:	Drawn by:	Approved by:
1:1000 @ A3	27.10.16	P.D	R.S

Job Ref:	Drg no:	Rev:
16-384	–	–



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LEGEND

	APPROXIMATE SITE BOUNDARY

rev.	date	amendments	drawn	chckd

Client:
STRATEGIC TEAM GROUP

Project Title:
Proposed Residential Development
Lairds Way
Penistone, South Yorkshire

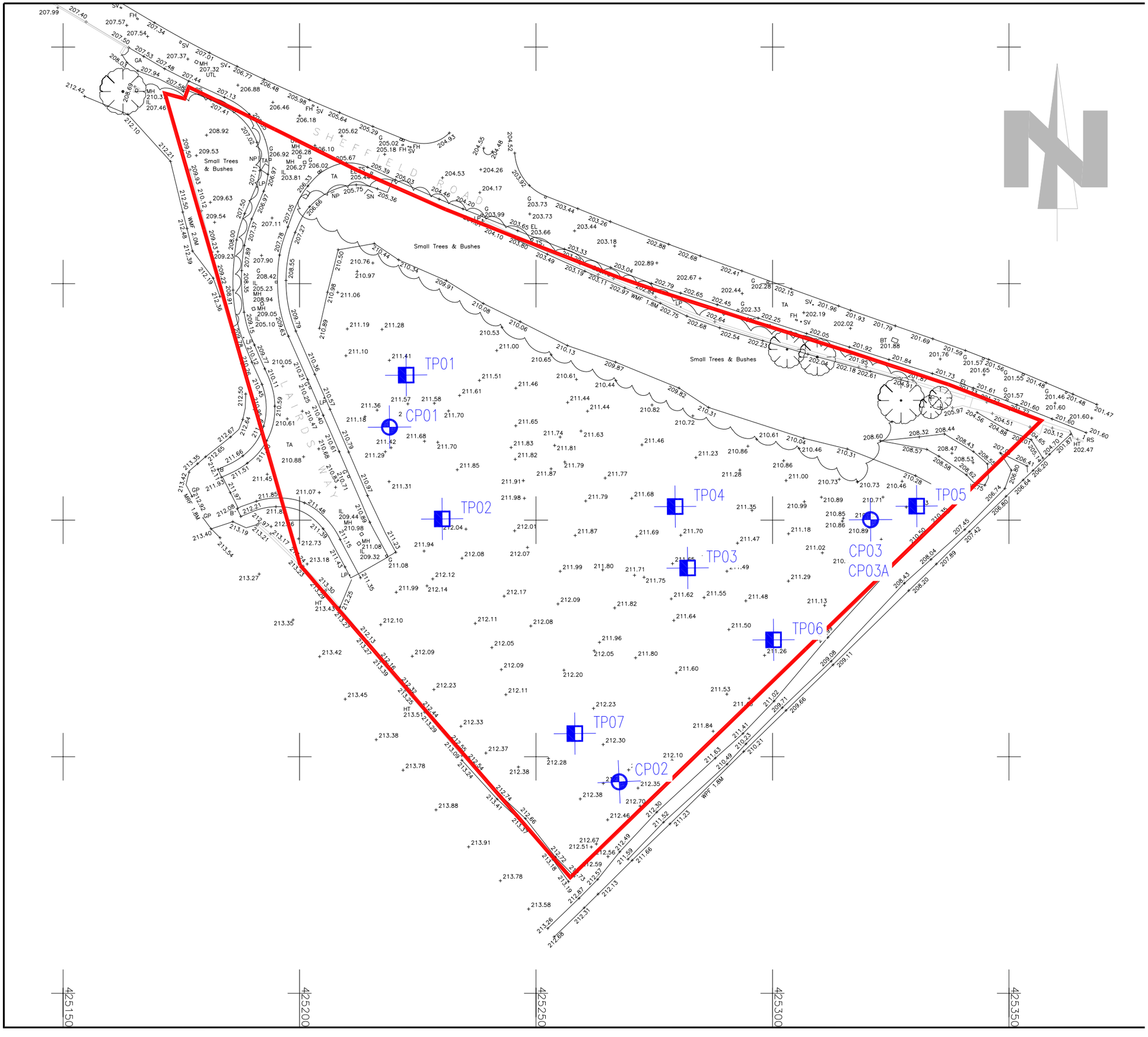
Drawing Title:
Proposed Development Layout Plan

Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	27.10.16	P.D	R.S

Job Ref:	Drg no:	Rev:
16-384	–	–

APPENDIX II

Trial Pit & Borehole Location Plan and Trial Pit & Borehole Record Sheets



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LEGEND	
	APPROXIMATE SITE BOUNDARY
	CABLE PERCUSSION BOREHOLE POSITION
	MECHANICALLY EXCAVATED TRIAL PIT POSITION

rev.	date	amendments	drawn	chckd

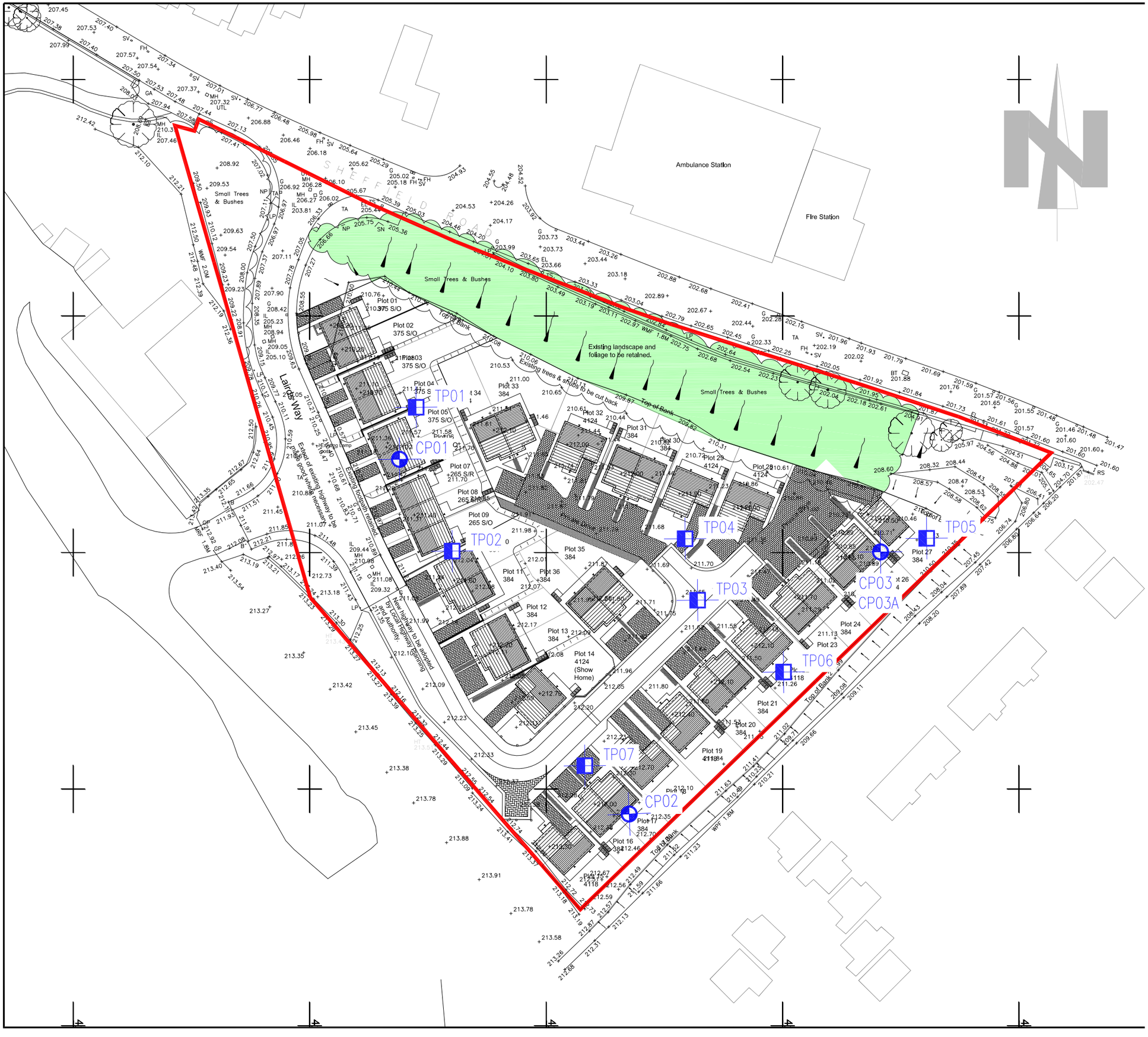
Client:
STRATEGIC TEAM GROUP

Project Title:
Proposed Residential Development
Lairds Way
Penistone, South Yorkshire

Drawing Title:
Borehole and Trial Pit Location Plan (Existing)

Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	27.10.16	P.D	R.S

Job Ref:	Drg no:	Rev:
16-384	–	–



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LEGEND	
	APPROXIMATE SITE BOUNDARY
	CABLE PERCUSSION BOREHOLE POSITION
	MECHANICALLY EXCAVATED TRIAL PIT POSITION

rev.	date	amendments	drawn	chckd

Client:
STRATEGIC TEAM GROUP

Project Title:
Proposed Residential Development
Lairds Way
Penistone, South Yorkshire

Drawing Title:
Borehole and Trial Pit Location Plan (Proposed)

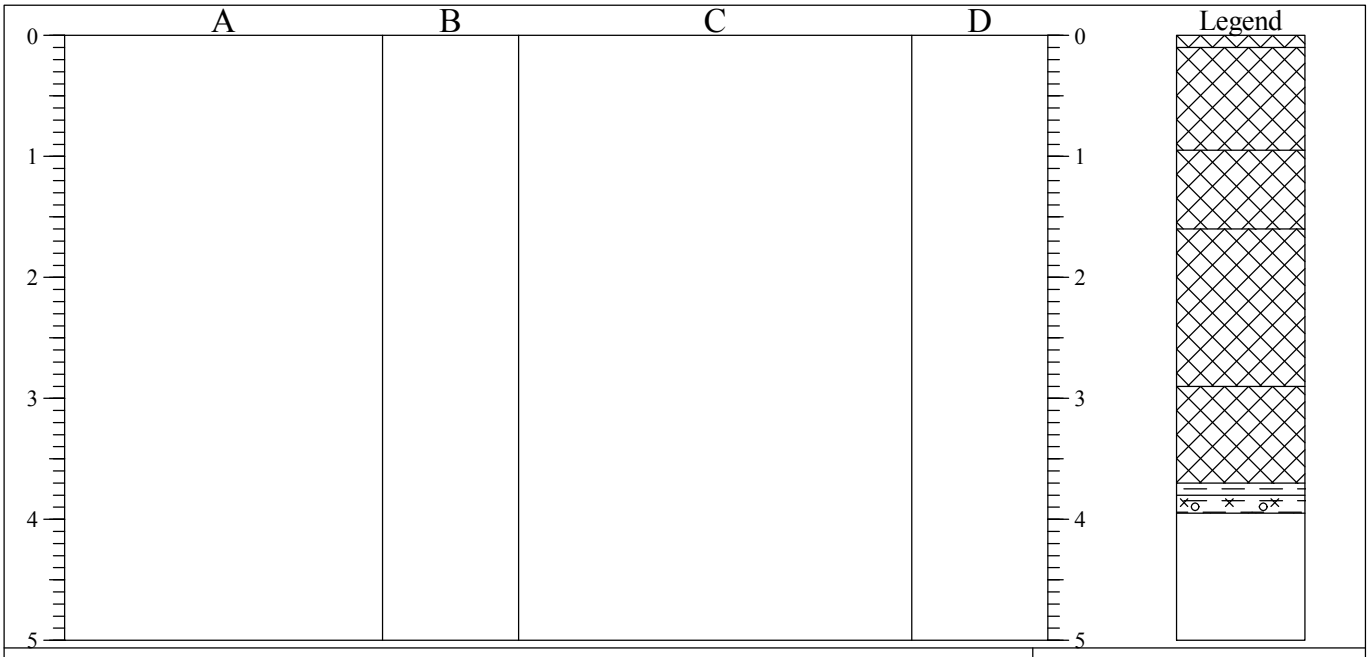
Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	27.10.16	P.D	R.S

Job Ref:	Drg no:	Rev:
16-384	–	–

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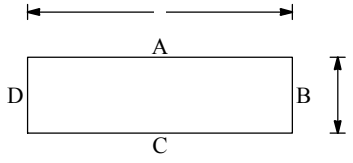
TRIAL PIT LOG

Project				TRIAL PIT No
Lairds Way, Penistone				TP01
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.10		Dark brown sandy clayey soil (MADE GROUND).			
0.10-0.95		Dark brown clayey gravelly sand with fragments of brick, sandstone and dark grey fused / vesicular slag (MADE GROUND).	0.80	J/D	
0.95-1.60		Very stiff light brown and grey gravelly clay with cobbles and boulders of dark grey fused / vesicular slag and sandstone (MADE GROUND).	0.95-1.60	J/D	
1.60-2.90		Black gravelly sand with fragments, cobbles and boulders of ash, clinker, cinder, coal and glassy / vitreous slag (MADE GROUND).	1.60-2.90	J/D	
2.90-3.70		Soft light brown and grey gravelly clay with fragments, cobbles and boulders of dark grey fused / vesicular slag, clinker, cinder and coal. Very large boulder sized fragment (c.1m square) of dark grey fused / vesicular slag noted in side wall of excavation (MADE GROUND).			
3.70-3.80		Stiff (high strength) brown and grey slightly sandy slightly gravelly CLAY.	3.70-3.80	B	
3.80-3.95		Soft yellowish light brown silty sandy gravelly CLAY. Gravel is fine to coarse of siltstone.	3.75	V	96kN/m^2
3.95		Trial pit terminated at c.3.95m bgl.	3.80-3.95	B	

Shoring/Support:
Stability:





GENERAL REMARKS

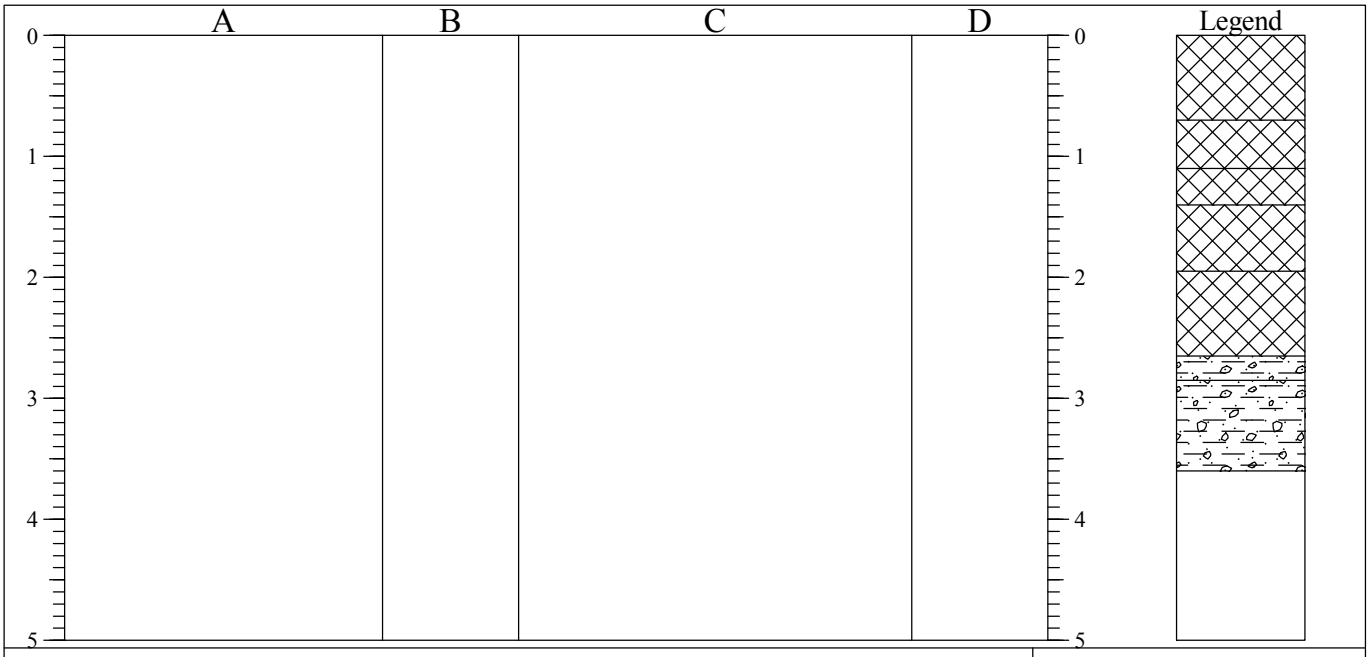
WATER: Trial pit remained dry on completion.

All dimensions in metres Scale 1:62.5	Client Strategic Team Group	Method/ Plant Used Hitachi ZX130 Excavator	Logged By RS

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Telephone: 01913786380

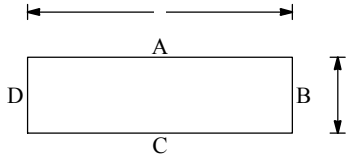
TRIAL PIT LOG

Project				TRIAL PIT No
Lairds Way, Penistone				**TP02**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.70		Overgrown grass underlain by dark brown very sandy very gravelly clay with fragments of brick and sandstone (MADE GROUND).	0.10-0.70	J/D	
0.70-1.10		Brown and yellowish brown very sandy very gravelly clay with fragments of sandstone (MADE GROUND).	0.70-1.40	J/D	
1.10-1.40		Grey very sandy very gravelly clay with fragments of sandstone (MADE GROUND).			
1.40-1.95		Black gravelly sand of ash with fragments, cobbles and boulders of dark grey fused / vesicular slag and brick (MADE GROUND).	1.40-1.95	J/D	
1.95-2.65		** Slight hydrocarbon odour noted ** Light brown sandy very gravelly clay with abundant fragments of sandstone (MADE GROUND).			
2.65-2.85		Dark grey and black mottled slightly sandy gravelly CLAY (Relic topsoil layer).	2.65-2.85	J/D	
2.85-3.60		** Very slight hydrocarbon odour noted ** Firm (high strength) light brown, greyish black and orange brown slightly sandy slightly gravelly CLAY. Note to become very gravelly with depth. Bedded siltstone noted in southern end of excavation.	3.00 3.00	B V	100kN/m^2
3.60		Trial pit terminated at c.3.60m bgl.			

Shoring/Support:
Stability:





GENERAL REMARKS

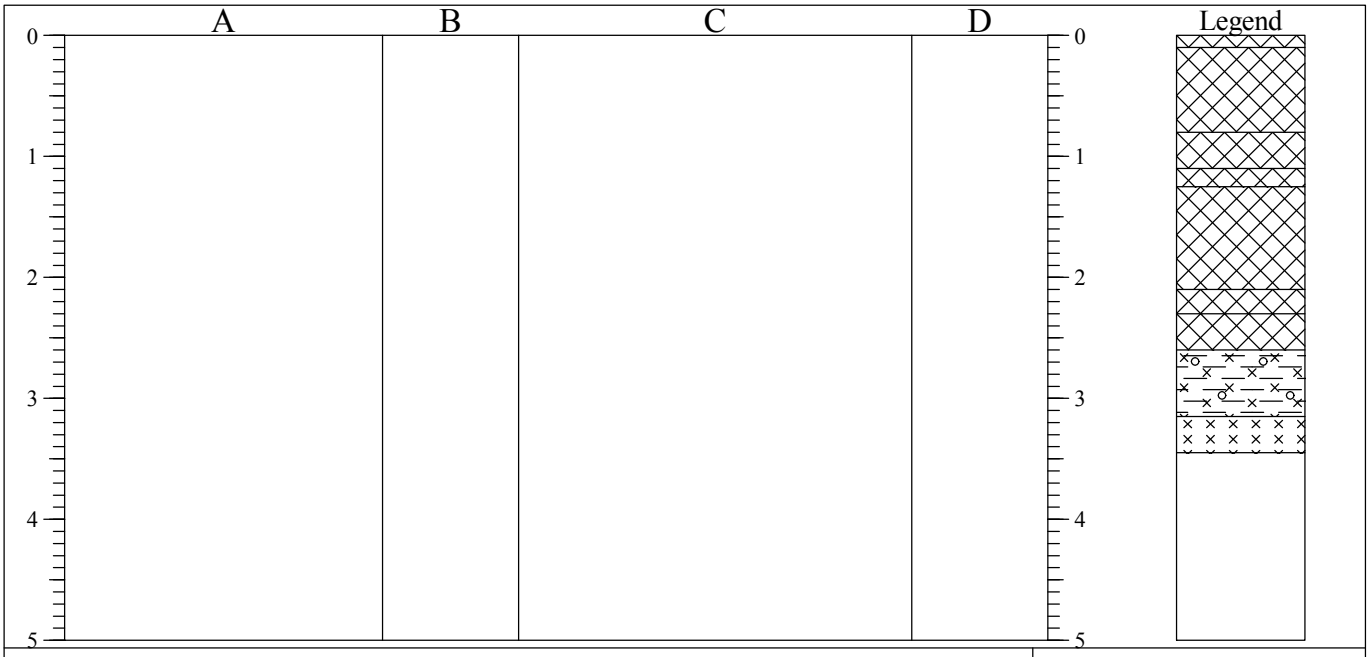
WATER: Trial pit remained dry on completion.

All dimensions in metres Scale 1:62.5	Client Strategic Team Group	Method/ Plant Used Hitachi ZX130 Excavator	Logged By RS

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TRIAL PIT LOG

Project				TRIAL PIT No
Lairds Way, Penistone				TP03
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1



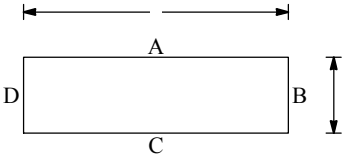
STRATA

Depth	No	DESCRIPTION
0.00-0.10		Dark brown sandy clayey soil (MADE GROUND).
0.10-0.80		Dark brown clayey very gravelly sand with fragments of brick, ash, sandstone and dark grey fused / vesicular slag (MADE GROUND).
0.80-1.10		Dark grey very sandy gravelly clay (MADE GROUND).
1.10-1.25		** Slight hydrocarbon odour noted **
1.25-2.10		Dark brown very sandy gravelly clay (MADE GROUND).
		Dark reddish brown gravelly sand with fragments, cobbles and boulders of concrete, sandstone, ash, cinder and dark grey fused / vesicular slag (MADE GROUND).
2.10-2.30		Light brown very gravelly sand with abundant fragments of sandstone (MADE GROUND).
2.30-2.60		Dark brown and grey slightly sandy very gravelly clay with fine fragments of brick (MADE GROUND/DISTURBED STRATA).
2.60-3.15		Soft light brown slightly sandy very gravelly CLAY. Gravel is fine to coarse of siltstone.
3.15-3.45		Light brown highly weathered bedded SILTSTONE, recovered as silty fine to coarse gravel and cobbles sized fragments with occasional blocks of carbonaceous mudstone (LOWER COAL MEASURES).
3.45		Trial pit terminated at c.3.45m bgl.

SAMPLES & TESTS

Depth	No	Remarks/Tests
0.00-0.10	J/D	
0.10-0.80	J/D	
0.80-1.10	J/D	
1.25-2.10	J/D	
2.30-2.60	J/D	
2.60-3.15	B	
3.15-3.45	B	

Shoring/Support:
Stability:





GENERAL REMARKS

WATER: Trial pit remained dry on completion.

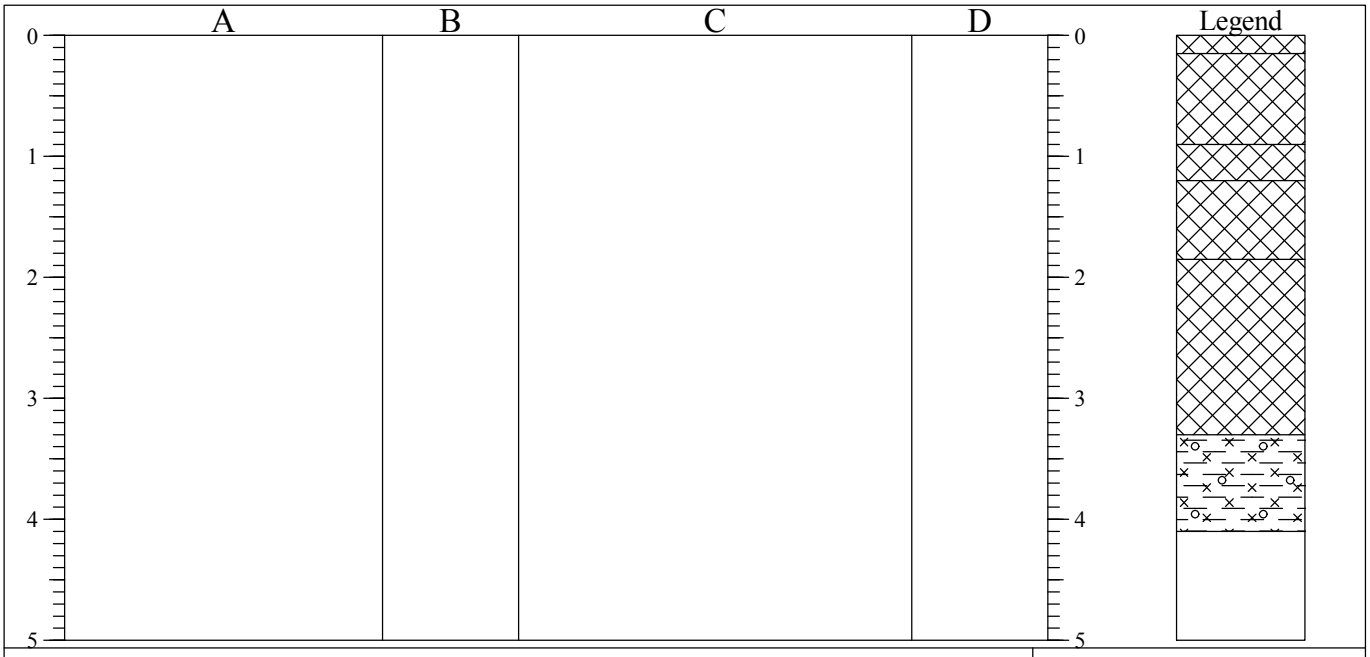
All dimensions in metres Scale 1:62.5	Client Strategic Team Group	Method/ Plant Used Hitachi ZX130 Excavator	Logged By RS

AGS3 UK TP 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

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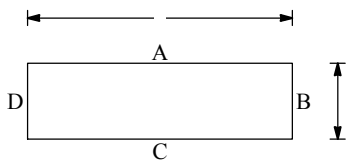
TRIAL PIT LOG

Project				TRIAL PIT No
Lairds Way, Penistone				TP04
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.15		Dark brown sandy clayey soil (MADE GROUND).	0.00-0.15	J/D	
0.15-0.90		Dark brown clayey very gravelly sand with fragments of brick, concrete, ash, sandstone and dark grey fused / vesicular slag (MADE GROUND).	0.15-0.90	J/D	
0.90-1.20		Dark grey and black gravelly sand of ash, cinder, clinker and dark grey fused / vesicular slag (MADE GROUND).	0.90-1.20	J/D	
1.20-1.85		** Slight hydrocarbon odour noted **	1.20-1.85	J/D	
1.85-3.30		Dark reddish brown gravelly sand with fragments, cobbles and boulders of concrete, sandstone, ash, cinder and dark grey fused / vesicular slag (MADE GROUND). Bright reddish brown sandy gravel and cobble sized fragments of burnt siltstone with ash, cinder and clinker (MADE GROUND).			
3.30-4.10		Light brown silty very gravelly CLAY. Gravel is fine to coarse of siltstone. Noted to become very highly weathered siltstone, recovered as clayey silty fine to coarse gravel and cobble sized fragments (RESIDUAL SOIL).	3.50	B	
4.10		Trial pit terminated at c.4.10m bgl.			

Shoring/Support:
Stability:





GENERAL REMARKS

WATER: Trial pit remained dry on completion.

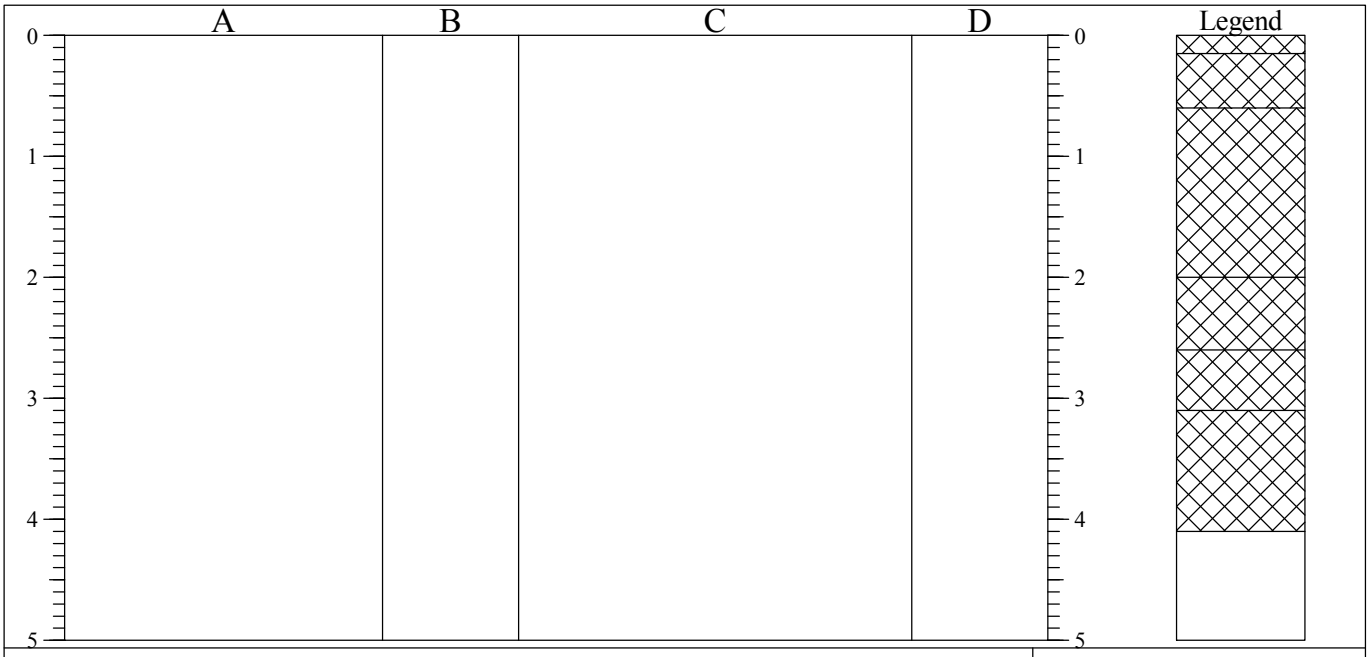
All dimensions in metres Scale 1:62.5	Client Strategic Team Group	Method/ Plant Used Hitachi ZX130 Excavator	Logged By RS

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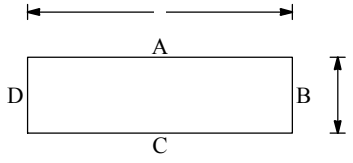
TRIAL PIT LOG

Project				TRIAL PIT No
Lairds Way, Penistone				TP05
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.15		Overgrown grass and bramble underlain by dark brown sandy clayey soil (MADE GROUND).	0.00-0.15	J/D	
0.15-0.60		Dark brown clayey very gravelly sand with fragments of brick, concrete, ash, sandstone and dark grey fused / vesicular slag (MADE GROUND).	0.15-0.60	J/D	
0.60-2.00		Greyish brown very gravelly sand with abundant fragments of bricks and concrete. Concrete obstruction with re-bar noted in excavation - moved to enable trial to be extended down (MADE GROUND).	1.00-2.00	J/D	
2.00-2.60		Brown very gravelly sand with fragments, cobbles and boulders of concrete, brick, refractory brick, furnace flue brick, dark grey fused / vesicular slag, sandstone, and occasional metal, timber. Boulder of fused dark grey fused / vesicular slag encountered at c.2.70m (c.1.20m x c.1.00m x c.0.5m) (MADE GROUND).			
2.60-3.10		Dark reddish brown gravelly sand with fragments, cobbles and boulders of concrete, sandstone, ash, cinder and dark grey fused / vesicular slag (MADE GROUND).	2.60-3.10	J/D	
3.10-4.10		Bright reddish brown sandy gravel and cobble sized fragments of burnt siltstone with ash, cinder and clinker (MADE GROUND).	3.10-4.10	J/D	
4.10		Trial pit terminated at c.4.10m bgl.			

Shoring/Support:
Stability:





GENERAL REMARKS

WATER: Trial pit remained dry on completion.

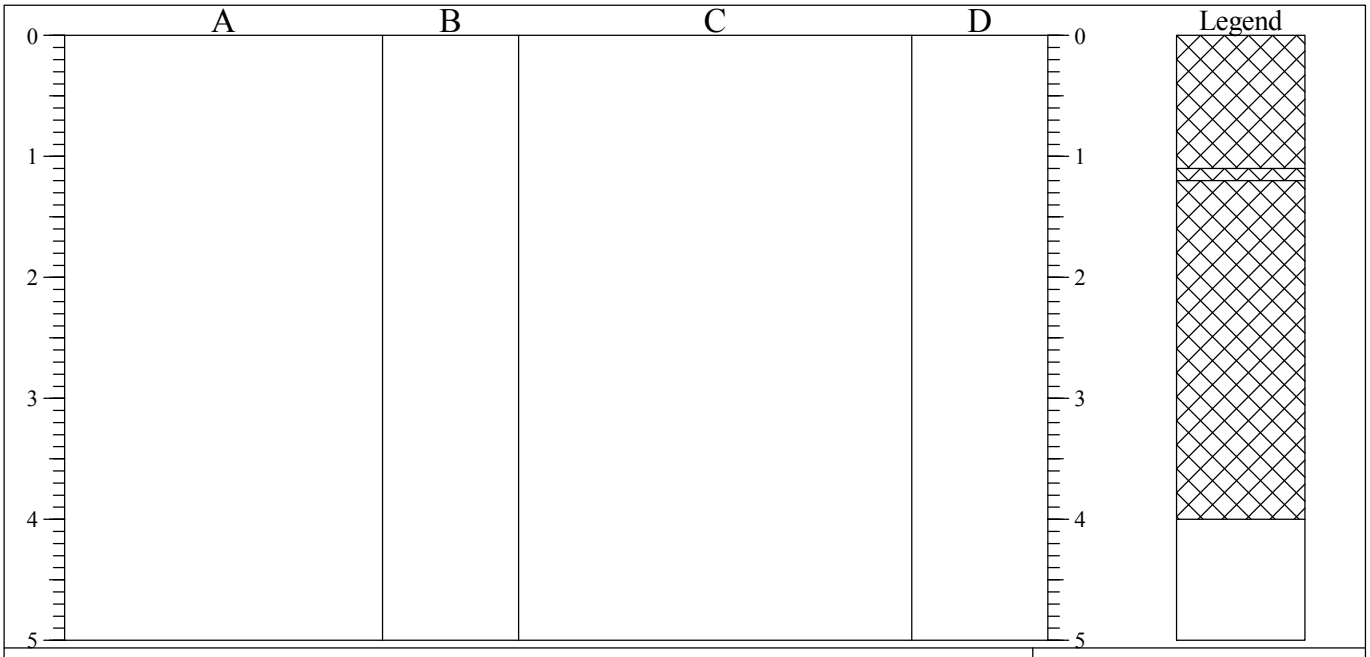
All dimensions in metres Scale 1:62.5	Client Strategic Team Group	Method/ Plant Used Hitachi ZX130 Excavator	Logged By RS

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Telephone: 01913786380

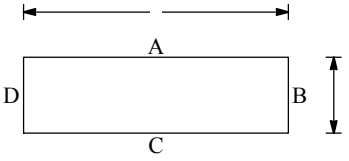
TRIAL PIT LOG

Project				TRIAL PIT No
Lairds Way, Penistone				TP06
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-1.10		Overgrown grass underlain by dark brown very sandy very gravelly clay with fragments of brick and sandstone (MADE GROUND).	0.00-1.00	J/D	
1.10-1.20		Hard / fused layer of greyish dark grey fused / vesicular slag (MADE GROUND).	1.00-2.00	J/D	
1.20-4.00		Dark brown clayey very gravelly sand with fragments, cobbles and boulders of concrete, brick, refractory brick, furnace flue brick, dark grey fused / vesicular slag and sandstone. Relic brick wall recorded at c.1.40m in end wall of excavation, extending to c.2.95m with concrete footing to c.3.10m. Brick wall and concrete footing underlain by possible natural insitu bedded siltstone. Based of excavation terminated on unknown flat surface - possible concrete slab (MADE GROUND).			
4.00		Trial pit terminated at c.4.00m bgl - due to possible concrete floor/slab.			

Shoring/Support:
Stability:





GENERAL REMARKS

WATER: Trial pit remained dry on completion.

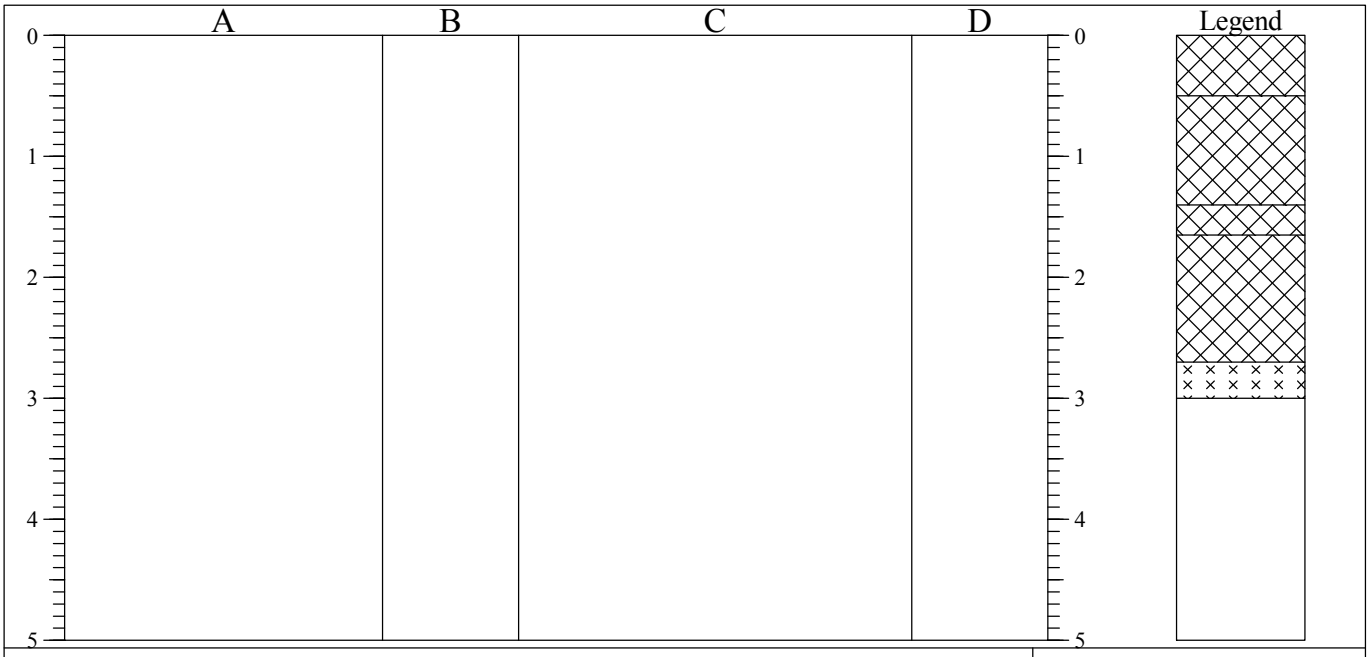
All dimensions in metres Scale 1:62.5	Client Strategic Team Group	Method/ Plant Used Hitachi ZX130 Excavator	Logged By RS

AGS3 UK TP 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

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Telephone: 01913786380

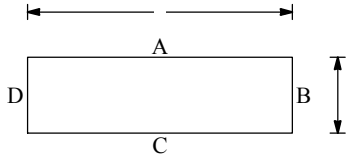
TRIAL PIT LOG

Project				TRIAL PIT No
Lairds Way, Penistone				TP07
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.50		Overgrown grass underlain by dark brown very sandy very gravelly clay with fragments of brick and sandstone (MADE GROUND).	0.00-0.50	J/D	
0.50-1.40		Dark brown very sandy gravelly clay with fragments and cobbles of brick, dark grey fused / vesicular slag, glassy / vitreous slag and sandstone (MADE GROUND).			
1.40-1.65		Hard / fused layer of greyish dark grey fused / vesicular slag (MADE GROUND).	1.40-1.80	J/D	
1.65-2.70		Red sandy gravels, cobbles and rubble of brick, refractory brick, sandstone and concrete with occasional metal. Concrete pad / pillar obstructing side wall of pit (MADE GROUND).	2.00-2.70	J/D	
2.70-3.00		Light brown highly weathered bedded SILTSTONE, recovered as silty fine to coarse gravel and cobble sized fragments (LOWER COAL MEASURES).			
3.00		Trial pit terminated at c.3.00m bgl.			

Shoring/Support:
Stability:





GENERAL REMARKS

WATER: Trial pit remained dry on completion.

All dimensions in metres Scale 1:62.5	Client Strategic Team Group	Method/ Plant Used Hitachi ZX130 Excavator	Logged By RS

AGS3 UK TP 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

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Durham, DH7 8PN
Telephone: 01913786380

BOREHOLE LOG

Project				BOREHOLE No
Lairds Way, Penistone				BH01
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	03-06-16 03-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
						0.10	Grass and brambles underlain by dark brown sandy clayey soil (MADE GROUND).		
0.50-1.00	J/D						Medium dense black very gravelly sand with large fragments and cobbles of brick, clinker and dark grey fused / vesicular slag (MADE GROUND).		
						(2.40)			
1.50-2.00	B								
1.50-1.95	CPT	N=19							
2.00-3.00	B								
						2.50			
2.50-2.95	CPT	N=10				(0.50)	'Soft' grey silty CLAY.		
						3.00			
						(0.60)	'Firm to stiff' grey and brown mottled CLAY.		
3.50	U100	N/R				3.60			
						(0.57)	Yellowish light brown SILTSTONE (LOWER COAL MEASURES).		
4.00	D					4.17			
4.00-4.17	SPT	75 blows					Borehole terminated at c.4.17m bgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
03-06-16	00.00	4.17	4.00	150	Dry	3.6	4	01:00			SERVICE PIT: 1hr hand dug pit to c.1.20m bgl. WATER: Borehole remained dry on completion.

All dimensions in metres Scale 1:43.75	Client Strategic Team Group	Method/ Plant Used Cable Percussive Borehole	Logged By SK

AGS3 UK BH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham, DH7 8PN
Telephone: 01913786380

BOREHOLE LOG

Project				BOREHOLE No
Lairds Way, Penistone				BH02
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	02-06-16 02-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
0.50-1.00	J/D						Overgrown grass and dark brown clayey sandy soil underlain by dense and very dense black very gravelly sand with large fragments and cobbles of brick, clinker and dark grey fused / vesicular slag (MADE GROUND).		
1.50-2.00 1.50-1.86	B CPT	68 blows							
2.50-3.00 2.50-2.95	B CPT	N=35				(5.20)			
3.50-4.00 3.50-3.95	B SPT	N=48							
5.00-5.50	B					5.20			
5.50-5.75	SPT	75 blows				(0.55) 5.75	Black gravelly sand of coal and ash (MADE GROUND).		
							Borehole terminated at c.5.75m bgl on possible bedrock - no returns in cutting shoe.		

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt
02-06-16	00.00	5.75	5.50	150	Dry

Chiselling

From	To	Hours
5.3	5.5	01:00

Water Added

From	To

GENERAL REMARKS

SERVICE PIT: 1hr hand dug pit to c.1.20m bgl.
WATER: Borehole remained dry on completion.

All dimensions in metres Scale 1:43.75	Client Strategic Team Group	Method/ Plant Used Cable Percussive Borehole	Logged By SK

AGS3 UK BH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham, DH7 8PN
Telephone: 01913786380

BOREHOLE LOG

Project				BOREHOLE No
Lairds Way, Penistone				BH03
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	03-06-16 03-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
0.50-1.00	J/D					(2.53)	Overgrown grass and dark brown clayey sandy soil underlain by dense black very gravelly sand with large fragments and cobbles of brick, clinker and dark grey fused / vesicular slag (MADE GROUND).		
1.50-2.00 1.50-1.95	B CPT	N=33				2.53			
2.50-2.53	CPT	75 blows					Borehole terminated at c.2.53m bgl on obstruction.		

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To
03-06-16	00.00	2.53	2.50	150	Dry	2.5	2.53	00:30		

GENERAL REMARKS

SERVICE PIT: 1hr hand dug pit to c.1.20m bgl.
WATER: Borehole remained dry on completion.

All dimensions in metres Scale 1:43.75	Client Strategic Team Group	Method/ Plant Used Cable Percussive Borehole	Logged By SK

AGS3 UK BH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham, DH7 8PN
Telephone: 01913786380

BOREHOLE LOG

Project				BOREHOLE No
Lairds Way, Penistone				**BH03A**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	03-06-16 03-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
0.50-1.00	J/D					(2.50)	Overgrown grass and dark brown clayey sandy soil underlain by black very gravelly sand with large fragments and cobbles of brick, clinker and dark grey fused / vesicular slag (MADE GROUND).		
1.50-2.00	B					2.50			
2.50-3.00	B					(3.30)	Dense and very dense black very gravelly sand with fragments, cobbles and boulders of brick, clinker and dark grey fused / vesicular slag (MADE GROUND).		
3.50-4.00 3.50-3.95	B CPT	N=39							
4.50-5.00 4.50-4.95	B CPT	N=68							
5.50-6.00 5.50-5.95	B CPT	N=41				5.80			
6.00-6.50	B					(0.77)	Yellowish light brown SILTSTONE (LOWER COAL MEASURES).		
6.50-6.57	SPT	75 blows				6.57	Borehole terminated at c.6.57m bgl.		

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To
03-06-16	00.00	6.57	6.50	150	Dry	6	6.5	01:00		

GENERAL REMARKS

SERVICE PIT: 1hr hand dug pit to c.1.20m bgl.
WATER: Borehole remained dry on completion.

All dimensions in metres Scale 1:43.75	Client Strategic Team Group	Method/ Plant Used Cable Percussive Borehole	Logged By SK

AGS3 UK BH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham, DH7 8PN
Telephone: 01913786380

DRILLHOLE LOG

Project				DRILLHOLE No
Lairds Way, Penistone				**RBH01**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	20-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 2

RUN DETAILS			STRATA							
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities	Detail	Main	Geology	Instrument/ Backfill
					0.10			Grass and brambles underlain by dark brown sandy clayey soil (MADE GROUND).		
					(3.20)			Black very gravelly sand with brick, clinker and slag (MADE GROUND).		
					3.30					
					(2.60)			Brown CLAY.		
					5.90					
					(4.70)			Brown and grey SILTSTONE with sandstone bands (LOWER COAL MEASURES).		
					10.60					
					(11.80)			Grey MUDSTONE (LOWER COAL MEASURES).		

Drilling Progress and Water Observations

Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing

Rotary Flush

From	To	Type	Returns
0	11.4	WATER	100
11.4	27.8	WATER	50

GENERAL REMARKS

All dimensions in metres Scale 1:106.25	Client Strategic Team Group	Method/ Plant Used Openhole Rotary	Logged By AM

AGS3 UK DH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham, DH7 8PN
Telephone: 01913786380

DRILLHOLE LOG

Project				DRILLHOLE No
Lairds Way, Penistone				RBH01
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	20-06-16			
Contractor				Sheet
Arc Environmental Ltd				2 of 2

RUN DETAILS			STRATA							
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities	Detail	Main	Geology	Instrument/ Backfill
								Grey MUDSTONE (LOWER COAL MEASURES). *(continued)*		
					22.40					
					(5.40)			Grey SILTSTONE with mudstone bands (LOWER COAL MEASURES).		
					27.80					
								Rotary borehole terminated at c.27.80m bgl. Strata details are based upon drillers observations, drilling rates maintained and chippings/flush returned to surface. Full flush maintained to c.11.40m bgl, intermittent/50% returns maintained for the remainder of borehole. Gas readings: Methane - 0%, Carbon Dioxide - 0.0%, Oxygen - 21.6%.		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing
20-06-16	00.00	27.80	3.00			

Rotary Flush			
From	To	Type	Returns

GENERAL REMARKS

All dimensions in metres Scale 1:106.25	Client Strategic Team Group	Method/ Plant Used Openhole Rotary	Logged By AM

AGS3 UK DH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

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Telephone: 01913786380

DRILLHOLE LOG

Project				DRILLHOLE No
Lairds Way, Penistone				RBH02
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	20-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 2

RUN DETAILS			STRATA							
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION Discontinuities	Detail	Main	Geology	Instrument/ Backfill
					(2.80) 2.80			Overgrown grass, soil and dark brown and black very gravelly sand with brick, clinker and slag (MADE GROUND).		
					(3.40) 6.20			Black very gravelly sand with brick, clinker and slag (MADE GROUND).		
					(5.90) 12.10			Grey SILTSTONE with sandstone bands (LOWER COAL MEASURES).		
								Brown and grey MUDSTONE (LOWER COAL MEASURES).		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From	To	Type	Returns
0	30	WATER	100

GENERAL REMARKS

All dimensions in metres Scale 1:106.25	Client Strategic Team Group	Method/ Plant Used Openhole Rotary	Logged By AM

AGS3 UK DH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
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Durham, DH7 8PN
Telephone: 01913786380

DRILLHOLE LOG

Project				DRILLHOLE No
Lairds Way, Penistone				RBH02
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	20-06-16			
Contractor				Sheet
Arc Environmental Ltd				2 of 2

RUN DETAILS			STRATA							
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities	Detail	Main	Geology	Instrument/ Backfill
					(12.20)			Brown and grey MUDSTONE (LOWER COAL MEASURES). *(continued)*		
					24.30					
					(5.70)			Grey SILTSTONE with mudstone bands (LOWER COAL MEASURES).		
					30.00					
								Rotary borehole terminated at c.30.00m bgl. Strata details are based upon drillers observations, drilling rates maintained and chippings/flush returned to surface. Full flush maintained throughout progression of borehole. Gas readings: Methane - 0%, Carbon Dioxide - 0.0%, Oxygen - 21.6%.		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing
20-06-16	00.00	30.00	3.00			

Rotary Flush			
From	To	Type	Returns

GENERAL REMARKS

All dimensions in metres Scale 1:106.25	Client Strategic Team Group	Method/ Plant Used Openhole Rotary	Logged By AM

AGS3 UK DH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham, DH7 8PN
Telephone: 01913786380

DRILLHOLE LOG

Project				DRILLHOLE No
Lairds Way, Penistone				RBH03
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	20-06-16			
Contractor				Sheet
Arc Environmental Ltd				1 of 2

RUN DETAILS			STRATA							
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities	Detail	Main	Geology	Instrument/ Backfill
					(3.60) 3.60			Overgrown grass, soil and dark brown and black very gravelly sand with brick, clinker and slag (MADE GROUND).		
					(3.10) 6.70			Black gravelly sand of coal and ash (MADE GROUND).		
					(5.90) 12.60			Brown and grey SILTSTONE with sandstone bands (LOWER COAL MEASURES).		
					(7.10)			Grey MUDSTONE (LOWER COAL MEASURES).		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From	To	Type	Returns
0	30	WATER	100

GENERAL REMARKS

All dimensions in metres Scale 1:106.25	Client Strategic Team Group	Method/ Plant Used Openhole Rotary	Logged By AM

AGS3 UK DH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

Solum House, Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham, DH7 8PN
Telephone: 01913786380

DRILLHOLE LOG

Project				DRILLHOLE No
Lairds Way, Penistone				RBH03
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-384	20-06-16			
Contractor				Sheet
Arc Environmental Ltd				2 of 2

RUN DETAILS			STRATA							
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities	Detail	Main	Geology	Instrument/ Backfill
					19.70			Grey MUDSTONE (LOWER COAL MEASURES). *(continued)*		
					(10.30)			Grey SILTSTONE with mudstone bands (LOWER COAL MEASURES).		
					30.00			Rotary borehole terminated at c.30.00m bgl. Strata details are based upon drillers observations, drilling rates maintained and chippings/flush returned to surface. Full flush maintained throughout progression of borehole. Gas readings: Methane - 0%, Carbon Dioxide - 0.0%, Oxygen - 21.6%.		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing
20-06-16	00.00	30.00	4.00			

Rotary Flush			
From	To	Type	Returns

GENERAL REMARKS

All dimensions in metres Scale 1:106.25	Client Strategic Team Group	Method/ Plant Used Openhole Rotary	Logged By AM

AGS3 UK DH 16-384 LOGS.GPJ AGS3_ALL.GDT 3/8/16

APPENDIX III

Insitu Testing (Ground Gas & Groundwater Monitoring Certificate)

Arc Environmental Ground Gas & Groundwater Monitoring Certificate

Site:	Lairds Way, Penistone
Ref:	16-384

Visit	Date	Time	Equipment	Weather	Initials	Comments	Borehole	Gas Flow (l/hr)	Atmospheric Pressure (mb)	Atmospheric Pressure Trend	Methane (% v/v)		Methane (% LEL)		Carbon Dioxide (% v/v)		Oxygen (% v/v)		Hydrocarbons (GFM 435 only)		Other Gases (PPM)			Depth to Water (m bgl)
											Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady	Hex %	PID Cf	PID (Isobutylene)	H_2S	CO	
1	09/06/2016	11:55am	GFM435	Sunny	IH		1	<0.1	990	Falling 1026-1020		0.0		0.0		0.4		19.7						4.10
							2	<0.1	990	Falling 1026-1020		0.0		0.0		0.3		19.3						5.11
							3A	<0.1	990	Falling 1026-1020		0.0		0.0		0.0		20.3						DRY 6.28
2	20/06/2016	09:00am	GFM430	Overcast, slight drizzle, still	RS		1	<0.1	981	Falling 1022-1008		0.0		0.0		0.2		20.4						Dry
							2	<0.1	981	Falling 1022-1008		0.0		0.0		2.2		7.2						5.06
							3A	<0.1	980	Falling 1022-1008		0.0		0.0		0.5		19.0						5.51
3	07/07/2016	10:10am	GFM435	Overcast, sunny spells	IH		1	<0.1	985	Falling 1022-1016		0.0		0.0		1.1		17.2						DRY 4.11
							2	<0.1	984	Falling 1022-1016		0.0		0.0		0.2		20.0						5.10
							3A	<0.1	985	Falling 1022-1016		0.0		0.0		0.0		20.3						5.97
4																								
5																								
6																								

Notes:

Atmospheric pressure tremd taken from www.wunderground.com for Leeds/Bradford Airport

Detection limits - Methane = 0.0%, Carbon Dioxide = 0.0%, LEL = 0.0%, Oxygen = 0.0%, Flow = 0.1l/hr

Monitoring order is from **Left to Right** across table

Monitoring should be for **Not Less** than 3 minutes. However, if high concentrations of gasses initially recorded, monitoring should be for up to 10 minutes

N/A = Not applicable >>> = Off the scale

Cf = PID compensation Factor (1-10) - Must be used to multiply the PID reading to give an accuate measure of the total hydrocarbons in the borehole when methane is present

Hex = Hexane (Valid and in range up to 2.000%) - Recorded when abnormally high methane is present.

PID = Photo Ionisation Detector (Calibrated to Isobutylene)

APPENDIX IV

Laboratory Testing Results (Geotechnical & Ground Contamination)

LABORATORY REPORT

4043

Contract Number: PSL16/3244

Report Date: 18 July 2016

Client's Reference: 16-384

Client Name: Arc Enviromental
Solum House
Unit 1 Elliott Court
St Johns Road, Meadowfield
Durham
DH7 8PN

For the attention of: Richard Stripp

Contract Title: Lairds Way, Penistone

Date Received: 13/07/2016
Date Commenced: 13/07/2016
Date Completed: 18/07/2016

Notes: Opinions and Interpretations are outside the UKAS Accreditation

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced in full, without the prior written approval of the laboratory.

Checked and Approved Signatories:

R Gunson (Director)
A Watkins (Director)
M Beastall (Laboratory Manager)



D Lambe (Senior Technician)
S Royle (Senior Technician)

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awatkins@prosoils.co.uk

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
BH01			2.50	3.00	Greyish brown slightly gravelly slightly sandy very silty CLAY.
TP01			3.80	3.95	Brown slightly gravelly very sandy very silty CLAY.
TP02			3.00		Brown slightly gravelly sandy very silty CLAY.
TP03			2.60	3.15	Brown very gravelly very sandy very silty CLAY.

UKAS TESTING 4043

PSL Professional Soils Laboratory

Checked / Approved		Date	18/07/16	Contract No:
Lairds Way, Penistone				PSL16/3244
				Client Ref:
				16-384

SUMMARY OF SOIL CLASSIFICATION TESTS

(BS1377 : PART 2 : 1990)

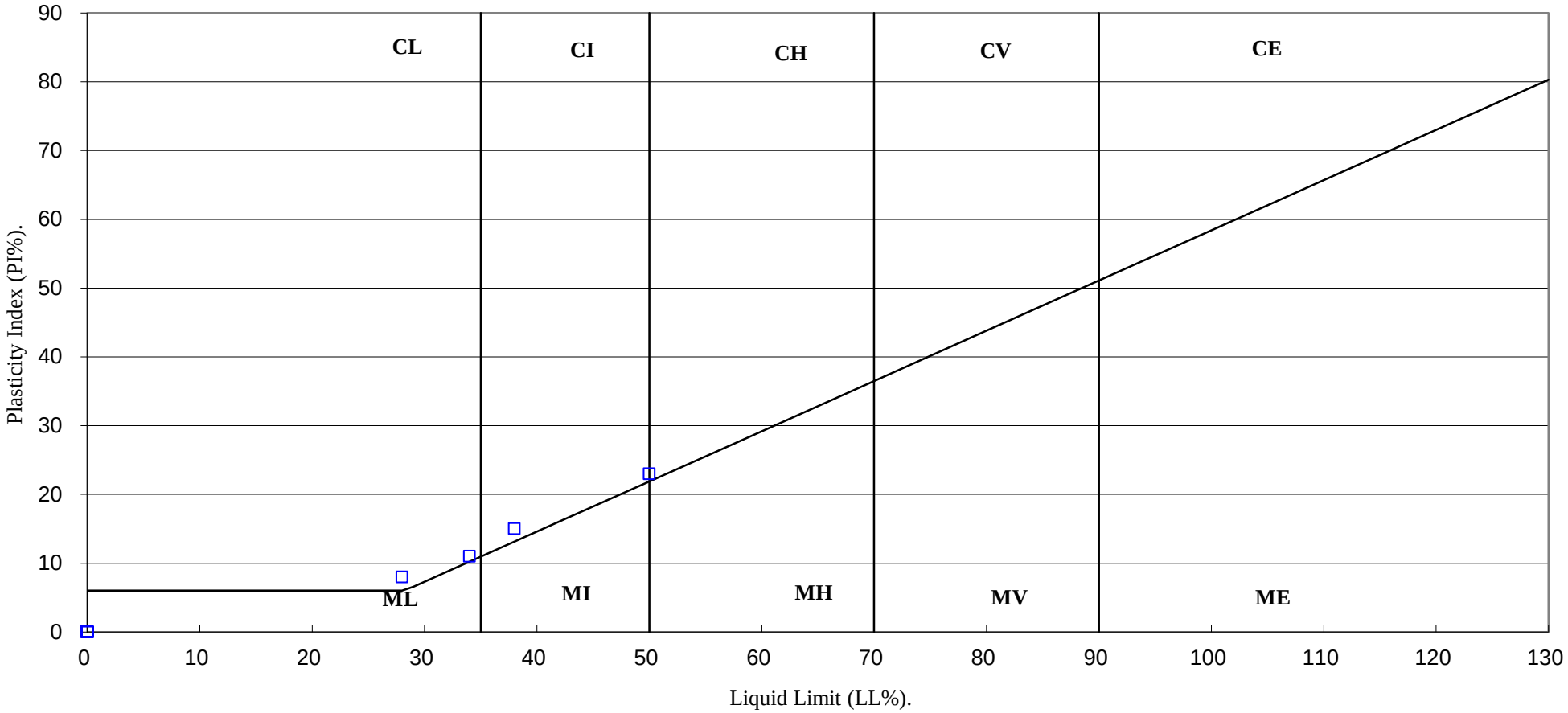
Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Moisture Content % Clause 3.2	Linear Shrinkage % Clause 6.5	Particle Density Mg/m^3 Clause 8.2	Liquid Limit % Clause 4.3/4	Plastic Limit % Clause 5.3	Plasticity Index % Clause 5.4	Passing .425mm %	Remarks
BH01			2.50	3.00	30			50	27	23	92	Intermediate plasticity CI.
TP01			3.80	3.95	23			34	23	11	87	Low plasticity CL.
TP02			3.00		20			38	23	15	90	Intermediate plasticity CI.
TP03			2.60	3.15	14			28	20	8	72	Low plasticity CL.

SYMBOLS : **NP : Non Plastic** *** : Liquid Limit and Plastic Limit Wet Sieved.**

UKAS TESTING 4043	PSL Professional Soils Laboratory	Checked / Approved	Date 18/07/16	Contract No: PSL16/3244
		Lairds Way, Penistone		Client Ref: 16-384

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.

(BS5930 :2015)



UKAS TESTING 4043	PSL Professional Soils Laboratory	**Checked /Approved**		**Date**	**18/07/16**	**Contract No:**
		Lairds Way, Penistone				**PSL16/3244**
						Client Ref:
						16-384

2531

ANALYTICAL TEST REPORT

Contract no: 59995(1)

Contract name: Lairds Way, Penistone

Client reference: 16-384

Clients name: ARC Environmental

Clients address: Solum House, Unit 1 Elliott Court
St Johns Road
Meadowfield
DH7 8PN

Samples received: 10 June 2016

Analysis started: 10 June 2016

Analysis completed 06 July 2016

Report issued: 06 July 2016

This is a supplementary report to report number 59995 issued 29 June 2016.

Notes:

Opinions and interpretations expressed herein are outside the UKAS accreditation scope.
Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.
Methods, procedures and performance data are available on request.
Results reported herein relate only to the material supplied to the laboratory.
This report shall not be reproduced except in full, withour prior written approval.
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.
BTEX compounds are identified by retention time only and may include interference from co-eluting compounds.

Key:

U UKAS accredited test
M MCERTS & UKAS accredited test
$ Test carried out by an approved subcontractor
I/S Insufficient sample to carry out test
N/S Sample not suitable for testing
NAD No Asbestos Detected

Approved by:

Dave Bowerbank
Customer Services Co-ordinator

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

Soil descriptions are only intended to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions. MCERTS accreditation applies for sand, clay and loam/topsoil, or combinations of these whether these are derived from naturally occurring soils or from made ground, as long as these materials constitute the major part of the sample. Other materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

All results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.
Analytical results are inclusive of stones.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
59995-1	BH01	4.00	Clay	-	-	10.5
59995-2	BH02	3.50-4.00	Sand with Gravel	-	-	9.3
59995-3	BH03A	6.00-6.50	Clay	-	-	11.5
59995-4	TP01	1.60-2.90	Sand with Gravel & Slag	-	-	13.6
59995-5	TP02	1.40-1.90	Sand & Clay with Gravel & Slag	-	-	10.8
59995-6	TP03	0.80-1.10	Sandy Clay with Gravel	-	-	19.0
59995-7	TP03	1.25-2.10	Sand with Gravel	-	-	8.1
59995-8	TP04	0.90-1.20	Sandy Clay with Slag	-	-	13.2
59995-9	TP04	1.20-1.85	Sand with Shale	-	-	11.9
59995-10	TP06	0.00-1.00	Loam with Slag	-	-	13.9

Chemtech Environmental Limited

SOILS

Lab number			59995-1	59995-2	59995-3	59995-4	59995-5	59995-6
Sample id			BH01	BH02	BH03A	TP01	TP02	TP03
Depth (m)			4.00	3.50-4.00	6.00-6.50	1.60-2.90	1.40-1.90	0.80-1.10
Date sampled			03/06/2016	02/06/2016	03/06/2016	02/06/2016	02/06/2016	02/06/2016
Test	**Method**	**Units**						
Arsenic (total)	CE127 M	mg/kg As	-	65	-	56	34	71
Cadmium (total)	CE127 M	mg/kg Cd	-	0.9	-	0.4	0.5	1.2
Chromium (total)	CE127 M	mg/kg Cr	-	42	-	78	84	74
Chromium (III)	-	mg/kg CrIII	-	42	-	78	84	74
Chromium (VI)	CE146	mg/kg CrVI	-	<1	-	<1	<1	<1
Copper (total)	CE054	mg/kg Cu	-	27361	-	-	-	-
Copper (total)	CE127 M	mg/kg Cu	-	-	-	778	225	734
Lead (total)	CE054	mg/kg Pb	-	1657	-	-	-	-
Lead (total)	CE127 M	mg/kg Pb	-	-	-	129	222	171
Mercury (total)	CE127 M	mg/kg Hg	-	<0.5	-	<0.5	<0.5	<0.5
Nickel (total)	CE127 M	mg/kg Ni	-	455	-	102	44	124
Selenium (total)	CE127 M	mg/kg Se	-	2.6	-	0.9	0.7	1.6
Zinc (total)	CE054	mg/kg Zn	-	3901	-	-	-	-
Zinc (total)	CE127 M	mg/kg Zn	-	-	-	445	159	314
pH	CE004 M	units	4.5	8.7	5.7	7.9	7.3	7.6
Sulphate (2:1 water soluble)	CE061 M	mg/l SO_4	87	194	97	100	211	1985
Cyanide (free)	CE077	mg/kg CN	-	<1	-	<1	<1	<1
Total Organic Carbon (TOC)	CE072 M	% w/w C	-	2.42	-	8.44	5.28	4.93
PAH								
Acenaphthene	CE087 M	mg/kg	-	<0.01	-	0.29	0.21	0.12
Acenaphthylene	CE087 M	mg/kg	-	<0.01	-	0.02	0.05	0.07
Anthracene	CE087 U	mg/kg	-	<0.02	-	0.69	<0.02	0.65
Benzo(a)anthracene	CE087 U	mg/kg	-	<0.02	-	1.75	0.33	3.46
Benzo(a)pyrene	CE087 U	mg/kg	-	<0.02	-	2.01	0.42	4.90
Benzo(b)fluoranthene	CE087 M	mg/kg	-	<0.02	-	1.83	0.42	4.22
Benzo(ghi)perylene	CE087 M	mg/kg	-	<0.02	-	0.97	0.28	2.58
Benzo(k)fluoranthene	CE087 M	mg/kg	-	<0.02	-	0.85	0.22	2.19
Chrysene	CE087 M	mg/kg	-	0.03	-	1.64	0.38	2.79
Dibenz(ah)anthracene	CE087 M	mg/kg	-	<0.02	-	0.30	0.07	0.52
Fluoranthene	CE087 M	mg/kg	-	0.03	-	4.40	1.10	8.66
Fluorene	CE087 U	mg/kg	-	<0.01	-	0.22	0.48	0.22
Indeno(123cd)pyrene	CE087 M	mg/kg	-	<0.02	-	1.28	0.33	3.62
Naphthalene	CE087 M	mg/kg	-	0.03	-	0.44	0.97	0.20
Phenanthrene	CE087 M	mg/kg	-	0.09	-	2.74	1.51	1.40
Pyrene	CE087 M	mg/kg	-	<0.02	-	3.69	1.26	7.95
PAH (total of USEPA 16)	CE087	mg/kg	-	<0.27	-	23.1	8.03	43.6
Benzo(j)fluoranthene	CE087	mg/kg	-	<0.02	-	0.41	0.09	1.87
PAH (total of OIL 8)	CE087	mg/kg	-	<0.08	-	10.1	2.26	23.6

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SOILS

Lab number			59995-1	59995-2	59995-3	59995-4	59995-5	59995-6
Sample id			BH01	BH02	BH03A	TP01	TP02	TP03
Depth (m)			4.00	3.50-4.00	6.00-6.50	1.60-2.90	1.40-1.90	0.80-1.10
Date sampled			03/06/2016	02/06/2016	03/06/2016	02/06/2016	02/06/2016	02/06/2016
Test	**Method**	**Units**						
BTEX & TPH								
MTBE	CE057 U	mg/kg	-	<0.02	-	<0.02	<0.02	<0.02
Benzene	CE057 U	mg/kg	-	<0.01	-	<0.01	<0.01	<0.01
Toluene	CE057 U	mg/kg	-	<0.01	-	<0.01	<0.01	<0.01
Ethylbenzene	CE057 U	mg/kg	-	<0.01	-	<0.01	<0.01	<0.01
m & p-Xylene	CE057 U	mg/kg	-	<0.02	-	<0.02	<0.02	<0.02
o-Xylene	CE057 U	mg/kg	-	<0.01	-	<0.01	<0.01	<0.01
TPH Aliphatic EC5-EC6	CE068	mg/kg	-	<0.01	-	<0.01	<0.01	<0.01
TPH Aliphatic EC6-EC8	CE068	mg/kg	-	<0.01	-	<0.01	<0.01	<0.01
TPH Aliphatic EC8-EC10	CE068	mg/kg	-	<0.01	-	<0.01	<0.01	<0.01
TPH Aliphatic EC10-EC12	CE068	mg/kg	-	2	-	7	193	8
TPH Aliphatic EC12-EC16	CE068	mg/kg	-	4	-	24	1110	136
TPH Aliphatic EC16-EC35	CE068	mg/kg	-	75	-	496	2444	6134
TPH Aliphatic EC35-EC44	CE068	mg/kg	-	22	-	83	53	891
TPH Aromatic EC5-EC7	CE068	mg/kg	-	<0.1	-	<0.1	<0.1	<0.1
TPH Aromatic EC7-EC8	CE068	mg/kg	-	<0.1	-	<0.1	<0.1	<0.1
TPH Aromatic EC8-EC10	CE068	mg/kg	-	<0.1	-	<0.1	0.90	<0.1
TPH Aromatic EC10-EC12	CE068	mg/kg	-	<1	-	<1	1	<1
TPH Aromatic EC12-EC16	CE068	mg/kg	-	<1	-	<1	<1	<1
TPH Aromatic EC16-EC21	CE068	mg/kg	-	<1	-	12	4	19
TPH Aromatic EC21-EC35	CE068	mg/kg	-	<1	-	10	2	22
TPH Aromatic EC35-EC44	CE068	mg/kg	-	<1	-	1	<1	3
Subcontracted analysis								
Asbestos (qualitative)	$	-	-	NAD	-	NAD	Amosite	NAD
Asbestos (quantitative)	$	% w/w	-	-	-	-	0.002	-

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SOILS

Lab number			59995-7	59995-8	59995-9	59995-10
Sample id			TP03	TP04	TP04	TP06
Depth (m)			1.25-2.10	0.90-1.20	1.20-1.85	0.00-1.00
Date sampled			02/06/2016	02/06/2016	02/06/2016	02/06/2016
Test	**Method**	**Units**				
Arsenic (total)	CE127 M	mg/kg As	20	27	37	47
Cadmium (total)	CE127 M	mg/kg Cd	<0.2	0.5	0.2	0.5
Chromium (total)	CE127 M	mg/kg Cr	122	93	73	108
Chromium (III)	-	mg/kg CrIII	122	93	73	108
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	<1	<1
Copper (total)	CE054	mg/kg Cu	-	-	-	-
Copper (total)	CE127 M	mg/kg Cu	232	328	184	279
Lead (total)	CE054	mg/kg Pb	-	-	-	-
Lead (total)	CE127 M	mg/kg Pb	460	78	99	133
Mercury (total)	CE127 M	mg/kg Hg	<0.5	<0.5	<0.5	<0.5
Nickel (total)	CE127 M	mg/kg Ni	38	69	53	64
Selenium (total)	CE127 M	mg/kg Se	0.8	1.0	1.1	1.0
Zinc (total)	CE054	mg/kg Zn	-	-	-	-
Zinc (total)	CE127 M	mg/kg Zn	112	136	62	137
pH	CE004 M	units	8.4	7.9	8.0	7.9
Sulphate (2:1 water soluble)	CE061 M	mg/l SO_4	139	774	394	65
Cyanide (free)	CE077	mg/kg CN	<1	<1	<1	<1
Total Organic Carbon (TOC)	CE072 M	% w/w C	5.38	2.52	3.27	4.16
PAH						
Acenaphthene	CE087 M	mg/kg	0.03	0.11	<0.01	0.14
Acenaphthylene	CE087 M	mg/kg	0.02	0.14	<0.01	0.10
Anthracene	CE087 U	mg/kg	0.09	0.83	0.03	0.47
Benzo(a)anthracene	CE087 U	mg/kg	0.36	7.51	0.19	1.37
Benzo(a)pyrene	CE087 U	mg/kg	0.47	9.59	0.22	1.55
Benzo(b)fluoranthene	CE087 M	mg/kg	0.47	8.47	0.25	1.67
Benzo(ghi)perylene	CE087 M	mg/kg	0.30	5.74	0.17	0.90
Benzo(k)fluoranthene	CE087 M	mg/kg	0.24	4.16	0.10	0.76
Chrysene	CE087 M	mg/kg	0.35	5.41	0.14	1.04
Dibenz(ah)anthracene	CE087 M	mg/kg	0.07	1.03	0.03	0.29
Fluoranthene	CE087 M	mg/kg	0.75	14.77	0.32	2.40
Fluorene	CE087 U	mg/kg	0.03	0.27	<0.01	0.19
Indeno(123cd)pyrene	CE087 M	mg/kg	0.35	7.63	0.18	1.24
Naphthalene	CE087 M	mg/kg	0.14	0.24	0.02	0.14
Phenanthrene	CE087 M	mg/kg	0.34	1.30	0.09	1.51
Pyrene	CE087 M	mg/kg	0.66	13.92	0.29	2.00
PAH (total of USEPA 16)	CE087	mg/kg	4.65	81.1	2.04	15.8
Benzo(j)fluoranthene	CE087	mg/kg	0.10	3.29	0.03	0.54
PAH (total of OIL 8)	CE087	mg/kg	2.40	47.1	1.15	8.45

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SOILS

Lab number			59995-7	59995-8	59995-9	59995-10
Sample id			TP03	TP04	TP04	TP06
Depth (m)			1.25-2.10	0.90-1.20	1.20-1.85	0.00-1.00
Date sampled			02/06/2016	02/06/2016	02/06/2016	02/06/2016
Test	**Method**	**Units**				
BTEX & TPH						
MTBE	CE057 U	mg/kg	<0.02	<0.02	<0.02	<0.02
Benzene	CE057 U	mg/kg	<0.01	<0.01	<0.01	<0.01
Toluene	CE057 U	mg/kg	<0.01	<0.01	<0.01	<0.01
Ethylbenzene	CE057 U	mg/kg	<0.01	<0.01	<0.01	<0.01
m & p-Xylene	CE057 U	mg/kg	<0.02	<0.02	<0.02	<0.02
o-Xylene	CE057 U	mg/kg	<0.01	<0.01	<0.01	<0.01
TPH Aliphatic EC5-EC6	CE068	mg/kg	<0.01	<0.01	<0.01	<0.01
TPH Aliphatic EC6-EC8	CE068	mg/kg	<0.01	<0.01	<0.01	<0.01
TPH Aliphatic EC8-EC10	CE068	mg/kg	<0.01	<0.01	<0.01	<0.01
TPH Aliphatic EC10-EC12	CE068	mg/kg	3	14	3	4
TPH Aliphatic EC12-EC16	CE068	mg/kg	15	129	6	13
TPH Aliphatic EC16-EC35	CE068	mg/kg	453	5800	242	512
TPH Aliphatic EC35-EC44	CE068	mg/kg	74	906	46	140
TPH Aromatic EC5-EC7	CE068	mg/kg	<0.1	<0.1	<0.1	<0.1
TPH Aromatic EC7-EC8	CE068	mg/kg	<0.1	<0.1	<0.1	<0.1
TPH Aromatic EC8-EC10	CE068	mg/kg	<0.1	<0.1	<0.1	<0.1
TPH Aromatic EC10-EC12	CE068	mg/kg	<1	<1	<1	<1
TPH Aromatic EC12-EC16	CE068	mg/kg	<1	<1	<1	<1
TPH Aromatic EC16-EC21	CE068	mg/kg	2	31	1	7
TPH Aromatic EC21-EC35	CE068	mg/kg	2	44	1	8
TPH Aromatic EC35-EC44	CE068	mg/kg	<1	6	<1	1
Subcontracted analysis						
Asbestos (qualitative)	$	-	NAD	NAD	NAD	NAD
Asbestos (quantitative)	$	% w/w	-	-	-	-

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METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE127	Arsenic (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg As
CE127	Cadmium (total)	Aqua regia digest, ICP-MS	Dry	M	0.2	mg/kg Cd
CE127	Chromium (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cr
-	Chromium (III)	Calculation: Cr (total) - Cr (VI)	Dry		1	mg/kg CrIII
CE146	Chromium (VI)	Acid extraction, Colorimetry	Dry		1	mg/kg CrVI
CE127	Copper (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cu
CE054	Copper (total)	Aqua regia digest, ICP-MS	Dry		1	mg/kg Cu
CE127	Lead (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Pb
CE054	Lead (total)	Aqua regia digest, ICP-MS	Dry		1	mg/kg Pb
CE127	Mercury (total)	Aqua regia digest, ICP-MS	Dry	M	0.5	mg/kg Hg
CE127	Nickel (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Ni
CE127	Selenium (total)	Aqua regia digest, ICP-MS	Dry	M	0.3	mg/kg Se
CE127	Zinc (total)	Aqua regia digest, ICP-MS	Dry	M	5	mg/kg Zn
CE054	Zinc (total)	Aqua regia digest, ICP-MS	Dry		5	mg/kg Zn
CE004	pH	Based on BS 1377, pH Meter	Wet	M	-	units
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry	M	10	mg/l SO_4
CE077	Cyanide (free)	Extraction, Continuous Flow Colorimetry	Wet		1	mg/kg CN
CE072	Total Organic Carbon (TOC)	Removal of IC by acidification, Carbon Analyser	Dry	M	0.1	% w/w C
CE087	Acenaphthene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Acenaphthylene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Anthracene	Solvent extraction, GC-MS	Wet	U	0.02	mg/kg
CE087	Benzo(a)anthracene	Solvent extraction, GC-MS	Wet	U	0.02	mg/kg
CE087	Benzo(a)pyrene	Solvent extraction, GC-MS	Wet	U	0.02	mg/kg
CE087	Benzo(b)fluoranthene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Benzo(ghi)perylene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Benzo(k)fluoranthene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Chrysene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Dibenz(ah)anthracene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Fluoranthene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Fluorene	Solvent extraction, GC-MS	Wet	U	0.01	mg/kg
CE087	Indeno(123cd)pyrene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Naphthalene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Phenanthrene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Pyrene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	PAH (total of USEPA 16)	Solvent extraction, GC-MS	Wet		0.27	mg/kg
CE087	Benzo(j)fluoranthene	Solvent extraction, GC-MS	Wet		0.02	mg/kg
CE087	PAH (total of OIL 8)	Solvent extraction, GC-MS	Wet		0.15	mg/kg
CE057	MTBE	Headspace GC-FID	Wet	U	0.02	mg/kg
CE057	Benzene	Headspace GC-FID	Wet	U	0.01	mg/kg
CE057	Toluene	Headspace GC-FID	Wet	U	0.01	mg/kg
CE057	Ethylbenzene	Headspace GC-FID	Wet	U	0.01	mg/kg
CE057	m & p-Xylene	Headspace GC-FID	Wet	U	0.02	mg/kg
CE057	o-Xylene	Headspace GC-FID	Wet	U	0.01	mg/kg

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METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE057	BTEX (total)	Headspace GC-FID	Wet		0.06	mg/kg
CE068	TPH Aliphatic/Aromatic fractions (C5-C10)	Headspace GC-FID	Wet		0.01-0.1	mg/kg
CE068	TPH Aliphatic/Aromatic fractions (C10-C44)	Solvent extraction, GC-FID	Wet		1	mg/kg
$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-
$	Asbestos (quantitative)	HSG 248, Microscopy & Gravimetry	Dry	U	0.001	% w/w

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DEVIATING SAMPLE INFORMATION

Comments
Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.
For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.
Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
A	Sampling date not provided
B	Sampling time not provided (waters only)
C	Sample exceeded holding time(s)
D	Sample not received in appropriate containers
E	Headspace present in sample container
F	Sample not chemically fixed (where appropriate)
G	Sample not cooled
H	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
59995-1	BH01	4.00	N	
59995-2	BH02	3.50-4.00	N	
59995-3	BH03A	6.00-6.50	N	
59995-4	TP01	1.60-2.90	N	
59995-5	TP02	1.40-1.90	N	
59995-6	TP03	0.80-1.10	N	
59995-7	TP03	1.25-2.10	N	
59995-8	TP04	0.90-1.20	N	
59995-9	TP04	1.20-1.85	N	
59995-10	TP06	0.00-1.00	N	

2531

ANALYTICAL TEST REPORT

Contract no: 60388

Contract name: Lairds Way, Penistone

Client reference: 16-384

Clients name: ARC Environmental

Clients address: Solum House, Unit 1 Elliott Court
St Johns Road
Meadowfield
DH7 8PN

Samples received: 07 July 2016

Analysis started: 07 July 2016

Analysis completed 14 July 2016

Report issued: 14 July 2016

Notes:

Opinions and interpretations expressed herein are outside the UKAS accreditation scope.

Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.

Methods, procedures and performance data are available on request.

Results reported herein relate only to the material supplied to the laboratory.

This report shall not be reproduced except in full, withour prior written approval.

Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

BTEX compounds are identified by retention time only and may include interference from co-eluting compounds.

Key:

U UKAS accredited test

M MCERTS & UKAS accredited test

$ Test carried out by an approved subcontractor

I/S Insufficient sample to carry out test

N/S Sample not suitable for testing

Approved by:

James Spittle
Customer Services Team Leader

Chemtech Environmental Limited

WATERS

Lab number			60388-1	60388-2
Sample id			BH02	BH03A
Depth (m)			5.10	5.97
Date sampled			07/07/2016	07/07/2016
Time sampled			-	-
Test	**Method**	**Units**		
Arsenic (dissolved)	CE128 U	µg/l As	4.38	2.74
Boron (dissolved)	CE128 U	µg/l B	318	177
Cadmium (dissolved)	CE128 U	µg/l Cd	<0.07	0.23
Chromium (dissolved)	CE128 U	µg/l Cr	<0.2	0.3
Copper (dissolved)	CE128 U	µg/l Cu	31.4	10.2
Lead (dissolved)	CE128 U	µg/l Pb	<0.2	0.2
Mercury (dissolved)	CE128 U	µg/l Hg	<0.008	<0.008
Nickel (dissolved)	CE128 U	µg/l Ni	5.5	18.7
Selenium (dissolved)	CE128 U	µg/l Se	0.63	3.22
Zinc (dissolved)	CE128 U	µg/l Zn	20	32
pH	CE004 U	units	8.1	7.2
Sulphate	CE049 U	mg/l SO_4	253	1664
Cyanide (free)	CE147	µg/l CN	<20	<20
PAH				
Acenaphthene	CE051	µg/l	1.6	<0.1
Acenaphthylene	CE051	µg/l	<0.1	<0.1
Anthracene	CE051	µg/l	2.6	<0.1
Benzo(a)anthracene	CE051	µg/l	1.0	<0.1
Benzo(a)pyrene	CE051	µg/l	1.0	0.5
Benzo(b)fluoranthene	CE051	µg/l	1.1	0.5
Benzo(ghi)perylene	CE051	µg/l	0.3	<0.1
Benzo(k)fluoranthene	CE051	µg/l	0.5	0.2
Chrysene	CE051	µg/l	1.1	<0.1
Dibenz(ah)anthracene	CE051	µg/l	<0.1	<0.1
Fluoranthene	CE051	µg/l	6.7	0.8
Fluorene	CE051	µg/l	1.9	<0.1
Indeno(123cd)pyrene	CE051	µg/l	<0.1	<0.1
Naphthalene	CE051	µg/l	1.1	0.2
Phenanthrene	CE051	µg/l	8.9	0.3
Pyrene	CE051	µg/l	5.9	0.9
PAH (total of USEPA 16)	CE051	µg/l	33.5	3.3
Benzo(j)fluoranthene	CE051	µg/l	0.1	<0.1
PAH (total of OIL 8)	CE051	µg/l	4.8	1.2
BTEX & TPH				
MTBE	CE057 U	µg/l	6	<1
Benzene	CE057 U	µg/l	1	<1
Toluene	CE057 U	µg/l	1	<1
Ethylbenzene	CE057 U	µg/l	2	<1
m & p-Xylene	CE057 U	µg/l	<2	<2
o-Xylene	CE057 U	µg/l	1	<1

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WATERS

Lab number			60388-1	60388-2
Sample id			BH02	BH03A
Depth (m)			5.10	5.97
Date sampled			07/07/2016	07/07/2016
Time sampled			-	-
Test	**Method**	**Units**		
VPH Aliphatic (>C5-C6)	CE067	µg/l	7	<1
VPH Aliphatic (>C6-C8)	CE067	µg/l	19	<1
VPH Aliphatic (>C8-C10)	CE067	µg/l	68	6
EPH Aliphatic (>C10-C12)	CE161	µg/l	296	<1
EPH Aliphatic (>C12-C16)	CE161	µg/l	1131	<1
EPH Aliphatic (>C16-C35)	CE161	µg/l	2909	14
EPH Aliphatic (>C35-C44)	CE161	µg/l	243	<1
VPH Aromatic (>EC5-EC7)	CE067	µg/l	1	<1
VPH Aromatic (>EC7-EC8)	CE067	µg/l	1	<1
VPH Aromatic (>EC8-EC10)	CE067	µg/l	3	<1
EPH Aromatic (>EC10-EC12)	CE161	µg/l	4	<1
EPH Aromatic (>EC12-EC16)	CE161	µg/l	6	<1
EPH Aromatic (>EC16-EC21)	CE161	µg/l	30	2
EPH Aromatic (>EC21-EC35)	CE161	µg/l	8	1
EPH Aromatic (>EC35-EC44)	CE161	µg/l	1	<1

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METHOD DETAILS

METHOD	WATERS	METHOD SUMMARY	STATUS	LOD	UNITS
CE128	Arsenic (dissolved)	ICP-MS	U	0.06	µg/l As
CE128	Boron (dissolved)	ICP-MS	U	6	µg/l B
CE128	Cadmium (dissolved)	ICP-MS	U	0.07	µg/l Cd
CE128	Chromium (dissolved)	ICP-MS	U	0.2	µg/l Cr
CE128	Copper (dissolved)	ICP-MS	U	0.4	µg/l Cu
CE128	Lead (dissolved)	ICP-MS	U	0.2	µg/l Pb
CE128	Mercury (dissolved)	ICP-MS	U	0.008	µg/l Hg
CE128	Nickel (dissolved)	ICP-MS	U	0.5	µg/l Ni
CE128	Selenium (dissolved)	ICP-MS	U	0.07	µg/l Se
CE128	Zinc (dissolved)	ICP-MS	U	1	µg/l Zn
CE004	pH	ICP-MS	U	-	units
CE049	Sulphate	Ion Chromatography	U	10	mg/l SO_4
CE147	Cyanide (free)	Distillation, Colorimetry		20	µg/l CN
CE051	PAH (speciated)	Solvent extraction, GC-MS		0.1	µg/l
CE051	PAH (total of USEPA 16)	Solvent extraction, GC-MS		1.6	µg/l
CE057	MTBE	Headspace GC-FID	U	2	µg/l
CE057	Benzene	Headspace GC-FID	U	1	µg/l
CE057	Toluene	Headspace GC-FID	U	1	µg/l
CE057	Ethylbenzene	Headspace GC-FID	U	1	µg/l
CE057	m & p-Xylene	Headspace GC-FID	U	2	µg/l
CE057	o-Xylene	Headspace GC-FID	U	1	µg/l
CE067	VPH Aliphatic (>C5-C6)	Headspace GC-FID		1	µg/l
CE067	VPH Aliphatic (>C6-C8)	Headspace GC-FID		1	µg/l
CE067	VPH Aliphatic (>C8-C10)	Headspace GC-FID		1	µg/l
CE161	EPH Aliphatic (>C10-C12)	Solvent extraction, GC-FID		1	µg/l
CE161	EPH Aliphatic (>C12-C16)	Solvent extraction, GC-FID		1	µg/l
CE161	EPH Aliphatic (>C16-C35)	Solvent extraction, GC-FID		1	µg/l
CE161	EPH Aliphatic (>C35-C44)	Solvent extraction, GC-FID		1	µg/l
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID		1	µg/l
CE067	VPH Aromatic (>EC7-EC8)	Headspace GC-FID		1	µg/l
CE067	VPH Aromatic (>EC8-EC10)	Headspace GC-FID		1	µg/l
CE161	EPH Aromatic (>EC10-EC12)	Solvent extraction, GC-FID		1	µg/l
CE161	EPH Aromatic (>EC12-EC16)	Solvent extraction, GC-FID		1	µg/l
CE161	EPH Aromatic (>EC16-EC21)	Solvent extraction, GC-FID		1	µg/l
CE161	EPH Aromatic (>EC21-EC35)	Solvent extraction, GC-FID		1	µg/l
CE161	EPH Aromatic (>EC35-EC44)	Solvent extraction, GC-FID		1	µg/l

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DEVIATING SAMPLE INFORMATION

Comments
Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.
For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.
Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
A	Sampling date not provided
B	Sampling time not provided (waters only)
C	Sample exceeded holding time(s)
D	Sample not received in appropriate containers
E	Headspace present in sample container
F	Sample not chemically fixed (where appropriate)
G	Sample not cooled
H	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
60388-1	BH02	5.10	N	
60388-2	BH03A	5.97	N	

APPENDIX V

Ground Contamination Risk Assessment Data:
Methodology & Notes for Off-site Disposal

CLEA Risk Assessment Data:
Level 1 CL:AIRE Calculation Sheets & Statistical Analysis Sheets

Conceptual Site Model (CSM)

Ground Contamination Risk Assessment

Assessment Framework:-

Ground contamination risk assessments are undertaken to identify potential risks from historical and recent land contamination on a given site and enable appropriate risk management actions to be undertaken in accordance with the regulatory context of the site and any future development. There are a range of technical approaches to the assessment of chemical contaminants in the UK, all of which broadly fit within a tiered/phased approach and the current UK approach is set out in the Defra and Environment Agency Publication: CLR 11: Model Procedures for the Management of Land Contamination (*Defra/EA 2004*).

ARC's approach to undertaking ground contamination risk assessments is based on the tiered/phased framework in accordance with CLR11, and for Human Health, the recently updated CLEA (Contaminated Land Exposure Assessment) framework and model for assessing potentially contaminated land in the UK. This framework and model is based primarily on the following publications and software: Science Reports SC050021/SR2 (EA 2008b Human Health toxicological assessment of contaminants in soil) and SC050021/SR3 (Updated technical background to CLEA model – replaces the previous guidance documents CLR9, CLR10 and Briefing notes 1 – 4); Science Report SC050021/SR4 (CLEA Software (version 1.06 beta) handbook) and the new CLEA software (replaces Science Report SC050021/H CLEA UK Handbook (draft) and the CLEA UK Software version 1.0 beta), along with the publication of a review of body weight and height data used within the Contaminated Land Exposure Assessment model (CLEA), Project no. SC050021/Technical Review 1.

All SGV's (Soil Guidance Values) published as part of the CLEA UK Handbook (draft) and software (version 1.0 beta), have been withdrawn along with guidance documents CLR7 and CLR8, and replacement of the SGV values to provide new Generic Assessment Criteria values (GAC's), using the updated model and software (version 1.06) has been derived by a combination of regulatory and non-governmental organisations (Defra, CL:AIRE and LQM). The newly published GAC's are known as Category 4 Screening Levels (C4SL's) and Suitable 4 Use Levels (S4UL's), and where assessment values for certain contaminants are not available the most appropriate alternative values from other sources will be utilised.

When considering ground contamination risk assessments for Controlled Waters (groundwater and surface waters), ARC follows the EA guidance on Remedial Targets Methodology, Hydrogeological Risk Assessment for Land Contamination, 2006.

Methodology:-

ARC consider that the most appropriate methodology for completing a ground contamination risk assessment for soils on this site is to utilise the recently published GAC values (LQM CIEH S4UL's – Arsenic, Cadmium, Chromium VI, Chromium III, Lead Copper, Mercury, Nickel, Selenium, Zinc, Benzene, Toluene, Ethylbenzene, Xylenes, Phenol, speciated PAH's, speciated TPH's and other organic compounds), combined with other published and recognised GAC's (generic assessment criteria) for the remaining analytes. It is widely recognised by ground contamination risk assessment practitioners that the new CLEA model will generally result in higher SGV and GAC (generic assessment criteria) values for the standard end uses, and consequently continued use of the former CLEA model will result in a slightly more conservative assessment.

For general soil surface contamination, the new S4UL value for inorganic Mercury can be compared with chemical analysis for total mercury content, as the concentrations of elemental and methylmercury compounds are likely to be very low, in accordance with Science Report SC050021 / Mercury SGV. In addition, the updated C4SL values are based upon a Soil Organic Matter (SOM) content of 6%, in line with the most recent Defra and EA guidance. Once all the relevant data is available, a reassessment of the ground contamination present on this site can be carried out, if felt necessary, as this may result in a reduction in the scope of remediation works (if required). It should be noted that guidance document CLR11: Model Procedures for the Management of Land Contamination has not been withdrawn.

Ground Contamination Risk Assessment (Cont'd)

Methodology (Cont'd):-

ARC ground contamination risk assessments, in accordance with CLR11, are based on the established *source-pathway-receptor* pollutant linkage methodology and 'suitable for use' approach (Part IIA, EPA 1990 - inserted through Section 57 EA 1995), and adopts the tiered/phased approach beginning with a preliminary assessment (also referred to a desk top study). If potential pollutant linkages are identified from the preliminary assessment, for both Human Health and/or Controlled Waters, then Level 1 Quantitative Risk Assessments are appropriate guideline values. For soils these typically comprise Generic Assessment Criteria values (GAC's) or site specific assessment criteria (SSAC), and for Controlled Waters, Environmental Quality Standards (EQS) or UK Drinking Water Standards.

Where any Level 1 criteria have been exceeded, various courses of action are available for recommendation, in order to try and 'break' the pollutant linkage by designing into the proposed development works and/or by recommending appropriate remediation works, i.e. removal of source, treatment of contaminants, installation of permanent barriers, etc. and/or by carrying out more detailed site specific quantitative risk assessment (DQRA, i.e. Level 2 or above). Completing further DQRA for any contaminants present, can take into account factors such as the introduction of physical barrier and the actual availability of plausible contaminant migration pathways, as well as site specific data such as the type, properties and characteristics (permeability, porosity, density, etc.) of the soil present on site, groundwater depth and flow, site specific exposure criteria and values, and contaminant retardation, attenuation, dilution and degradation. Similarly, when considering potential risks to off-site receptors, these are considered by assessing the potential risks to on-site receptors, as well as the potential mobility of any contaminants present within either the soils or water/groundwater below this site.

For the purpose of this report, the preliminary and level 1 risk assessment considers one main category of receptor, and this is as follows:

- On site Human Health – (CLEA Model).

When considering the risk to construction workforce, the results of the screening can be used by the Main Contractor/Project Coordinator, when devising an adequate Site Health & Safety Plan, in accordance with current CDM Regulations, and when assessing the level of PPE required on site. Similarly, when considering the risks to building materials, again the results of the contamination screening can be used to determine the level of protection that may be required, and reference should be made to the utilities suppliers for their comments.

Level 1 - Human Health:-

Level 1 human health related assessments are based upon the current CLEA Model, with site values assessed against published Generic Assessment Criteria Values (GAC's – C4SL's & S4UL's), and where these values are not available against the published CIEM (Chartered Institute of Environmental Health)/LQM Generic Assessment Criteria (GAC), CL:AIRE, Atkins ATRISKsoil© SSV values and USEPA Region 9 Screening Values (2009). For statistical analysis, the site is assessed to delineate any potentially differing areas of contamination (averaging areas), based on the results of the preliminary investigation as well as the result of any visual, olfactory or analytical evidence following completion of the intrusive investigation works. Following this geographical delineation of the site, where generic or pervasive contaminants are anticipated, for each 'averaging area' under consideration, the results are assessed using the established methods of statistical analysis given in the CL:AIRE Guidance on Comparing Soil Contamination Data with a Critical Concentration (C_C), May 2008. In this case, the results of the sample population are assessed to determine whether they represent a normal or non-normal distribution and the statistical upper confidence limit is (95% percentile – $UCL_{0.95}$) is calculated and then compared with the chosen Level 1 Critical Concentration (C_C) value for the site (i.e. the appropriate GAC or SSV).

In addition, further statistical analysis is undertaken to determine whether the maximum concentration(s) recorded represent statistical outliers, i.e. potential 'hot spots', and where necessary these are removed from the sampling populations and a reassessment of the averaging areas/potential hot spot areas identified.

Ground Contamination Risk Assessment (Cont'd)

Notes for Off-Site Disposal

When considering the removal of any materials from this site as a waste, to be disposed of at a landfill, it can be seen that where the uncontaminated natural strata (excluding any 'topsoil' or 'peat' materials) can be kept separate from any made ground or contaminated natural strata, then these materials can be considered as 'inert' and taken to an Inert Landfill Site. Prior to disposal of these 'inert' materials, full WAC screening may need to be undertaken, with the number of samples to be screened dependant upon the volume of material to be disposed of.

Where made ground or contaminated natural strata is to be removed off site as a 'waste', a preliminary classification assessment, regarding off-site disposal, can be made utilising the contamination soils screening undertaken as part of the Level 1 Risk Assessment for Human Health. If there is sufficient screening to classify these materials as Non-Hazardous, then they can be disposed of at a Non-Hazardous Landfill. If insufficient preliminary screening has been undertaken to carryout the classification assessment, then further preliminary soils screening should be undertaken, where required.

If the results of the preliminary classification assessment indicate that the materials to be removed from site as a 'waste' should be classified as Hazardous Waste, then prior to disposal, full WAC screening should be completed so that these materials can be classified as either Stable Non-Reactive Hazardous Waste or Hazardous Waste, and disposed of at a suitable waste disposal facility.

If possible, removal of materials from site as a 'waste' should be kept to a minimum, however, if materials have to be removed to accommodate finished ground levels etc., it is recommended that the volume to be disposed of is calculated, as the amount of additional screening required, including any full WAC screening, will be dependant upon the volume of material to be disposed of.

CL:AIRE Statistical Analysis Calculation Sheet - Level 1 GQRA for Generic Contaminants

Client/client ref: STG
Project ref: Penistone
Site ref: 16-384
Data description: Contamination Results
Contaminant(s): Generic
Test scenario: Planning
Date: 6 July 2016
User details: RS

	Arsenic (total) (mg/kg)	Cadmium (total) (mg/kg)	Chromium (III) (mg/kg)	Chromium (VI) (mg/kg)	Copper (total) (mg/kg)	Lead (total) (mg/kg)	Mercury (total) (mg/kg)	Nickel (total) (mg/kg)	Selenium (total) (mg/kg)	Zinc (total) (mg/kg)	Cyanide (free) (mg/kg)
Critical concentration, C_c	**37**	**11**	**910**	**6**	**2400**	**200**	**40**	**130**	**250**	**3700**	**34**
Notes	S4UL - Residential with home-grown produce - LQM, 2014	S4UL - Residential without home-grown produce - LQM, 2014	S4UL - Residential without home-grown produce - LQM, 2014	S4UL - Residential without home-grown produce - LQM, 2014	S4UL - Residential without home-grown produce - LQM, 2014	C4SL - Residential with home-grown produce - CL:AIRE, 2014	S4UL - Residential without home-grown produce - LQM, 2014	S4UL - Residential without home-grown produce - LQM, 2015	S4UL - Residential without home-grown produce - LQM, 2014	S4UL - Residential without home-grown produce - LQM, 2014	ATRISK(SOIL) SSV - 2015
Sample size, n	13	13	13	7	13	13	13	13	13	13	13
Sample mean, $\overline{x}$	43.8008672	1.08128962	66.9328878	0.5	352.679515	143.197788	0.18615385	62.2459353	1.29469165	172.291473	0.29230769
Standard deviation, s	22.0729227	0.84149459	30.4527883	0	225.521948	106.658277	0.07847913	28.9429214	1.21224	102.824462	0.23349353
Number of non-detects	0	**1**	0	**7**	0	0	**7**	0	**1**	0	**13**
Set non-detect values to:	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit
Outliers?	No	No	No	No	No	No	No	No	No	No	No
Distribution	Normal	Normal	Normal	Single value	Non-normal	Non-normal	Non-normal	Normal	Non-normal	Non-normal	Non-normal
Statistical approach	Auto: One-sample t-	Auto: One-sample t-	Auto: One-sample t-	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: One-sample t-	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev

Test scenario:	Planning: is true mean lower than critical concentration (μ < Cc)?				**Evidence level required:**		**95%**	Use Log-Normal distribution to test for outliers			
t statistic, t_0 (or k_0)	1.110902969	-42.49869158	-99.81751651	N/A	-32.73170989	-1.920181859	-1829.159648	-8.440431817	-739.7212938	-123.6994941	-520.5061165
Upper confidence limit (on true mean concentration, μ)	54.711902	1.49725523	81.9862379	0.5	625.322256	272.141357	0.28103049	76.5529316	2.76021835	296.600186	0.57458761
Evidence level	**14%**	**100%**	**100%**	**100%**	**100%**	**79%**	**100%**	**100%**	**100%**	**100%**	**100%**
Base decision on:	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level
Result	**μ ≥ Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ ≈≥ Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**
Select dataset	○ Y	○ Y	○ Y	○ Y	○ Y	◉ Y	○ Y	○ Y	○ Y	○ Y	○ Y

CL:AIRE Statistical Analysis Calculation Sheet - Level 1 GQRA for Speciated PAH's

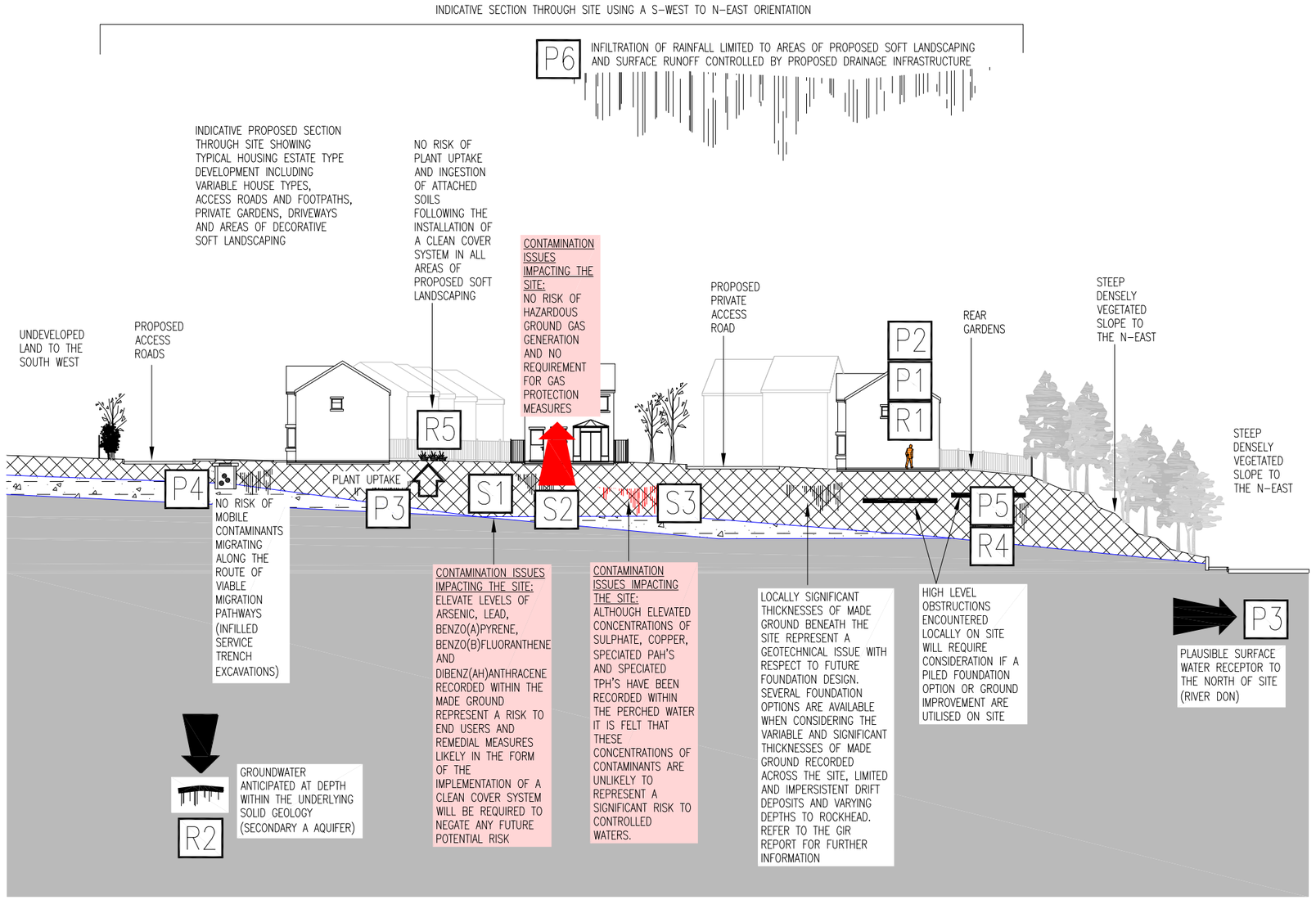
Client/client ref: STG
Project ref: Penistone
Site ref: 16-384
Data description: Contamination Results
Contaminant(s): Speciated PAH (USEPA 16)
Test scenario: Planning
Date: 6 July 2016

	Acenaphthene (mg/kg)	Acenaphthylene (mg/kg)	Anthracene (mg/kg)	Benzo(a)anthracene (mg/kg)	Benzo(a)pyrene (mg/kg)	Benzo(b)fluoranthene (mg/kg)	Benzo(ghi)perylene (mg/kg)	Benzo(k)fluoranthene (mg/kg)	Chrysene (mg/kg)	Dibenz(ah)anthracene (mg/kg)	Fluoranthene (mg/kg)	Fluorene (mg/kg)	Indeno(123cd)pyrene (mg/kg)	Naphthalene (mg/kg)	Phenanthrene (mg/kg)	Pyrene (mg/kg)
Critical concentration, C_c	**1100**	**920**	**11000**	**13**	**3**	**3.7**	**350**	**100**	**27**	**0.3**	**890**	**860**	**41**	**13**	**440**	**2000**
Notes	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014	S4UL - Residential with home-grown produce, 6% SOM - LQM, 2014
Sample size, n	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Sample mean, $\overline{x}$	0.12729553	0.0893676	0.40079367	1.41659549	1.90846229	1.8136755	1.15678552	0.7744217	1.13866778	0.31978067	3.25703051	0.20449547	1.37106524	0.19662034	1.2873543	2.83691254
Standard deviation, s	0.08733204	0.08324278	0.53486797	2.08286364	2.66123324	2.31410609	1.55863642	1.16823046	1.51912832	0.28274147	4.29061392	0.17593474	2.10791723	0.25873841	1.55691327	3.99934448
Number of non-detects	**4**	**4**	**4**	**3**	**1**	**1**	**2**	**3**	**3**	**1**	**1**	**2**	**2**	**4**	**1**	**2**
Set non-detect values to:	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit
Outliers?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Distribution	Normal	Non-normal	Non-normal	Non-normal	Non-normal	Non-normal	Non-normal	Non-normal	Non-normal	Normal	Non-normal	Normal	Non-normal	Non-normal	Non-normal	Non-normal
Statistical approach	Auto: One-sample t	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: One-sample t	Auto: Chebychev	Auto: One-sample t	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev
Test scenario:	Planning: is true mean lower than critical concentration (μ < Cc)?			**Evidence level required:**			**95%**	Use Log-Normal distribution to test for outliers								
t statistic, t_0 (or k_0)	-45408.8477	-39844.71866	-74148.42787	-20.05150897	-1.478861429	-2.939035395	-806.9695267	-306.2434354	-61.38017301	0.252245298	-745.1607869	-17620.379	-67.7845193	-178.4166547	-1015.985261	-1800.513549
Upper confidence limit (on true mean concentration, μ)	0.17046529	0.19000321	1.04741751	3.93465485	5.1257364	4.61129335	3.04108507	2.18674346	2.97520437	0.45954476	8.44412981	0.29146311	3.91941291	0.50941982	3.16957066	7.67188425
Evidence level	**100%**	**100%**	**100%**	**100%**	**69%**	**90%**	**100%**	**100%**	**100%**	**40%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Base decision on:	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level	evidence level
Result	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ ≈≥ Cc**	**μ ≈≥ Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ ≥ Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**	**μ < Cc**
Select dataset	○ Y	○ Y	○ Y	○ Y	◉ Y	○ Y	○ Y	○ Y	○ Y	○ Y	○ Y	○ Y	○ Y	○ Y	○ Y	○ Y

CRITICAL POLLUTANT LINKAGES

SOURCE		PATHWAY		RECEPTOR	
S	1. MADE GROUND ASSOCIATED WITH HISTORICAL DEVELOPMENT AND USAGE OF THE SITE (I.E. IRON & STEEL WORKS, RAILWAY LAND, AND DEMOLITION OF HISTORICAL INFRASTRUCTURE) 2. HAZARDOUS GROUND GAS/VAPOURS GENERATION – MADE GROUND 3. DEPOSITS AND HYDROCARBON IMPACTED SOILS & WATER LOCALISED HYDROCARBON CONTAMINATION – SOIL & PERCHED WATER	P	1. INGESTION & DERMAL CONTACT 2. INHALATION OF INDOOR / OUTDOOR AIR 3. PLANT UPTAKE AND ATTACHED SOIL 4. MIGRATION THROUGH EXISTING SERVICES 5. DIRECT CONTACT WITH BUILDING MATERIALS 6. SURFACE RUNOFF & INFILTRATION	R	1. HUMAN HEALTH 2. DEEP GROUNDWATER (SECONDARY A AQUIFER –BEDROCK) 3. RIVER DON – C.60M NORTH 4. BUILDING MATERIALS 5. FLORA AND FAUNA

INDICATIVE SECTION THROUGH SITE USING A S–WEST TO N–EAST ORIENTATION



STRATA DETAILS

MADE GROUND:
FROM 0.00M UP TO C.2.50M AND C.6.70M.
THE SITE SURFACING COMPRISES OVERGROWN GRASS AND TREES AND A DARK BROWN SANDY CLAYEY SOIL UNDERLAIN BY MADE GROUND COMPRISING MIXTURES OF CLAY, SAND AND GRAVEL CONTAINING PREDOMINANTLY BRICK, CONCRETE AND SLAG RUBBLE (CONSTITUTES APPROX. C.30%–C.40% OF THE MADE GROUND MATRIX), ASH, CINDER, CLINKER, COAL AND BURNT SILTSTONE

DRIFT DEPOSITS:
FROM C.2.50M TO C.3.70M UP TO C.3.15M AND C.4.10M.
LIMITED NATURAL DEPOSITS WERE NOTED ACROSS THE SITE COMPRISING SOFT SILTY SANDY GRAVELLY CLAY, AND FIRM TO STIFF (HIGH STRENGTH) SLIGHTLY SANDY SLIGHTLY GRAVELLY CLAY. A DARK GREY AND BLACK MOTTLED SLIGHTLY SANDY GRAVELLY RELIC TOPSOIL LAYER WAS NOTED IN TP02 BETWEEN C.2.65M AND C.2.85M

SOLID GEOLOGY (LOWER COAL MEASURES):
FROM C.3.15M TO C.6.70M UP TO AT LEAST C.30.00M.
THE SOLID GEOLOGY INITIALLY COMPRISES YELLOWISH LIGHT BROWN SILTSTONE WHICH IS NOTED TO BE HIGHLY WEATHERED, RECOVERED AS SILTY FINE TO COARSE ANGULAR GRAVELS AND COBBLE SIZED FRAGMENTS. WITHIN THE ROTARY BOREHOLES THE SILTSTONE ALTERNATES WITH THE PRESENCE OF GREY MUDSTONE.
NO COAL SEAMS WERE ENCOUNTERED WITHIN THE DEEPER ROTARY BOREHOLES, AND NO SOFT GROUND INDICATIVE OF BROKEN GROUND ASSOCIATED WITH HISTORIC MINE WORKINGS WAS ENCOUNTERED ACROSS THE SITE. CONSISTENT DRILLING RATES AND BETWEEN 50% AND 100% OF THE FLUSH MEDIUM WAS MAINTAINED DURING THE DRILLING PERIOD.

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The contractor shall check all dimensions on site before commencement of any works. No dimensions to be scaled off this drawing.
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rev.	date	amendments	drawn	chckd

Client:
STRATEGIC TEAM GROUP

Project Title:
Proposed Residential Development
Lairds Way
Penistone, South Yorkshire

Drawing Title:
Conceptual Site Model

Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	27.10.16	P.D	R.S

Job Ref:	Drg no:	Rev:
16–384	–	–