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PHASE 2: GROUND INVESTIGATION REPORT

GUS ROBINSON DEVELOPMENTS LTD

PROPOSED RESIDENTIAL DEVELOPMENT

GORDON HOUSE

GORDON STREET

SOUTH SHIELDS

TYNE AND WEAR

NE33 4JP

Project No: 16-911

Prepared By:

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Date: 24th January 2017

Checked By:

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Date: 24th January 2017

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APPENDICES

1.0 Introduction

January 2017

As requested by Portland Consulting Engineers on behalf of Gus Robinson Developments Ltd, and in conjunction with a Phase 1: Desk Top Study Report & Coal Mining Risk Assessment (DTS) completed for this site by Arc Environmental Ltd (Ref. No. 16-911, January 2017), Phase 2 Ground Investigation works have been carried out for a proposed residential development at Gordon House on Gordon Street in South Shields, Tyne and Wear. It is proposed to demolish the existing office block on site and construct c.20 no. residential properties, with associated infrastructure and soft landscaped areas. (CLEA end use category: *Residential – With Home Grown Produce).*

The intrusive investigation works comprised the sinking of 2 no. rotary open boreholes (labelled RBH's 1 - 2) and the sinking of 8 no. windowless sampling boreholes (labelled BH's 1 - 8) accompanied by the installation of 3 no. combined ground gas and groundwater monitoring wells, installed at the location of BH's 1, 3 & 5. The positions of the investigation locations can be seen on the Borehole Location Plan, a copy of which can be seen in Appendix II. It should be noted that this plan is for orientating purposes only, as the positions shown are approximate and the plan is not to a standard scale.

2.0 Site Details

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

Site Name & Address:	Proposed Residential Development, Gordon House, Gordon Street, South Shields, Tyne and Wear NE33 4JP.
National Grid Reference:	436500, 565720 (representative for the central part of the site).
Description of Location:	The site is in a residential setting to the south of South Shields Town Centre.
Site Boundaries:	N, E & S = Residential properties on Gordon Street, Hampden Street and Garrick Street, W = Car park, Day Centre and Nursery.
Site Shape & Development Details:	The site is irregular in shape, occupying an area of c.0.32 hectares (Ha) where it is proposed to demolish the existing office block and develop 20 no. residential properties with associated infrastructure and soft landscaping.
General Topography (AOD):	The site and vicinity generally falls to the west.
Site Surfacing:	The external areas around the office block comprise tarmac, paving and soft landscaping.
Above Ground Structures:	The current 'L' shaped office block is present across the northern portion of the site.
Sub-surface Structures & Services:	A small plant room is present below the western portion of the existing office block. Current and relic services will also be present which may pass below the proposed development area.

3.0 Scope of Works

Table 3.1

Client:	Gus Robinson Developments Ltd.
Consultant:	Portland Consulting Engineers.
Project type:	Residential development.
Site Location plan:	See Appendix I.
Layout plans (existing):	See Appendix I.
Layout plans (proposed):	See Appendix I.
Investigation Works:	2 no. rotary openhole boreholes (RBH's 1 & 2). 8 no. windowless sampling boreholes (BH's 1 - 8). 3 no. combined ground gas and groundwater monitoring wells (BH's 1, 3 & 5).
Laboratory Testing:	Geotechnical & Ground Contamination.
CLEA End-Use Classification:	Level 1 GQRA – Taken as *Residential With Home Grown Produce.*

The information contained in this report is limited to the area of the proposed development, 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.

3.0 Scope of Works (Cont'd)

3.1 Investigation Rationale:-

This ground investigation has been designed to provide information on the general ground and groundwater conditions where access would allow, in the area of the proposed development. The boreholes were created primarily for geotechnical purposes to assist in the design of new foundations for the proposed development with some contamination screening undertaken to aid in assessing the risks to Human Health, Controlled Waters and for off site disposal.

The rationale behind the location of each exploratory hole is summarised in Table 3.2 below.

Table 3.2

Potential issue	Exploratory Hole
Determine the nature of the underlying shallow ground conditions, including shallow groundwater.	BH's 1 - 8
Investigate possible shallow mine workings below the site.	RBH's 1 & 2
Determine the sites ground gas regime.	BH's 1, 3 & 5
Determine existing slab and fill thickness below existing office block.	BH's 7 & 8
Assessment of ground conditions for the management of surface water.	BH's 1, 3 & 5
Determine the levels of contamination present within the initial soil deposits with a view to determining the risks posed towards the future site end-users and Controlled Waters.	BH's 1 - 8

3.2 Sampling & Site Protocols:-

All works associated with this ground contamination assessment and investigations have generally been completed in accordance with BS10175: British Standard Code of Practice for the Investigation of Potentially Contaminated Sites (2011) & CLR11, with the following precautions specific to this project.

3.2.1 Contamination Sampling:-

Samples were recovered by a representative of ARC Environmental Ltd. during the intrusive investigation works. All samples were stored at approximately 4°C using cool boxes and ice packs prior to delivery to a UKAS/MCERTS accredited laboratory. Sampling was carried out in accordance with 'Technical Policy Statement 63: UKAS Policy on Deviating Samples'.

3.2.2 Onsite Health & Safety Requirements:-

All site representatives wore relevant and appropriate PPE including (where appropriate) safety footwear, high visibility jacket/vest, hard hat, eye protection and overalls. In addition, disposable latex gloves were used when handling any potentially contaminated materials and when rinsing all sampling tools. Each site vehicle contained a suitable First Aid kit with hand wash station/cleansing products (i.e. sanitary wipes).

3.2.3 Avoiding Cross-Contamination between Sample Locations:-

To avoid cross-contamination of materials between soil horizons, drill casing was used to seal off the made ground. In addition, disposable plastic liners were used to collect samples from the windowless sampling boreholes carried out.

4.0 Ground Conditions

For an accurate description of the ground conditions encountered at each investigation position, reference should be made to the borehole logs in Appendix II. It should be noted that there is always the possibility of variation in the ground conditions around and between the borehole locations.

4.0 Ground Conditions (Cont'd)

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.0.35m and c.2.20m.	The made ground materials comprised initial site surfacing of tarmac, paving and turf over sandy clayey soil, loose hardcore limestone fill, builders sand, sandy gravel, soft and stiff sandy gravelly clay and gravelly sand. The gravel comprised fragments of limestone, sandstone, concrete, brick and coal.
DRIFT GEOLOGY:	~	No natural drift deposits were encountered across the site with weathered sandstone deposits encountered directly below the made ground.
SOLID GEOLOGY: (Middle Coal Measures)	From c.0.35m and c.2.20m to c.>30.00m (Base of rotary boreholes).	Solid deposits were encountered below the site initially comprising medium dense and dense highly weathered SANDSTONE, recovered as gravelly sand over more competent SANDSTONE to a depth in excess of c.30.00m. BH's 1 - 8 were terminated at shallow depths within solid deposits due to effective refusal. No coal or soft ground indicative of broken ground associated with historic mine workings was encountered across the site. Consistent drilling rates and 100% flush medium was maintained during the drilling period.

bgl = Below ground level.

Made ground was encountered within the boreholes, to a depth of between c.0.35m and c.2.20m across the site. There may be deeper made ground materials in the area of the plant room below the western portion of the existing building on site. There was no visual or olfactory evidence of significant or 'gross' contamination (fuel, oils or visual asbestos) noted on or below the site during the ground investigation works.

4.2 Shallow Coal Mining Assessment:-

As highlighted within the Phase 1: Desk Top Study & Coal Mining Risk Assessment Report, the site is in an area where it is believed that the Usworth Coal Seam (Us) may exist at shallow depth and within which workings may exist. Therefore, a series of open hole rotary boreholes have been completed on site to determine the level of risk to the proposed development with details of each rotary borehole shown in Table 4.2 below.

Table 4.2

Position	Drift Thickness (BGL)	Evidence of Coal Y/N	Evidence of Workings Y/N	Depth to Coal (BGL)	Thickness
RBH1	~	N	N	~	~
RBH2	~	N	N	~	~

Although the BGS information suggests that the Us Coal Seam could be present at shallow depth below the site, there was no evidence of coal or workings in the form of broken ground or voids during the excavation of the boreholes. 100% flush return was noted within all boreholes which were taken to a terminal depth of c.30.00m.

4.0 Ground Conditions (Cont'd)

4.3 Groundwater & Stability:-

During the investigation works, no water ingresses were noted within the boreholes However, pockets of trapped surface water may be present within the made ground and initial highly weathered solid deposits below the site. It would therefore be prudent to allow for the introduction of groundwater control techniques (i.e. sump pumping equipment), in order to take care of any ingresses of groundwater, during the construction period, especially during the wetter periods of the year.

Owing to the nature of the made ground and initial highly weathered solid deposits present across the site, adequate lateral trench support may be required for excavations, in order to prevent trench wall collapse or over excavations, as well as to create a safe working environment below a depth of 1.20m, and any excavations on this site should remain open for as short a period as possible, since some of these materials may be susceptible to deterioration, if left open to the natural elements for any significant period of time. Reference to CIRIA 97 'Trenching Practice' would be beneficial to establish a suitable means of support or battering of excavation sides during construction.

In order to carry out a programme of ground gas and groundwater monitoring, combined monitoring wells were installed at the locations of BH's 1, 3 & 5, the results of which are discussed further in Section 5.2 below.

5.0 Insitu Testing

5.1 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 cohesive made ground deposits encountered in the shallow boreholes. The results obtained can be found adjacent to the appropriate sample level, on the graphic borehole record sheets attached in Appendix II.

From the results of the testing completed within the made ground materials, shear strength values were recorded ranging between 21kN/m^2 to 32kN/m^2 indicative of soft deposits.

5.2 Insitu Gas & Water Monitoring:-

Ground gas & water monitoring standpipes were installed within BH's 1, 3 & 5, primarily to check for the possible presence of hazardous ground gases, and to monitor any shallow water levels. 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. Monitoring was undertaken using a Gas Data GFM 435 series soil gas analyser, with integral flow meter, and a Geotechnical Instruments electronic dipmeter. The response zones were designed to target any ground gas from on and off site sources.

Based on the findings of the intrusive investigation works, in accordance with CIRIA Report C665, November 2007, Report Edition No. 04, March 2007 and BS8485:2015 – Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, it is felt that an adequate risk assessment can be undertaken based on the following limiting factors:

- The development has been considered as **high sensitivity** i.e. Residential development (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 intrusive works).
- 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).

5.0 Insitu Testing & Sampling (Cont'd)

5.2 Insitu Gas & Water Monitoring (Cont'd):-

- **Negligible** flow rates are recorded during the monitoring period (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).

For this site, the monitoring visit undertaken to date was taken during a falling and low atmospheric pressure trend. As a comparison to the falling and low atmospheric pressure trend, monitoring will also be undertaken during rising and high pressures, in order to correlate with differing conditions. Monitoring of the weather conditions and predicated atmospheric pressures (Met Office Surface Pressure Charts) will be carried out up to 72 hours in advance of proposed monitoring visits, in order that a reasonable period of data is obtained to determine atmospheric trends, and also to target the 'worst case' scenario.

A summary of the results for the visit undertaken to date, compared with the 'inert' background gas levels is presented in Table 5.1 below, whilst a copy of the monitoring certificate is attached in Appendix III. A further 5 no. monitoring visits have been scheduled and the results along with the final recommendations will be issued as an addendum report.

Table 5.1

Position	Date	Atmospheric Pressure (mbar)	Water (m bgl)	CH_4 (%v/v)	LEL (%v/v)	CO_2 (%v/v)	O_2 (%v/v)	Flow Rate (l/hr)
Background		**~**	**~**	**0**	**0**	**0**	**21.0**	**<0.1**
WS1	13/01/17	1002-1003 (*trend - Falling 1029 – 994mb)	Dry	0.0	0.0	0.0	20.0	<0.1
WS3			Dry	0.0	0.0	0.7	19.3	<0.1
WS5			Dry	0.0	0.0	0.0	19.9	<0.1
5 no. outstanding visits to be completed – results to follow as Addendum Letter Report.								

* Note – Atmospheric trend taken from www.wunderground.com for Leeds / Bradford Airport.

As can be seen from the results undertaken to date, no levels of Methane (CH_4) have been recorded during the monitoring period. However, detectible concentrations of Carbon Dioxide (CO_2) have been recorded (to date), up to a maximum recorded level of 0.7% *v/v*, with associated oxygen (O_2) concentrations (minimum 19.3% *v/v)*. A negligible flow rate of <0.1l/hr has been recorded during the monitoring period undertaken to date.

Based on the results undertaken to date, in accordance with CIRIA Report C665, a preliminary risk assessment has been completed for this site, by converting the results in Table 5.1 above to a gas screening value (GSV), calculated by multiplying the typical maximum gas concentrations with the recorded maximum positive flow rates (after Wilson & Card).

Using the maximum values recorded, as no increased levels of Methane have been recorded to date, the gas screening value (GSV) for Carbon Dioxide only has been calculated, the results of which are shown below:

Carbon Dioxide GSV = 0.007 (0.7%) x 0.1 = 0.0007 l/hr

When considering the gas screening value (GSV) for Carbon Dioxide, the GSV of 0.0007 l/hr falls below the lower target concentration of 0.07 l/hr and as such equates to a Characteristic Situation 1 (CS1), in accordance with Table 8.5 in CIRIA C665. Consequently, at this stage, based upon the results of this preliminary assessment, gas protective measures are unlikely to be required for the proposed development.

5.0 Insitu Testing & Sampling (Cont'd)

5.2 Insitu Gas & Water Monitoring (Cont'd): -

However, as previously highlighted, a further five monitoring visits have been scheduled for this site and the final results along with the final recommendations will be issued as an Addendum Letter Report.

No water levels have been recorded within the monitoring wells during the monitoring visit to date.

5.3 Insitu Standard Penetration Tests (SPT):-

Standard penetration tests (SPT's) were carried out with the use of a normal split spoon sampler in the made ground and weathered solid deposits encountered within the shallow boreholes in order to determine the relative strength / density of the materials tested. The results are shown as 'N' values on the graphic borehole record sheets, adjacent to the appropriate sample level.

A summary of the test results can be seen in Table 5.2 below;

Table 5.2

Type of strata	Range of SPT 'N' Values	Result details
MADE GROUND:	4 - 36	Indicative of loose to dense deposits
SOLID GEOLOGY: (Middle Coal Measures)	14 - 49 Blows of 50 for limited penetration	Indicative of medium dense to very dense / hard deposits

5.4 Variable Head (Falling) Permeability Tests:-

Variable head (falling) permeability tests were carried out at a depth of between c.1.73m and c.2.25m within BH's 1, 3 & 5. The tests and calculations were carried out in accordance with BS5930:2015:cl.25.4 – after Hvorslev (general approach), with the summarised results indicated in Table 5.3 below. The Permeability Calculation Sheets for the tests undertaken have also been attached in Appendix II.

Table 5.3

Position	Depth (m)	Coefficient of Permeability, k (ms^{-1})	Permeability Classification	Drainage Characteristics
BH1	1.73	3.24×10^{-7}	Low	Poor
BH3	2.25	8.53×10^{-8}	Very low	Practically Impervious
BH5	2.00	7.47×10^{-8}	Very low	Practically Impervious

From these results, poor and practically impervious drainage characteristics along with low and very low permeability classifications have been recorded for the weathered solid deposits recorded below the site suggesting that these materials are unlikely to be suitable for using traditional soakaways.

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:-

A single representative sample of the clayey made ground recovered from a depth of c.1.40m in BH3 was tested in order to determine its liquid and plastic limits, so that this material could be classified. The results are summarised in Table 6.1 on the following page and are also contained in the PSL Analytical Report (ref no.: PSL17/0147), a copy of which is contained in Appendix IV.

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
BH3	1.40	12	31	16	15	CL	93

M/C = Moisture Content, LL = Liquid Limit, PL = Plastic Limit, PI = Plasticity Index, CI = Clay Intermediate.

From these results it can be seen that the sample tested is inorganic in nature, and when plotted on the plasticity chart falls within the low plasticity range. From the resulting plasticity indices, this material displays a low volume change (shrinkage or swelling) potential, when taking into account the amount passing the 425µm sieve.

Therefore, it can be seen that the made ground materials tested are unlikely to undergo significant changes in volume, if large changes in their natural moisture content were to occur due to seasonal variations or the like.

6.2 Determination of pH & SO_4:-

In total, ten representative samples of the made ground and weathered solid deposits recovered from the investigations 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 are also contained in the Chemtech Environmental Limited Analytical Report (ref. no.: 62896), a copy of which can be seen in Appendix IV.

Table 6.2

Position	Depth (m)	Strata	SO_4 (mg/l)	pH value	Design SO_4 Class	ACEC Class
BH1	0.90	MG	<10	8.7	DS-1	AC-1
BH3	0.30	MG	31	8.0	DS-1	AC-1
BH3	1.80	NS	26	8.0	DS-1	AC-1
BH4	0.80	MG	32	8.0	DS-1	AC-1
BH5	0.60	MG	28	8.0	DS-1	AC-1
BH5	1.10	NS	21	8.4	DS-1	AC-1
BH6	0.50	MG	22	8.7	DS-1	AC-1
BH6	2.45	NS	23	9.1	DS-1	AC-1
BH7	0.70	MG	42	7.8	DS-1	AC-1
BH8	2.00	NS	88	8.1	DS-1	AC-1

MG = Made Ground, NS = Natural Strata, ACEC = Aggressive Chemical Environment for Concrete site classification

Based on the results obtained, the site should be given a classification of Class DS-1, 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 site is AC-1.

6.3 Determination of Particle Size Distribution (PSD):-

Three representative samples of the weathered solid deposits recovered from across the site, were tested in order to determine their particle size distribution (PSD) so they might be further classified. The results of the tests are represented both graphically and numerically on the PSD results sheets contained in the PSL Report no. PSL17/0147, a copy of which can be found in Appendix III and are also summarised in Table 6.3 on the following page.

6.0 Laboratory Testing (Cont'd)

6.3 Determination of Particle Size Distribution (PSD):-

Table 6.3

Position	Depth (m)	Clay/Silt Fraction (%)	Sand Fraction (%)	Gravel Fraction (%)	Cobble Fraction (%)	Grading Characteristics	Brief Soil Description
BH1	1.50	33	64	3	0	Poorly graded	Slightly gravelly very clayey silty SAND
BH4	1.60	30	69	1	0	Poorly graded	Slightly gravelly slightly clayey very silty SAND
BH6	1.50	17	80	3	0	Poorly graded	Slightly gravelly very silty SAND

From the results of the grading analysis, it can be seen that the samples tested are poorly graded. The laboratory results/descriptions generally correspond with the field descriptions of these materials and also concurs with in-situ permeability testing carried out, i.e. high fine soil content resulting in low permeability.

6.4 Contamination Screening:-

Representative samples of the made ground materials recovered from across the site were passed onto Chemtech Environmental of Stanley, Co. Durham, so that soil screening could be carried out. The catalogue of testing results can be found in the Chemtech Environmental Analytical Report (ref no.: 62896), a copy of which is contained in Appendix IV, and the total analysis carried out is summarised below:

- 6 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).
- 6 no. soil samples tested for Speciated Poly-cyclic Aromatic Hydrocarbons (PAH's) – based on the current USEPA 16 PAH's + Benzo(j)fluoranthene.
- 6 no. soil samples tested for Speciated Total Petroleum Hydrocarbons (8 carbon band split).
- 6 no. soil samples tested for Asbestos (presence).

The 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 on the following pages.

7.0 Ground Contamination Risk Assessment

7.1 Methodology:-

Following completion of the contamination screening undertaken on various samples from the trial pits, 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).

7.0 Ground Contamination Risk Assessment (Cont'd)

7.2 Revised Conceptual Site Model (CSM):-

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.

Following the results of the intrusive investigation works, a Revised 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 the potential presence of hazardous ground gases. 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.

Table 7.1

	Sources (S)		***Pathways (P)***		***Receptors (R)***
S1	Made ground to a depth of between c.0.35m and c.2.20m.	P1	Ingestion & Dermal Contact	R1	Human health
		P2	Inhalation of indoor / outdoor air	R2	Controlled Waters - Potential groundwater within the underlying solid geology (designated as Secondary A Aquifer)
		P3	Plant Uptake & attached soil	R3	Adjacent sites
S2	Potential for hazardous ground gas.	P4	Migration through services		
		P5	Surface runoff & Infiltration	R4*	Building materials
		P6	Direct contact with building materials	R5*	Flora and fauna

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

7.2.1 Sources:-

Made ground represents the primary source of ground contamination for this site, recorded to a depth of between c.0.35m and c.2.20m and comprises the types of materials described in Section 4.1 of this report.

There was no visual or olfactory evidence of any contamination such as fuels, or visual asbestos or the like. Representative samples of the shallow soils (made ground) encountered have been assessed using an appropriate soil screening suite.

7.2.2 Pathways:-

When considering the proposed end use (taken as *Residential With Home Grown Produce*), 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.

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 overleaf.

7.0 Ground Contamination Risk Assessment (Cont'd)

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

7.2.2 Pathways (Cont'd):-

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 has hard cover and below new structures, a number of these pathways may not be available. 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.

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, the Level 1 Risk Assessment has taken a conservative best fit end use category as:

1) Residential - with home grown produce

For Controlled Waters and assuming a worst case scenario, the primary receptors for this Level 1 Risk Assessment is potential deep groundwater within the underlying Secondary A Aquifer designated by the EA.

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.

7.0 Ground Contamination Risk Assessment (Cont'd)

7.3 Screening Strategy (Cont'd):-

There was no visual, olfactory or analytical evidence of significant heavy or gross contamination, such as waste oils, fuels, etc. or the like found across the site. However, due to the setting and for completeness, representative samples have also been screened for speciated PAH, speciated TPH and asbestos.

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

7.4.1 Soil Screening Suites:-

The soil screening results have been assessed by comparing the maximum values recorded for each analyte to the critical concentration values chosen for this site. The results of the testing are contained in Appendix IV, and the risk assessment has been summarised in Table 7.2 below.

Table 7.2

Analyte	Critical Conc. (C_C)	No. of Samples Screened	Max. Conc. (C_M) Recorded	No. of Samples > C_C
Arsenic	37[1]	6	17	0
Cadmium	11[1]	6	0.5	0
Chromium III	910[1]	6	77	0
Chromium VI	6[1]	6	<1	0
Copper	2400[1]	6	56	0
Lead	200[2]	6	103	0
Mercury	40[1]	6	<0.5	0
Nickel	180[1]	6	36	0
Selenium	250[1]	6	1.3	0
Zinc	3700[1]	6	143	0
Cyanide	34[3]	6	<1	0
Speciated PAH's				
Acenaphthene	210[1]	6	0.01	0
Acenaphthylene	170[1]	6	0.02	0
Anthracene	2400[1]	6	0.07	0
Benzo(a)anthracene	7.2[1]	6	0.30	0
Benzo(a)pyrene	2.2[1]	6	0.30	0
Benzo(b)fluoranthene	2.6[1]	6	0.40	0
Benzo(ghi)perylene	320[1]	6	0.19	0
Benzo(k)fluoranthene	77[1]	6	0.16	0
Chrysene	15[1]	6	0.37	0
Dibenz(ah)anthracene	0.24[1]	6	0.05	0
Fluoranthene	280[1]	6	0.67	0
Fluorene	170[1]	6	0.03	0
Indeno(123cd)pyrene	27[1]	6	0.21	0
Naphthalene	2.3[1]	6	0.04	0
Phenanthrene	95[1]	6	0.46	0
Pyrene	620[1]	6	0.53	0
Speciated TPH's				
TPH (C5-C7)	42[1]	6	<0.1	0
TPH (C7-C8)	100[1]	6	<0.1	0
TPH (C8-C10)	27[1]	6	<0.1	0
TPH (C10-C12)	74[1]	6	<4	0
TPH (C12-C16)	140[1]	6	6	0
TPH (C16-C21)	260[1]	6	12	0
TPH (C21-C35)	1100[1]	6	45	0
TPH (C35-C44)	1100[1]	6	<10	0

[1] = LQM CIEH Suitable 4 Use Levels (S4UL Nov 2014 (Revised August 2015)) – *Residential with home grown produce - 1% SOM*, [2] = C4SL Values (*Residential with home grown produce*), [3] = ATRISK^{SOIL} SSV, **Bold** = result exceeds critical concentration, Note = All units are mg/kg.

7.0 Ground Contamination Risk Assessment (Cont'd)

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

7.4.1 Soil Screening Suites (Cont'd):-

The results have identified the following:

- None of the maximum concentration (C_M) values for any of the generic metals, metalloids, non-organics, speciated PAH's or speciated TPH's exceed the critical concentration (C_C) values taken for this site.
- The results of the contamination screening and analysis have 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 in order to protect future end users (i.e. no risk to human health), and these materials may be suitable for re-use on site.

7.4.2 Asbestos Screening:-

The results of the asbestos screening is summarised in Table 7.3 below.

Table 7.3

Position	Depth (m)	Chrysotile (white)	Amosite (brown)	Crocidolite (blue)	Anthophyl-lite	Actinolite	Tremolite
BH1	0.90	NAD	NAD	NAD	NAD	NAD	NAD
BH3	0.30	NAD	NAD	NAD	NAD	NAD	NAD
BH4	0.80	NAD	NAD	NAD	NAD	NAD	NAD
BH5	0.60	NAD	NAD	NAD	NAD	NAD	NAD
BH6	0.50	NAD	NAD	NAD	NAD	NAD	NAD
BH7	0.70	NAD	NAD	NAD	NAD	NAD	NAD

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

The results have identified the following:

- As can be seen from the samples screened, the results have not identified the presence of any asbestos fibres.
- Consequently, there is no requirement for removal, treatment, protection measures and/or further risk assessment in order to protect the existing end users (i.e. no risk to Human Health) from potential Asbestos fibres.

7.5 Level 1 Generic Quantitative Risk Assessment – Controlled Waters:-

The following hydrogeological and hydrological issues have been taken into consideration when assessing the risks towards controlled waters;

- A shallow continuous groundwater surface (water table) is not anticipated to be present below this site.
- Groundwater is anticipated at depth within the solid deposits (Secondary A Aquifer).
- The site is not located within c.1km of a Source Protection Zone (SPZ).
- There are no Water Abstractions recorded within c.1km from the site boundaries.
- No surface water features within c.500m of the site.
- Low contamination results.

When taking into account the above site setting and based on the soil screening results the risk of significant contamination being present below the site and impacting groundwater is felt to be negligible and therefore no leachate screening was deemed necessary.

8.0 Conclusions & Recommendations

8.1 Ground Conditions:-

From the investigation works completed, made ground has been recorded to a depth of between c.0.35m and c.2.20m below current ground levels (bcgl's) comprising initial site surfacing of tarmac, paving and turf over sandy clayey soil, loose hardcore limestone fill, builders sand, sandy gravel, soft and stiff sandy gravelly clay and gravelly sand. The gravel comprised fragments of limestone, sandstone, concrete, brick and coal.

Limestone hardcore was encountered to a depth of between c.0.50ma nd c.1.60m below the concrete floor (c.0.30m thick) of the existing office block.

No natural drift deposits were encountered across the site with weathered sandstone deposits encountered directly below the made ground.

Solid deposits comprising sandstone was recorded from a depth of between c.0.35m and c.2.20m bcgl's to a depth in excess of c.30.00m. No coal or soft ground indicative of broken ground associated with historic mine workings was encountered across the site with consistent drilling rates and 100% flush medium 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 & Stability:-

During the investigation works, no water ingresses were noted within the boreholes. Furthermore, no water levels were recorded within the monitoring wells during the monitoring visit undertaken to date.

However, pockets of trapped surface water may be present within the made ground and initial weathered solid deposits below the site. Therefore, it would be prudent to allow for the possible introduction of groundwater control measures, i.e. pumping equipment, in order to take care of any surface water ingresses and pockets of trapped surface drainage within the made ground and natural strata particularly during the wetter periods of the year.

Owing to the nature of the made ground and initial highly weathered solid deposits present across the site, adequate lateral trench support may be required for excavations, in order to prevent trench wall collapse or over excavations, as well as to create a safe working environment below a depth of 1.20m, and any excavations on this site should remain open for as short a period as possible, since some of these materials may be susceptible to deterioration, if left open to the natural elements for any significant period of time. Reference to CIRIA 97 'Trenching Practice' would be beneficial to establish a suitable means of support or battering of excavation sides during construction.

8.3 Foundation Options:-

With regards to new foundations, it can be seen that made ground materials were recorded to depths of between c.0.35m and c.2.20m below ground levels before natural highly weathered sandstone deposits were encountered.

Therefore, it is felt that strip or pad foundations should be acceptable for the proposed development, with foundations based wholly within the highly weathered sandstone, where a maximum allowable bearing pressure of c.150kN/m^2 is available at a depth of c.0.60m below finished ground levels when first encountered in its weathered condition i.e. resembling a "gravelly sand". However, if required, a greater bearing pressure of 300kN/m^2 is available towards the base of the exploratory holes in the more competent sandstone deposits.

8.0 Conclusions & Recommendations (Cont'd)

8.3 Foundation Options (Cont'd):-

In addition, when considering the depths at which bedrock was encountered, although initially weathered, an allowance should be made for plant & equipment capable of excavating and breaking out competent intact rock. In addition, care should be taken when excavating the rock to prevent significant "overbreak" from occurring i.e. rock breakage beyond the intended excavation lines.

During the construction phase, it may also be beneficial for a suitably qualified Geotechnical Engineer / Engineering Geologist to attend site and confirm the correct founding strata has been achieved within all foundation excavations.

If any new access roads, areas of hardstanding, car parking, etc., or ground bearing slabs are to be considered without any ground improvement taking place, then based upon the results of these intrusive works a design CBR value of 5.0% is recommended for the natural highly weathered sandstone where this is to be used as an undisturbed subgrade.

It is recommended that the sub-grade materials are 'proof rolled' to identify any potential 'soft spots' below this development area, and these can be dealt with by introducing an increased thickness of compacted sub-base and/or a geotextile reinforcement. In addition, it may also be prudent to allow for an engineer to attend site during the development works, to confirm the design CBR value of the materials to be utilised prior to construction.

8.4 Hazardous Ground Gas Risk Assessment:-

From the results of the gas monitoring visit to date, no detectable concentrations of Methane (CH_4) have been recorded. However, concentrations of Carbon Dioxide (CO_2) have currently been recorded up to a maximum level of 0.7%, with negligible flow rates being recorded (<0.1l/hr) and a GSV for CO_2 of 0.00071l/hr.

Based on these results, it is felt that the site can be assessed as Characteristic Situation 1 (CS1) indicating that no gas protection would be required for the proposed development.

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

8.5 Ground Contamination:-

8.5.1 Made Ground

From the results of the contamination screening carried out on this site and the Level 1 Risk Assessment (Section 7.0), it can be seen that the made ground materials present on this site do not represent a risk to future end users, and therefore there is no requirement for remediation and the materials will be suitable for re-use on this site.

The results of the asbestos screening suggests that the made ground materials present on-site are not contaminated with asbestos fibres, however the potential for unforeseen asbestos containing materials, 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 the possible presence of any suspicious materials.

8.0 Conclusions & Recommendations (Cont'd)

8.5 Ground Contamination (Cont'd):-

8.5.2 Controlled Waters

When considering the contamination results, the levels of contaminants in the samples screened are not considered to represent a significant risk to controlled waters or adjacent sites, and as such no further treatment, removal, protection measures and/or DQRA is considered necessary in this regard.

8.5.3 General

When considering the risk to building materials, it is recommended that a concrete design class of DS-1 and ACEC class of AC-1 is used for all foundations and buried concrete. Recourse to the relevant utility suppliers should be made for their advice / comments regarding any service material precautions necessary.

When considering the risks to the construction workforce, adequate PPE will be required to provide protection against the levels of 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. If during future redevelopment works, any excavated materials are to be removed from this site as a waste and disposed of at a landfill, reference should be made to the notes on off-site disposal within Appendix IV, particularly when assessing the likely classification of these materials prior to disposal.

8.6 General Comments:-

For future site works, adequate lateral trench support will be required for excavations, in order to prevent trench wall collapse or over excavations, as well as to create a safe working environment below a depth of 1.20m, and any excavations on this site should remain open for as short a period as possible, since some of these materials may be susceptible to deterioration, if left open to the natural elements for any significant period of time.

It is also recommended for the development of this site, 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 the existing surface drainage system is disrupted or damaged.

In addition, for deeper excavations, drainage, service runs or the like that may pass close to or beneath any existing or 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 or adjacent old foundation 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

- Phase 1: Desk Top Study & Coal Mining Risk Assessment Report completed for this site by Arc Environmental Ltd (Ref. No. 16-911, January 2017)

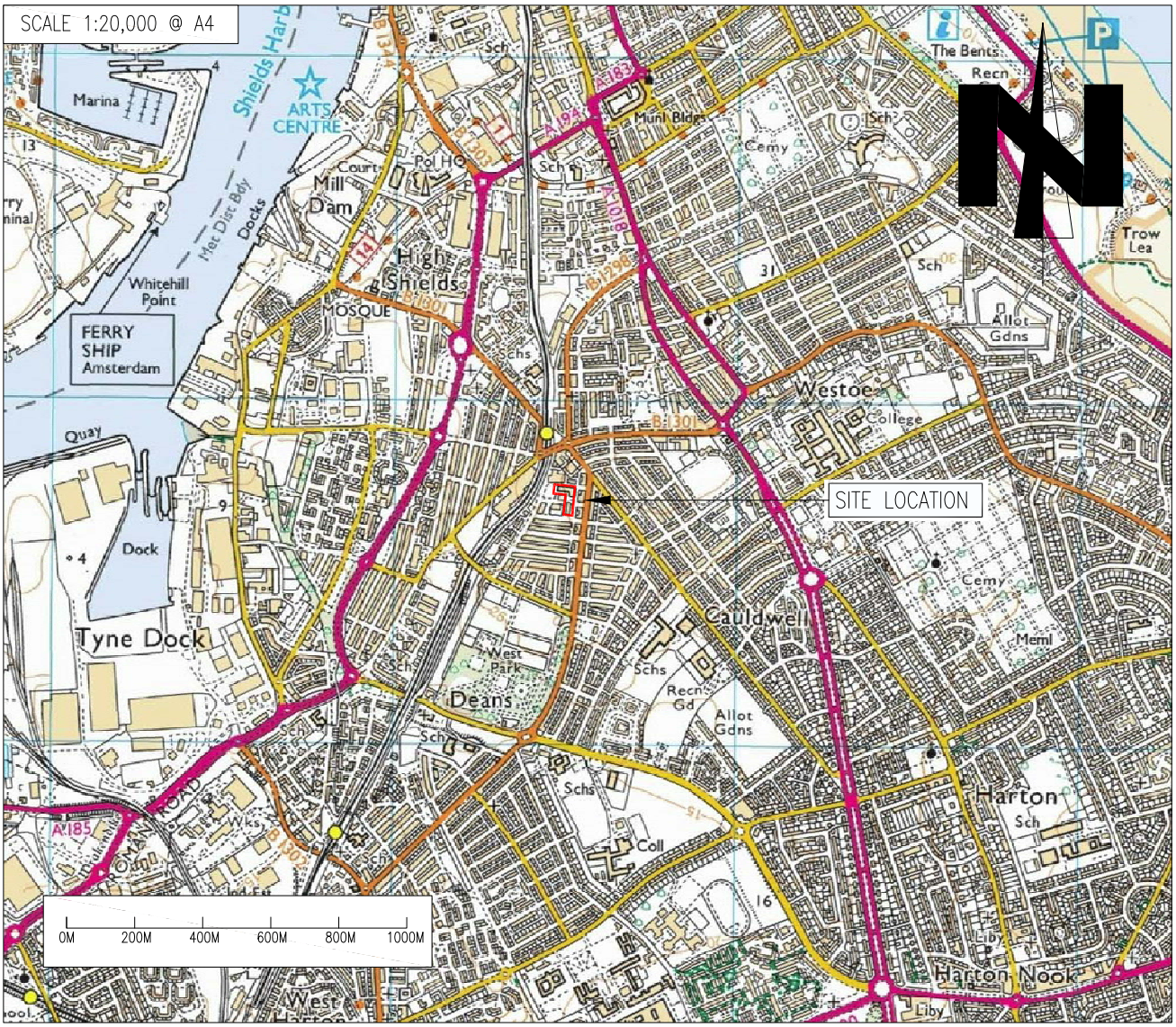
- DoE, DEFRA & EA - Contaminated Land Reports

  CLR 1: A framework for assessing the impact of contaminated land on groundwater and surface water. Report by Aspinwall & Co. Volumes 1 & 2. DoE, 1994.
  CLR 2: Guidance on preliminary site inspection of contaminated land. Report by Applied Environmental Research Centre Ltd. Volume 1. DOE, 1994.
  CLR 3: Documentary research on industrial sites. Report by RPS Group plc. DoE, 1994.
  CLR 4: Sampling strategies for contaminated land. Report by The Centre for Research into the Built Environment, The Nottingham Trent University. DoE, 1994.
  CLR 5: Information systems for land contamination. Report by Meta Generics Ltd. DoE, 1994.
  CLR 6: Prioritisation & categorisation procedure for sites which may be contaminated. Report by M J Carter Associates. DoE, 1995.
  CLR11: Model Procedures for the Management of Land Contamination. DEFRA/EA, 2004.
  Science Report Final SC050021/SR2: Human Health Toxicological Assessment of Contaminants in Soils, 2009.
  Science Report Final SC50021/SR3: Updated Technical Background to the CLEA Model, 2009.
  Science Report SC050021/SR4: CLEA software (version 1.05) handbook, 2009.

- Guidance on Comparing Soil Contamination Data with Critical Concentrations, CL:AIRE/CIEH, May 2008
- BS 1377: 1990: Methods of test for soils for civil engineering purposes. British Standards Institution (BS 1377-9:1990 is partially superseded by BS EN 1997-2: 2007)
- BS 5930: 2015: Code of practice for site investigations. British Standards Institution
- BS EN 1997-1: 2004: Eurocode 7 - Geotechnical design. Part 1: General rules. British Standards Institution
- BS EN 1997-2: 2007: Eurocode 7 - Geotechnical design. Part 2: Ground investigation and testing British Standards Institution
- BS EN ISO 9001: 2000: Quality Management Systems - requirements. British Standards Institution
- BS EN ISO 14688-1: 2002: Geotechnical investigation and testing. Identification and classification of soil. Identification and description.
- BS EN ISO 14688-2: 2004: Geotechnical investigation and testing. Identification and classification of soil. Principles for a classification.
- BS EN ISO 14689-1: 2003: Geotechnical investigation and testing - Identification and classification of rock. Identification and description. British Standards Institution. Amended 2007 (Partially supersedes BS 5930:1999)
- BS EN ISO 22476-3: 2005: Geotechnical investigation and testing. Field testing. Standard penetration test. British Standards Institution
- BS5837: 2012: Trees in relation to design, demolition and construction - recommendations
- NHBC Standards 2007: Chapter 4.2 – Building near trees
- BRE Special Digest 1 2005: Concrete in Aggressive Ground 3rd Edition
- BS10175:2011 + A1:2013: Investigation of potentially contaminated sites – Code of practice
- Guidance for the Safe Development of Housing on Land Affected by Contamination, R&D66, 2008 (NHBC, EA, CIEH)
- Asbestos in soil and made ground: a guide to understanding and managing risks, CIRIA C733, 2014
- Assessing Risks Posed by Hazardous Ground Gases to Buildings, CIRIA C665, 2007
- Methane and Associated Hazards to Construction - CIRIA Reports 149,150,151 & 152
- BS8485:2015 – Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings
- BS8576:2013: Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds

APPENDIX I

Site Location Plan
Aerial Photograph
Existing Site Layout Plan
Proposed Development Layout Plan



Client:

GUS ROBINSON DEVELOPMENTS LTD

Project Title:	Drawing Title:
Proposed Residential Housing Gordon House, Gordon Street South Shields, Tyne & Wear	Location Plan

rev.	date	amendments	drawn	chckd

Job Reference:	Drawing Number:	Revision:
16-911	–	–

Drawn by:	Date:	Scale at A4:
P.D	24.01.17	As Shown

Checked by:	Approved by:	
M.P.B	M.P.B	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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LEGEND	
	APPROXIMATE SITE BOUNDARY

rev.	date	amendments	drawn	chckd

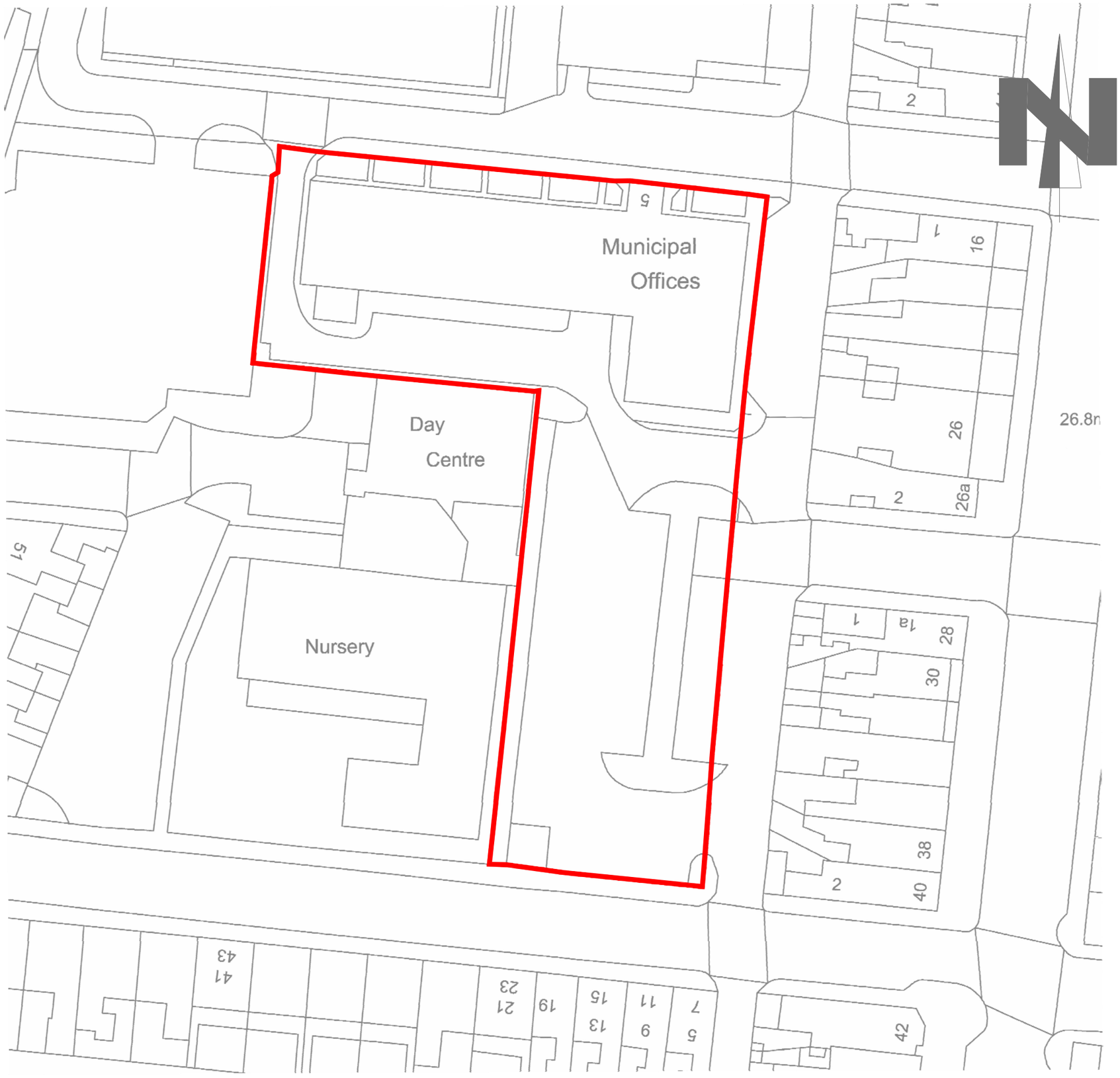
Client:
GUS ROBINSON DEVELOPMENTS LTD

Project Title:
Proposed Residential Housing
Gordon House, Gordon Street
South Shields, Tyne & Wear, NE33 4JP

Drawing Title:
Aerial Photograph

Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	24.01.17	P.D	M.P.B

Job Ref:	Drg no:	Rev:
16-911	–	–



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LEGEND

	APPROXIMATE SITE BOUNDARY

rev.	date	amendments	drawn	chckd

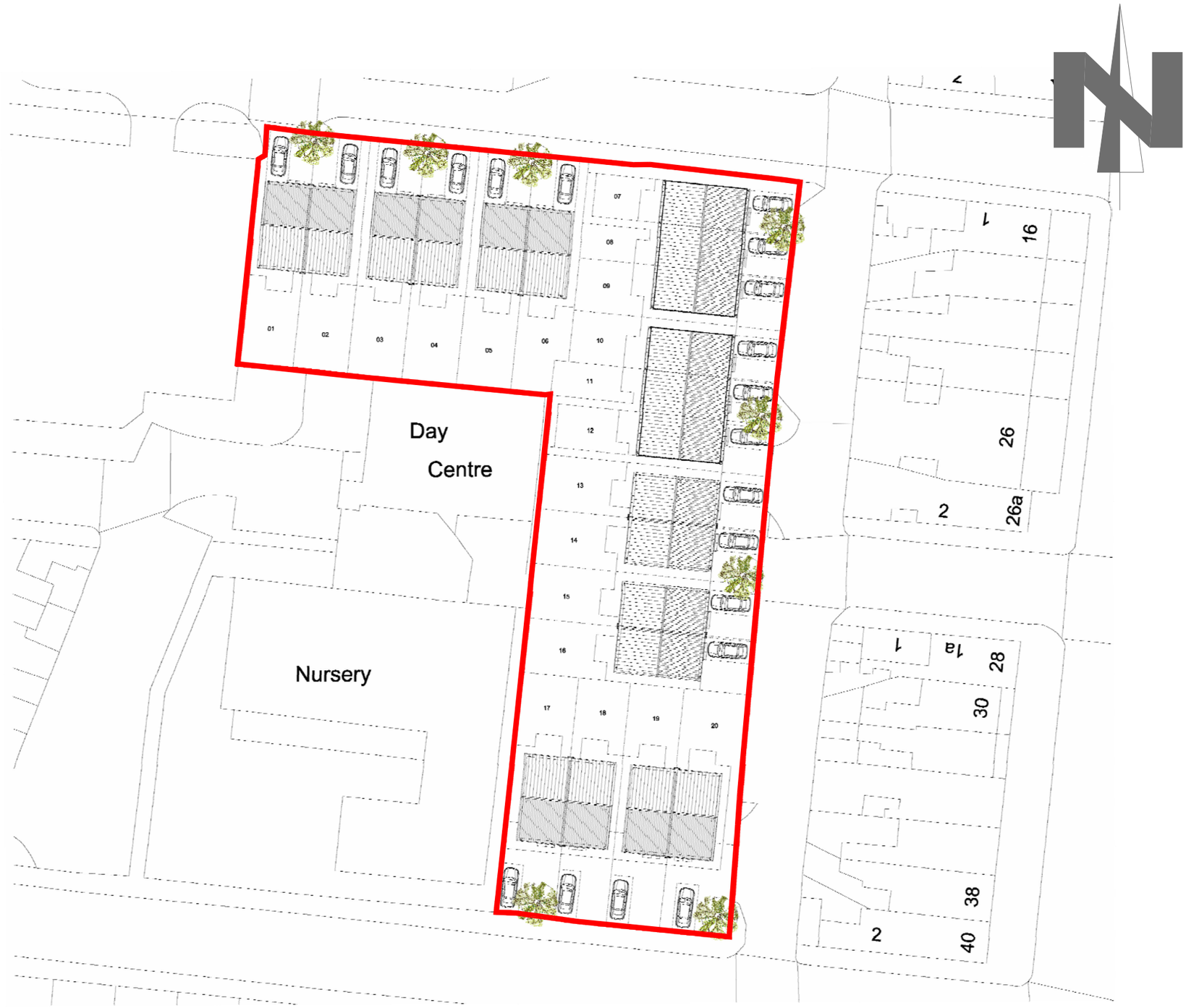
Client:
GUS ROBINSON DEVELOPMENTS LTD

Project Title:
Proposed Residential Housing
Gordon House, Gordon Street
South Shields, Tyne & Wear, NE33 4JP

Drawing Title:
Existing Site Layout Plan

Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	24.01.17	P.D	M.P.B

Job Ref:	Drg no:	Rev:
16-911	–	–



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LEGEND

	APPROXIMATE SITE BOUNDARY

rev.	date	amendments	drawn	chckd

Client:
GUS ROBINSON DEVELOPMENTS LTD

Project Title:
Proposed Residential Housing
Gordon House, Gordon Street
South Shields, Tyne & Wear, NE33 4JP

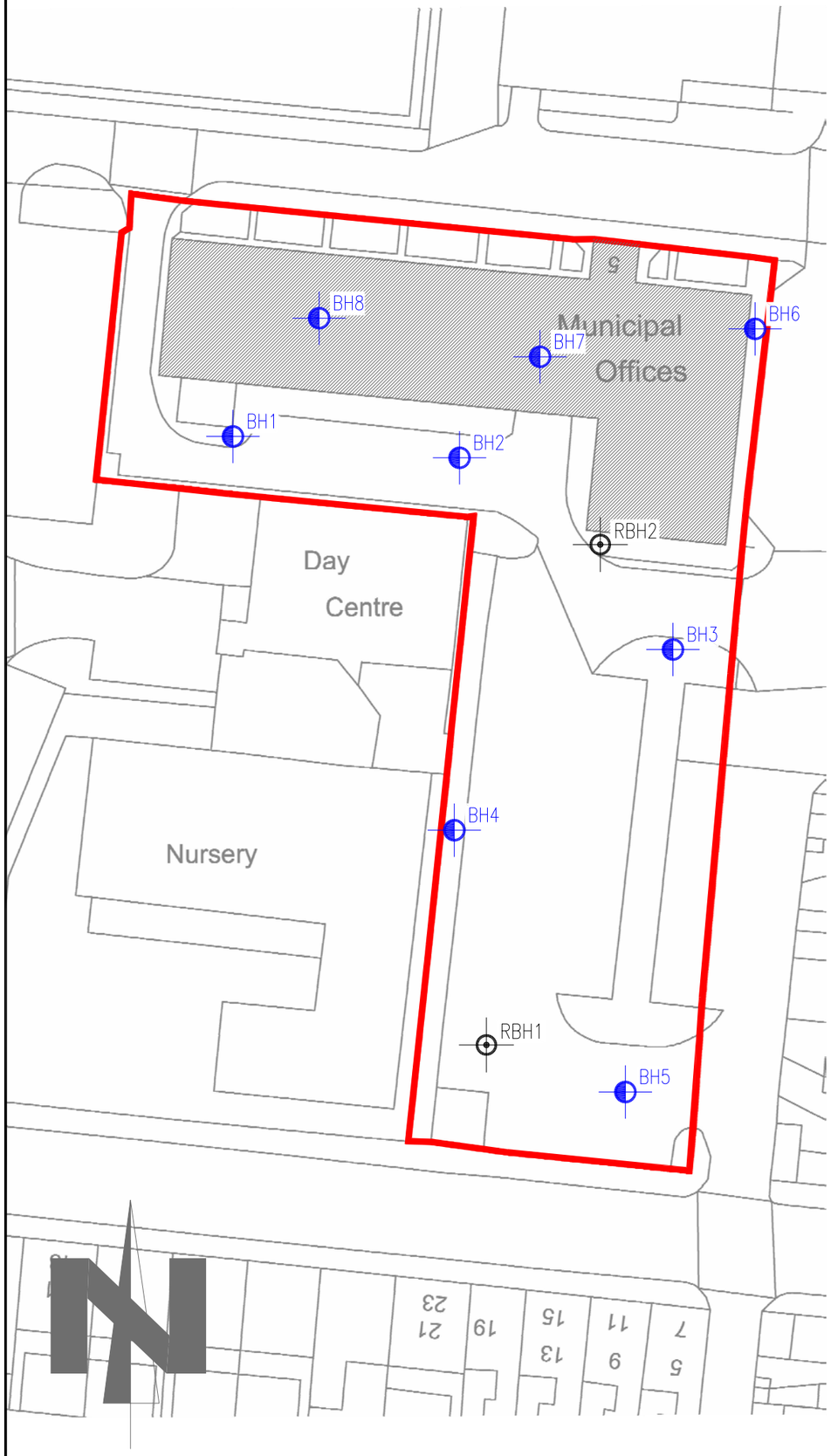
Drawing Title:
Proposed Development Layout Plan

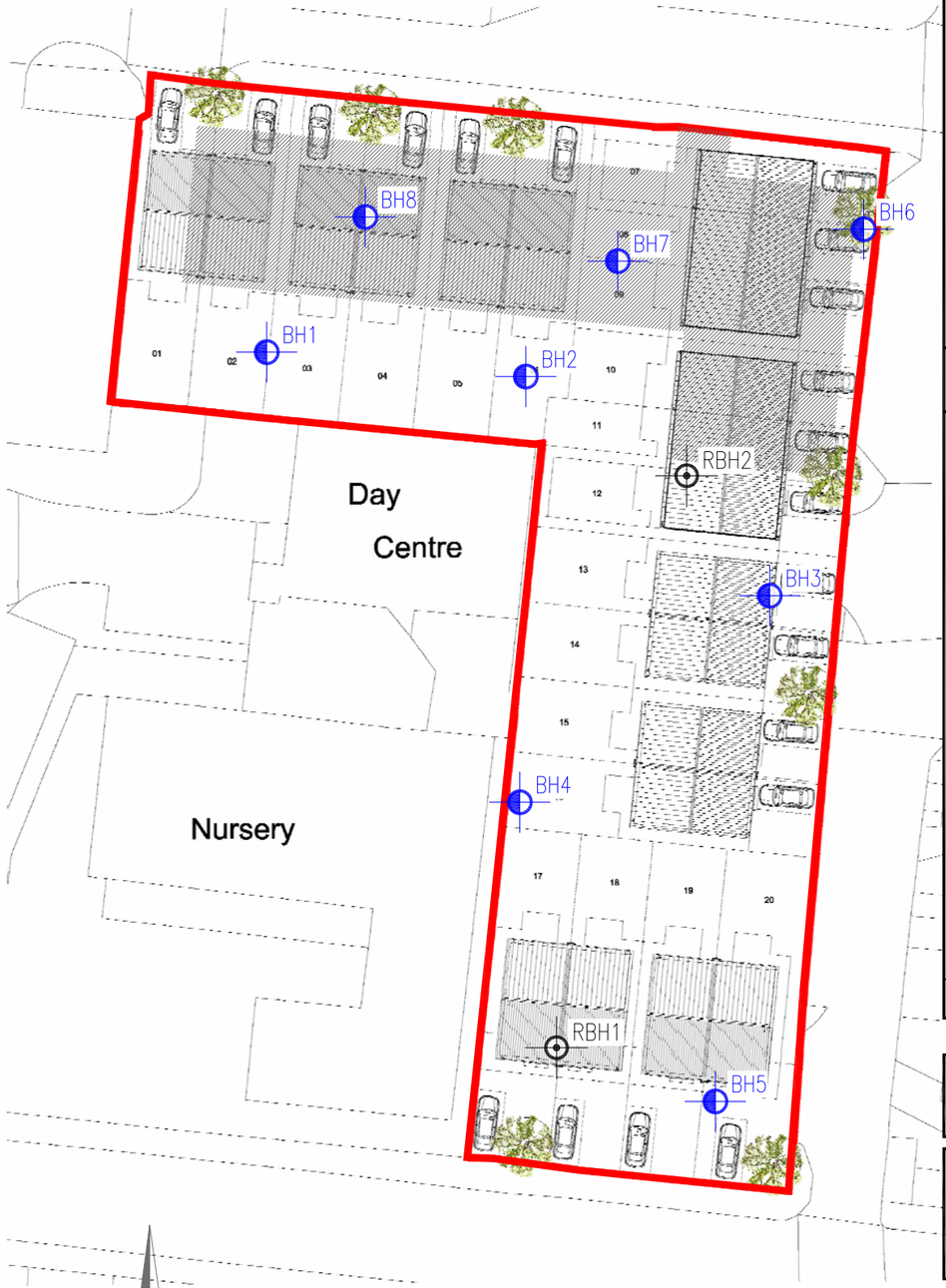
Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	24.01.17	P.D	M.P.B

Job Ref:	Drg no:	Rev:
16-911	–	–

APPENDIX II

Borehole Location Plan
Borehole Record Sheets
Variable Head (Falling) Permeability Tests





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LEGEND	
	APPROXIMATE SITE BOUNDARY
	WINDOWLESS SAMPLING BOREHOLE POSITION
	ROTARY BOREHOLE POSITION

rev.	date	amendments	drawn	chckd

Client:
GUS ROBINSON DEVELOPMENTS LTD

Project Title:
Proposed Residential Housing
Gordon House, Gordon Street
South Shields, Tyne & Wear, NE33 4JP

Drawing Title:
Borehole Location Plan

Scale at A3:	Date:	Drawn by:	Approved by:
NTS @ A3	24.01.17	P.D	M.P.B

Job Ref:	Drg no:	Rev:
16-911	–	–

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BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				BH1
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	04-01-17			
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		
						0.05	Paving (MADE GROUND).		
						0.10	Brown sand (MADE GROUND).		
							Limestone fill (MADE GROUND).		
						(0.80)			
						0.90			
0.90	J/D						Medium dense becoming dense brown highly weathered SANDSTONE. Recovered as clayey gravelly sand. Gravel is fine to coarse of sandstone.		
1.20-1.65	SPT	N=15				(0.83)			
1.50	B								
1.70-1.73	SPT	50 Blows				1.73			
							Borehole terminated at 1.725m due to refusal.		

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	
											Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

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

BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				BH2
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	04-01-17			
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		
						0.08	Block Paving (MADE GROUND).		
						0.18	Brown sand (MADE GROUND).		
0.80	B					(2.02)	Loose limestone fill (MADE GROUND).		
1.20-1.65	SPT	N=4							
2.00-2.40	SPT	50 Blows				2.20			
						(0.30)	Dense brown SANDSTONE. Recovered as gravelly sand. Gravel is fine to coarse of sandstone.		
						2.50	Borehole terminated at 2.50m due to refusal.		

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	
											Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

Solum House, Unit 1 Elliott Court
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Telephone: 01913786380

BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				BH3
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	04-01-17			
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		
						(0.45)	Turf over brown sandy clayey sandy soil (MADE GROUND).		
0.30	J/D					0.45			
						(0.55)	Brown sandy gravel. Gravel is fine to coarse comprising fragments of sandstone and concrete (MADE GROUND).		
0.60	J/D					1.00			
						(0.40)	Stiff grey and brown sandy gravelly clay. Gravel is fine to coarse comprising fragments of brick sandstone and coal (MADE GROUND).		
1.20-1.65	SPT	N=21							
1.20	V	80kN/m^2				1.40			
1.40	B					(0.85)	Medium dense becoming dense medium brown highly weathered SANDSTONE. Recovered agravelly sand. Gravel is fine to coarse of sandstone.		
1.80	B								
1.90-2.25	SPT	50 Blows				2.25			
							Borehole terminated at 2.25m due to refusal.		

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	Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

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Telephone: 01913786380

BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				**BH4**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	04-01-17			
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		
						0.05	Paving (MADE GROUND).		
						0.10	Concrete (MADE GROUND).		
0.20	J/D					0.25	Limestone fill (MADE GROUND).		
						(0.35)	Brown clayey gravelly sand. Gravel is fine to coarse comprising fragments of brick coal sandstone and concrete (MADE GROUND).		
0.50	J/D					0.60			
0.80	J/D					(0.50)	Soft light brown sandy gravelly clay. Gravel is fine to coarse comprising fragments of brick coal and sandstone (MADE GROUND).		
1.00	V	30kN/m^2				1.10			
1.10-1.55	SPT	N=33				(0.90)	Dense medium brown highly weathered SANDSTONE. Recovered as clayey gravelly sand. Gravel is fine to coarse of sandstone.		
1.60	B								
1.70-2.00	SPT	50 Blows				2.00			
							Borehole terminated at 2.00m due to refusal.		

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	Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

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

BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				BH5
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	04-01-17			
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		
						0.08	Block Paving (MADE GROUND).		
						0.18	Brown sand (MADE GROUND).		
						(0.30)	Limestone fill (MADE GROUND).		
0.40	J/D					0.48			
0.60	J/D					(0.42)	Soft brown sandy gravelly clay. Gravel is fine to coarse comprising fragments of brick coal and sandstone (MADE GROUND).		
0.70	V	32kN/m^2				0.90			
1.10	B					(1.10)	Dense medium brown highly weathered SANDSTONE. Recovered as gravelly sand. Gravel is fine to coarse of sandstone.		
1.10-1.55	SPT	N=40							
1.60	B								
1.70-2.00	SPT	50 Blows				2.00			
							Borehole terminated at 2.00m due to refusal.		

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	Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

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

BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				BH6
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	05-01-17			
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		
						0.05	Paving (MADE GROUND).		
						(0.30)	Limestone fill (MADE GROUND).		
						0.35			
0.50	J/D						Medium dense becoming dense medium brown highly weathered SANDSTONE. Recovered as gravelly sand. Gravel is fine to coarse of sandstone.		
1.20-1.65	SPT	N=14							
1.50	B					(2.40)			
2.00-2.45	SPT	N=49							
2.45	B								
2.45-2.75	SPT	50 Blows							
						2.75			
							Borehole terminated at 2.75m due to refusal.		

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	
											Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

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

BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				**BH7**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	05-01-17			
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		
						(0.32) 0.32	Concrete with rebar (MADE GROUND).		
						(0.18) 0.50	Limestone fill (MADE GROUND).		
						(0.20) 0.70	Dark brown gravelly sand. Gravel is fine to coarse comprising fragments of sandstone (MADE GROUND).		
0.70	J/D					(0.50) 1.20	Medium brown highly weathered SANDSTONE. Recovered as gravelly sand. Gravel is fine to coarse of sandstone.		
1.00	B						Borehole terminated at 1.20m due to refusal.		

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	Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

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

BOREHOLE LOG

Project				BOREHOLE No
Gordon House, South Shields				BH8
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	05-01-17			
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		
						(0.30) 0.30	Concrete with rebar (MADE GROUND).		
1.00-1.45	SPT	N=36				(1.30) 1.60	Limestone fill (MADE GROUND).		
2.00 2.00-2.45	B SPT	N=32				(1.40) 3.00	Dense medium brown highly weathered SANDSTONE. Recovered as gravelly sand. Gravel is fine to coarse of sandstone.		
							Borehole terminated at 3.00m due to refusal.		

Boring Progress and Water Observations					
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt

Chiselling			Water Added	
From	To	Hours	From	To

GENERAL REMARKS

Borehole remained dry on completion

All dimensions in metres Scale 1:21.875	Client Gus Robinson Developments Ltd	Method/ Plant Used Windowless Sampling	Logged By DF

AGS3 UK BH BH.GPJ AGS3_ALL.GDT 16/1/17

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

DRILLHOLE LOG

Project				DRILLHOLE No
Gordon House, South Shields				RBH1
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	04-01-17			
Contractor				Sheet
Arc Environmental Ltd				1 of 1

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
					0.05			Block Paving (MADE GROUND).		
					0.15			Brown sand (MADE GROUND).		
					(2.45)			Limestone fill (MADE GROUND).		
					2.60			Highly weathered SANDSTONE.		
					(6.60)			Yellow SANDSTONE.		
					9.20					
					(5.60)			Red SANDSTONE.		
					14.80					
					(15.20)			Grey SANDSTONE.		
					30.00					
								Borehole terminated at 30.00m.		

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

Borehole remained dry on completion

All dimensions in metres Scale 1:193.75	Client Gus Robinson Developments Ltd	Method/ Plant Used Cable Percussive	Logged By JT

AGS3 UK DH BH.GPJ AGS3_ALL.GDT 16/1/17

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

DRILLHOLE LOG

Project				DRILLHOLE No
Gordon House, South Shields				RBH2
Job No	Date	Ground Level (m)	Co-Ordinates ()	
16-911	04-01-17			
Contractor				Sheet
Arc Environmental Ltd				1 of 1

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
					0.08			Block Paving (MADE GROUND).		
					0.18			Brown sand (MADE GROUND).		
					(2.32)			Limestone fill (MADE GROUND).		
					2.20			Yellow SANDSTONE.		
					(27.50)					
					30.00			Borehole terminated at 30.00m.		

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

Borehole remained dry on completion

All dimensions in metres Scale 1:193.75	Client Gus Robinson Developments Ltd	Method/ Plant Used Cable Percussive	Logged By JT

AGS3 UK DH BH.GPJ AGS3_ALL.GDT 16/1/17

ARC ENVIRONMENTAL LIMITED

VARIABLE HEAD PERMEABILITY TEST

Variable Head (Falling) Permeability Test in Borehole BH1 1.73 mBGL

SITE Gordon House, South Shields

CONTRACT 16-911 BH1 DEPTH 1.73 mBGL

INITIAL CONDITIONS

Bottom of Borehole	1.73	mBGL
Base of casing	1.00	mBGL
Diameter of casing	50.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	1.73	mBGL

Operator	IH	
Date	13/01/2017	
Time	11.30am	
Weather	Overcast, Wet	
Input volume of water	20	litres
Test Zone	0.73	m

TEST CALCULATION

Intake Factor (F)

$$F = \frac{2\pi L}{\log_e [(L/D) + \sqrt{\{1+(L/D)^2\}}]} \quad \text{(i)}$$

(From BS 5930:2015 for standpipes)

L=length of test zone
D=diameter of standpipe

Permeability (k)

$$k = \frac{A}{F(t_2 - t_1)} \times \log_e (H_1/H_2) \quad \text{(ii)}$$

or

$$k = \frac{A}{FT} \quad \text{(iii)}$$

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

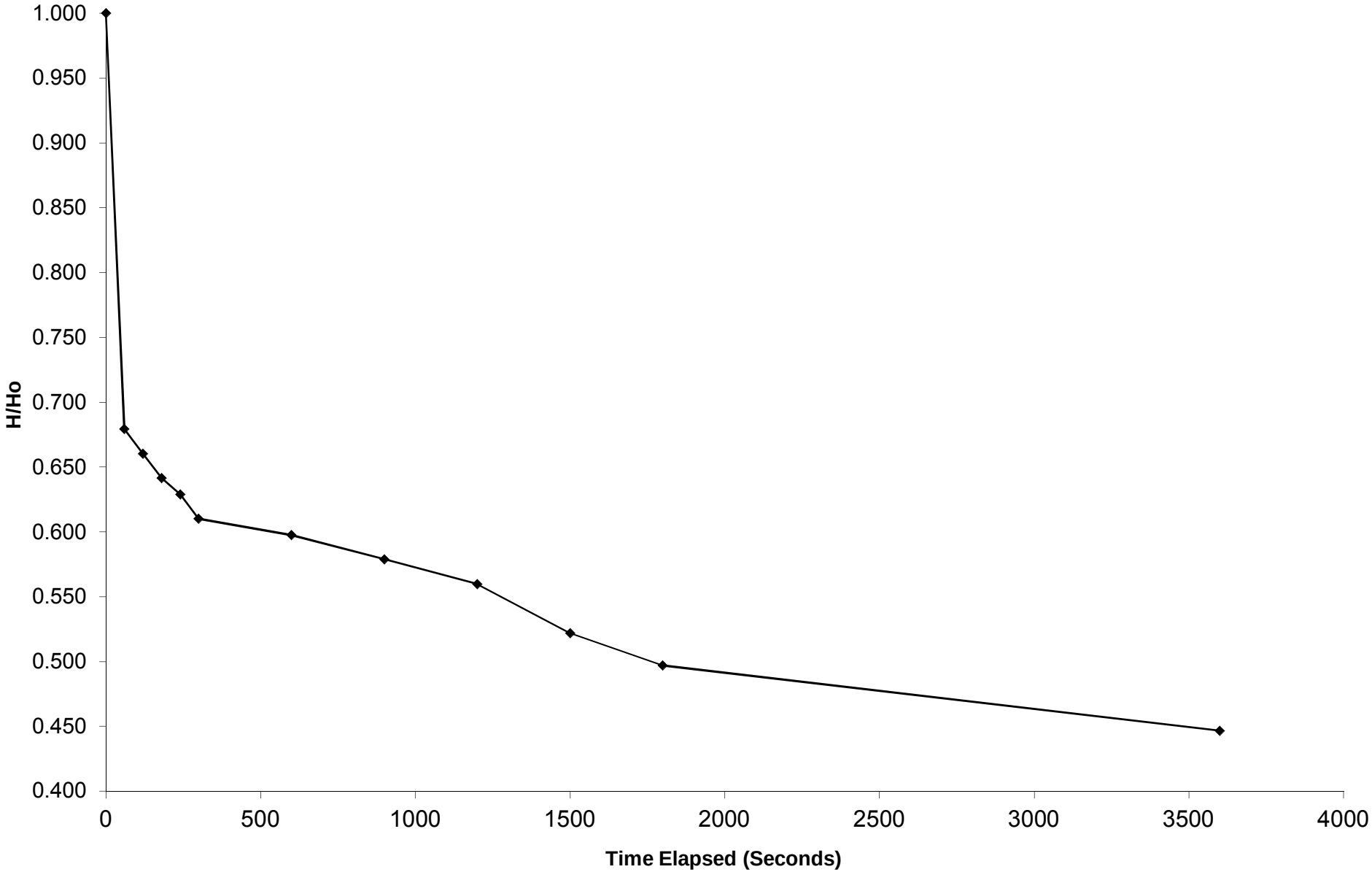
L=	0.73	m	
D=	0.050	m	
L/D=	14.60		
t_1=	0	s	
t_2=	3600	s	
H_1=	1.59	m	
H_2=	0.71	m	
A=	0.00196	m^2	
F=	1.3589		From (i)
T=		s	
k=	3.23592E-07	ms^{-1}	From (ii)
k=		ms^{-1}	From (iii)

Remarks

Drainage Characteristics: POOR
Permeability Classification: LOW

Elapsed (minutes)	Elapsed (seconds)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0	0	0	0.140	1.590	1.000
1	0	60	0.650	1.080	0.679
2	0	120	0.680	1.050	0.660
3	0	180	0.710	1.020	0.642
4	0	240	0.730	1.000	0.629
5	0	300	0.760	0.970	0.610
10	0	600	0.780	0.950	0.597
15	0	900	0.810	0.920	0.579
20	0	1200	0.840	0.890	0.560
25	0	1500	0.900	0.830	0.522
30	0	1800	0.940	0.790	0.497
60	0	3600	1.020	0.710	0.447

16-911 Gordon House, South Shields
Variable Head (Falling) Permeability Test in BH1



ARC ENVIRONMENTAL LIMITED

VARIABLE HEAD PERMEABILITY TEST

Variable Head (Falling) Permeability Test in Borehole BH3 2.25 mBGL

SITE Gordon House, South Shields

CONTRACT 16-911 BH3 DEPTH 2.25 mBGL

INITIAL CONDITIONS

Bottom of Borehole	2.25	mBGL
Base of casing	1.00	mBGL
Diameter of casing	50.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	2.25	mBGL

Operator	IH	
Date	13/01/2017	
Time	10.55am	
Weather	Overcast, Wet	
Input volume of water	15	litres
Test Zone	1.25	m

TEST CALCULATION

Intake Factor (F)

$$F = \frac{2\pi L}{\text{Log}_e\left[(L/D) + \sqrt{\{1+(L/D)^2\}}\right]} \quad \text{(i)}$$

(From BS 5930:2015 for standpipes)

L=length of test zone
D=diameter of standpipe

Permeability (k)

$$k = \frac{A}{F(t_2 - t_1)} \times \text{Log}_e (H_1/H_2) \quad \text{(ii)}$$

or

$$k = \frac{A}{FT} \quad \text{(iii)}$$

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

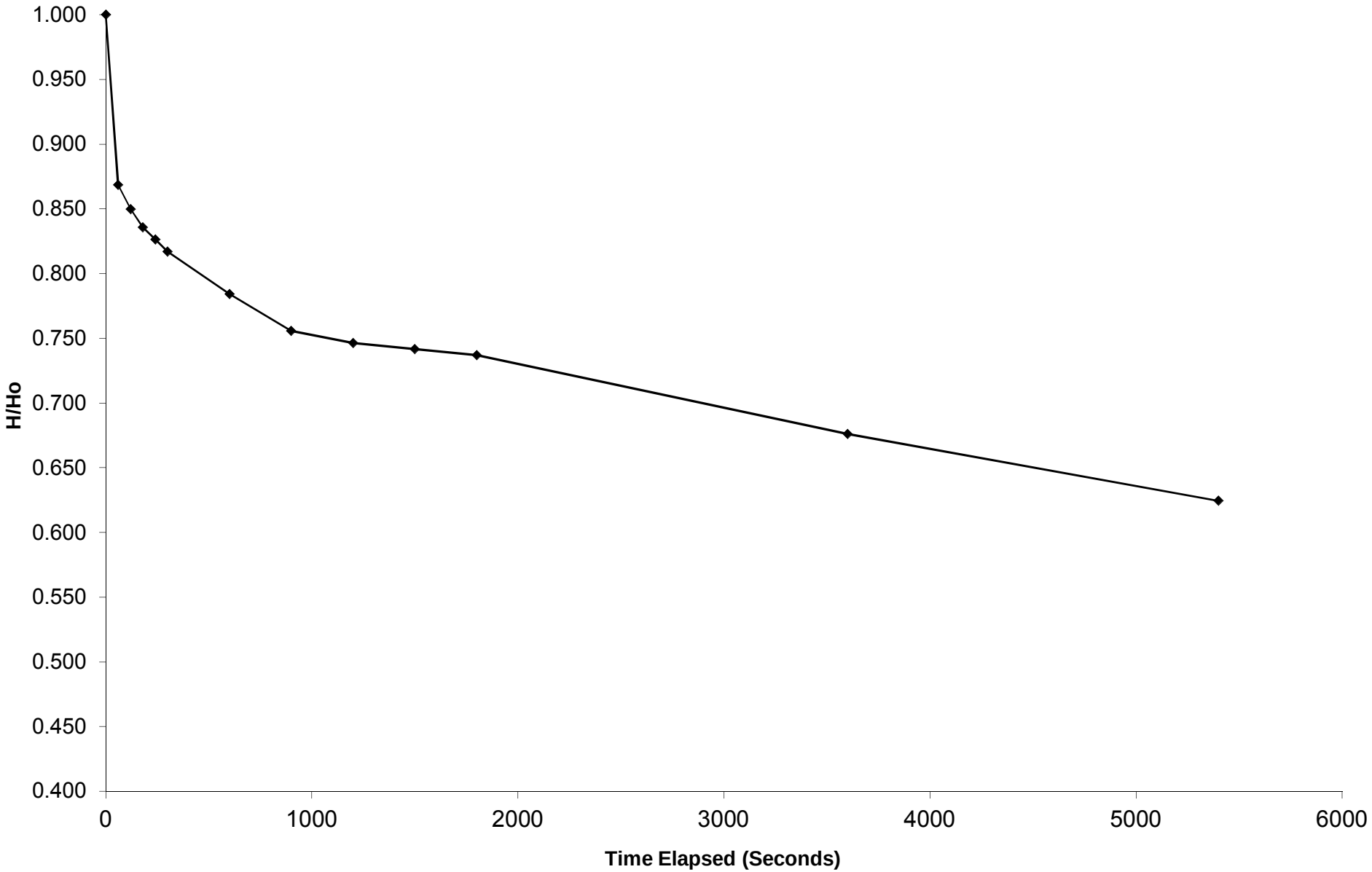
L=	1.25	m	
D=	0.050	m	
L/D=	25.00		
t_1=	0	s	
t_2=	5400	s	
H_1=	2.13	m	
H_2=	1.33	m	
A=	0.00196	m^2	
F=	2.0075		From (i)
T=		s	
k=	8.53022E-08	ms^{-1}	From (ii)
k=		ms^{-1}	From (iii)

Remarks

Drainage Characteristics: PRECTICALLY IMPERVIOUS
Permeability Classification: VERY LOW

Elapsed (minutes)	Elapsed (seconds)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0	0	0	0.120	2.130	1.000
1	0	60	0.400	1.850	0.869
2	0	120	0.440	1.810	0.850
3	0	180	0.470	1.780	0.836
4	0	240	0.490	1.760	0.826
5	0	300	0.510	1.740	0.817
10	0	600	0.580	1.670	0.784
15	0	900	0.640	1.610	0.756
20	0	1200	0.660	1.590	0.746
25	0	1500	0.670	1.580	0.742
30	0	1800	0.680	1.570	0.737
60	0	3600	0.810	1.440	0.676
90	0	5400	0.920	1.330	0.624

16-911 Gordon House, South Shields
Variable Head (Falling) Permeability Test in BH2



ARC ENVIRONMENTAL LIMITED

VARIABLE HEAD PERMEABILITY TEST

Variable Head (Falling) Permeability Test in Borehole BH5 2.00 mBGL

SITE Gordon House, South Shields

CONTRACT 16-911 BH5 DEPTH 2.00 mBGL

INITIAL CONDITIONS

Bottom of Borehole	2.00	mBGL
Base of casing	1.00	mBGL
Diameter of casing	50.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	2.00	mBGL

Operator	IH	
Date	13/01/2017	
Time	10.15am	
Weather	Overcast, Wet	
Input volume of water	12	litres
Test Zone	1.00	m

TEST CALCULATION

Intake Factor (F)

$$F = \frac{2\pi L}{\text{Log}_e\left[(L/D) + \sqrt{\{1+(L/D)^2\}}\right]} \quad \text{(i)}$$

(From BS 5930:2015 for standpipes)

L=length of test zone
D=diameter of standpipe

Permeability (k)

$$k = \frac{A}{F(t_2 - t_1)} \times \text{Log}_e (H_1/H_2) \quad \text{(ii)}$$

or

$$k = \frac{A}{FT} \quad \text{(iii)}$$

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

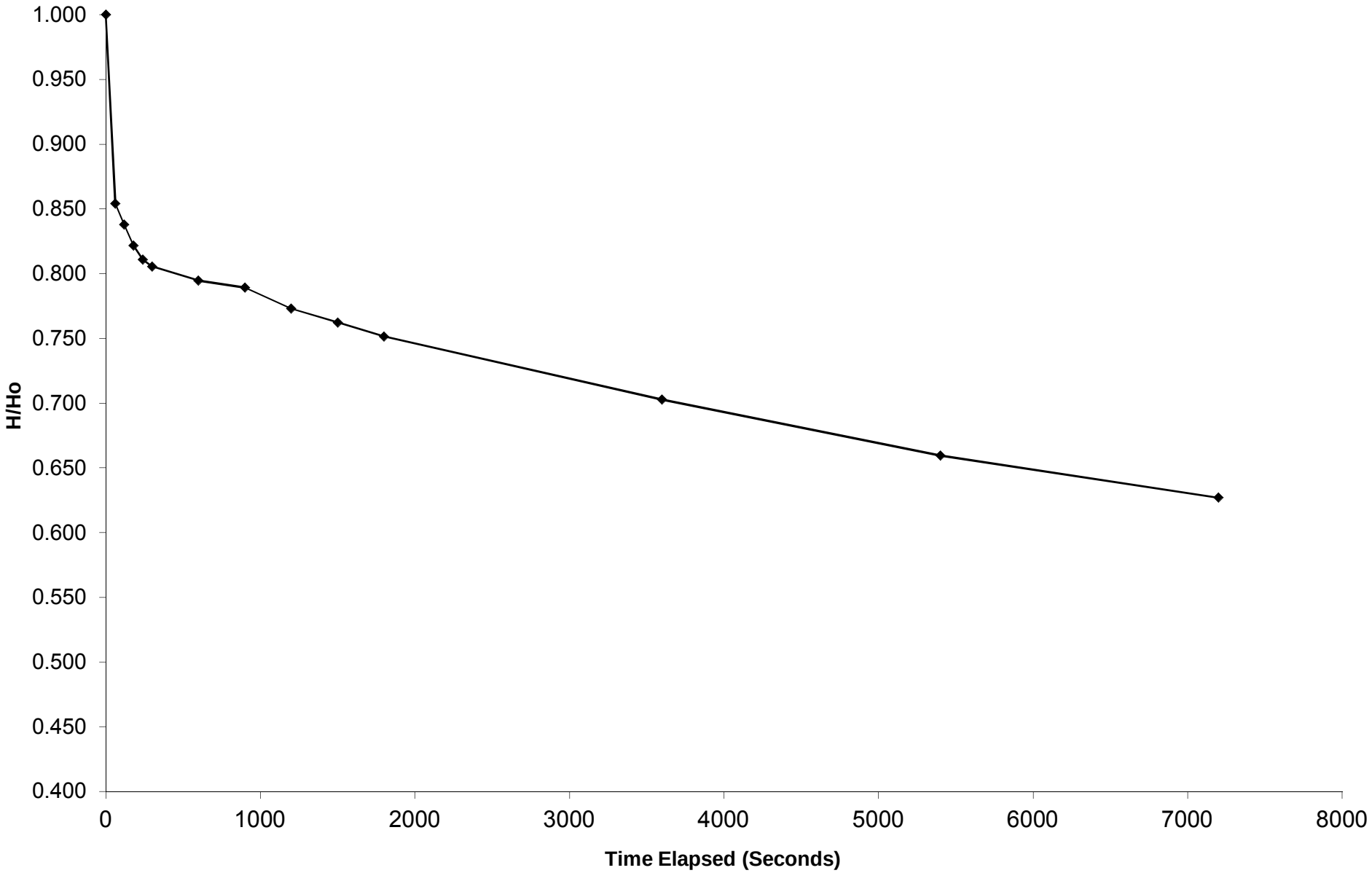
L=	1.00	m	
D=	0.050	m	
L/D=	20.00		
t_1=	0	s	
t_2=	7200	s	
H_1=	1.85	m	
H_2=	1.16	m	
A=	0.00196	m^2	
F=	1.7030		From (i)
T=		s	
k=	7.47454E-08	ms^{-1}	From (ii)
k=		ms^{-1}	From (iii)

Remarks

Drainage Characteristics: PRECTICALLY IMPERVIOUS
Permeability Classification: VERY LOW

Elapsed (minutes)	Elapsed (seconds)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0	0	0	0.150	1.850	1.000
1	0	60	0.420	1.580	0.854
2	0	120	0.450	1.550	0.838
3	0	180	0.480	1.520	0.822
4	0	240	0.500	1.500	0.811
5	0	300	0.510	1.490	0.805
10	0	600	0.530	1.470	0.795
15	0	900	0.540	1.460	0.789
20	0	1200	0.570	1.430	0.773
25	0	1500	0.590	1.410	0.762
30	0	1800	0.610	1.390	0.751
60	0	3600	0.700	1.300	0.703
90	0	5400	0.780	1.220	0.659
120	0	7200	0.840	1.160	0.627

16-911 Gordon House, South Shields
Variable Head (Falling) Permeability Test in BH3



APPENDIX III

Gas and Water Monitoring Certificate

Arc Environmental Ground Gas & Groundwater Monitoring Certificate

Site:	Gordon House, South Shields
Ref:	16-911

Visit	Date	Time	Equipment	Weather	Initials	Comments	Borehole	Gas Flow (l/hr)	Atmospheric Pressure (mb)	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)
										R/F/S	Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady	Hex %	PID Cf	PID (Isobutylene)	H_2S	CO	
1	13/01/2017	9:15am	GFM435	Overcast, wet	IH		1	<0.1	1003	Falling 1029 994mb		0.0		0.0		0.0		20.0						Dry
							3	<0.1	1002			0.0		0.0		0.7		19.3						Dry
							5	<0.1	1002			0.0		0.0		0.0		19.9						Dry
2																								
3																								
4																								
5																								
6																								

Notes: * Trend taken from www.wunderground.com for Newcastle 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 Results (Geotechnical & Ground Contamination)

2531

ANALYTICAL TEST REPORT

Contract no:	62896
Contract name:	Gordon House, South Shields
Client reference:	16-911
Clients name:	ARC Environmental
Clients address:	Solum House, Unit 1 Elliott Court St Johns Road Meadowfield DH7 8PN
Samples received:	11 January 2017
Analysis started:	11 January 2017
Analysis completed	18 January 2017
Report issued:	18 January 2017

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, without prior written approval.
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

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
62896-1	BH1	0.90	Clayey Sand	-	-	11.8
62896-2	BH3	0.30	Clay with Gravel	-	-	19.4
62896-3	BH3	1.80	Clayey Sand	-	-	7.2
62896-4	BH4	0.80	Sandy Clay with Gravel	-	-	12.9
62896-5	BH5	0.60	Sandy Clay with Gravel	-	-	12.8
62896-6	BH5	1.10	Sand & Clay	-	-	11.2
62896-7	BH6	0.50	Sand & Clay	-	-	9.5
62896-8	BH6	2.45	Sand & Clay	-	-	8.3
62896-9	BH7	0.70	Sand & Clay with Gravel	-	-	8.9
62896-10	BH8	2.00	Sand & Clay with Gravel	-	-	9.4

Chemtech Environmental Limited

SOILS

Lab number			62896-1	62896-2	62896-3	62896-4	62896-5	62896-6
Sample id			BH1	BH3	BH3	BH4	BH5	BH5
Depth (m)			0.90	0.30	1.80	0.80	0.60	1.10
Date sampled			04/11/2017	04/11/2017	04/11/2017	04/11/2017	04/11/2017	04/11/2017
Test	Method	Units						
Arsenic (total)	CE127 M	mg/kg As	1.7	17	-	4.5	4.2	-
Cadmium (total)	CE127 M	mg/kg Cd	0.2	0.5	-	<0.2	<0.2	-
Chromium (total)	CE127 M	mg/kg Cr	29	59	-	55	77	-
Chromium (III)	-	mg/kg CrIII	29	59	-	55	77	-
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	-	<1	<1	-
Copper (total)	CE127 M	mg/kg Cu	23	56	-	16	19	-
Lead (total)	CE127 M	mg/kg Pb	26	103	-	19	17	-
Mercury (total)	CE127 M	mg/kg Hg	<0.5	<0.5	-	<0.5	<0.5	-
Nickel (total)	CE127 M	mg/kg Ni	4.3	36	-	9.1	13	-
Selenium (total)	CE127 M	mg/kg Se	0.4	1.3	-	0.5	0.4	-
Zinc (total)	CE127 M	mg/kg Zn	46	143	-	32	31	-
pH	CE004 M	units	8.7	8.0	8.0	8.0	8.0	8.4
Sulphate (2:1 water soluble)	CE061 M	mg/l SO_4	<10	31	26	32	28	21
Cyanide (free)	CE077	mg/kg CN	<1	<1	-	<1	<1	-
Total Organic Carbon (TOC)	CE072 M	% w/w C	0.19	7.50	-	1.50	0.93	-
PAH								
Acenaphthene	CE087 M	mg/kg	<0.01	0.01	-	<0.01	<0.01	-
Acenaphthylene	CE087 M	mg/kg	<0.01	0.02	-	<0.01	<0.01	-
Anthracene	CE087 U	mg/kg	<0.02	0.07	-	<0.02	<0.02	-
Benzo(a)anthracene	CE087 U	mg/kg	<0.02	0.30	-	<0.02	<0.02	-
Benzo(a)pyrene	CE087 U	mg/kg	<0.02	0.30	-	<0.02	<0.02	-
Benzo(b)fluoranthene	CE087 M	mg/kg	<0.02	0.40	-	<0.02	<0.02	-
Benzo(ghi)perylene	CE087 M	mg/kg	<0.02	0.19	-	<0.02	<0.02	-
Benzo(k)fluoranthene	CE087 M	mg/kg	<0.02	0.16	-	<0.02	<0.02	-
Chrysene	CE087 M	mg/kg	<0.01	0.37	-	<0.01	<0.01	-
Dibenz(ah)anthracene	CE087 M	mg/kg	<0.02	0.05	-	<0.02	<0.02	-
Fluoranthene	CE087 M	mg/kg	<0.02	0.67	-	<0.02	<0.02	-
Fluorene	CE087 U	mg/kg	<0.01	0.03	-	<0.01	<0.01	-
Indeno(123cd)pyrene	CE087 M	mg/kg	<0.02	0.21	-	<0.02	<0.02	-
Naphthalene	CE087 M	mg/kg	<0.01	0.04	-	<0.01	<0.01	-
Phenanthrene	CE087 M	mg/kg	<0.02	0.46	-	<0.02	<0.02	-
Pyrene	CE087 M	mg/kg	<0.02	0.53	-	<0.02	<0.02	-
PAH (total of USEPA 16)	CE087	mg/kg	<0.27	3.79	-	<0.27	<0.27	-
Benzo(j)fluoranthene	CE087	mg/kg	<0.02	0.05	-	<0.02	<0.02	-
PAH (total of OIL 8)	CE087	mg/kg	<0.15	1.84	-	<0.15	<0.15	-
TPH								
VPH (>C5-C7)	CE067	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-
VPH (>C7-C8)	CE067	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-
VPH (>C8-C10)	CE067	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-
EPH (>C10-C12)	CE033 M	mg/kg	<4	<4	-	<4	<4	-
EPH (>C12-C16)	CE033 M	mg/kg	<4	6	-	<4	<4	-

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SOILS

Lab number			62896-1	62896-2	62896-3	62896-4	62896-5	62896-6
Sample id			BH1	BH3	BH3	BH4	BH5	BH5
Depth (m)			0.90	0.30	1.80	0.80	0.60	1.10
Date sampled			04/11/2017	04/11/2017	04/11/2017	04/11/2017	04/11/2017	04/11/2017
Test	Method	Units						
EPH (>C16-C21)	CE033 M	mg/kg	<4	12	-	<4	<4	-
EPH (>C21-C35)	CE033 M	mg/kg	<6	45	-	<6	<6	-
EPH (>C35-C44)	CE033 M	mg/kg	<10	<10	-	<10	<10	-
Subcontracted analysis								
Asbestos (qualitative)	$	-	NAD	NAD	-	NAD	NAD	-

Chemtech Environmental Limited

SOILS

Lab number			62896-7	62896-8	62896-9	62896-10
Sample id			BH6	BH6	BH7	BH8
Depth (m)			0.50	2.45	0.70	2.00
Date sampled			05/01/2017	05/01/2017	05/01/2017	05/01/2017
Test	Method	Units				
Arsenic (total)	CE127 M	mg/kg As	2.7	-	4.7	-
Cadmium (total)	CE127 M	mg/kg Cd	<0.2	-	<0.2	-
Chromium (total)	CE127 M	mg/kg Cr	59	-	43	-
Chromium (III)	-	mg/kg CrIII	59	-	43	-
Chromium (VI)	CE146	mg/kg CrVI	<1	-	<1	-
Copper (total)	CE127 M	mg/kg Cu	12	-	15	-
Lead (total)	CE127 M	mg/kg Pb	12	-	18	-
Mercury (total)	CE127 M	mg/kg Hg	<0.5	-	<0.5	-
Nickel (total)	CE127 M	mg/kg Ni	10	-	12	-
Selenium (total)	CE127 M	mg/kg Se	<0.3	-	0.6	-
Zinc (total)	CE127 M	mg/kg Zn	15	-	34	-
pH	CE004 M	units	8.7	9.1	7.8	8.1
Sulphate (2:1 water soluble)	CE061 M	mg/l SO_4	22	23	42	88
Cyanide (free)	CE077	mg/kg CN	<1	-	<1	-
Total Organic Carbon (TOC)	CE072 M	% w/w C	0.16	-	0.79	-
PAH						
Acenaphthene	CE087 M	mg/kg	<0.01	-	<0.01	-
Acenaphthylene	CE087 M	mg/kg	<0.01	-	<0.01	-
Anthracene	CE087 U	mg/kg	<0.02	-	<0.02	-
Benzo(a)anthracene	CE087 U	mg/kg	<0.02	-	<0.02	-
Benzo(a)pyrene	CE087 U	mg/kg	<0.02	-	<0.02	-
Benzo(b)fluoranthene	CE087 M	mg/kg	<0.02	-	<0.02	-
Benzo(ghi)perylene	CE087 M	mg/kg	<0.02	-	<0.02	-
Benzo(k)fluoranthene	CE087 M	mg/kg	<0.02	-	<0.02	-
Chrysene	CE087 M	mg/kg	<0.01	-	<0.01	-
Dibenz(ah)anthracene	CE087 M	mg/kg	<0.02	-	<0.02	-
Fluoranthene	CE087 M	mg/kg	<0.02	-	<0.02	-
Fluorene	CE087 U	mg/kg	<0.01	-	<0.01	-
Indeno(123cd)pyrene	CE087 M	mg/kg	<0.02	-	<0.02	-
Naphthalene	CE087 M	mg/kg	<0.01	-	<0.01	-
Phenanthrene	CE087 M	mg/kg	<0.02	-	<0.02	-
Pyrene	CE087 M	mg/kg	<0.02	-	<0.02	-
PAH (total of USEPA 16)	CE087	mg/kg	<0.27	-	<0.27	-
Benzo(j)fluoranthene	CE087	mg/kg	<0.02	-	<0.02	-
PAH (total of OIL 8)	CE087	mg/kg	<0.15	-	<0.15	-
TPH						
VPH (>C5-C7)	CE067	mg/kg	<0.1	-	<0.1	-
VPH (>C7-C8)	CE067	mg/kg	<0.1	-	<0.1	-
VPH (>C8-C10)	CE067	mg/kg	<0.1	-	<0.1	-
EPH (>C10-C12)	CE033 M	mg/kg	<4	-	<4	-
EPH (>C12-C16)	CE033 M	mg/kg	<4	-	4	-

Chemtech Environmental Limited

SOILS

Lab number			62896-7	62896-8	62896-9	62896-10
Sample id			BH6	BH6	BH7	BH8
Depth (m)			0.50	2.45	0.70	2.00
Date sampled			05/01/2017	05/01/2017	05/01/2017	05/01/2017
Test	Method	Units				
EPH (>C16-C21)	CE033 M	mg/kg	<4	-	5	-
EPH (>C21-C35)	CE033 M	mg/kg	<6	-	9	-
EPH (>C35-C44)	CE033 M	mg/kg	<10	-	<10	-
Subcontracted analysis						
Asbestos (qualitative)	$	-	NAD	-	NAD	-

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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
CE127	Lead (total)	Aqua regia digest, ICP-MS	Dry	M	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
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
CE067	VPH (>C5-C7)	Headspace GC-FID	Wet		0.1	mg/kg
CE067	VPH (>C7-C8)	Headspace GC-FID	Wet		0.1	mg/kg
CE067	VPH (>C8-C10)	Headspace GC-FID	Wet		0.1	mg/kg
CE033	EPH (>C10-C12)	Solvent extraction, GC-FID	Wet	M	4	mg/kg
CE033	EPH (>C12-C16)	Solvent extraction, GC-FID	Wet	M	4	mg/kg
CE033	EPH (>C16-C21)	Solvent extraction, GC-FID	Wet	M	4	mg/kg
CE033	EPH (>C21-C35)	Solvent extraction, GC-FID	Wet	M	6	mg/kg
CE033	EPH (>C35-C44)	Solvent extraction, GC-FID	Wet	M	10	mg/kg
$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

Chemtech Environmental Limited

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)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
IT	Sample not cooled
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
62896-1	BH1	0.90	N	
62896-2	BH3	0.30	N	
62896-3	BH3	1.80	N	
62896-4	BH4	0.80	N	
62896-5	BH5	0.60	N	
62896-6	BH5	1.10	N	
62896-7	BH6	0.50	N	
62896-8	BH6	2.45	N	
62896-9	BH7	0.70	N	
62896-10	BH8	2.00	N	

LABORATORY REPORT

4043

Contract Number: PSL17/0147

Report Date: 18 January 2017

Client's Reference: 16-911

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

For the attention of: Matt Bradford

Contract Title: Gordon House, South Shields

Date Received: 13/1/2017
Date Commenced: 13/1/2017
Date Completed: 18/1/2017

Notes: Opinions and Interpretations are outside the UKAS Accreditation

Checked and Approved Signatories:

R Gunson (Director)	A Watkins (Director)	R Berriman (Quality Manager)
L Knight (Senior Technician)	S Royle (Senior Technician)	A Fry (Senior Technician)

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Doncaster DN4 0AR
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e-mail: rgunson@prosoils.co.uk
awatkins@prosoils.co.uk

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
BH1		B	1.50		Brown mottled grey slightly gravelly very clayey silty SAND.
BH3		B	1.40		Brown slightly gravelly very sandy CLAY.
BH4		B	1.60		Brown mottled grey slightly gravelly slightly clayey very silty SAND.
BH6		B	1.50		Brown slightly gravelly very silty SAND.

UKAS TESTING 4043	PSL Professional Soils Laboratory	Checked / Approved	Date 18/01/17	Contract No: PSL17/0147
		Gordon House, South Shields		Client Ref: 16-911

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
BH3		B	1.40		12			31	16	15	93	Low plasticity CL.

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

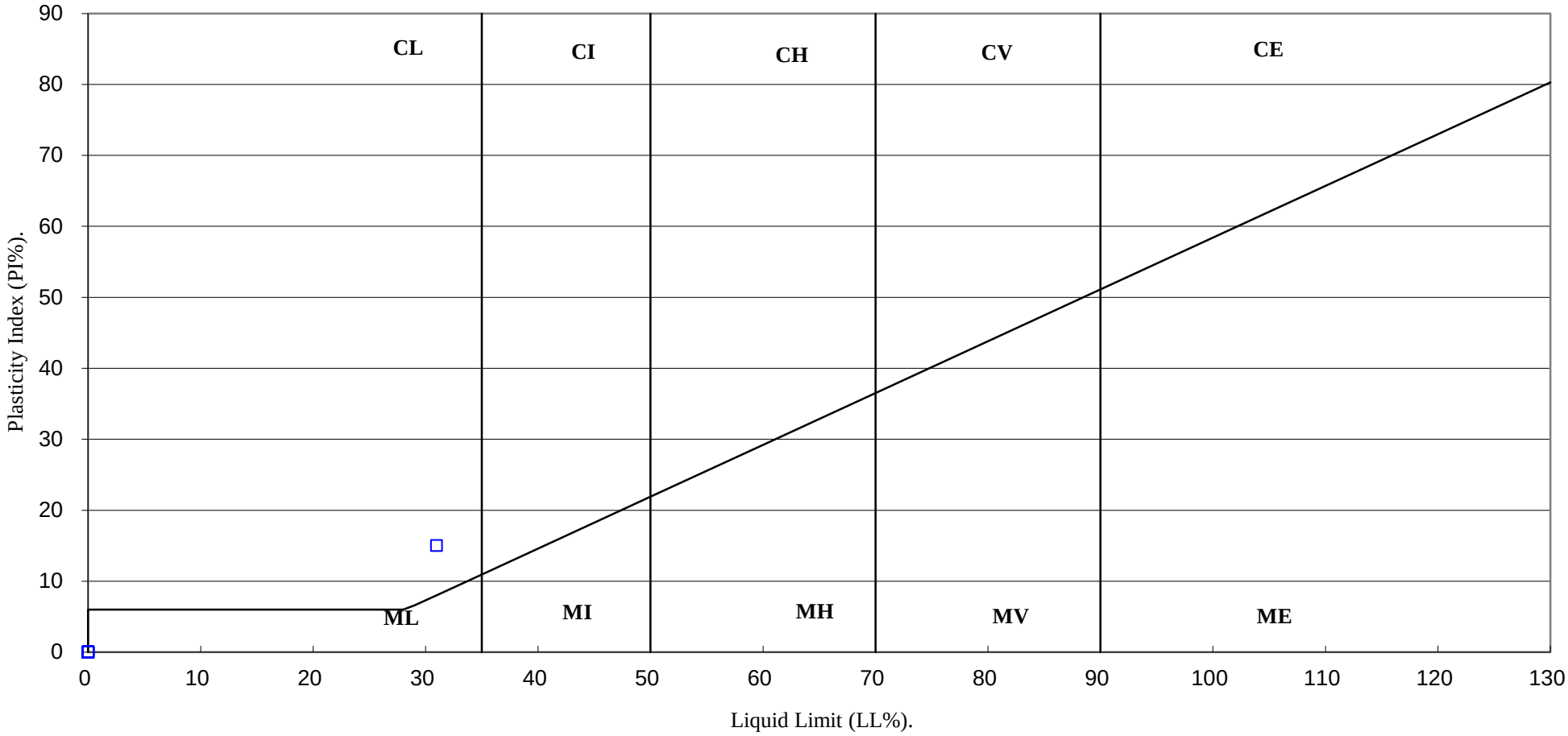
UKAS TESTING 4043

PSL Professional Soils Laboratory

Checked / Approved		Date	18/01/17	Contract No:
Gordon House, South Shields				PSL17/0147
				Client Ref:
				16-911

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.

(BS5930 :2015)



UKAS TESTING 4043 / PSL Professional Soils Laboratory	**Checked /Approved**		**Date**	**18/01/17**	**Contract No:**
	Gordon House, South Shields				**PSL17/0147**
					Client Ref:
					16-911

PARTICLE SIZE DISTRIBUTION TEST

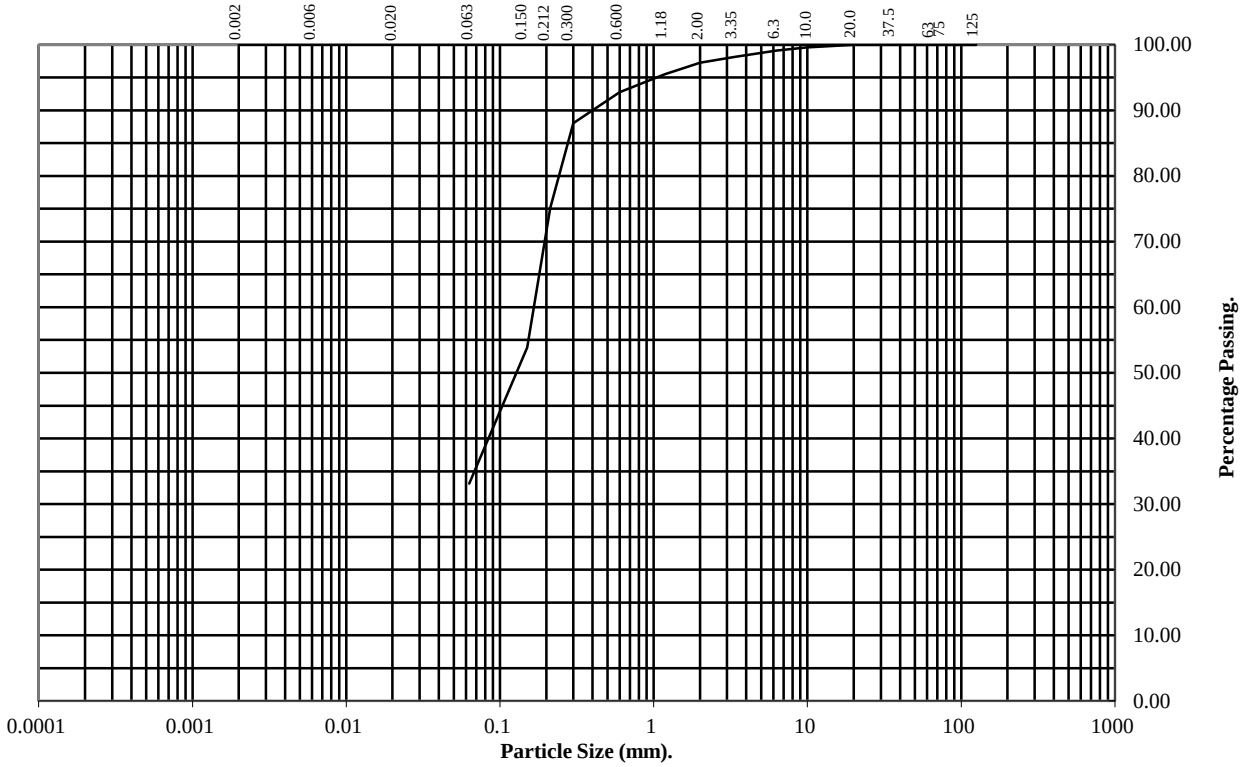
BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number: **BH1** **Top Depth (m):** **1.50**

Sample Number: **Base Depth(m):**

Sample Type: **B**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	99
3.35	98
2	97
1.18	96
0.6	93
0.3	88
0.212	75
0.15	54
0.063	33

Soil Fraction	Total Percentage
Cobbles	0
Gravel	3
Sand	64
Silt/Clay	33

Remarks:

See summary of soil descriptions.

UKAS TESTING 4043	PSL Professional Soils Laboratory	**Checked / Approved**		**Date** **18/01/17**	**Contract No:** **PSL17/0147**
		Gordon House, South Shields			**Client Ref:** **16-911**

PARTICLE SIZE DISTRIBUTION TEST

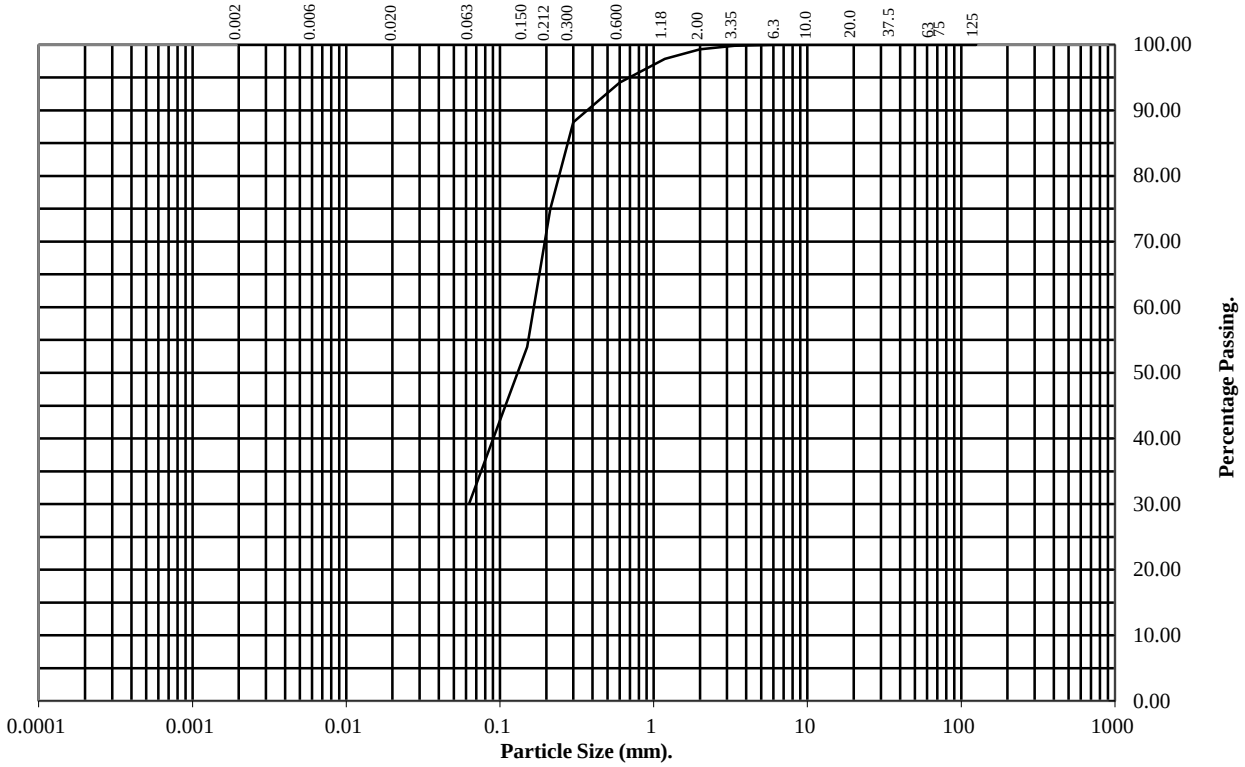
BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number: **BH4** **Top Depth (m):** **1.60**

Sample Number: **Base Depth(m):**

Sample Type: **B**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	99
1.18	98
0.6	94
0.3	88
0.212	75
0.15	54
0.063	30

Soil Fraction	Total Percentage
Cobbles	0
Gravel	1
Sand	69
Silt/Clay	30

Remarks:

See summary of soil descriptions.

UKAS TESTING 4043	PSL Professional Soils Laboratory	**Checked / Approved**	**Date** 18/01/17	**Contract No:** PSL17/0147
		Gordon House, South Shields		**Client Ref:** 16-911

PARTICLE SIZE DISTRIBUTION TEST

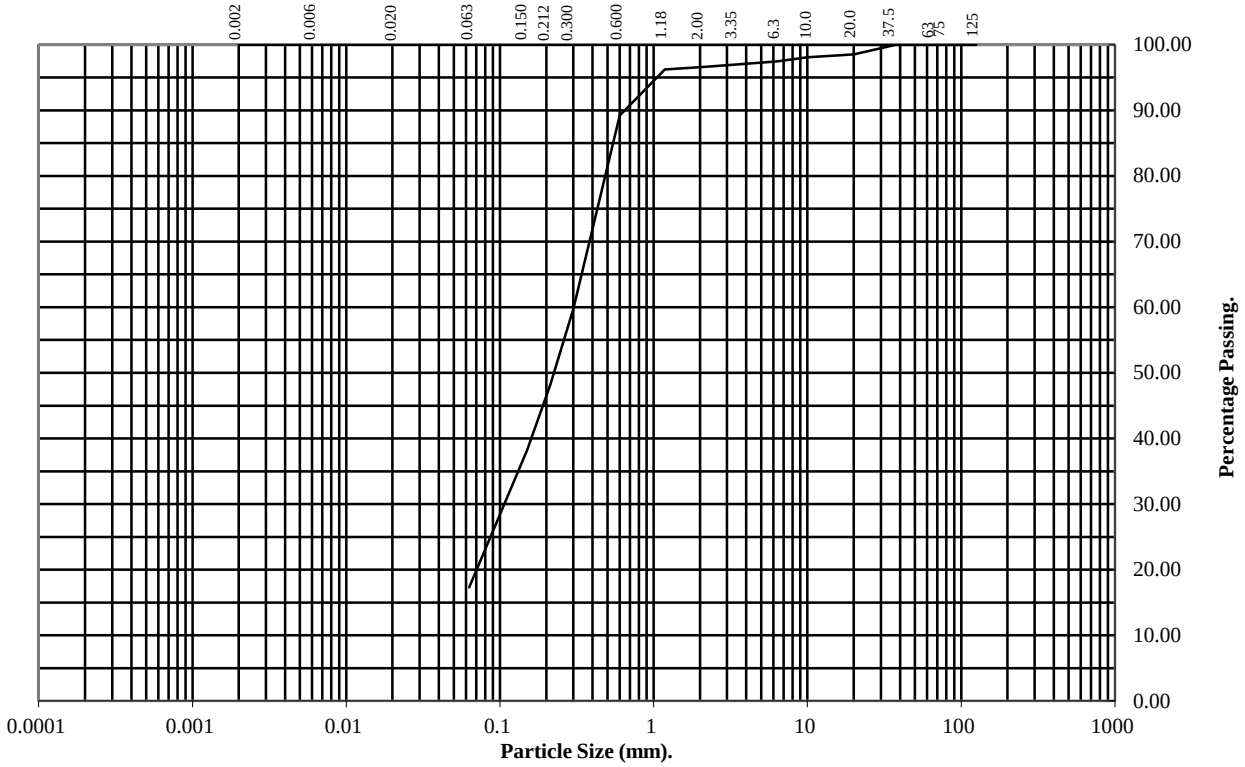
BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number: **BH6** **Top Depth (m):** **1.50**

Sample Number: **Base Depth(m):**

Sample Type: **B**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	98
10	98
6.3	97
3.35	97
2	97
1.18	96
0.6	89
0.3	60
0.212	48
0.15	38
0.063	17

Soil Fraction	Total Percentage
Cobbles	0
Gravel	3
Sand	80
Silt/Clay	17

Remarks:

See summary of soil descriptions.

UKAS TESTING 4043	PSL Professional Soils Laboratory	**Checked / Approved**	**Date**	**Contract No:**
		Gordon House, South Shields		**PSL17/0147**
				Client Ref:
				16-911

APPENDIX V

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

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.

At present, the SGV's (Soil Guidance Values) published as part of the previous 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, using the updated model and software (version 1.071), is currently ongoing, and the new guidance documents for CLR7 & CLR8 have yet to be published. Currently, Defra and the EA have published TOX and SGV reports for the following select substances: Benzene, Toluene, Ethylbenzene, Xylenes, Arsenic, Cadmium, Mercury, Nickel, Selenium and Phenol. Although updated SGV values have been calculated for the aforementioned analytes, at present for the majority of the potential contaminants, relevant data is yet to be made available for the new model. According to Defra and the EA, the schedule for publication of the remaining reports will depend on various factors, and they anticipate publishing the remaining TOX and SGV reports for Cyanide, Lead, Dioxins, Dioxin-like Polychlorinated Biphenyls and Polycyclic Aromatic Hydrocarbons during the remainder of 2010.

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

Methodology:-

During this transitional period, prior to the publication of all the new SGV values for the above mentioned analytes, ARC consider that the most appropriate methodology for completing a ground contamination risk assessment for soils on this site will be to utilise the recently published SGV values (Benzene, Toluene, Ethylbenzene, Xylenes, Arsenic, Cadmium, Chromium (III & VI), Mercury, Nickel, Selenium and Phenol), combined with the former CLEA model SGV's based on the CLEA UK software and other newly 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 SGV 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 SGV 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 Water Environment, then Level 1 Quantitative Risk Assessments are appropriate guideline values. For soils these typically comprise soil guideline values (SGV's), generic assessment criteria (GAC) or site specific assessment criteria (SSAC) and for Water Environment, 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, preliminary and level 1 risk assessments consider two main categories of receptor, and these are as follows:

- On site Human Health – (CLEA Model).
- Water Environment – (groundwater) – (EA Remedial Targets Methodology).

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 Soil Guidance Values (SGV's), and where these values are not available against the published CIEM (Chartered Institute of Environmental Health)/LQM Generic Assessment Criteria (GAC), 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 SGV, 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)

Methodology (Cont'd):-

Level 1 - Human Health (Cont'd):-

Where targeted screening is undertaken, i.e. speciated PAH's for 'ashy' type materials, screening for suspected organic contamination, etc., the maximum site values recorded (C_M) at each location have been compared to the chosen Level 1 Critical Concentration (C_C), with no requirement for statistical analysis to be undertaken on for these samples.

Level 1 – Water Environment:-

The Level 1 Water Environment risk assessment has been carried out (in accordance with the guidance; Remedial Targets Methodology, Hydrogeological Risk Assessment for Land Contamination, Environment Agency, 2006) by comparing samples of leachate, with the chosen Level 1 Critical Concentration (C_C) value, based on an appropriate water quality standard (EQS, UK Drinking Water, etc.), and which is also taken as the Level 1 Leachate Remedial Target (LTC_1).

The number of samples chosen for screening is determined by assessing the potential risk of contamination reaching a sensitive receptor, i.e. shallow groundwater, nearby surface water feature, etc., based on the results of the preliminary investigation, as well as olfactory, visual, anecdotal and analytical evidence collected during the intrusive investigation works.

Where the potential risk is considered to be low between 0% and c.25% of the samples are targeted for screening, c.25% to c.50% where the risk is considered to be moderate and c.75% to 100% where the risk is considered to be high. This is to ensure that the potential risk is adequately assessed without carrying out unnecessary testing. When considering any 'hot spots' identified, samples are specifically targeted for screening on a sample by sample and analyte by analyte basis.

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.

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.