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INTERIM
Phase II Interpretative Ground Assessment

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SUTCLIFFE INVESTIGATIONS

Phase II Interpretative Ground Assessment

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FOREWORD (Geotechnical and Environmental Assessment)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Sutcliffe Investigation; such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their risk and the authors owe them no duty of care and skill.

The report presents observations and factual data obtained during our site investigation, and provides an assessment of Geotechnical and environmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from Sutcliffe Investigation prior to significant revision of the development proposals. Primary aims of this exploratory phase of investigation were to identify salient geotechnical and environmental issues affecting the site to enable the client to obtain budget costs for the necessary site preparatory and remedial works.

The report should be read in its entirety, including all associated drawings and appendices. Sutcliffe Investigation cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context.

The findings and opinions conveyed in this report (including review of any third party reports) are based on information obtained from a variety of sources as detailed within this report, and which Sutcliffe Investigation believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, Sutcliffe Investigation cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced Geotechnical and environmental consultants. Sutcliffe Investigations does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Sutcliffe Investigation, whilst fully appropriate, may not have encountered all significant subsurface conditions. Any opinions expressed as to the possible configuration of strata between or below exploratory holes are for guidance only and no responsibility is accepted as to its accuracy.

It should be borne in mind that the timescale over which the investigation was undertaken might not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during the wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

This report assumes that ground levels will not change significantly from those existing at present. If this is not to be the case, then some modification to this report may be required.

It should be noted that the banning of the co-disposal of hazardous and non-hazardous waste was introduced in 2011, as a result of the implementation within the UK of the Landfill Directive. This will considerably affect the current practices and procedures for the handling and disposal of wastes, in particular hazardous wastes. In addition, it will be a requirement for all wastes to be pre-treated and to comply with certain waste acceptance procedures prior to sending wastes to landfill. The full potential effects of these important changes are not known at this stage, but it is perceived that disposal costs will rise, particularly for hazardous wastes, and waste pre-treatment may, in some cases, become an ‘additional’ redevelopment cost with regard to the remediation of contaminated sites.

Should this report recommend that materials could be excavated and removed off site for landfill disposal, then it should be noted that the costs, timescales and implications of the pending changes to waste management legislation couldn’t be predicted at this stage. Sutcliffe Investigation will not be responsible for changing practices, etc that may affect the viability of necessary remedial actions or of the implications of potential alternative treatment techniques.

Sutcliffe Investigation reserves the right to amend their conclusions and recommendations in the light of further information that may become available. General notes and limitations relevant to all Sutcliffe Investigations are described in the Foreword and should be read in conjunction with this report.

Executive Summary

INTRODUCTION	Sutcliffe Investigations was instructed by Anwyl Construction (*the "client"*) to undertake a Phase II ground assessment for the site known as Bryn Awel Hotel, Denbigh Road, Mold CH7 1BL. The site is centred on National Grid Reference (NGR) 323620, 364400 and is approximately 0.26ha in area. This report assesses the ground based geotechnical and environmental risks, constraints and liabilities associated with the proposed development of the site. This is required in support of the discharge of contaminated land planning conditions assigned to the site and to allow the design of economic foundation solutions.
SITE DESCRIPTION	The site is built into the hillside with two buildings noted on site, the site is tiered with the northern portion of the site noted as the lower section and the southern portion noted as the upper section. Macadam covered car parking areas are also noted. An overgrown ornamental garden is present to the northeast of the site; again this area is steeply terraced, with a large grassed area at the lowest level. The buildings on site appear to be in reasonably good condition. The northern building is a large Victorian house with extensions and additions from around the 1960s onwards, were as the southern building dates from the 1960s and forms the restaurant part of the complex. This building has storage areas below the main level that can be accessed from the rear of the building.
DEVELOPMENT PROPOSAL	The proposed development for the site is for apartments with associated communal gardens and associated car parking facilities.
PRELIMINARY CONCEPTUAL MODEL	The earliest available historical map (1871) indicated that buildings and trees were noted on the northern portion of the site however the purpose of these buildings was unclear. Due to the scale of the maps it was unclear if there had been any further changes on site until 1899 when more buildings were noted on site, but again their purpose was still unclear. No further notable changes were evident until 1961 when the building formation was clear, and Bryn Awel was noted. By 1971 there has been slight changes to the layout of the site, this is also the first map has identified the Bryn Awel Hotel. No further changes were evident from the historic maps to date and visits to the site have confirmed that buildings are still noted on the site. With the exception of made ground potentially being present on site, no significant identifiable sources of environmental concern were identified. The potential for significant contamination to have arisen at the site as a result of the current and former usage on site is considered to be low. However, the possibility of contamination albeit likely to be localised cannot be discounted.
PREVIOUS WORKS	Sutcliffe's have completed a Phase I Desk Study, a synopsis of which is provided in Section 2 of this report. No other previous studies are known to have been undertaken to Sutcliffe's knowledge.
SITE INVESTIGATION	Site work was undertaken on 10th 12th and 13th September 2018 and consisted of: 4No. Window Sample Holes. 2No. Cable Percussion Boreholes 6No. Can dug pits Contamination samples from various depth in the made ground and natural ground Leachate samples. Gas monitoring wells. Monitoring of ground gas / ground water with installed locations (Sutcliffe's 2018).
GROUND CONDITIONS	Made Ground: The made ground, identified in the Window Samples and Borehole Samples comprises of macadam over a graded granular limestone hardcore subbase over a mixture of loose brown / red / grey / black ashy occasionally clayey fine to coarse grained SAND with occasional brick fragments, fine to medium sub-rounded to rounded GRAVEL, loose brown sandy CLAY with fine to medium brick and mortar fragments and yellow / brown and orange very clayey, slightly gravelly fine to medium grained SAND. The Made Ground in the Hand Dug Pits comprised of grass over dark brown

	clayey occasionally ashy (HD105 and HD106) fine to medium grained SAND with root material, over dark grey / brown gravelly fine to medium grained SAND with fine to coarse brick both whole and part and mortar fragments. Gravel was noted to be fine to coarse subangular to angular and of limestone. Natural Ground: Natural ground comprised of bands of sands and clays. Sand comprised of Loose to medium brown / grey / yellow / orange slightly silty, clayey gravelly fine to coarse grained SAND. Gravel is fine to coarse subangular and sub rounded to rounded and of mixed lithology including limestone. Clay comprised of firm to very stiff brown / grey slightly silty slightly sandy gravelly CLAY with occasional fine to medium sand pockets. Sand is fine, gravel is fine to medium subangular to sub-rounded and of mixed lithology.
GROUNDWATER	Groundwater was recorded in WS102 at 2.10m, in WS103 at 1.40m and in WS104 at 2.00m during site investigation works, all of which were noted to have no rise after 20 minutes.
ENVIRONMENTAL RISK ASSESSMENT	Long Term Human Health Elevated levels of Lead indicate the presence of site wide contamination that will require remediation to be safe for Human Health. Elevated levels of C8 to C10 Aliphatic, C10 to C12 Aliphatic, C8 to C10 Aromatic, C10 to C12 Aromatic, C12 to C16 Aromatic, C16 to C21 Aromatic, Naphthalene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenzo(ah)anthracene have also indicated hotspot areas of contamination. Given the extent of the identified contamination a site wide strip will be required to a depth of 600mm, with a capping layer being placed in garden areas to bring site levels back up. In the area of WS103 it is proposed to remove material to a depth of 1.00m due to TPH and PAH contamination noted to a depth of 0.90m. It would also be Sutcliffes recommendation to carry out delineation sampling in this area to ensure the extent of the TPH and PAH contamination has been removed before bringing site levels back up. **NOTE:** Further works are still required, these works include an investigation of the lower tier when accessible and soakaway testing. Controlled Waters Risk Assessment For controlled waters there are two assessment criteria, the Environmental Quality Standard (EQS) and the UK Drinking Water Standard (UKDWS). The UK DWS Leachate screening identified slightly elevated concentrations of Lead that could pose a risk to the Secondary A aquifer. However, due to the likely depth of groundwater and the effects of natural attenuation, the risk is unlikely to be significant. The EQS Leachate screening identified concentrations of Cadmium, Copper, Lead and Zinc that could pose a risk to the local surface water features. However, as there are no surface water features within 250m south of the site, the risk is unlikely to be significant
ASBESTOS	Asbestos sampling was undertaken on 9 Made Ground samples and 2 Natural Ground samples. No Asbestos was identified in any of the samples.
GROUND GAS RISK ASSESSMENT	Although ground gas monitoring is ongoing, based on the results of the gas monitoring to date and due to elevated CO_2 readings, an Amber 1 classification is recommended for the site, as such as gas membrane will be required as part of the ground floor design in all the new developments on site. **NOTE:** The membrane will also need to protect against Radon.
RADON	The site is in a higher probability radon area (10 to 30% of homes are estimated to be at or above the Action Level) therefore full radon protective measures are necessary in the construction of new dwellings or extensions.
GEOTECHNICAL ASSESSMENT	General - It is understood that consideration is being given to the development of housing with associated garden areas and infrastructure. Due to the ground conditions encountered it would be Sutcliffe's recommendation that a piled foundation solution is adopted, with piles being taken to a suitable depth in natural strata for bearing. Final pile design will be undertaken by a specialist piling contractor. Limited groundwater ingress was recorded during site investigation works and

	subsequent monitoring. Sub-surface concrete that is only in contact with Made Ground can be Design Sulphate Class DS-1, with an ACEC Classification of AC-1s. Ground Floor Construction - Based upon the amount of Made Ground noted on site it is not recommended that a ground-bearing slab is utilised on site. Sutcliffe Investigations therefore propose a suspended P.C Unit ground floor be adopted. Geotechnical Uncertainty The site has been subject to previous development and therefore, the potential for relic foundations and obstructions cannot be discounted.
RECOMMENDATIONS	The following actions are recommended: • Design a Phase III Remediation & Validation Proposal for submission to planning department. • Design SMMP – management of material on and off site. • Investigation of the lower tier when accessible. • Delineation in the area of WS103 due to TPH and PAHs. • Post demolition sampling. • Carryout Soakaway Testing. • Good hygiene practices should be employed during construction work, in addition, the findings of this investigation should be included within the contractors H&S file and an assessment of risks associated with short term human health completed. No consumption of food or smoking should occur without prior hand washing. If dust is encountered, dust masks should be worn and dust suppression employed.

NOTE: The executive summary is an overview of the key findings and conclusions of the report. There may be other information contained in the body of the main report which puts into context the information presented within the executive summary. No reliance should be placed on the executive summary.

Contents

1 Introduction

1.1 Terms of Reference

Sutcliffe Investigations was instructed by Anwyl Construction (*the "client"*) to undertake a Phase II ground assessment for the site known as Bryn Awel Hotel, Denbigh Road, Mold CH7 1BL.

The location of the site is presented as *Figure* 1*.* The site is centred on National Grid Reference (NGR) 323620, 364400 and is approximately 0.26ha in area. An aerial photograph of the site is presented as *Figure 2*.

A plan detailing the sites existing site layout is presented as *Drawing No 29982 - 700– P1.*

This report assesses the ground based geotechnical and environmental risks, constraints and liabilities associated with the proposed development of the site. This is required in support of the discharge of contaminated land planning conditions assigned to the site and to allow the design of economic foundation solutions.

1.2 Development Proposal & Legislative Context

Development Proposal

The proposed development for the site is for apartments with associated communal gardens and associated car parking facilities. The proposed development is presented as *Drawing No: TEP / BA / SK 007* produced by The Eureka Project Limited.

Legislative Context

The presence of contaminants which may pose a risk to human health or the environment is a material planning consideration. For planning it should be considered whether the site is suitable for its new use, and the responsibility for securing a safe development (including cumulative effects of pollution on health, and the potential sensitivity of the proposed development to adverse effects from pollution,) rests with the developer and/or landowner. Planning is concerned with the site's proposed use not its current use, where the amount of contamination is expected to be low relative to the level of risk. This is the opposite to Part 2A which considers high levels (significant harm) and the current use of the site.

Section 57 of the Environment Act 1995, adds Part 2A (ss.78A-18YC) to the Environmental Protection Act 1990 and contains the legislative framework for identifying and dealing with contaminated land. Where development is undertaken on land which may be affected by contamination, the National Planning Policy Framework, paragraphs 120 to 122 considers pollution and

remediation. This links the contaminated land regime within the development process.

For there to be an environmental liability associated with the site there must be a perceived source (a contaminant), a receptor (humans, living organisms or property) and a pathway between them. The potential presence of all of these aspects would result in a complete contaminant linkage.

In accordance with environmental legislation and the associated guidelines, assuming the site is to be redeveloped as housing, it should be noted that any redevelopment of the site could actually create new pathways that could increase the liabilities associated with the site. In addition, the basis of the intrusive ground assessment is to refine the preliminary conceptual model.

1.3 Site Location and Setting

The site is located at Bryn Awel Hotel, Denbigh Road, Mold CH7 1BL at National Grid Reference (NGR) 323620, 364400 (*Figure 1*), within a predominantly residential area with a historical feature (Mold Castle) and recreational amenities also noted in the area.

A location plan and aerial photograph of the site are shown as *Figure 1 & 2*.

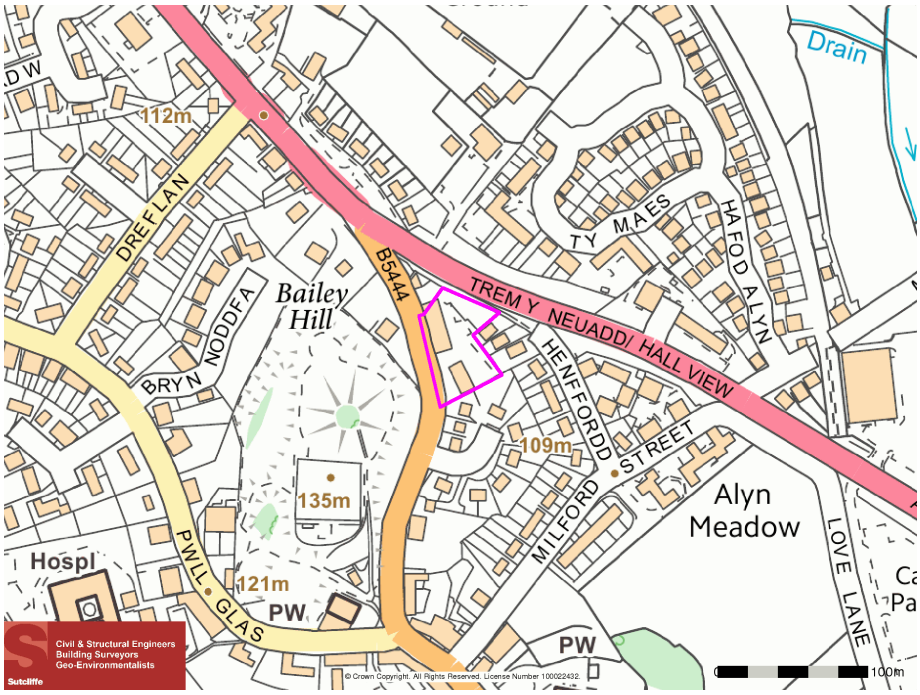

Figure 1: General Location of Site

1.4 Site Description and Layout

The site is built into the hillside with two buildings noted on site, the site is tiered with the northern portion of the site noted as the lower section and the southern portion noted as the upper section. Macadam covered car parking areas are also noted. An overgrown ornamental garden is present to the northeast of the site; again this area is steeply terraced, with a large grassed area at the lowest level.

The buildings on site appear to be in reasonably good condition. The northern building is a large Victorian house with extensions and additions from around the 1960s onwards, were as the southern building dates from the 1960s and forms the restaurant part of the complex. This building has storage areas below the main level that can be accessed from the rear of the building.

Figure 2: Aerial Photograph of the Site

1.5 Previous Studies

Sutcliffe's have completed a Phase I Preliminary Risk Assessment (PRA). (*Report Reference: 29982LG*), a synopsis of which is provided in *Section 2* of this report. No other previous studies are known to have been undertaken to Sutcliffe's knowledge.

1.6 Objectives & Scope of Assessment

The aim of the intrusive ground investigation is to identify potential geotechnical & environmental liabilities and constraints, associated with the development of the site area in support of the following:

- A planning application and the discharge of contaminated land conditions where reasonably practicable that may have been assigned to the site and to include the design of a remediation scheme, if required as part of the National Planning Policy Framework (NPPF).
- To assess the likelihood of reuse of materials that are site won or disposal options for surplus material.
- The preliminary design of detailed and economic foundations options inclusive of all information and specifications relating to foundation types, the location of underlying rock, (if encountered), preparation of ground, concrete grades, reuse of materials for both the proposed building, and the existing foundations.

1.7 Averaging Areas

As the site is solely to comprise as apartments, the results will be assessed as one dataset, however as buildings were still present on site at the time of the investigation post demolition sampling will be required following the demolition of these buildings.

2 Preliminary Conceptual Risk Assessment

2.1 Introduction

The Phase I PRA completed by Sutcliffe is summarised below. This report should be read in conjunction with Report Ref.: *Phase I Preliminary Risk Assessment, Bryn Awel, Mold Ref.: 29982LG.*

2.2 Site History

The earliest available historical map (1871) indicated that buildings and trees were noted on the northern portion of the site however the purpose of these buildings was unclear. Due to the scale of the maps it was unclear if there had been any further changes on site until 1899 when more buildings were noted on site, but again their purpose was still unclear. No further notable changes were evident until 1961 when the building formation was clear, and Bryn Awel was noted. By 1971 there has been slight changes to the layout of the site, this is also the first map has identified the Bryn Awel Hotel. No further changes were evident from the historic maps to date and visits to the site have confirmed that buildings are still noted on the site.

With the exception of made ground potentially being present on site, no significant identifiable sources of environmental concern were identified. The potential for significant contamination to have arisen at the site as a result of the current and former usage on site is considered to be low. However, the possibility of contamination albeit likely to be localised cannot be discounted.

It is proposed to develop the site with apartments, associated communal gardens and associated car parking facilities.

2.3 Geotechnical Constraints

Coal Mining

The site does fall within a coal mining area. The site is in a surface area that could be affected by underground mining in 2 seams of coal at 50m to 120m depth and last worked in 1893, however, the site is not within the zone of likely physical influence from present or future underground coal mining and there are no known coal mining entries on or within 20m of the site.

Radon

The site is in a higher probability radon area (10 to 30% of homes are estimated to be at or above the Action Level) therefore full radon protective measures are necessary in the construction of new dwellings or extensions.

Geology

There are no records of any artificial ground onsite however there are two records of artificial ground within 500m of the site the nearest of which is approximately 30m west of the site and is noted as Made Ground.

Four faults and rock segments are noted within 250m of the site, the nearest of which relates to a fault noted approximately 20m north of the site.

Historical Land Use

The site has been subject to previous development and therefore, the potential for relic foundations and obstructions cannot be discounted.

2.4 Potential Contaminant Linkages

Sources

The likely contaminants from made ground associated with former site usage, infilling activity which may be present on site could include: heavy metals such as cadmium, chromium, copper, lead, nickel and zinc, asbestos, hydrocarbons and organic compounds such as Polycyclic Aromatic Hydrocarbons (PAHs). Furthermore, ground gases such as methane and carbon dioxide may be generated from areas of made ground material.

Although infilled land has been noted in the surrounding area of the site, no off-site sources have been identified that would represent a significant risk to the site.

The likely contaminants from previous land uses are shown below in *Table 2.1*.

Table 2.1: Potential Source(s) of contamination

Reference	Potential Sources	Potential Contaminants
S1 – Onsite	Demolition of former on-site buildings	All metals, fuel, hydrocarbons and oils and localised ground gas.
S2 – Off Site	Infilled land	All metals, fuel, hydrocarbons and oils and localised ground gas.

Receptors

The most sensitive receptors identified using the conceptual site model are considered to be site and adjacent site users, construction and maintenance workers, controlled waters (Secondary A Aquifer) infrastructure and buried services. These are most likely to be affected by made ground and any associated contaminants and gas generated from made ground, if present on site.

Human receptors would comprise construction workers, future site users and adjacent site users. It is likely that the exposure to contamination by construction workers will be limited due to the short exposure to the potential contamination and the use of PPE. If ground gases are produced this could be a potential risk to the future site users and properties and workers in confined spaces / trenches etc.

Due to the potential for contaminants to be present on site there is the potential for contaminants to leach and migrate to the underlying Secondary A Aquifer. Drift material is noted to be present under the site and is classified as Glaciofluvial Sheet Deposits; which will act as an aquiclude, reducing the risk to the underling aquifer.

Table 2.2 below details the potential receptors.

Table 2.2: Receptors

Ref	Receptor	Description
R1	Current & future site users	Site users; personnel, general workers and maintenance workers,
R2	Construction Workers	Contractors working on the development of the site. Construction workers, maintenance workers or other personnel who may be directly exposed to contaminated materials in the course of their activities).
R3	Controlled Waters	Secondary A Aquifer and on-site drainage
R4	Adjacent Site Users	Adjacent site users. Third-party land (*i.e.* the possibility of contamination migrating off-site onto third party land *via* contaminated groundwater, surface water run-off).
R5	Infrastructure / Buried services	Proposed buildings and buried services

Pathways creating contaminant linkages

Table 2.3: Pathways

Ref	Pathway	Description
P1	Direct contact with potential contaminants.	Dermal absorption, ingestion and inhalation of contaminants via direct contact. Construction workers may come into contact during the site works, however this will be for a short time and therefore limited exposure will occur. PPE can be used Construction workers may come into contact during the site works, however this will be for a short time and therefore limited exposure will occur. PPE can be used and worn as a precaution to reduce the risk.
P2	Ingestion of potential contaminants.	
P3	Inhalation of potential contaminants.	
P4	Leaching and migration of contaminants.	Leaching of possible contaminants could migrate into the underlying Secondary A Aquifer via shallow groundwater. On site drainage is also at risk from shallow contamination, if present.
P5	Vertical and lateral migration of ground gases / vapours.	There is the potential for contaminants to be present on the site, which could generate ground gas & vapours on site.

2.5 Risk Evaluation

Each potential contaminant linkage is identified in *Table 2.4* below. An evaluation of the risk that each contaminant linkage poses to the project (as identified in the *Section 2*) has been undertaken, in general accordance with CIRIA guidance document C552, 2001 (as detailed in *Appendix B*).

The evaluation and the resultant actions identified are based on the available information presented within this report. A visual representation of the Preliminary CSM is presented as *Figure 3.*

The evaluation and resultant actions identified are based on available information presented within the Phase I PRA (Report reference: 29982LG)

During the development there is a potential for short term human health risk to construction workers. These should be assessed and anticipated by the contractor under CDM Regulations 2015.

Table 2.4: Preliminary Risk Evaluation of Potential Contaminant Linkages

1. Hazard Identification		2. Hazard Assessment				3. Risk Estimation		4. Risk Evaluation	5. Managing the Risk
Contaminant Source		Pathway		Receptor		Consequence of risk being realised	Probability of risk being realised	Classification	Action required
S1	Potentially contaminated soil on Site	P1	Dermal contact	R1/2	Site users	Medium	Low	Moderate / Low	It is possible that harm could arise to a designated receptor from an identified hazard. Investigation is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
		P2	Ingestion of soil / soil dust	R1/2	Site users	Medium	Low	Moderate / Low	
		P3	Inhalation of vapours / soil gas	R1/2	Site users	Severe	Unlikely	Moderate / Low	
		P4	Leaching and migration of contaminants	R3/5	Secondary A aquifer	Medium	Low	Moderate / Low	
		P5	Lateral migration of soil gas / vapours	R1	Site users	Severe	Unlikely	Moderate / Low	
				R4	Property	Severe	Unlikely	Moderate / Low	
S2	Infilled Land (68m North east)	P3	Inhalation of vapours / soil gas	R1/2	Site users	Severe	Unlikely	Moderate / Low	It is possible that harm could arise to a designated receptor from an identified hazard. Investigation is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
		P4	Leaching and migration of contaminants	R3/5	Secondary A aquifer	Medium	Low	Moderate / Low	
		P5	Lateral migration of soil gas / vapours	R1	Site users	Severe	Unlikely	Moderate / Low	
				R4	Property	Severe	Unlikely	Moderate / Low	

3 Ground Investigation

3.1 Design Rationale

The aim and design of the ground assessment is to satisfy planning conditions assigned to the site by reference to the National Planning Policy Framework (NPPF). This will identify elevated concentrations of determinants with the aim of assessing long term human health risks to site users and groundwater resources. In addition, the works have been designed to allow the design of economic foundation solutions for the proposed new builds.

3.2 Fieldwork

Field works were undertaken on the 10th 12th and 13th September 2018 by PM Drilling, a specialist ground investigation contractor, all works were supervised by a suitably qualified Sutcliffe engineer. Sutcliffes returned to site on the 1st October 2018 to undertake hand dug pits required due to access restraints encountered. The investigation was carried out in general accordance with the following standards:

- *BS10175:2011 Code of Practice for the Investigation of Potentially Contaminated Sites;*
- *R&D Technical Report P5-066/TR Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination, 2001 (Environment Agency).*
- *BS 5930:2015 Code of practice for site investigations; and,*
- *BS EN ISO 22475-1:2006 Geotechnical investigation and testing. Sampling methods and groundwater measurements. Technical principles for execution.*

Boreholes, Window sample and Hand dug pit logs collated as part of the ground investigation completed by Sutcliffe's are presented in *Appendix C.*

3.3 Health & Safety

Service plans for the development site have been obtained and are included as part of the Phase I PRA. A copy of these plans are maintained on site by the Sutcliffe engineer who is also responsible for clearing the areas to be investigated by use of a Cable Avoidance Tool (CAT) and signal generator (Genny).

3.4 Sampling Strategy

Due to the history of the site, with limited development having occurred, a non-targeted sampling strategy was used to obtain a site wide representation of the site and the potential contamination issues.

The site area is 2600m^2 ÷ 9 sample positions = 288.89m^2 ÷ 0.8 = 361.11

√361.11m^2 = a 19.00m grid.

Therefore, this gives an 80% probability of finding a circular area of interest of 361.11m^2.

A summary of exploratory hole detailing rationale is shown in *Table 3.1* below.

Table 3.1: Summary of Site Activities

Exploratory Hole ID	Location Rationale	Method	Completed Depth (mbgl)	Installation Details	Testing & Sampling details
WS101	General Site Coverage (GG, CW, HH)	Window Sampler	5.45	Standpipe installed to 4.00m bgl	SPTs, small bulk sample
WS102	General Site Coverage (GG, HH)	Window Sampler	5.45	Standpipe installed to 4.00m bgl	SPTs, small bulk sample
WS103	General Site Coverage (HH)	Window Sampler	3.45	No installation	SPTs, small bulk sample
WS104	General Site Coverage (GG, CW, HH)	Window Sampler	3.45	Standpipe installed to 2.00m bgl	SPTs, small bulk sample
BH101	General Site Coverage (HH)	Cable Percussion	7.95	No installation	SPTs, small bulk sample
BH102	General Site Coverage (GG, HH)	Cable Percussion	7.50	Standpipe installed to 7.00m bgl	SPTs, small bulk sample
HD101	General Site Coverage (CW, HH)	Hand Dug Pit	1.10	No installation	small bulk sample
HD102	General Site Coverage	Hand Dug Pit	0.70	No installation	-
HD103	General Site Coverage	Hand Dug Pit	1.40	No installation	-

Exploratory Hole ID	Location Rationale	Method	Completed Depth (mbgl)	Installation Details	Testing & Sampling details
HD104	General Site Coverage	Hand Dug Pit	1.30	No installation	-
HD105	General Site Coverage (CW, HH)	Hand Dug Pit	1.40	No installation	small bulk sample
HD106	General Site Coverage (HH)	Hand Dug Pit	1.20	No installation	small bulk sample

GG – Ground Gas / CW – Controlled Water / HH – Human Health

A plan detailing the position of sampling locations on an existing layout of the site is presented as *Drawing No 29982 – 700 – P1.*

3.5 Chemical Laboratory Testing

Selected soil samples (made ground & natural) were collected at various depths and horizons and submitted for chemical analysis, details of which are presented in *Table 3.2.*

Table 3.2: Summary of Soils Analysis (Total & Leachate Concentrations)

Suite Reference	Analysis Suite
Soils Suite – total	*Metals suite, speciated (16) polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons according to the Total Petroleum Hydrocarbon Working Group (TPHCWG), asbestos screen, total cyanide, phenols and soil organic matter.*
Leachate – total	*Metals suite, speciated (16) PAHs.*

All samples were stored in airtight containers appropriately labelled and transported in cool boxes with icepacks maintained at 4ºC, under completed chain of custody documentation to Envirolab laboratories.

All samples were analysed by MCERTS accredited soil analysis laboratory Envirolab under UKAS accredited methods. All samples have been taken in accordance with current British Standards.

Envirolab are appropriately accredited for the works required and are an approved supplier under the Sutcliffe's Quality Management System.

Analytical test certificates are presented in *Appendix D.*

TPH Speciated aromatic and aliphatic bands with BTEX analysis have been carried out in line with the TPHCWG. The toxicity and migration risk associated with a TPH is dependent on the specific aliphatic aromatic carbon banding. Of particular concern are the low molecular weight compounds, which are highly mobile and show a greater level of toxicity that the higher molecular weight compounds. Therefore, a low TPH consisting of low molecular weight aliphatic and aromatic carbon banding compounds may present more of a risk than a high TPH consisting of heavy weight aliphatic and aromatic carbon banding compounds.

Based on the TPHCWG the aromatic band C5 – C7 is considered to consist only of Benzene and the aromatic band C7 – C8 of Toluene. Therefore, the more specific BTEX analysis has been used for risk assessment rather than the aromatic bands.

3.6 Drainage

It is recommended that the client / developer contact United Utilities with respect to capacity in existing foul and surface water sewers in the vicinity of the development area.

3.7 Water Supply

Please note the testing suite carried out for this site is for human health purposes and may not cover the suite of contaminants required by United Utilities for pipe selection and therefore further testing may be required.

3.8 Services

It is recommended that the client / developer contact the relevant service provided to ascertain the requirements for power reinforcement and / or relocation / diversion of existing services.

4 Ground Model

4.1 General

The following section describes the ground conditions encountered during the intrusive ground assessment completed by Sutcliffe. The ground comprises between of made ground to a maximum depth of 2.80m overlying bands of SANDS and CLAYS.

A summary of the strata depths and thicknesses is detailed in *Table 4.1.*

Table 4.1: Ground Conditions Encountered

Strata	Depths encountered (mbgl)		Thickness (m)		
	Min	Max	Min	Max	Average
Made Ground	0.00	2.80*	0.50	2.80	1.21*
Loose to medium brown / grey / yellow / orange slightly silty, clayey gravelly fine to coarse grained SAND. Gravel is fine to coarse subangular and sub rounded to rounded and of mixed lithology including limestone.**	0.50	7.50*	0.30	3.55	1.22*
Firm to very stiff brown / grey slightly silty slightly sandy gravelly CLAY with occasional fine to medium sand pockets. Sand is fine, gravel is fine to medium subangular to sub-rounded and of mixed lithology. ***	0.7	7.00*	0.20	4.20	1.82*

* Final Depth of Strata not proven, average thickness on identified ground.
** Sand was not encountered in HD102 and HD106
*** Clay was not encountered in WS101, WS103, HD101-104 and HD106

4.2 Made Ground

The made ground, identified in the Window Samples and Borehole Samples comprises of macadam over a graded granular limestone hardcore subbase over a mixture of loose brown / red / grey / black ashy occasionally clayey fine to coarse grained SAND with occasional brick fragments, fine to medium sub-rounded to rounded GRAVEL, loose brown sandy CLAY with fine to medium brick and mortar fragments and yellow / brown and orange very clayey, slightly gravelly fine to medium grained SAND.

The Made Ground in the Hand Dug Pits comprised of grass over dark brown clayey occasionally ashy (HD105 and HD106) fine to medium grained SAND with root material, over dark grey / brown gravelly fine to medium grained SAND with fine to coarse brick both whole and part and mortar fragments. Gravel was noted to be fine to coarse subangular to angular and of limestone.

The characteristic values for the made ground are shown below in *Table 4.2* and *Figure 5.*

Table 4.2: Material Properties MADE GROUND

Property	No. of Tests	Range	Average
SPT N Values	5	5 - 19	9.8

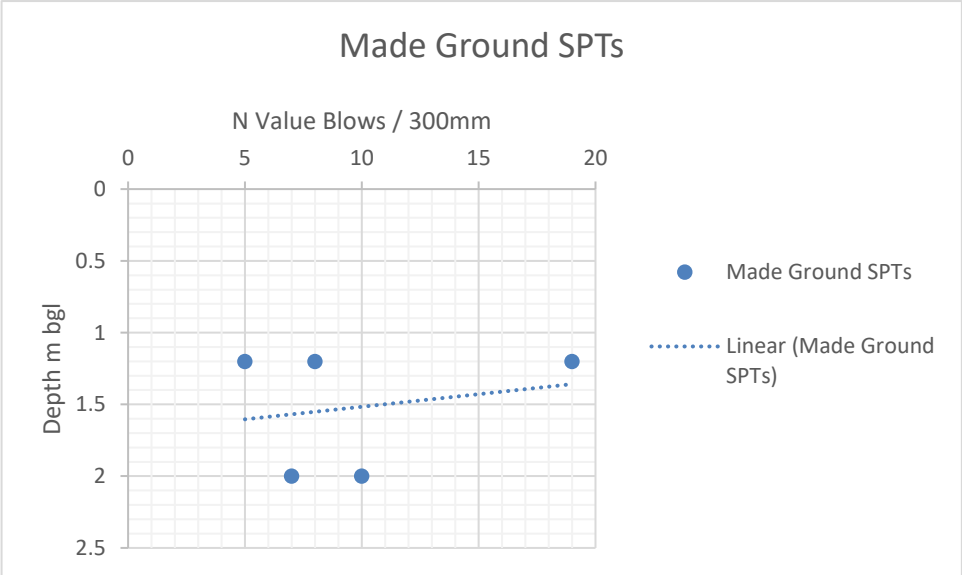

Figure 5: Material Properties MADE GROUND

4.3 Natural Ground

Natural ground comprised of bands of sands and clays. Sand comprised of Loose to medium brown / grey / yellow / orange slightly silty, clayey gravelly fine to coarse grained SAND. Gravel is fine to coarse subangular and sub rounded to rounded and of mixed lithology including limestone.

Clay comprised of firm to very stiff brown / grey slightly silty slightly sandy gravelly CLAY with occasional fine to medium sand pockets. Sand is fine, gravel is fine to medium subangular to sub-rounded and of mixed lithology.

The characteristic values for the natural ground are shown below in *Table 4.3, Table 4.4 and Figure 6*.

Table 4.3: Material Properties SAND

Property	No. of Tests	Range	Average
SPT N Values	12	5 - 21	11.42

NOTE: Refusal in the sand was noted in BH102

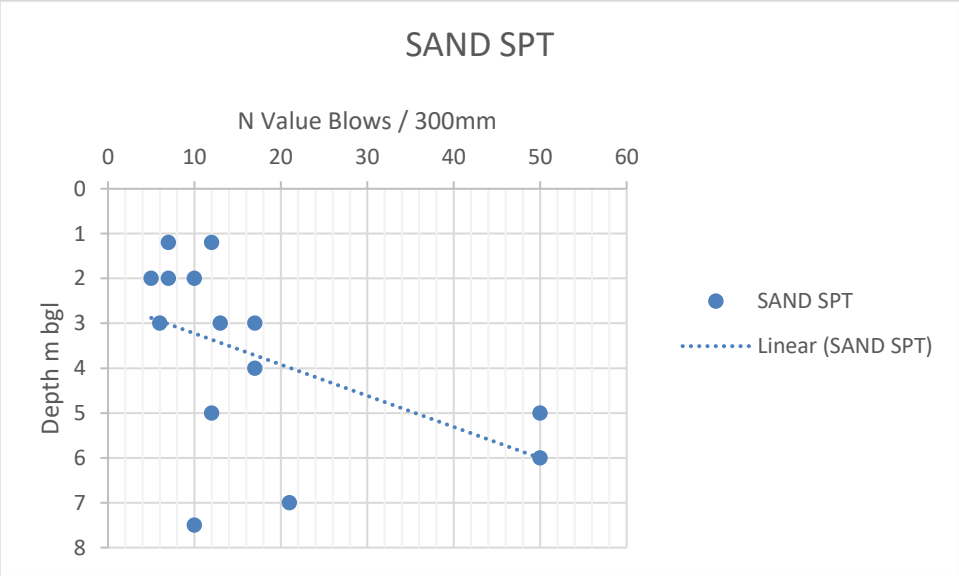

Figure 6: Material Properties SAND

Table 4.4: Material Properties CLAY

Property	No. of Tests	Range	Average
SPT N Values	10	6 - 27	14.8

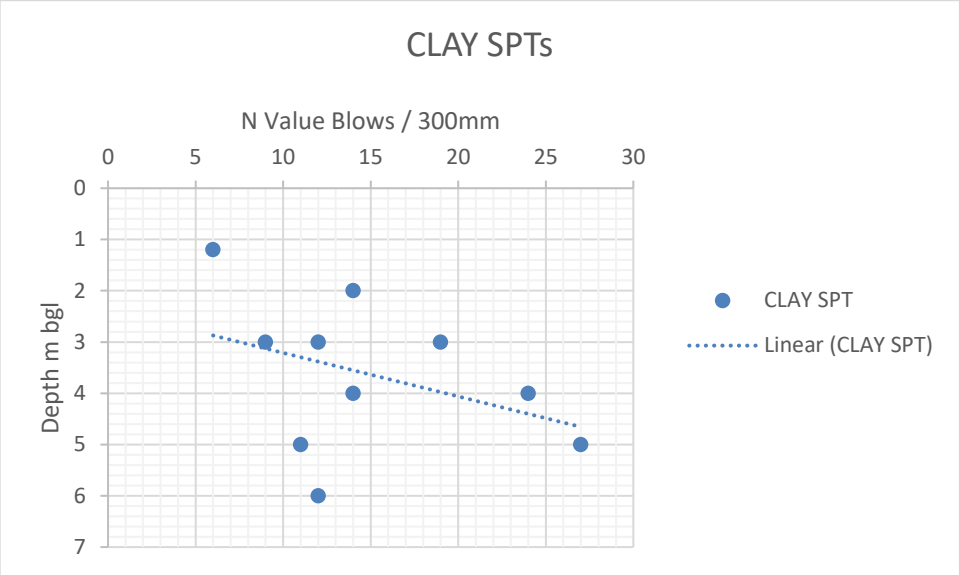

Figure 7: Material Properties CLAY

4.4 Field Evidence of Contaminated Soils

Although no field evidence of contamination was identified, a strong diesel odour smell was noted in WS103 at a depth of 0.70m 3.00m and in WS104 at a depth of 1.90 – 3.00m, no previous on-site features have been noted that would explain these odours.

4.5 Groundwater

Groundwater was recorded in WS102 at 2.10m, in WS103 at 1.40m and in WS104 at 2.00m during site investigation works, all of which were noted to have no rise after 20 minutes.

In accordance with the agreed scope of works monitoring of groundwater installations completed by Sutcliffe's (2018) will be undertaken using an electronic ATEX Dipmeter on six occasions, results of which are presented in *Table 4.5.*

Table 4.5: Groundwater Monitoring Data

Location	Water Level (m bgl)					
	01.10.18	16.10.18	30.10.18	-	-	-
WS101	DRY	DRY	DRY	-	-	-
WS102	0.58	0.52	0.56	-	-	-
WS104	1.70	1.67	1.75	-	-	-
BH102	6.50	6.50	6.20	-	-	-

Based on the Resting Groundwater Levels (RWLs) no discernible groundwater flow has been recorded.

A full set of groundwater monitoring data is presented as *Appendix E.*

5 Geotechnical Laboratory Testing and Assessment

General

In total 3 samples were recovered from site for the purpose of geotechnical laboratory testing from the following positions BH102 at 4.00m bgl, WS102 at 2.00m bgl and WS104 at 2.70m bgl. A breakdown of the testing scheduled is set out in *Table 5.1* below.

Table 5.1: Geotechnical Testing

Borehole Number	Plasticity Index	Moisture Content	Particle Size Distribution	Hand Vane
BH102	✓	✓		✓
WS102	✓	✓	✓	✓
WS104	✓	✓		

Plasticity Index

A total of three samples were tested to determine the plasticity index of the underlying CLAY strata spread across BH102, WS102 and WS104 and taken from depths of between 2.00-4.45m bgl. The plasticity results and the modified plasticity index are outlined in *Table 5.2* below.

Table 5.2: Plasticity Test Results

Borehole Number	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425mm (%)	Modified Plasticity Index (%)	Soil Classification
BH102	4.00	29	16	13	76	9.88	CL
WS102	2.00	23	12	11	72	7.92	CL
WS104	2.70	29	15	14	100	14	CL

The results indicate that the underlying CLAY is low plasticity. Plasticity test results are included in *Appendix F*.

Particle Size Distribution

PSD testing was scheduled on 1 sample recovered from site from WS102. The results of this testing is outlined below in *Table 5.3*.

Table 5.3: PSD Test Results

Borehole Number	Depth From (m)	Sieve Percentage (%)		
		Gravel	Sand	Silt/Clay
WS102	2.00	24	42	34

The results of this testing indicate that the ground conditions are variable across the site.

Hand Vane Testing

Two hand vane tests were scheduled recovered from site at BH102 and WS102. The results of this testing is outlined below in *Table 5.4*.

Table 5.4: Hand Vane Test Result

Borehole Number	Depth From (m)	Moisture Content (%)	Average Reading (kPa)	Sample Description
BH102	4.00	15	53	Dark brown slightly sandy slightly gravelly CLAY
WS102	2.00	18	36	Dark brown sandy slightly gravelly CLAY

Stability

Evidence of instability was noted in WS103 following borehole collapse back to 2.50m, this borehole was unable to continue past 3.45m and was terminated. Instability was also noted in WS104 as the borehole collapsed at 2.50m, it was re-drilled with a smaller diameter sampler but collapsed again at 3.00, the borehole was terminated at 3.50m following its collapse back to 2.00m.

Soluble Sulphate and pH

It is envisaged foundations will extend through the Made Ground and into the natural strata and samples taken from the Made Ground and Natural Ground have been submitted for pH and water-soluble sulphate (2:1 soil/water extract) analysis.

The highest water-soluble sulphate concentration and the lowest pH value for the Made Ground is shown in *Table 5.5.*

Table 5.5: Soluble sulphate and pH classification

Soil Type	Lowest pH Values	Highest Soluble Sulphate Concentration (g/l)
Made Ground	7.94	0.05
Natural Ground	7.91	0.05

Therefore, in accordance with Table C2 of BRE: Special Digest 1 2005, sub-surface concrete that is in contact with Made Ground should be Design Sulphate Class **DS-1**, with the ACEC classification of **AC-1s**.

A complete set of geotechnical laboratory certificates are presented in *Appendix F*.

5.1 Foundation Recommendations

General

The proposed development for the site is for apartments with associated communal gardens and associated car parking facilities.

Due to the ground conditions encountered it would be Sutcliffe's recommendation that a piled foundation solution is adopted due to the amount of made ground that has been identified on site. Final pile design will be undertaken by a specialist piling contractor.

Limited groundwater ingress was recorded during site investigation works and subsequent monitoring.

Sub-surface concrete that is only in contact with Made Ground can be Design Sulphate Class DS-1, with an ACEC Classification of AC-1s.

Ground Floor Construction

Based upon the amount of Made Ground noted on site it is not recommended that a ground-bearing slab is utilised on site. Sutcliffe Investigations therefore propose a suspended P.C Unit ground floor be adopted.

Designated Concrete Mixes

The following designated mix in accordance with BRE Special Digest SD1 and BS 8500: Part1: 2015 will be suitable for use on this site.

Table 5.6: Designated Concrete Mixes

Application	DS-1 Conditions (Made Ground and Natural) ACEC Class AC-1s
Unreinforced strip / trench fill footings	GEN1
Reinforced strip / trench fill footing (mesh reinforcement)	RC30
Reinforced strip / trench fill footings (rebar etc)	RC30
Unreinforced concrete floor slabs	GEN2
In situ reinforced concrete floor slabs	RC30

*Note: Although RC 30 is in line with BS8500, Sutcliffe Investigation recommend the use of RC35 for concrete used in structurally sensitive works, to provide greater certainty of compliance with strength verification tests. Tolerable mixes dispatched by a batching plant are +/- 10%, and delays on site can also result in deterioration of the concrete.

5.2 Geotechnical Uncertainty

Based on historic plans and field evidence, there is potential for relic foundations and/or basements to be present on the site.

6 Long Term Human Health Risk Assessment

6.1 Soils – Long Term Human Health

Methodology

Based on the Preliminary Risk Assessment and Ground Model for this site, a Generic Quantitative Risk Assessment for human health has been undertaken in accordance with CLR and SR (SC050021 series) (DEFRA) guidance as well as CL:AIRE guidance on Comparing Soil Contamination Data with a Critical Concentration, May 2008 and comprises the following:

- *Selection of appropriate generic screening values for human health assessment.*
- *Creation of relevant datasets from which to undertake the assessment.*
- *Assessment of contamination distribution and comparison of site data to screening values using relevant statistical tests (in accordance with CIEH guidance).*
- *Assessment of risks to receptors.*
- *Determination of requirements for further investigation or remediation.*

Selection of Soil Screening Values

Soil screening values appropriate for a residential without plant uptake end use scenario were selected.

Creation of Relevant Datasets

As part of the desk study assessment and Preliminary Conceptual Model, made ground was identified as the principal potential source identified for contamination in the risk evaluation *(Section 2.0*). Consequently, the sampling strategy targeted made ground encountered on site.

Assessment

The soil analytical data has been assessed following CL:AIRE/CIEH guidance, CLR11 Model Procedures Section 2.3, and NHBC R&D Publication 66 2008 *"Guidance for the Safe Development of Housing on Land Affected by Contamination".*

The purpose of human health risk assessment for planning is to decide whether the land is suitable for the proposed end use and does not pose a risk to human health. Therefore, the key question to answer is*, "Is there sufficient evidence that the true mean concentration is less than the critical concentration"?*

Statistics are used to assist in answering the key question raised above and to help decide whether to support a particular hypothesis. The null hypothesis is the starting point because it is believed to be true but needs to be proved.

In terms of planning, the hypotheses are as follows:

- *Null Hypothesis (H0) - the true mean is equal to, or greater than the critical concentration.*
- *Alternative Hypothesis (H1) - the true mean is less than the critical concentration.*

The null hypothesis needs to be rejected in order to confirm that the land does not pose a human health risk and is suitable for use under the planning regime.

Identification of Contaminants of Concern – Made Ground

The results of the soil analysis from the investigation are shown in *Appendix G.* These results were then compared against the relevant GACs for 2.5% soil organic matter (SOM). The average percentage SOM was 2.7% for 9 samples.

Elevated levels of contamination were recorded in four of the made ground samples taken from site when assessed against the *2.5%* SOM residential without plant uptake end use values. These are recorded below in *Table 6.1*.

Table 6.1: Statistical Analysis Results for Made Ground Stratum

Contaminant	Guideline Assessment Value	95% ile	Mean Value Test	Max Value Test	No. of Outliers removed to pass
Lead	310 (C4SL)	13942.336	Fails	1 Outlier	N/A – Still fails with outlier removed
C8 to C10 Aliphatic	65 (LQM 2.5%)	117.05605	Inconclusive	1 Outlier	1 (WS103)
C10 to C12 Aliphatic	330 (LQM 2.5%)	500.21733	Inconclusive	1 Outlier	1 (WS103)
C8 to C10 Aromatic	110 (LQM 2.5%)	412.76751	Fails	2 Outliers	1 (WS103)
C10 to C12 Aromatic	590 (LQM 2.5%)	1295.1533	Inconclusive	2 Outliers	1 (WS103)
C12 to C16 Aromatic	2300 (LQM 2.5%)	2751.1392	Inconclusive	3 Outliers	1 (WS103)
C16 to C21 Aromatic	1900 (LQM 2.5%)	2108.4284	Inconclusive	2 Outliers	1 (WS103)
Naphthalene	5.6 (LQM 2.5%)	69.671755	Fails	1 Outlier	1 (WS103)
Benzo(a)anthracene	14 (LQM 2.5%)	12.235204	Passes	2 Outliers	N/A
Benzo(b)fluoranthene	4 (LQM 2.5%)	6.5679918	Inconclusive	2 Outliers	1 (WS103)
Benzo(a)pyrene	3.2 (LQM 2.5%)	10.294342	Fails	2 Outliers	1 (WS103)
Dibenzo(ah)anthracene	0.32 (LQM 2.5%)	0.7887165	Fails	3 Outliers	1 (WS103)

Lead was noted to fail the mean value test with one outlier, when this outlier was removed from the dataset Lead was still noted to fail indicating the presence of site wide Lead contamination.

C8 to C10 Aliphatic was noted to be inconclusive with regards to a pass or fail with 1 outlier, when this outlier was removed from the dataset, C8 to C10

Aliphatic was noted to pass the mean value test indicating a ‘hotspot’ area of C8 to C10 Aliphatic contamination in the area of WS103.

C10 to C12 Aliphatic was noted to be inconclusive with regards to a pass or fail with 1 outlier, when this outlier was removed from the dataset, C10 to C12 Aliphatic was noted to pass the mean value test indicating a ‘hotspot’ area of C10 to C12 Aliphatic contamination in the area of WS103.

C8 to C10 Aromatic was noted to fail the mean value test with 2 outliers, when the first identified outlier was removed from the dataset, C8 to C10 Aromatic was noted to pass the mean value test indicating a ‘hotspot’ area of C8 to C10 Aromatic contamination in the area of WS103. The second outlier was therefore only noted to be a statistical outlier within the dataset.

C10 to C12 Aromatic was noted to be inconclusive with regards to a pass or fail with 2 outliers, when the first identified outlier was removed from the dataset, C10 to C12 Aromatic was noted to pass the mean value test indicating a ‘hotspot’ area of C10 to C12 Aromatic contamination in the area of WS103. The second outlier was therefore only noted to be a statistical outlier within the dataset.

C12 to C16 Aromatic was noted to be inconclusive with regards to a pass or fail with 3 outliers, when the first identified outlier was removed from the dataset, C12 to C16 Aromatic was noted to pass the mean value test indicating a ‘hotspot’ area of C12 to C16 Aromatic contamination in the area of WS103. The other outliers were therefore only noted to be a statistical outlier within the dataset.

C16 to C21 Aromatic was noted to be inconclusive with regards to a pass or fail with 2 outliers, when the first identified outlier was removed from the dataset, C16 to C21 Aromatic was noted to pass the mean value test indicating a ‘hotspot’ area of C16 to C21 Aromatic contamination in the area of WS103. The second outlier was therefore only noted to be a statistical outlier within the dataset.

Naphthalene was noted to fail the mean value test with one outlier, when this outlier was removed from the dataset, Naphthalene was noted to pass the mean value test with no outliers indicating the presence of a ‘hotspot’ area of Naphthalene contamination in the area of WS103.

Despite an elevated level of Benzo(a)anthrancene noted in WS103, Benzo(a)anthrancene was noted to pass the mean value test with 2 outliers. These outliers are therefore statistical outliers within the dataset and Benzo(a)anthrancene does not pose a significant risk of significant harm to future end users of the site.

Benzo(b)fluoranthene was noted to be inconclusive with regards to a pass or fail with 2 outliers, when the first identified outlier was removed from the dataset Benzo(b)fluoranthene was noted to pass the mean value test indicating a

'hotspot' area of Benzo(b)fluoranthene contamination in the area of WS103. The second outlier was therefore only noted to be a statistical outlier within the dataset.

Benzo(a)pyrene was noted to fail the mean value test with 2 outliers, when the first identified outlier was removed from the dataset Benzo(a)pyrene was noted to pass the mean value test indicating a 'hotspot' area of Benzo(a)pyrene contamination in the area of WS103. The second outlier was therefore only noted to be a statistical outlier within the dataset.

Dibenzo(ah)anthracene was noted to fail the mean value test with 3 outliers, when the first identified outlier was removed from the dataset Dibenzo(ah)anthracene was noted to pass the mean value test indicating a 'hotspot' area of Dibenzo(ah)anthracene contamination in the area of WS103. The other outliers are therefore only noted to be a statistical outlier within the dataset.

Soil screening tables are shown in *Appendix G.*

Identification of Contaminants of Concern – Natural Ground

The results of the soil analysis from the investigation are shown in *Appendix G.* These results were then compared against the relevant GACs for 1% soil organic matter (SOM). The average percentage SOM was 0.6% for 2 samples.

No elevated levels of contamination were recorded in the two natural ground samples taken from site when assessed against the *1%* SOM residential without plant uptake end use values.

Asbestos

Asbestos sampling was undertaken on 9 Made Ground samples and 2 Natural Ground samples. No Asbestos was identified in any of the samples.

Discussion

The statistical analysis indicates that the null hypothesis cannot be rejected for all the contaminants must be accepted for Lead, C8 to C10 Aliphatic, C10 to C12 Aliphatic, C8 to C10 Aromatic, C10 to C12 Aromatic, C12 to C16 Aromatic, C16 to C21 Aromatic, Naphthalene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenzo(ah)anthracene. For all other contaminants the alternative hypothesis can be accepted.

Conclusions

Currently the site does pose a risk to human health, and remediation works will be required as part of the development to ensure that the site is suitable for occupation and no longer poses a risk to human health.

Given the extent of the identified contamination a site wide strip will be required to a depth of 600mm, with a capping layer being placed in garden areas to bring site levels back up. In the area of WS103 it is proposed to remove material to a depth of 1.00m due to TPH and PAH contamination noted to a depth of 0.90m. It would also be Sutcliffes recommendation to carry out delineation sampling in this area to ensure the extent of the TPH and PAH contamination has been removed before bringing site levels back up.

It would be anticipated that the remainder of the site that is not formed of gardens/landscaping will be covered by hardstanding, this along with the capping system would provide a break layer to source pathway receptor linkages.

NOTE: Further works are still required, these works include an investigation of the lower tier when accessible and soakaway testing.

7 Controlled Waters Risk Assessment

7.1 Methodology

Based on the Preliminary Risk Assessment and Ground Model for this site, a Level 1 Screening Assessment has been undertaken in general accordance with Environment Agency guidance Environment Agency Remedial Targets Methodology, Hydrogeological Risk Assessment for Land Contamination, 2006.

The methodology comprises:

- Identification of potential contaminant linkages.
- Selection of appropriate generic screening values for controlled waters.
    - *Screening measured concentrations of leachate against the generic screening values available for UK Drinking Water Standards (UK DWS) and Environmental Quality Standards (EQS).*
- Assessment of contaminant distribution and risk to receptors.
    - *Identification of contaminants of concern and relevant contaminant linkages.*
    - *Identification of potential contaminants and contaminant linkages which are no longer of concern.*

Identification of Potential Contaminant Linkages

Contaminant linkages have been identified in *Section 3.0* between the made ground and the underlying aquifer via infiltration and/or migration of dissolved phase contaminants.

Selection of Generic Screening Values

Screening values for Drinking Water Standards (DWS) have been used to assess leachability. DWS are relevant to potable receptors (Secondary A Aquifer).

Environmental Quality Standards (EQS) screening values have been used to assess risks to surface water resources.

Leachate Screening – UK DWS & EQS

Metals and Speciated PAHs were assessed, exceedances of relevant EQS and UK DWS screening criteria were encountered, details of which are identified in *Table 7.1 and 7.2.* It should be noted that several determinants have limits of detection greater than their respective screening values these include Cadmium, speciated Chromium, Mercury, Phenols, Sulphide,

Benzo(ghi)perylene and Indeno(123cd)pyrene, due to the level of uncertainty associated with such results, these exceedances are not considered significant and are excluded from the table below.

Table 7.1: Leachate Exceedances Summary - EQS

Determinant	EQS Screening Value (µg/l)	Range of concentrations (µg/l)	Location and depth of outliers, if present
Copper	1	<1 – 5	WS104 at 0.20 – 0.60m - 2 HD101 at 0.20 – 0.60m - 5 HD105 at 0.30 – 0.60m - 5
Lead	14	4 – 26	WS104 at 0.20 – 0.60m - 26 HD101 at 0.20 – 0.60m - 21 HD105 at 0.30 – 0.60m - 20
Zinc	10.9	2 – 22	WS104 at 0.20 – 0.60m - 22 HD101 at 0.20 – 0.60m - 13 HD105 at 0.30 – 0.60m - 14

Table 7.2: Leachate Exceedances Summary – UK DWS

Determinant	EQS Screening Value (µg/l)	Range of concentrations (µg/l)	Location and depth of outliers, if present
Lead	10	4 – 26	WS104 at 0.20 – 0.60m - 26 HD101 at 0.20 – 0.60m - 21 HD105 at 0.30 – 0.60m - 20

Leachate screening tables are presented in *Appendix G.* Analytical certificates are presented in *Appendix D.*

Contaminant Distributions and Risk to Receptors

Several determinants exceeded the DWS and EQS screening values. However, the risk to controlled waters (groundwater & surface waters) is diminished as a result of the following:

- There are no surface water features within 250m of the site, therefore the slightly elevated EQS values pose no risk.

- The site is underlain by a layer of Glaciofluvial Sheet Deposits which is classified as Unproductive Strata that will act as an aquiclude impeding the flow of water to the underlying Secondary A Aquifer.

Conclusion

Exceedances of DWS and EQS screening criteria are not considered significant given the likely depth to groundwater, effects of natural attenuation, lack of nearby groundwater abstractions and the absence of any surface water courses that could be in continuity with ground water beneath the site.

8 Ground Gas Risk Assessment

8.1 CIRIA C665 Assessment

Gas monitoring wells were installed in 4No exploratory hole locations (BH102, WS101, WS102 and WS104) as part of the 2018 ground investigation completed by Sutcliffe's.

A full copy of all gas monitoring readings and water levels to date can be found in *Appendix E.*

8.2 Methodology

A ground gas risk assessment has been undertaken in general accordance with the British Standard BS8485:2015, "*Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings".*

The guidance is written specifically for use by designers of gas protection measures relating to the development of a site. Reference has also been made to the CIRIA document C665:2007: "*Assessing Risks Posed by Hazardous Ground Gases to Buildings"* and to the Health and Safety Executive document EH40/2005 "Workplace Exposure Limits".

Our assessment comprises the following:

- *Review of results.*
- *Calculation of Gas Screening Values for methane (CH_4) and carbon dioxide (CO_2).*
- *Assessment of risks from ground gas.*
- *Development options.*

8.3 Review of Field Data

To date three (3) rounds of gas monitoring have been undertaken. Gas monitoring was undertaken using a fully calibrated GA2000 gas monitor which measured concentrations of oxygen, carbon dioxide and methane as well as gas flow emission rates.

The findings are summarised below, and the results are presented in full in *Appendix E*. Calibration certificates are also presented in *Appendix E.*

Table 8.1: Summarised Ground Gas Monitoring Data

Maximum gas readings encountered during monitoring						
Location	*MAX CH_4 %*	*MAX CO_2 %*	*MIN O_2 %*	*MAX ppm*	*Atmospheric Pressure mb*	*MAX Flow Rate l/hr*
1st October 2018						
BH102	0.1	4.2	14.8	-	1014	0.0
WS101	0.1	2.5	18.5	-	1014	0.0
WS102	0.1	1.1	19.8	-	1014	0.0
WS104	0.1	7.2	10.5	-	1014	-0.3
16th October 2018						
BH102	0.1	3.9	14.6	-	1000	0.0
WS101	0.1	2.2	18.5	-	1000	0.0
WS102	0.1	1.2	19.0	-	1000	-0.3
WS104	0.1	5.5	14.3	-	1000	-0.1
30th October 2018						
BH102	0.1	3.6	14.7	-	985	0.0
WS101	0.1	3.8	17.4	-	985	0.0
WS102	0.0	1.2	20.1	-	985	0.0
WS104	0.1	6.1	13.6	-	985	0.0
-						
BH102	-	-	-	-	-	-
WS101	-	-	-	-	-	-
WS102	-	-	-	-	-	-
WS104	-	-	-	-	-	-
-						
BH102	-	-	-	-	-	-
WS101	-	-	-	-	-	-
WS102	-	-	-	-	-	-
WS104	-	-	-	-	-	-
-						
BH102	-	-	-	-	-	-
WS101	-	-	-	-	-	-
WS102	-	-	-	-	-	-
WS104	-	-	-	-	-	-

8.4 Calculation of Gas Screening Values

Methane (CH4)

Although ground gas monitoring is ongoing, slightly positive concentrations of methane (maximum concentration 0.1%) were recorded during monitoring visits

to date along with and a worst-case flow rate of -0.3l/hr. The GSV will be calculated as:

Limiting volume flow rate of gas = gas concentration x measured borehole flow rate

= 0.001 x 0.3 (gas concentration in table is %)

= 0.0003

The GSV classifies the site as Green for Methane.

Carbon Dioxide (CO_2)

Although monitoring is ongoing, Carbon dioxide (maximum concentration 7.2%) was recorded during monitoring visits to date, along with a worst-case flow rate of -0.3l/hr. The GSV will be calculated as:

Limiting volume flow rate of gas = gas concentration x measured borehole flow rate

= 0.072 x 0.3 (gas concentration in table is %)

= 0.0216

The GSV classifies the site as Green for Carbon Dioxide. However, as the 5% threshold value has been exceeded, this classification will need to be increased to Amber 1. An Amber 1 classification requires gas protection measures.

8.5 Radon

The site is in a higher probability radon area (10 to 30% of homes are estimated to be at or above the Action Level) therefore full radon protective measures are necessary in the construction of new dwellings or extensions.

8.6 Discussion

Ground gas monitoring is currently ongoing however based on reading to date and in accordance with CIRIA C665 the ground gas monitoring results indicate that the site has a Gas Screening Value (GSV) of 0.0003l/hr for methane and 0.0216l/hr for carbon dioxide.

This results in the site being classified as Green.

However, CIRIA C665 states in Table 8.7 (NHBC) that for a typical Carbon Dioxide maximum concentration above 5% that an **Amber 1** classification be considered. As there have been a number of readings above 5% CO_2 during the monitoring period it is Sutcliffe's recommendation that the site is classified as Amber 1 under the NHBC Traffic light system.

This classifies the site as having low to intermediate gas regime identified, which requires low level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be as prescribed in BRE Report 414 (Johnson, 2001). Ventilation of the sub floor void should facilitate a minimum of one complete volume change per 24 hours

NOTE: Gas protection measure will also need to protect against Radon.

8.7 Groundwater Protection Measures

There is no evidence at this stage of significant perched water either in the made ground or in the natural stratum encountered on site that would suggest special groundwater protection measures to the building foundations are required.

9 Land Contamination Risks and Remediation Requirements

9.1 Revised Conceptual Model

Based on the findings of the human health, the preliminary conceptual model has been revised and finalised as shown in *Figure 4*. The drawing shows all contaminant linkages from the preliminary conceptual model, identifying those which remain relevant.

9.2 Discounted Contaminant Linkages

Controlled Waters – Groundwater & Surface Waters

Groundwater Resources

The UK DWS Leachate screening identified slightly elevated concentrations of Lead that could pose a risk to the Secondary A aquifer. However, due to the likely depth of groundwater and the effects of natural attenuation, the risk is unlikely to be significant.

Surface Water Resources

The EQS Leachate screening identified concentrations of Cadmium, Copper, Lead and Zinc that could pose a risk to the local surface water features. However, as there are no surface water features within 250m south of the site, the risk is unlikely to be significant.

9.3 Remaining Potential Contaminant Linkages

Long Term Human Health

Elevated levels of Lead indicate the presence of site wide contamination that will require remediation to be safe for Human Health. Elevated levels of C8 to C10 Aliphatic, C10 to C12 Aliphatic, C8 to C10 Aromatic, C10 to C12 Aromatic, C12 to C16 Aromatic, C16 to C21 Aromatic, Naphthalene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenzo(ah)anthracene have also indicated hotspot areas of contamination.

Given the extent of the identified contamination a site wide strip will be required to a depth of 600mm, with a capping layer being placed in garden areas to bring site levels back up. In the area of WS103 it is proposed to remove material to a depth of 1.00m due to TPH and PAH contamination noted to a depth of 0.90m. It would also be Sutcliffes recommendation to carry out delineation sampling in this area to ensure the extent of the TPH and PAH contamination has been removed before bringing site levels back up.

Construction workers may be exposed via dermal contact, ingestion and inhalation of soil / dust during the construction period. Adjacent site users may also be exposed to contaminated soils via inhalation of dust generated during the construction phase.

Ground Gas

Although ground gas monitoring is ongoing, based on the results of the gas monitoring to date and due to elevated CO_2 readings, an Amber 1 classification is recommended for the site, as such as gas membrane will be required as part of the ground floor design in all the new developments on site.

Table 9.1: Summary of Remaining Contaminant Linkages

1. Hazard Identification		2. Hazard Assessment				3. Risk Estimation		4. Risk Evaluation	5. Managing the Risk
Contaminant Source		Pathway		Receptor		Consequence of risk being realised	Probability of risk being realised	Classification	Action required
Table 3.1:Sources		Table 3.2: Receptors		Table 3.3: Pathways					
S1	Made Ground (on site)	P1	Direct contact	R1	Future site users,	Medium	Likely	Moderate	As site wide contamination has been identified a 600mm site strip is required across the site, with a capping layer placed in all proposed garden/landscaped areas. This, combined with the associated hardstanding will break the source pathway receptor linkages. Additionally, delineation and a deeper site strip to 1.00m is required in the area of WS103 due to the presence of TPHs and PAHs Although ground gas monitoring is ongoing, based on the gas monitoring data collated to date the site would be classified as Amber 1 and will require a gas membrane to be installed as part of the ground floor design. NOTE: Full Radon protection measures are also required.
		P2	Ingestion	R2	Construction workers	Medium	Likely	Moderate	
		P3	Inhalation of dust / vapours	R4	Adjacent site users	Medium	Unlikely	Low	
		P1	Direct contact	R5	Infrastructure / Buried Services	Mild	Unlikely	Very Low	
		P5	Vertical and lateral migration of ground gas	R1	Future site users,	Severe	Low	Moderate	
				R2	Construction Workers	Severe	Low	Moderate	
				R4	Adjacent	Severe	Unlikely	Moderate / Low	
				R5	Infrastructure / Buried Services	Severe	Unlikely	Moderate / Low	

9.4 Additional Works Required to Assess Outstanding Contaminant Linkages

Based on the proposed development plan, the risk to future site users, with respect to areas of new communal gardens included within the planning boundary, a remediation strategy will be required and will include delineation and validation of imported material and site derived material scheduled for reuse would need to be designed to assess the risks to future site users.

On completion of the scheduled demolition works of the existing buildings, further investigation will be required in the area of the building to determine that the underlying material does not cause a human health risk and to determine the spread of any demolition waste and the potential risk it poses.

9.5 Remediation Requirements

Human Health – Soils

Elevated levels of Lead indicate the presence of site wide contamination that will require remediation to be safe for Human Health. Elevated levels of C8 to C10 Aliphatic, C10 to C12 Aliphatic, C8 to C10 Aromatic, C10 to C12 Aromatic, C12 to C16 Aromatic, C16 to C21 Aromatic, Naphthalene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenzo(ah)anthracene have also indicated hotspot areas of contamination.

Given the extent of the identified contamination a site wide strip will be required to a depth of 600mm, with a capping layer being placed in garden areas to bring site levels back up. In the area of WS103 it is proposed to remove material to a depth of 1.00m due to TPH and PAH contamination noted to a depth of 0.90m. It would also be Sutcliffes recommendation to carry out delineation sampling in this area to ensure the extent of the TPH and PAH contamination has been removed before bringing site levels back up.

Human Health – Ground Gas

Although ground gas monitoring is still ongoing, ground gas readings to date have indicated elevated levels of Carbon Dioxide. As values of Carbon Dioxide recorded are above the 5% threshold value the site will currently be classified as Amber 1 under the NHBC Traffic light system as outline in CIRIA C665. As such gas protection measures will be required as part of the development of the site.

NOTE: Full Radon Protection Measures are also required in the construction of new dwellings and extensions.

10 Recommendations

10.1 Further works

The following actions are recommended:

- Design a Phase III Remediation & Validation Proposal for submission to planning department.
- Design SMMP – management of material on and off site.
- Investigation of the lower tier when accessible.
- Delineation in the area of WS103 due to TPH and PAHs.
- Post demolition sampling.
- Carry out Soakaway Testing.
- Good hygiene practices should be employed during construction work, in addition, the findings of this investigation should be included within the contractors H&S file and an assessment of risks associated with short term human health completed. No consumption of food or smoking should occur without prior hand washing. If dust is encountered, dust masks should be worn and dust suppression employed.

References

BRE Special Digest (1991) 'Sulphate and acidic resistance of concrete in the ground' **363**

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Environment Agency (2000) 'Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies For Land Contamination. Research and Development. Technical Report. P5-066/TR', Bristol.

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Appendix A – General Notes

Generic Notes – Sutcliffe Investigations

Environmental Setting

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority, the Local Authority etc is presented in the Correspondence Appendix of the Geoenvironmental Report.

Geology, Mining & Quarrying

In order to establish the geological setting of a site, Sutcliffe Investigations refer to BGS maps for the area and the relevant geological memoir.

A coal mining report is obtained from the Coal Authority. Further information is sourced from the Local Authority and by reference to current and historical OS plans.

Landfills

Sutcliffe Investigations obtain data from the Landmark Information Group, the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site. Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite) and can move through fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, Sutcliffe Investigations refer to BRE Report BR211, 1999: *"Radon: guidance on protective measures for new dwellings".*

BR211 provides a preliminary indication of the measures required for a particular site, but it is also often necessary to request a Stage 2 Protective Measures Site Report from the BGS.

The level of protection needed is site-specific and is determined by reference to the radon potential map for the area followed by a geological assessment of the site. This information is contained in the Annexes of BR211.

Annex A – derived from statistical analysis of radon measurements in existing houses carried out by the NRPB and grouped on 5km grid.

Annex B – based on an assessment of the same radon measurements grouped by geological units. The maps show the 5km grid squares underlain completely or in part, by geological units which potentially exceed the action levels for radon protective measures. The grid squares are coded according to highest potential within the square. In many cases the actual geological radon potential varies considerably within a grid square.

Sutcliffe Investigations adopt the following procedure when assessing risk associated with radon.

Firstly, Annex A maps are reviewed to see whether the site requires full, basic or no measures. If the site is in a dark brown square, full radon protection measures are required. If the site is in a light brown square, reference should be made to Annex B.

Secondly, Annex B maps are reviewed to see whether a further geological assessment is required which may result in upgrading the result from Annex A. If a site lies within a shaded square, it may require radon protection and Sutcliffe Investigations request a Stage 2 Protective Measures Site Report from the BGS.

If the site is in a square that is not coloured or shaded in either set of maps then no radon protection is needed and therefore a BGS Report is not normally necessary.

The BGS geological assessment involves checking whether the site is on or close to a geological unit that has statistically been found to have elevated radon potential. The geological assessment is based on either 1:50,000 or the 1:250,000 scale data. The search area specified as part of the request is increased by 50m in areas where 1:50,000 data is available and by 500m in areas with 1:250,000 scale data to allow for potential inaccuracies in the position of boundaries. The BGS report indicates the highest level of protection required within the search area and its buffer zone.

When requesting a BGS report, Sutcliffe Projects select the search radius carefully, since too large a search radius may result in the inclusion of areas underlain by geological units of a higher radon potential, thereby giving rise to recommending too high a level of protection.

The report also includes (where available), a list of the geological units included in the assessment. Sutcliffe Investigations check that these actually underlie the site, rather than the buffer zone only.

On the basis of radon measurements in dwellings and on their geological interpretation, the BGS report stipulates the level of protective measures required for the proposed development site, and this could be:

1. no measures
2. basic measures or
3. full measures

Details of these measures are provided in the Hazardous Gas section of this Geoenvironmental Report.

Hydrogeology

Sutcliffe Investigations obtain information from the Environment Agency (EA) and the Landmark Information Group with respect to:

- groundwater quality
- recorded pollution incidents
- licensed groundwater abstractions

Reference is also made to the EA document “Policy and Practice for the Protection of Groundwater” (1998) and the relevant Groundwater Vulnerability Map.

Bedrock and any overlying granular Drift deposits are classified by the EA.

Major aquifers: “*Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public water supply and other purposes*”.

Minor aquifers: “*Fractured or potentially fractured rocks which do not have a high primary permeability, or other formations or variable permeability. Although these acquifers will seldom produce large quantities of water for abstractions, they are important both for local supplies and in supplying base flow to rivers*”.

Non-aquifers: “*Formations which are generally regarded as containing insignificant quantities of groundwater. However groundwater flow through such rocks, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants. Some non-acquifers can yield water in sufficient quantities for domestic use*”.

Groundwater vulnerability is determined by 4 variables:

1. The presence and nature of overlying soil (the weathered zone affected by living organisms; soil in the UK can extend up to 2m in depth). Physical properties of the soil affect the downward passage of water and its ability to attenuate pollutants. The EA make reference to a three-fold classification of soil types:-

   - Soils of **low** leaching potential are defined as "*soils in which the pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants*".

   - Soils of **intermediate** leaching potential are defined as "*soils which have a moderate ability to attenuate diffuse source pollutants or in which it is possible that some non-absorbed diffuse source pollutants and liquid discharges could penetrate the soil layer*".

   - Soils of high leaching potential are defined as "*soils with little ability to attenuate diffuse source pollutants and in which non-absorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater*".

   In urban areas and restored mineral workings the soil information is based on fewer observations than elsewhere. A worst-case vulnerability (H) is therefore assumed for these areas and for current mineral workings by the EA. All are given a designation of **HU** unless proved otherwise.

2. The presence and nature of Drift, which often overlies bedrock. Where Drift is of substantial thickness and low permeability, it can provide an effective barrier to surface pollutant migration. Permeability Drift is classified as a Minor Aquifer except where it is in probable hydraulic continuity with a Major Aquifer, where it is regarded as part of the Major Aquifer unless proven otherwise by site investigation.

3. The nature of the geological strata (bedrock). Rocks that contain groundwater in exploitable quantities are called aquifers.

4. The depth of the unsaturated zone; i.e. that part of the aquifer which lies above the water table.

The EA have also designated Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone may vary from tens to several thousand hectares.

Hydrology

Sutcliffes obtain information from the Environment Agency and the Landmark Information Group with respect to:

- Surface water quality
- Recorded pollution incidents
- Licensed abstractions (groundwater & surface waters)
- Licensed discharge consents
- Site susceptibility to flooding

The EA have set **water quality** targets for all rivers. These targets are known as River Quality Objectives (RQOs). The water quality scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are six GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to **flooding** is assessed by reference to a Flood Map on the Environment Agency's website. These maps provides show natural floodplains – areas potentially at risk of flooding it a river rises above its banks or high tides and stormy seas cause flooding in coastal areas.

There are different kinds of area shown on the Flood Map:

1. Dark blue areas could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 200) or greater chance of happening each year.

2. Light blue areas show the additional extend of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance or occurring each year.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements.

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year (or 1 in 200 year as appropriate) areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist consultant who can advise on appropriate mitigating measures; i.e. raising slab levels, provision of storage etc.

COMAH & Explosive Sites

Sutcliffe Investigations obtain information from the Landmark Information Group with respect to COMAH or explosive sites within 1km of the proposed development site. Sutcliffe Investigations' report refers to any that are present and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise its emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say and they are likely to place more weight on advice from the HSE).

Preliminary Conceptual Ground Model

The site's environmental setting (and proposed end use) is used by Sutcliffe Investigations to assess the significance of any contamination encountered during the subsequent ground investigation.

Generic Notes – Sutcliffes Geoenvironmental Investigations

2. Ground Investigation Fieldwork

General

Sutcliffe Ground Investigations are undertaken in accordance with current UK guidance including:

- BS5930:1999 "*Code of practice for site investigation*"
- BS10175:2001 "Code of practice for the identification of potentially contaminated sites"
- Contaminated Land Reports 1 to 6, most notably CLR Report No. 4 "*Sampling strategies for contaminated land*"
- "*Guidance on the protection soil sampling strategies for land contamination*" – EA R&D Technical report P5-066/TR (2001)
- AGS: 1996 "*Guide to the selection of Geotechnical Soil Laboratory Testing*"

Exploratory hole logs are represented in Appendices to this Geoenvironmental Report. These logs include details of the:

- Investigation technique adopted
- Samples taken
- Descriptions of the solid strata and any groundwater encountered
- Results of any insitu testing
- Any gas/groundwater monitoring well installed

Exploratory Hole Locations

Exploratory hole locations are selected by Sutcliffe Investigations, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation Techniques

Ground conditions can be investigated by a number of techniques; the procedures used are in general accordance with BS5930: 1999 and BS1377: 1990. Techniques most commonly used by Sutcliffe Investigations include:

- Machine excavated trial pits, usually equipped with a backactor and a 0.6m wide bucket
- Cable percussive (Shell & Auger) boreholes, typically using 150mm diameter tools and casing
- Window or windowless sampling boreholes. Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material).
- Rotary percussive open-hole probeholes are typically drilled using a tricone rock roller bit with air as the flushing medium. Probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse.

Where installed, gas/groundwater monitoring wells typically comprise a lower slotted section, surrounded by a filter pack of 10mm non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter steel borehole helmet set in concrete.

Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

Insitu Testing

Where relative densities of granular materials given on the trial pit and window sample logs are based on visual inspection only, they do not relate to any specific bearing capacities. However, wherever possible, Sutcliffe Investigations employ a mackintosh probe to assess relative density. Mackintosh probe results can be related to approximate allowable bearing capacities.

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPTs are carried out boreholes, in accordance with BS 1377 1990, Part 9 Section 3.3. Where full penetration (600mm) is not possible, N values are calculated by linear extrapolation and are shown on the logs as N* = x.

The strength of cohesive deposits is determined using a hand shear vane.

Shear strength test results reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Representative soil/fill samples are taken at regular intervals from the exploratory holes to assist in description of the ground and to allow selected laboratory testing to be performed. The type of sample taken is dependent on the nature of the stratum and the purpose of the analysis.

Where the soils encountered contain a significant proportion of coarse grained material, truly representative samples are not typically obtained – only the finer fraction is placed in sample containers. However, a visual estimate of the amount of coarse material is made on site.

NB: Coarse constituents not sampled are defined as: coarse gravel, cobble and boulder (i.e. any ‘particles’ with an average diameter greater than 20mm).

Occasionally, unrepresentative ‘spot’ samples are also taken from some exploratory locations for contaminant analysis, typically where unusual, localised pockets of materials are encountered.

Samples of soil for chemical testing are placed into 1 litre plastic tubs prior to delivery to the selected laboratory. Samples of water are taken in one litre brown glass bottles and stored in cool boxes, at a temperature of approximately 4°C, until delivery to the selected laboratory. Soil/fill samples for organic analysis are also stored in cool boxes.

Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during this investigation.

Long term monitoring of standpipes of piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

Description of Strata

The soils encountered during an Sutcliffes ground investigation are described (logged) in general accordance with BS 5930. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section within the main body of text.

The materials encountered in the trial pits are logged, samples taken and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

Key to Exploratory Hole Logs

Keys to logs are presented in the Appendix(ces) containing the logs. These are two keys – Symbols and Legends and Terms and Definitions.

Health and Safety

All work was carried out in accordance with the procedures detailed in the DGEL Health and Safety Manuel and SUKD health and Safety Procedures.

Generic Notes – Sutcliffes Geoenvironmental Investigations

3. Geotechnical Laboratory Tests

General

Soil Samples are delivered to the laboratory for testing along with a schedule of testing drawn up by Sutcliffe Investigations. All tests are carried out in accordance with BS 1377:1990.

The test results are presented as received in an Appendix to this Geoenvironmental Report.

The following laboratory testing are routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading
- Compaction tests
- Particle density

Attenberg Limits & Moisture Content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each "type" of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. Sutcliffe Investigations typically only consider a soil to be shrinkable if the proportion finer than 63µm is > 35%.

PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003) which advocates the use of modified Plasticity Index (I'p) defined as:

I'p = Ip * (% < 425µm/100)

ie if PI is 30%, but the soil contains 80% < 425µm, then I'p = 30 * 80/100 = 24%

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425µm sieve is routinely reported by testing labs.

Sutcliffe Investigations apply engineering judgement where PI results are spread over a range of classifications. Consideration is given to:

- The average values for each particular soil type (ie differentiate between residual soil and alluvium)
- The number of results in each class and
- The actual values

Unless the judgement strongly indicates otherwise, Sutcliffe Investigations typically adopt a conservative approach and recommend assumption of the higher classification.

Soluble Sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

Sutcliffe Investigations refer to BRE Special Digest 1 (SD1) “Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment” (2001). SD 1 provides definitions of:

- The nature of the site (Greenfield, brownfield or pyretic)
- The groundwater regime (static, mobile or highly mobile)
- The Design Sulphate Class (DC Class) and
- The Aggressive Chemical Environment for Concrete (ACEC Class)

Sutcliffe reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of “representative” sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Generic Notes – Sutcliffe Investigations Geoenvironmental Investigations

4. Contamination Laboratory Analysis & Interpretation (including WAC)

General

An assessment of potential contaminants associated with the former usages of the site is undertaken with reference to CLR 8 "*Potential contaminants for the assessment of land*" and the relevant DETR Industry Profile(s).

Common Inorganic Contaminants

These include:

- Metals, most notably cadmium, copper, chromium, mercury, lead, nickel and zinc
- Semi-metals, most notably arsenic, selenium and (water soluble) boron
- Non-metals, most notably sulphur
- Inorganic anions, most notably cyanides (free & complex), sulphates, sulphides and nitrates

With respect to the terminology used by most analytical laboratories:

Total cyanide = Free cyanide + Complex cyanide

Total cyanide (CN) is determined by acid extraction; whereas free cyanide is the water soluble fraction.

Complex cyanide is "bound" in compounds and is hard to breakdown. Laboratory determination of complex CN involves subjecting the sample to uv digestion for determination of both free and total CN.

Thiocyanate (SCN) is a different species combined with sulphur.

Elemental sulphur (S) and free sulphur are the same. Total sulphur is all forms, including that present in sulphates (SO_4) sulphates etc.

There are 2 forms of chromium (Cr), chromium VI and chromium III. Chromium VI is the more toxic of these. In soils, total chromium is determined by a strong aqua regia acid digestion. Chromium VI is an empirical method based on a water extract test.

Common Organic Contaminants

Petroleum hydrocarbons are a mixture of hydrocarbons produced from the distillation of crude oil. They include aliphatics (alkanes, alkenes and cycloalkanes), aromatics (single or multi benzene ringed compounds) and hydrocarbon-like compounds containing minor amounts of oxygen, sulphur or nitrogen.

Petroleum hydrocarbons can be grouped based on the carbon number range:-

GRO – Gasoline Range Organics (typically C_6 to C_{10}). Also referred to as PRO – Petroleum Range Organics
DRO – Diesel Range Organics (typically C_{10} to C_{28})
LRO – Lubricating Oil Range Organics (typically C_{28} to C_{40})
MRO – Mineral Oil Range Organics (typically C_{18} to C_{44})

However, it should be borne in mind that the terms "GRO" and "DRO" analysis are purely descriptive terms, the exact definition of which varies.

Total Petroleum Hydrocarbons (TPH) is also a poorly defined term; some testing laboratories regard TPH as hydrocarbons ranging from C_5 – C_{40}, whereas other define TPH as C_{10} – C_{30}.

The composition of a TPH plume migrating through the ground can vary significantly; this is primarily dictated by the nature of the source (eg petrol, diesel, engine oil etc). Furthermore, different hydrocarbons are affected differently by weathering processes and this can result in further variation in the chemical composition of the TPH.

Gasoline contains light aliphatic hydrocarbons rapidly (especially within the C4 to C5 range) that will evaporate. The aromatic hydrocarbons in gasoline are primarily benzene, toluene, ethylbenzene and xylenes, referred to as BTEX. Small amounts of polyaromatic hydrocarbons (PAHs) such as benzo(a)pyrene may also be present.

Diesel and light fuel oils have higher molecular weights than gasoline. Consequently, they are less volatile and less water soluble. About 25 to 35% is composed of aromatic hydrocarbons. BTEX concentrations are generally low.

Heavy Fuel Oils are typically dark in colour and considerably more viscous than water. They contain 15 to 40% aromatic hydrocarbons. Polar NSO compounds are also present.

Lubricating Oils are relatively viscous and insoluble in groundwater. They may contain 10 to 30% aromatics, including the heavier PAHs. NSO compounds are also common.

Polycyclic Aromatic Hydrocarbons (PAHs) have more than two fused benzene rings as a structural characteristic. PAH compounds are present in both petrol and diesel, although insignificantly lower concentrations than in coal tars. Certain PAH compounds are carcinogenic (Benzo(a)pyrene) and/or mobile in the environment (naphthalene).

Polychlorinated Biphenyls (PCBs)

Volatile Organic Compounds (VOCs) The volatile organic compound (VOC) headspace concentration of all soil samples was made with a photoionization detector (PID) fitted with a 10.2 eV lamp. This gives a semi-quantitative VOC concentration record as parts per million (ppm) (Vol/Vol). Prior to the VOC headspace reading, the background levels of VOCs were recorded. The PID was recalibrated with standard isobutylene in zero air after every 10 headspace readings.

Semi-Volatile Organic Compounds (sVOCs)

Phenols

Solvents, pesticides, herbicides

Dioxins & furans

Methods of Analysis (Organic Compounds)

Toluene Extractable Matter (TEM) results provide a screening test for organic contamination. The sample is air dried a 30°C and ground prior to addition of the solvent (toluene). The solvent extraction is aggressive and most organic compounds (fuels, oils, tars, humic material, animal fats and vegetable oil) are dissolved, as are some other inorganic contaminants such as sulphur. However, the volatiles (lighter fuel fraction etc) are lost during evaporation of the solvent.

Total Petroleum Hydrocarbon (TPH) by IR (also known as mineral oil by some testing laboratories) is undertaken on “as received” samples. Tetrachloroethylene is the solvent, and fluoroscil is used to removed humic material, animal fats and vegetable oil. Consequently this analysis detects a wide range of “mineral” organics from volatiles (BTEX and gasoline) through diesel and oils to tars (including the very heavy, stable tars such as asphalt and bitumen).

TPH by GC-FID is more refined analytical technique which only detects hydrocarbons (aliphatic and aromatic) in the range C_{10} to C_{40} (volatiles, heavy tars, humic material and sulphur are not detected). The laboratory can provide a breakdown of the TPH results into diesel range organics (**DRO**) and heavier lubricating oil range organics (**LRO**).

GRO (PRO) by GC-FID analysis detects the more volatile C_6 – C_9 hydrocarbons (aliphatic and aromatic) including those organic compounds present in petrol.

Speciated VOC (by GC-MS) analysis quantifies the concentrations of 30 USA-EPA priority compounds. These include chlorinated alkanes and alkenes (in the molecular weight range chloroethane to tetrachloroethane); trimethlybenzenes; and the 4 BTEX compounds (benzene, ethyl-benzene, toluene & xylene).

Speciated sVOC by (GC-MS) analysis quantifies the concentration of a variety of organic compounds, including the 16 USA-EPA priority PAHs, phenols, 7 USA EPA priority PCB congeners, herbicides & pesticides.

Note: PAHs are hydrocarbons and consequently (where present) will be picked up when scheduling TPH by GC-FID. Napthalene (the lightest PAH) is also one of the 58 US EPA VOCs.

Speciated TPH by GC-FID provides a "banded "TPH", initially split into aromatic and aliphatic fractions and then further divided into fraction specific carbon bandings based upon behavioural characteristics.

Note: Risk assessment models require physiochemical properties (solubilities, toxicitities etc) of compounds in order to model their behaviour in the environment. These physiochermical properties cannot be derived from a single "TPH", "GRO" or "DRO" value. However, the carbon banded fractions can be used in risk assessment models.

If the relative proportion of each carbon banding within the "TPH" impact at a site is known, the risks posed by each individual fraction can be assessed and a simple back calculation applied to calculate an overall "TPH" screening value based upon the percentage weight fraction of each banding present in the "TPH". Specialised analytical techniques and data interpretation skills are required to identify each carbon banding.

Current Guidance

The UK approach to the consideration of contaminated land is based upon the principles of risk assessment. This in turn is founded upon the use of so called source⇒ pathway⇒ target principles in order to establish the presence or potential presence of a pollutant linkage.

Sutcliffe Investigations adopt a tiered approach to risk assessment, consistent with UK guidance and best practice. The initial step of such a risk assessment (or Tier 1) is the comparison of site data with appropriate guidance levels, intervention levels or remedial targets.

In March 2002 DEFRA and the Environment Agency published a series of technical research papers (R & D Publications CLR 7, 8, 9 and 10) introducing the UK approach to the assessment of risk to **human health** from land contamination. This methodology and approach represents current scientific knowledge and thinking. The overall methodology also included the Contaminated Land Exposure Model (CLEA) and some Soil Guidance Values (SGV's).

At the time of writing this report, these guidelines only address seven contaminants and the development of both the CLEA model and additional SGV's in ongoing. Where published, SGV's have been utilised as intervention values for the purpose of an initial Tier 1 assessment.

Where SGV's were not published at the time of writing this report, appropriate Tier 1 human health related assessment have been based upon information that was best available at the time of the study.

With respect to the assessment of potential **phytotoxic effects** of contaminants, Sutcliffe Investigations refer to "The Soil Code" (Maff, 1998) for copper and zinc. The CLEA SGV is adopted for nickel.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Sulphate and Acid Resistance of Concrete in the Ground', 2001.

With respect to the interpretation of the calorific values, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that:

"In general ……. it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn".

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate concentrations with the appropriate water quality standard. Depending upon the specific characteristics and environmental setting of the site the appropriate standard is likely to be one of the following:

- Water Supply (Water Quality) Regulations 1989
- Environmental Quality Standards (for Freshwater)
- The Surface Waters (Abstraction for Drinking Water) Regulations

The tier 1 risk assessment of **landfill gas** is undertaken through reference to the following documents:

- Approved Document C, Building Regulations 1991
- CIRIA Report 149, “Protecting Development from Methane”, 1995

Should any Tier 1 criteria be exceeded, then three potential courses of action are available. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or landfill gas).

- Undertake further statistical following the approach set out in Appendix A of CLR 7 in order to determine whether contaminant concentrations of inorganic contaminants within soil/fill actually present a risk (only applicable to assessing the risk to human health).
- Based on a qualitative risk assessment, advocate an appropriate level of remediation to “break” the pollutant linkage – for example the removal of the contaminated materials or the provision of a clean cover.
- Carry out a more detailed quantitative risk assessment in order to determine whether contamination risks actually exist.

However, the issue of **averaging area** requires further consideration. CLR 7 is ambiguous and could be interpreted as advocating the concept of a single garden as an appropriate averaging area.

This concept has massive implications with respect to ground investigation design and cost. To comply, investigations for residential development on brownfield sites would need to recover and analyse about 6 samples from each garden; this implies exploratory locations on a very tight grid, perhaps 5m to 10m spacings, with a huge increase in the number of samples analysed (cf test schedules currently issued by most practitioners).

In any case, Sutcliffe Investigations consider the concept of a single garden as an averaging area to be inappropriate. Statistical analysis of sample results by fill type, and/or by former use in a given sub-area of the site (i.e. with reference to the Conceptual Site Model), is considered a more appropriate methodology.

Analysis by soil/fill type is appropriate for essentially immobile contaminants associated with a particular fill type, for example arsenic in colliery spoil, metals in ash & clinker, sulphate in plaster-rich demolition rubble etc.

Analysis by former use is appropriate where more mobile contaminants have entered the ground, for example diesel associated with leakage from a former fuel tank, downward migration of leachable metals through granular materials, various soluble contaminants present in a wastewater leaking into the ground via a fractured sewer etc. In these circumstances, it may be appropriate to undertake statistical analysis of sample results from a variety of different soil/fill types. However, consideration would have to be given to factors such as porosity which might influence impregnation of a mobile contaminant into the soil mass; ie contamination would be normally be more pervasive and significant in granular soils than cohesive soils.

There is a suggestion in para 4.7 of CLR 7 that the approach outlined above was intended and the Environment Agency have confirmed that an averaging area can be larger than a single garden, if:

- Contaminant concentrations are within the same statistical population as determined using the maximum value test. The sample data being representative of the averaging area and the mean concentration of the averaging area.
- “Hot spots” are treated as separate zones or averaging areas (as defined by the maximum value test).
- The sampling strategy takes into account uncertainty (spatial heterogeneity) in contaminant concentration

Waste Classification & WAC

In the context of waste soils generated by remediation and/or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated ‘natural soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds).
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds).

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

From 16th July 2005, landfill operators will require Waste Acceptance Citeria (WAC) laboratory data, if soil is classified as **hazardous** and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Sutcliffe Investigations typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated for example where redevelopment proposals include basement construction etc.

If off-site disposal of soils classified as hazardous waste were undertaken during redevelopment, then WAC analysis should be scheduled at an early stage in the remediation programme.

However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous. These contaminants can often be dealt with by alternative technologies (eg by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (eg WAC) is required.

Generic Notes – Sutcliffe Investigations

5. Hazardous Gas

General

Hazardous gas is considered to be any mixture of potentially explosive, toxic or asphyxiating gases, most notably methane, carbon dioxide and oxygen (deficiency).

In addition, radon, a naturally occurring radioactive gas is also considered. Further information about radon is included in Notes 1 – Environmental Setting.

Assessment of potential risks associated with hazardous gas are based on a review of data obtained from the Landmark information Group, the Environment Agency and the Local Authority and the British Geological Survey.

Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Where landfilling has occurred within 250m of the site boundary, the Local Planning Authority may request a landfill gas investigation in accordance with the Town and Country Planning General Development Order, 1988.

Sources

Potential sources of hazardous gas are:

- Landfill sites
- Made ground, especially where significant depths are present
- Shallow mineworks associated with coal extraction
- Geological strata, including peat, organic silts, coal-bearing strata and limestone (reaction with acidic waters), granite (radon)
- Groundwater can sometimes act as a “carrier” for hazardous gas
- Leakages from pipelines or storage tanks
- Sewers, septic tanks and cess pits

Generation

Wherever biodegradable material is deposited, landfill gas (principally a mixture of methane and carbon dioxide) is likely to be generated by microbial activity. Carbon dioxide is an asphyxiant and toxic; methane is flammable and a mixture containing between 5% and 15% methane by volume in air is explosive. Landfill gas in the ground is unlikely in itself to pose a significant risk, though it may damage vegetation. However, infiltration of landfill gas into confined spaces (e.g. cellars, services, etc) may give rise to considerable risk.

There is no typical figure for the length of time that landfill gas will be evolved, but at many sites significant gas generation continues for at least 15 years after the last deposit of waste.

Migration

Gas migration from a landfill site may occur in several ways. It may migrate through adjacent strata; the distance of migration being dependent on the pressure gradients, volume of gas and permeability of the strata. Where there are faults, cavities and fissures within the strata, gas may move considerable distances. Other migration pathways for gas include man-made features such as mine shafts, roadways and underground services.

Gas migration is influenced by a number of climatic factors, such as atmospheric pressure variations, water table level variations and the influence of a covering of snow or ice over the surface of the site and surrounding area.

Current Guidance

Guidance on landfill gas monitoring control at landfill sites is given two technical memoranda, Waste Management Paper Nos. 26 and 27 published by the Department of the Environment.

Waste Management Paper 27, 1991 recommends that no dwellings should be constructed within 50m of any landfill that has the capacity to produce large volumes of landfill gas. No garden should extend to within 10m of the landfilled waste. However, development closer to landfill has been permitted where a comprehensive gas risk assessment has been completed (typically based on a minimum of 6 to 12 month monitoring programme) and appropriate gas exclusion measures designed.

The current advice with regard to monitoring for landfill gas is that if the trigger value of 1% volume (20% LEL) for methane and 1.5% volume for carbon dioxide is exceeded then remedial/control measures will be required.

It should be noted that the guideline limit for carbon dioxide of 1.5% volume recommended in Waste Management paper No. 27 is the short term (10 minute) occupational exposure limit for carbon dioxide quoted by the Health and Safety Executive in their publication EH40. The long term (8 hour) occupational exposure limit for carbon dioxide is 0.5% volume.

Approved Document C to the Department of the Environment's Building Regulations 1992 requires what where there may be gaseous contamination of the ground but the level of methane is unlikely to exceed 1% by volume, the ground floor of any house or similar small building shall be constructed of suspended concrete and ventilated as described in BRE Digest Report "Construction of New Buildings on Gas Contaminated Land". The document also requires specific design measures to be taken if a level of 5% volume carbon dioxide exists or is exceeded within the ground.

Although the above guidance is still relevant it has been more recently updated within the following documents published by the Construction Industry Research and Information Association (CIRIA).

CIRIA Report 149 'Protecting Development from Methane' (1995)
CIRIA Report 150 'Methane Investigation Strategies' (1995)
CIRIA Report 151 'Interpreting Measurement of Gas in the Ground' (1995)
CIRIA Report 152 'Risk Assessment for Methane and other gases from the ground' (1995)

The above documents are intended to provide advice on how to investigate and deal with the gas contaminated ground with respect to development.

CIRIA Report 149 characterised sites based on the recorded methane/carbon dioxide concentration and emission rates recorded during a suitable gas investigation. Characteristic situation 1 is deemed to be the lowest risk scenario with the risk rating increasing up to 6. The characteristic situations are classified as follows:

Gassing regime in ground			
Methane (% by volume in air)	Carbon dioxide (% by volume in air)	Emission rate [1] (m/s)	Characteristic situation [2]
< 0.1	< 1.5	not detected	1
> 0.1 – 1	> 1.5 – 5	not detected	2
> 1 - 5	< 5	not detected	3
> 5 – 20	< 20	< 0.01	4
> 20	> 20	> 0.01 – 0.05	5
> 20	> 20	> 0.05	6

Notes:
1. Emission rate values measures as equivalent total gas flow velocity from a 50mm diameter borehole: for methods of measurement see Crowhurst and Manchester (1992).
2. Highest measures parameter used as determining factor.

CIRIA Report 151 (1995) identified that there is currently inadequate guidance on trigger concentrations for ground gases. The current emphasis on using gas concentrations for trigger values particularly in Waste Management Paper 27 and the Building Regulations, should be revised to consider gas pressures, borehole flow rates and estimated surface emission rates.

It was concluded that the most important aspect of relating the gas regime below or adjacent to a site, to the risk it poses to any development, is the surface emission rate i.e. how quickly the gas is coming out of the ground. The lower the surface emission rate the lower the risk. This is considered further in the DETR Partners in Technology Report 'Passive venting of soil gases beaneath buildings' (September 1997).

CIRIA Report 149 (1995), reference Table 28, reviewed over 100 case studies of development affeceted by gas to establish current UK practices for gas control. The report classified the gassing regimes fround within 6 Characteristic Situations. The highest measures parameter, either methane or carbon dioxide concentration and/or emission rate were used to define the Characteristic Situation for each case history site. The report then related the typical range of mitigation measures that has been adopted at each study site to the characteristic gas situation.

To achieve a more consistent design of protection measures Table 28 of CIRIA 149 was rewritten (Wilson and Card, 1999) in terms of borehole gas volume flow rate and gas concentrations, as reproduced in the table below. This was done to reflect the importance of recognising the gas surface emission rate.

Characteristic situations based on Gas Flux

Characteristic Situation	Limiting CH_4 Concentration (% v/v)	Limiting CO_2 Concentrations (% v/v)	Limiting Borehole Flow Velocity (m/s)	Limiting Borehole Gas Volume Flow (litre/hour)	
				CH_4	CO_2
1	< 0.1	< 0.1	< 0.005	< 0.035	< 0.035
2	< 1.0	< 1.5	< 0.005	< 0.35	< 0.5
3	< 5.0	< 5.0	< 0.005	< 1.75	< 1.75
4	< 20	< 20	< 0.01	< 14	< 14
5	> 20	> 20	< 0.05	< 70	< 70
6	> 20	> 20	< 0.05	> 70	> 70

Gas Monitoring Procedure

Sutcliffe Investigations adopt a standard gas monitoring procedure, in accordance with CIRIA guidance. This procedure involves the measurement, in the following order of:

- Atmospheric temperature, pressure and ambient oxygen concentration on site immediately prior to and on completion of monitoring.
- Gas emission rate.
- Methane, oxygen and carbon dioxide concentrations using and infra-red gas analyser.
- Standing water level using a dipmeter.

In addition, ground conditions at each sampling location are recorded together with prevailing weather conditions and any other observations such as any vandalism.

Where samples of gas are required for laboratory analysis, Gresham Tubes are used. Gas concentrations in the well are typically recorded immediately before and after retrieval of a sample.

Appendix B – Ciria Guidance Document C552 2001

RISK ASSESSMENT FOR THE WATER ENVIRONMENT

The risk assessment has been developed to provide a greater level of standardisation. It includes relevant elements from TAG (Transport Analysis Guidance) Table 1 relating to the features described as river, floodplain, groundwater and stillwaters, including their attributes/services and selected/modified indicators of quality and possible measures. Two additional columns have been added for 'grading' and 'importance level'. These columns expand on the limited number of examples provided in TAG Table 2. Table 1 has been developed with reference to TAG, Highways Agency's 'New Approach to Appraisal' (NATA), the Water Framework Directive and other sources as referenced in the table.

Table 1 here relies on easily available data to avoid unnecessary data collection. Should inadequate data be available a 'worst case' should be assumed. The table is designed to act as a guide to determining importance and to raise the level of compatibility in predicting the significance of impacts on the water environment.

Once Table 1 has been used to determine the importance of the environmental attributes that may be affected by a particular development project, Tables 3 and 4 of TAG Unit 3.3.11 can be used to estimate the significance of potential impacts. These tables are reproduced here as Tables 2 and 3 respectively. Table 2 provides a methodology for determining impact magnitude. Table 3 is a matrix that allows the significance of the impact to be calculated based on the impact magnitude and the importance of the attribute. The significance of impacts can range from 'insignificant' to 'very significant'.

Table 1: Water features, their attributes, indicators of quality, grading and importance (adapted from Table 1 of TAG unit 3.3.11)

Feature	Attribute / Service	Indicator of Quality	Measure	Grading	Importance Level
River	Water Supply	Chemical water quality	Environment Agency's Chemical General Quality Assessment (GQA)	A B C-D E-F	Very High High Medium Low
		Industrial / agricultural abstractions	Location and volume of abstraction	All abstractions within 2km downstream: >1000m3/day 500-1000m3/day 50-499m3/day <50m3/day	 Very High High Medium Low
		Drinking water supply	Classification defined within The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996. No 3001[2]	Classification: DW1 or DW2 within critical travel time for pollution downstream DW3 within critical time downstream Not designated	 Very High High Medium - Low
	Biodiversity[3]	Biological Water Quality	Environment Agency's Biological GQA[1]	A B C-D E-F	Very High High Medium Low
		Fisheries Quality	Fisheries status as defined within the Freshwater Fish Directive 78/659/EEC	Designated salmonid fishery Designated cyprinid fishery Undesignated fishery Not a fishery	Very High High Medium Low

Feature	Attribute / Service	Indicator of Quality	Measure	Grading	Importance Level
River	Transport and dilution of waste product	Surface Water / effluent discharges	Type of discharges with reference to the EC Dangerous Substances Directive (76/464/EEC and Daughter Directives)	All discharges within 2km up or downstream: List I List II Other discharge / no discharge	Very High - High Medium Medium - Low
	Recreation	Riverside access	Presence / absence of route and importance	National trail / cycleway Regional trail Definitive footpath / bridleway No route	Very High High Medium Low
		Presence of clubs/ recreation use	Presence / absence	Club recreation use present No club / recreation use	Very High - High - Medium Low
	Conveyance of flow and material	Presence of water courses	Size of watercourses[5]	Main River > 10m wide Main River < 10m wide Ordinary watercourse >5m wide Other	Very High High Medium Low
Floodplain	Flood defence	Importance in relation to flood defence	Status of flood plain area	Designated washland Active floodplain Existing defended area Does not flood	Very High High Medium Low
			Return period	> (ie more frequent then) 1 in 25 years < 1 in 25 years <1 in 100 years (urban) <1 in 50 years <1 in 200 years	Very High High Medium Medium Low
Groundwater	Water supply	Industrial / agricultural abstractions	Location and volume of abstraction	All abstraction points within zone of influence of development: >1000m3/day >500-1000m3/day 50-499m3/day <50m3/day	Very High High Medium Low
		Drinking water supply	Presence of potable public supply or private water supply within zone of influence of development	Public supply Private water supply >10m3/day or serves >50 people[6] Other private water supply No supply	Very High High Medium Low
		Groundwater vulnerability	Source protection status	Within zone 1,2 or 3 of a source protection zone Not within a source protection zone	Very High High Medium Low
			Classification of aquifer vulnerability	Major aquifer with H soils or I soils or U soils. Minor aquifer with H soils or U soils Major aquifer with L soils. Minor aquifer with L soils or non aquifer	Very High High Medium Low
	Conveyance of flood flows	Acceptance potential of flood flows	Soil type / groundwater table levels[8]	Gravels with low water table (>1m below infiltration point) Sands with low water table All soil types with high water table Clay	Very High High Medium Low
Stillwaters (lakes and ponds)	Biodiversity[3]	Biological water quality	Classification system to be developed under the Water Framework Directive for ecological status / potential		
		Fisheries quality	Fisheries status as defined within the Freshwater Fish Directive 78/659/EEC	Designated salmonid fishery Designated cyprinid fishery Undesignated fishery Not a fishery	Very High-high High - medium Medium - low Low
	Water supply	Use for abstraction	Presence / absence	Abstraction No abstraction	Very High - High – Medium[9] Low
	Recreation	Presence of clubs / recreation use	Presence / absence	Club recreation use present No club / recreation use	Very High - High - Medium[4] Low

Notes to Table 1

1 If the river is unclassified and hence has no GQA grade, the quality can be measured or assumptions can be made based on the grade of the nearest classified stretch.

2 An importance level of high or very high must also be awarded if the water feature provides more than 10m3/day of drinking water, or serves more than 50 people, which is the definition used in the Water Framework Directive to define drinking water protected areas.

3 Conservation value is not included, as this should be included within an ecology/nature conservation assessment.

4 This required judgement on a case by case basis because the importance of use by people is being assessed, and they are sensitive to being categorised as unimportant. Careful assessment is thus required, using as much data as possible eg on the facilities, their scale and frequency of use, membership levels and economic value.

5 An importance level of 'Medium' or greater must also be awarded if a river has a catchment greater than 10km2, as this means that it will be classified as a water body under the Water Framework Directive. Other measures are available for describing the ability of watercourses to convey flow and material (such as the carrying capacity of the channel for flood flows) and could if necessary be substituted.

6 Based on criteria given within the Water Frame Work Directive for features to be designated as drinking water protected areas.

7 Adapted from NRA Policy and Practice for the Protection of Groundwater, Groundwater Vulnerability Sheets, NRA 1994. Because soil information in urban areas is less reliable and based on fewer observations than in rural areas, the worst case is assumed and such land is classified as being high of leaching potential. H = high, I = Intermediate, L = Low and U = Unclassified leaching potential.

8 This uses a coarse basis of permeability together with the ability of the existing ground conditions to accept additional flows. For example, gravels in a river floodplain are unlikely to have a high acceptance potential because of raised water table due to river flows. Sands above a relatively dry substrata would have a high potential, however caution is required in areas such as chalk with highly fluctuating groundwater levels.

9 Depends on use of water, volume abstracted etc. An importance level of 'High' or 'Very high' mus be awarded if the water feature provides more than 10m3/day of drinking water, or serves more than 50 people, which is the definition used in the Water Framework Directive to define drinking water protected areas.

Table 2: Criteria for determining impact magnitude (reproduced from Table 3 of TAG unit 3.3.11)

Magnitude	Criteria	Example
Major	Results in loss of attribute	• Loss of EC designated Salmonid fishery • Compromise employment source • Pollution of potable source of abstraction • Change in GQA grade of river reach • Loss of flood storage / increased flood risk
Moderate	Results in impact on integrity of attribute or loss of art of attribute	• Loss in productivity of a fishery • Contribution of a significant proportion of the effluent in the receiving river, but insufficient to change its GQA grade • Reduction in the economic value of the feature
Minor	Results in minor impact on attribute	• Measurable change in attribute, but of limited size and/or proportion
Negligible	Results in an impact on attribute but of insufficient magnitude to affect the use / integrity	• Discharges to watercourse but no significant loss in quality, fishery productivity or biodiversity • No significant impact on the economic value of the feature • No increase in flood risk

Table 3: Significance Criteria of Potential Impacts
(Reproduced from Table 4 of TAG unit 3.3.11)

Magnitude of Potential impact	Importance of Attribute			
	Very High	**High**	**Medium**	**Low**
Major	Very Significant	Very Significant	Significant	Low Significant
Moderate	Very Significant	Significant	Low Significant	Insignificant
Minor	Significant	Low Significant	Insignificant	Insignificant
Negligible	Low Significant	Insignificant	Insignificant	Insignificant

Table 4: Proposed impact assessment summary table

Feature	Attribute / Service	Importance Level	Magnitude of Impact	Significance of Impact
River	Water Supply	Very High	Minor	Significant

References

1 The Highways Agency et al, Design Manual for Roads and Bridges, Vol 11. Environmental Assessment, 1993.
2 DETR ‘Guidance on the New Approach to Appraisal, 1998.
3 Department for Transport, Transport Analysis Guidance (TAG) 2003

RISK ASSESSMENT METHODOLOGY

GENERAL

The purpose of this appendix is to describe in detail the concepts underlying the risk based approach to assessing potentially contaminated land, introduce the roles of key legislation and describe the qualitative methodology adopted for evaluating and characterising risk.

Current best practice in the UK promotes a risk-based approach to dealing with both soil and groundwater contamination. The principal aim of the approach is to ensure protection of human health and the environment in a thorough, transparent and cost-effective manner.

Fundamental to the risk-based approach is the concept that for 'Contaminated Land' to be designated, as a consequence of historic activities, a pathway for contamination must be shown to exist between a source of contamination and a receptor. The combined presence of a source, pathway and a receptor is described as a 'pollutant linkage'.

The concepts associated with a contaminant source, pathway and receptor are defined in DETR Circular 02/2000 'Contaminated Land Environmental Protection Act 1990: Part II A'. A ***source*** of contamination may be considered as a 'substance, which is in, on or under land that has the potential to cause harm or to cause pollution of controlled waters'. A ***receptor*** can be considered as either 'a living organism, a group of living organisms, an ecological system or a piece of property which is being, or could be harmed, by a contaminant or controlled waters which are being, or could be, polluted by a contaminant'. A ***pathway*** may be considered as one or more routes by, or through, which a receptor is being, or could be, exposed to or affected, by a contaminant. Typical pathways may include migration in groundwater, surface water run-off or infiltration, inhalation, dermal contact and ingestion.

The risks posed by an identified pollutant linkage can often be mitigated by removing the source of contamination, treating the source of contamination, blocking the relevant pathway(s) or by protecting the receptor.

PRINCIPLES OF RISK EVALUATION

The risk evaluation methodology presented below is qualitative in nature, and is therefore a subjective method. It is based upon guidance presented in CIRIA publication referenced C552, 'Contaminated land risk assessment - A guide to good practice', 2001 and involves the classification of the following.

The magnitude of the potential **consequence** (severity) of risks occurring (Table 1).

The magnitude of the **probability** (likelihood) of the risk occurring (Table 2).

These are then considered in conjunction to give a risk matrix (Table 3)

Table 1 - Classification of consequence

Classification	Definition	Examples
Severe	Short-term (acute) risk to human health likely to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIA. Short-term risk of pollution (note: Water Resources Act contains no scope for considering significance of pollution) of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem, or organism forming part of such ecosystem (note the definitions of ecological systems within the Draft Circular on Contaminated Land, DETR, 2000).	High concentrations of cyanide on the surface of an informal recreation area. Major spillage of contaminants from site into controlled water. Explosion, causing building collapse (can also equate to a short-term human health risk if buildings are occupied).
Medium	Chronic damage to Human Health ("significant harm" as defined in DETR, 2000). Pollution of sensitive water resources (note: Water Resources Act contains no scope for considering significance of pollution). A significant change in a particular ecosystem, or organism forming part of such ecosystem. (Note: the definitions of ecological systems within Draft Circular on Contaminated Land, DETR, 2000).	Concentrations of a contaminant from site exceed the generic or site-specific assessment criteria. Leaching of contaminants from a site to a major or minor aquifer. Death of a species within a designated nature reserve.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ("significant harm" as defined in the *Draft Circular on Contaminated Land*, DETR, 2000). Damage to sensitive buildings/structures/ services or the environment.	Pollution of non-classified groundwater. Damage to building rendering it unsafe to occupy (e.g. foundation damage resulting in instability).
Minor	Harm although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.	The presence of contaminants at such concentrations that protective equipment is required during site works. The loss of plants in a landscaping scheme. Discolouration of concrete.

Table 2 - Classification of probability

Classification	Definition
High likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low Likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term.

Table 3 - Comparison of consequence against probability

		Consequence			
		Severe	*Medium*	*Mild*	*Minor*
Probability	High Likelihood	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
	Likely	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate/Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate/Low Risk	Low Risk	Very Low Risk	Very Low Risk

Table 4 - Description of the classified risks and likely action required

Very High Risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term.
Moderate Risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low Risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.

Table 5 - Response action likely to be required in relation to estimated risk

KEY

- Mitigation and remedial measures required
- Mitigation and remedial measures likely
- Remedial measures unlikely
- Remedial measures not required

Appendix C – Window Sample / Borehole / Hand Dug Pit Logs

Sutcliffe Investigations

Site	Borehole Number
Former Bryn Awel Hotel, Mold	BH101

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion			Anwyl Construction	29982LG
	Location	**Dates** 10/09/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						0.10 (0.15) 0.25	MADE GROUND (macadam)		
0.20-0.60	ES1						MADE GROUND (graded granular limestone hardcore sub base)		
							MADE GROUND (loose dark brown slightly ashy fine to coarse grained SAND with fine to medium brick fragments)		
1.20-1.65	SPT N=8			1,2/1,2,3,2		(2.55)			
2.00-2.45	SPT N=10			1,2/2,3,2,3					
						2.80	Stiff to very stiff brown very sandy gravelly CLAY. Sand is fine Gravel is fine to medium subangular to rounded and of mixed lithology		
3.00-3.45	SPT N=12			4,4/3,3,3,3					
4.00-4.45	SPT N=14			2,3/3,3,4,4					
5.00-5.45	SPT N=11			3,3/3,2,3,3		(4.20)			
6.00-6.45	SPT N=12			3,3/2,3,3,4					
						7.00 (0.50) 7.50	Medium dense dark brown fine to coarse grained SAND and fine to coarse subrounded to rounded GRAVEL		
7.50-7.95	SPT N=10			3,2/2,2,3,3			Complete at 7.95m		

Remarks
Unable to continue beyond 7.95m - unable to collect material in sampler
Borehole dry

Scale (approx)	Logged By
1:50	AT

Figure No. 29982LG.BH101

Sutcliffe Investigations

Site	Borehole Number
Former Bryn Awel Hotel, Mold	**BH102**

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion			Anwyl Construction	29982LG
	Location	**Dates** 13/09/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						0.10 (0.20)	MADE GROUND (macadam)			
0.20-0.60	ES1					0.30 0.40	MADE GROUND (graded granular limestone hardcore sub base)			
							MADE GROUND (grey fine to coarse grained SAND with graded granular limestone hardcore)			
1.20-1.65	SPT N=19			2,4/3,4,7,5		(2.30)	MADE GROUND (grey clayey fine to coarse grained SAND with graded granular limestone hardcore)			
2.00-2.45	SPT N=7			2,3/2,1,2,2						
						2.70	Grey brown clayey gravelly fine to coarse grained SAND. Gravel is fine to coarse subangular and of limestone			
3.00-3.45	SPT N=13			2,2/2,3,4,4		(1.10)				
						3.80	Grey brown slightly silty sandy gravelly CLAY. Sand is fine Gravel is fine to medium subangular to rounded and of mixed lithology			
4.00-4.45	U1			63 blows		(0.70)				
						4.50	Brown very sandy gravelly CLAY. Sand is fine Gravel is fine to medium subangular to rounded and of mixed lithology			
						(0.60)				
5.00-5.29	SPT 50/135			19,6/22,28		5.10	Brown fine to coarse grained SAND and fine to coarse subrounded to rounded GRAVEL			
6.00-6.44	SPT 50/285			9,7/9,14,20,7		(2.40)				
7.00-7.45	SPT N=21			6,6/6,5,5,5						
						7.50	Complete at 7.50m			

Remarks
Unable to continue beyond 7.95m - unable to collect material in sampler
Borehole dry
Water added from 7.00m to 7.50m.

Scale (approx)	Logged By
1:50	AT

Figure No. 29982LG.BH102

Sutcliffe Investigations

Site	Trial Pit Number
Former Bryn Awel Hotel, Mold	HD101

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Hand Excavated Trial Pit			Anwyl Construction	29982LG
	Location	**Dates** 01/10/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	Grass over dark brown clayey fine to medium grained SAND with root material (TOPSOIL)		
0.20-0.60	ES1				(0.50) 0.70	MADE GROUND (dark grey and brown gravelly fine to medium grained SAND. Gravel is fine to coarse subangular to angular and of limestone)		
					(0.40) 1.10	Brown very clayey slightly gravelly fine to medium grained SAND. Gravel is fine to coarse subrounded to rounded and of mixed lithology		
						Complete at 1.10m		

Plan

Remarks

Trial pit dry
Unable to progress beyond 1.10m - auger encountered resistance due to due to ground conditions

Scale (approx)	Logged By	Figure No.
1:25	AT	29982LG.HD101

Sutcliffe Investigations

Site	Trial Pit Number
Former Bryn Awel Hotel, Mold	HD102

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Trial Pit			Anwyl Construction	29982LG
	Location	**Dates** 01/10/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.30) 0.30	Grass over dark brown clayey fine to medium grained SAND with root material (TOPSOIL)		
					(0.40) 0.70	MADE GROUND (dark grey and brown gravelly fine to medium grained SAND. Gravel is fine to coarse subangular to angular and of limestone)		
						Complete at 0.70m		

Plan

Remarks

Unable to progress beyond 0.70m - due to ground conditions

Scale (approx)	Logged By	Figure No.
1:25	AT	29982LG.HD102

Sutcliffe Investigations

Site	Trial Pit Number
Former Bryn Awel Hotel, Mold	HD103

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Trial Pit			Anwyl Construction	29982LG
	Location	**Dates** 01/10/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	Grass over dark brown clayey fine to medium grained SAND with root material (TOPSOIL)		
					(0.30) 0.50	MADE GROUND (dark grey and brown gravelly fine to medium grained SAND. Gravel is fine to coarse subangular to angular and of limestone)		
					(0.50) 1.00	Brown clayey gravelly fine to medium grained SAND. Gravel is fine to medium subrounded to rounded and of mixed lithology		
					(0.40) 1.40	Light brown clayey gravelly fine to medium grained SAND. Gravel is fine to medium subrounded to rounded and of mixed lithology ..becoming very clayey with depth		
						Complete at 1.40m		

Plan

Remarks

Trial pit dry
Unable to progress beyond 1.40m - auger encountered resistance due to ground conditions

Scale (approx)	Logged By	Figure No.
1:25	AT	29982LG.HD103

Sutcliffe Investigations

Site	Trial Pit Number
Former Bryn Awel Hotel, Mold	HD104

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Trial Pit			Anwyl Construction	29982LG
	Location	**Dates** 01/10/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.30) 0.30	Grass over dark brown clayey fine to medium grained SAND with root material (TOPSOIL)		
					(0.30) 0.60	MADE GROUND (dark grey and brown gravelly fine to medium grained SAND. Gravel is fine to coarse subangular to angular and of limestone)		
					(0.70) 1.30	Brown slightly clayey slightly gravelly fine to medium grained SAND. Gravel is fine to coarse subrounded to rounded and of mixed lithology		
						Complete at 1.30m		

Plan

Remarks

Trial pit dry
Unable to progress beyond 1.30m - auger encountered resistance due to due to ground conditions

Scale (approx)	Logged By	Figure No.
1:25	AT	29982LG.HD104

Sutcliffe Investigations

Site	Trial Pit Number
Former Bryn Awel Hotel, Mold	HD105

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Trial Pit			Anwyl Construction	29982LG
	Location	**Dates** 01/10/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.30) 0.30	Grass over dark brown clayey fine to medium grained SAND with root material (TOPSOIL)		
0.20-0.60	ES1				(0.40) 0.70	MADE GROUND (dark brown ashy slightly clayey fine to medium grained SAND with fine to coarse brick and motar fragments and whole brick)		
					(0.20) 0.90	Light brown sandy CLAY. Sand is fine to medium		
					(0.50) 1.40	Brown very clayey gravelly fine to medium grained SAND with very sandy clay bands. Gravel is fine to medium subrounded to rounded and of mixed lithology		
						Complete at 1.40m		

Plan

Remarks

Trial pit dry
Unable to progress beyond 1.40m - auger encountered resistance due to due to ground conditions

Scale (approx)	Logged By	Figure No.
1:25	AT	29982LG.HD105

Sutcliffe Investigations

Site	Trial Pit Number
Former Bryn Awel Hotel, Mold	HD106

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Trial Pit			Anwyl Construction	29982LG
	Location	**Dates** 01/10/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	Grass over dark brown clayey fine to medium grained SAND with root material (TOPSOIL)		
0.20-0.60	ES1				(0.40) 0.60	MADE GROUND (Brown clayey fine to medium grained SAND)		
					(0.60) 1.20	MADE GROUND (dark brown ashy slightly clayey fine to medium grained SAND with fine to coarse brick and motar fragments and whole brick)		
						Complete at 1.20m		

Plan

Remarks

Trial pit dry
Unable to progress beyond 1.20m - auger encountered resistance due to due to ground conditions

Scale (approx)	Logged By	Figure No.
1:25	AT	29982LG.HD106

Sutcliffe Investigations

Site	Number
Former Bryn Awel Hotel, Mold	WS101

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Windowless Sampler			Anwyl Construction	29982LG
	Location	**Dates** 12/09/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					0.10	MADE GROUND (macadam)			
0.30-0.60	ES1				(0.90)	MADE GROUND (graded granular limestone hardcore sub base)			
					1.00				
1.20-1.65	SPT N=5		1,1/2,1,1,1		(0.40)	MADE GROUND (loose light brown fine to coarse grained SAND and fine to medium subrounded to rounded GRAVEL)			
					1.40 (0.15) 1.55				
					(0.35)	MADE GROUND (loose dark brown fine to coarse grained SAND with occasional fine brick fragments)			
					1.90				
2.00-2.45	SPT N=7		1,0/1,2,2,2		(0.45)	MADE GROUND (loose brown sandy CLAY with fine to medium brick and motar fragments. Sand is fine)			
					2.35	Loose brown slightly clayey gravelly fine to medium grained SAND. Gravel is fine to medium subangular and of mixed lithology			
3.00-3.45	SPT N=17		2,3/3,5,5,4			Medium dense light brown gravelly fine to medium grained SAND with clay pocket. Gravel is fine to medium subangular and of mixed lithology			
					(3.10)				
4.00-4.45	SPT N=17		2,3/4,4,5,4						
5.00-5.45	SPT N=12		3,3/3,3,3,3						
					5.45	Complete at 5.45m			

Remarks
Borehole dry

Scale (approx)	Logged By
1:50	AT

Figure No. 29982LG.WS101

Sutcliffe Investigations

Site	Number
Former Bryn Awel Hotel, Mold	WS102

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Windowless Sampler			Anwyl Construction	29982LG
	Location	**Dates** 12/09/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					0.10	MADE GROUND (macadam)			
0.20-0.60	ES1				(0.60)	MADE GROUND (black ashy fine to coarse grained SAND with graded granular limestone subase and fine to medium brick fragments)			
					0.70 (0.30) 1.00	Grey and light grey clayey fine to coarse grained SAND			
1.20-1.65	SPT N=6		1,2/2,1,1,2		(1.00)	Firm light brown slightly silty slightly sandy gravelly CLAY with some fine to medium sand pockets. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology			
2.00-2.45	SPT N=14		2,3/3,4,3,4 Water strike(1) at 2.10m, no rise after 20 mins.		2.00	Stiff to very stiff grey brown slightly silty slightly sandy gravelly CLAY with some fine to medium sand pockets. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology		▼1	
3.00-3.45	SPT N=19		4,3/4,3,6,6		(3.45)				
4.00-4.45	SPT N=24		4,4/5,5,6,8						
5.00-5.45	SPT N=27		5,8/8,5,6,8		5.45	Complete at 5.45m			

Remarks

Scale (approx)	Logged By
1:50	AT

Figure No. 29982LG.WS102

Sutcliffe Investigations

Site	Number
Former Bryn Awel Hotel, Mold	WS103

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Windowless Sampler			Anwyl Construction	29982LG
	Location	**Dates** 12/09/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.10	MADE GROUND (macadam)		
					(0.20) 0.30	MADE GROUND (graded granular limestone hardcore sub base)		
					(0.60)	MADE GROUND (yellow brown and orange brown very clayey slightly gravelly fine to medium grained SAND. Gravel is fine to medium subrounded to subangular and of mixed lithology)		
0.70-0.90	ES1				0.90	Loose brown slightly silty clayey fine to medium grained SAND Strong diesel odour from 0.70m to 3.00m		▼1
1.20-1.65	SPT N=7		1,1/2,2,2,1 Water strike(1) at 1.40m, no rise after 20 mins.					
2.00-2.45	SPT N=5		1,2/1,2,1,1		(2.55)			
2.70-2.90	ES2							
3.00-3.45	SPT N=6		1,2/1,1,2,2		3.45	Terminated at 3.45m		

Remarks
Borehole collapsed back to 2.50m - unable to continue beyond 3.45m
Borehole initially damp during drilling operations - water encountered at 1.40m after operations ceased

Scale (approx)	Logged By
1:50	AT

Figure No. 29982LG.WS103

Sutcliffe Investigations

Site	Number
Former Bryn Awel Hotel, Mold	WS104

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Windowless Sampler			Anwyl Construction	29982LG
	Location	**Dates** 12/09/2018	**Engineer** AT	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					0.05				
					(0.15)	MADE GROUND (macadam)			
					0.20				
0.20-0.60	ES1					MADE GROUND (graded granular limestone hardcore sub base)			
					(0.90)	MADE GROUND (red brown fine to coarse grained SAND and fine to medium subangular GRAVEL)			
					1.10				
1.20-1.65	SPT N=12		2,3/3,4,2,3			Medium dense yellow brown fine to medium grained SAND			
					(0.50)				
					1.60				
						Medium dense grey silty fine to medium grained SAND			
					(0.60)			▼1	
2.00-3.00	ES2		Water strike(1) at 2.00m, no rise after 20 mins.		2.20				
2.00-2.45	SPT N=10		1,1/0,4,3,3			Medium dense orange brown silty fine to medium grained SAND Hydrocarbon odur from 1.90m to 3.00m			
					(0.50)				
					2.70				
2.70-2.90	D1					Firm brown slightly silty slightly sandy CLAY. Sand is fine			
3.00-3.45	SPT N=9		1,2/2,3,2,2		(0.75)				
					3.45				
						Terminated at 3.45m			

Remarks
Minimal recovery from 2.00m to 3.00m
Hole collapsed at 2.50m - redrilled with smaller diameter sampler
Hole collapsed again at 3.00m - borehole terminated at 3.50m - collapased back to 2.00m

Scale (approx)	Logged By
1:50	AT

Figure No. 29982LG.WS104

Appendix D – Analytical Certificates

envirolab
Units 7 & 8 Sandpits Business Park
Mottram Road, Hyde, Cheshire, SK14 3AR

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 18/07435
Issue Number: 1 **Date:** 26 September, 2018

Client: Sutcliffe
18-20 Harrington Street
Liverpool
L2 9QA

Project Manager: Alex Tosh; Kelly Davies, Adrian Lewis; David Bowen
Project Name: Bryn Awel, Mold
Project Ref: 29982LG
Order No: 7297
Date Samples Received: 14/09/18
Date Instructions Received: 17/09/18
Date Analysis Completed: 26/09/18

Prepared by:

Melanie Marshall
Laboratory Coordinator

Approved by:

Richard Wong
Client Manager

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

UKAS TESTING 1247

Envirolab Job Number: 18/07435

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/07435/1	18/07435/2	18/07435/3	18/07435/4	18/07435/5	18/07435/6	18/07435/7	18/07435/8	Units	Method ref
Client Sample No	1	1	1	1	1	2	1	2		
Client Sample ID	BH101	BH102	WS101	WS102	WS103	WS103	WS104	WS104		
Depth to Top	0.20	0.30	0.30	0.20	0.70	2.70	0.20	2.00		
Depth To Bottom	0.60	0.60	0.60	0.60	0.90	2.90	0.60	3.00		
Date Sampled	10-Sep-18	13-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18		
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES		
Sample Matrix Code	6A	4A	4A	4AB	1A	4	4A	5A		
% Moisture at <40C$_{A}$	19.4	6.9	4.4	13.0	10.3	15.9	6.8	15.3	% w/w	A-T-044
% Stones >10mm$_{A}$	<0.1	17.6	32.8	23.1	14.2	<0.1	14.0	5.9	% w/w	A-T-044
pH$_{D}^{M\#}$	8.05	8.49	8.69	8.19	8.15	8.57	7.94	7.91	pH	A-T-031s
Sulphate (water sol 2:1)$_{D}^{M\#}$	0.05	0.02	0.02	0.03	<0.01	<0.01	0.03	0.05	g/l	A-T-026s
Sulphate (acid soluble)$_{D}^{M\#}$	570	820	<200	760	<200	<200	430	300	mg/kg	A-T-028s
Cyanide (total)$_{A}^{M\#}$	<1	<1	<1	<1	<1	<1	<1	<1	mg/kg	A-T-042sTCN
Phenols - Total by HPLC$_{A}$	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	mg/kg	A-T-050s
Sulphide$_{A}$	<5	<5	<5	410	9	31	<5	<5	mg/kg	A-T-S2-s
Sulphur (elemental)$_{D}^{M\#}$	<5	11	<5	81	7	23	<5	<5	mg/kg	A-T-029s
Organic matter$_{D}^{M\#}$	2.1	1.4	<0.1	5.8	0.3	<0.1	<0.1	1.1	% w/w	A-T-032 OM
Arsenic$_{D}^{M\#}$	8	3	2	15	<1	<1	2	3	mg/kg	A-T-024s
Boron (water soluble)$_{D}^{M\#}$	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	mg/kg	A-T-027s
Cadmium$_{D}^{M\#}$	1.3	62.5	0.5	11.3	<0.5	<0.5	8.6	1.1	mg/kg	A-T-024s
Copper$_{D}^{M\#}$	21	40	7	35	3	6	14	17	mg/kg	A-T-024s
Chromium$_{D}^{M\#}$	15	7	10	10	8	8	7	10	mg/kg	A-T-024s
Chromium (hexavalent)$_{D}$	<1	<1	<1	<1	<1	<1	<1	<1	mg/kg	A-T-040s
Chromium (trivalent)	15	7	10	10	8	8	7	10	mg/kg	Calc
Lead$_{D}^{M\#}$	293	22900	89	2220	18	40	1670	206	mg/kg	A-T-024s
Mercury$_{D}$	<0.17	1.44	<0.17	0.33	<0.17	<0.17	0.50	<0.17	mg/kg	A-T-024s
Nickel$_{D}^{M\#}$	21	6	15	23	10	9	10	17	mg/kg	A-T-024s
Selenium$_{D}^{\#}$	2	<1	<1	<1	<1	1	<1	<1	mg/kg	A-T-024s
Zinc$_{D}^{M\#}$	142	6570	56	1300	29	22	1320	143	mg/kg	A-T-024s

Envirolab Job Number: 18/07435

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/07435/1	18/07435/2	18/07435/3	18/07435/4	18/07435/5	18/07435/6	18/07435/7	18/07435/8	Units	Method ref
Client Sample No	1	1	1	1	1	2	1	2		
Client Sample ID	BH101	BH102	WS101	WS102	WS103	WS103	WS104	WS104		
Depth to Top	0.20	0.30	0.30	0.20	0.70	2.70	0.20	2.00		
Depth To Bottom	0.60	0.60	0.60	0.60	0.90	2.90	0.60	3.00		
Date Sampled	10-Sep-18	13-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18		
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES		
Sample Matrix Code	6A	4A	4A	4AB	1A	4	4A	5A		
Leachate Prep NRA (10:1)$_{A}$	-	-	*	-	-	-	*	-		A-T-001
pH (leachable)$_{A}^{\#}$	-	-	7.64	-	-	-	7.43	-	pH	A-T-031w
Sulphate (leachable)$_{A}^{\#}$	-	-	3.97	-	-	-	11.60	-	mg/l	A-T-026w
Cyanide (total) (leachable)$_{A}$	-	-	<0.005	-	-	-	<0.005	-	mg/l	A-T-042wTCN
Phenols (total by HPLC) (leachable)$_{A}$	-	-	<0.01	-	-	-	<0.01	-	mg/l	A-T-050w
Sulphide (leachable)$_{A}$	-	-	<0.1	-	-	-	<0.1	-	mg/l	A-T-S2-w
DOC (leachable)$_{A}^{\#}$	-	-	1.5	-	-	-	1.7	-	mg/l	A-T-032w
Arsenic (leachable)$_{A}^{\#}$	-	-	<1	-	-	-	<1	-	µg/l	A-T-025w
Boron (leachable)$_{A}^{\#}$	-	-	17	-	-	-	39	-	µg/l	A-T-025w
Cadmium (leachable)$_{A}^{\#}$	-	-	<1	-	-	-	<1	-	µg/l	A-T-025w
Copper (leachable)$_{A}^{\#}$	-	-	<1	-	-	-	2	-	µg/l	A-T-025w
Chromium (leachable)$_{A}^{\#}$	-	-	<1	-	-	-	<1	-	µg/l	A-T-025w
Chromium (hexavalent) (leachable)$_{A}$	-	-	<0.05	-	-	-	<0.05	-	mg/l	A-T-040w
Chromium (trivalent) (leachable)	-	-	<0.05	-	-	-	<0.05	-	mg/l	Calc
Lead (leachable)$_{A}^{\#}$	-	-	4	-	-	-	26	-	µg/l	A-T-025w
Mercury (leachable)$_{A}^{\#}$	-	-	<0.1	-	-	-	<0.1	-	µg/l	A-T-025w
Nickel (leachable)$_{A}^{\#}$	-	-	<1	-	-	-	<1	-	µg/l	A-T-025w
Selenium (leachable)$_{A}^{\#}$	-	-	<1	-	-	-	<1	-	µg/l	A-T-025w
Sulphur (elemental/free) (leachable)$_{A}$	-	-	<0.1	-	-	-	<0.1	-	mg/l	A-T-029w
Zinc (leachable)$_{A}^{\#}$	-	-	2	-	-	-	22	-	µg/l	A-T-025w
TPH total (>C6-C40) (leachable)$_{A}$	-	-	<80	-	-	-	<80	-	µg/l	A-T-007w

Envirolab Job Number: 18/07435

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/07435/1	18/07435/2	18/07435/3	18/07435/4	18/07435/5	18/07435/6	18/07435/7	18/07435/8	Units	Method ref
Client Sample No	1	1	1	1	1	2	1	2		
Client Sample ID	BH101	BH102	WS101	WS102	WS103	WS103	WS104	WS104		
Depth to Top	0.20	0.30	0.30	0.20	0.70	2.70	0.20	2.00		
Depth To Bottom	0.60	0.60	0.60	0.60	0.90	2.90	0.60	3.00		
Date Sampled	10-Sep-18	13-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18		
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES		
Sample Matrix Code	6A	4A	4A	4AB	1A	4	4A	5A		
Asbestos in Soil (inc. matrix)										
Asbestos in soil$_{A}^{\#}$	NAD	NAD	NAD	NAD	NAD	NAD	NAD	NAD		A-T-045
Asbestos ACM - Suitable for Water Absorption Test?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Envirolab Job Number: 18/07435

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/07435/1	18/07435/2	18/07435/3	18/07435/4	18/07435/5	18/07435/6	18/07435/7	18/07435/8	Units	Method ref
Client Sample No	1	1	1	1	1	2	1	2		
Client Sample ID	BH101	BH102	WS101	WS102	WS103	WS103	WS104	WS104		
Depth to Top	0.20	0.30	0.30	0.20	0.70	2.70	0.20	2.00		
Depth To Bottom	0.60	0.60	0.60	0.60	0.90	2.90	0.60	3.00		
Date Sampled	10-Sep-18	13-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18		
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES		
Sample Matrix Code	6A	4A	4A	4AB	1A	4	4A	5A		
PAH-16MS										
Acenaphthene$_{A}^{M\#}$	0.01	<0.01	<0.01	0.08	56.5	0.67	0.02	0.21	mg/kg	A-T-019s
Acenaphthylene$_{A}^{M\#}$	0.04	<0.01	<0.01	0.13	28.2	0.33	0.09	0.12	mg/kg	A-T-019s
Anthracene$_{A}^{M\#}$	0.12	<0.02	<0.02	0.28	46.7	2.75	0.10	0.23	mg/kg	A-T-019s
Benzo(a)anthracene$_{A}^{M\#}$	0.42	<0.04	<0.04	2.13	20.2	1.88	0.11	0.14	mg/kg	A-T-019s
Benzo(a)pyrene$_{A}^{M\#}$	0.31	<0.04	0.06	2.16	16.9	1.51	0.39	0.22	mg/kg	A-T-019s
Benzo(b)fluoranthene$_{A}^{M\#}$	0.37	<0.05	0.06	2.45	10.5	0.96	0.36	0.17	mg/kg	A-T-019s
Benzo(ghi)perylene$_{A}^{M\#}$	0.15	<0.05	<0.05	1.10	8.84	0.65	0.42	0.24	mg/kg	A-T-019s
Benzo(k)fluoranthene$_{A}^{M\#}$	0.15	<0.07	<0.07	0.96	2.97	0.32	0.08	<0.07	mg/kg	A-T-019s
Chrysene$_{A}^{M\#}$	0.42	<0.06	<0.06	2.08	18.6	1.69	0.20	0.16	mg/kg	A-T-019s
Dibenzo(ah)anthracene$_{A}^{M\#}$	<0.04	<0.04	<0.04	0.21	1.28	0.10	0.06	<0.04	mg/kg	A-T-019s
Fluoranthene$_{A}^{M\#}$	0.97	<0.08	<0.08	5.59	65.9	6.09	0.18	0.40	mg/kg	A-T-019s
Fluorene$_{A}^{M\#}$	0.06	<0.01	<0.01	0.03	50	1.24	0.02	0.20	mg/kg	A-T-019s
Indeno(123-cd)pyrene$_{A}^{M\#}$	0.17	<0.03	0.05	1.36	6.07	0.44	0.31	0.17	mg/kg	A-T-019s
Naphthalene$_{A}^{M\#}$	<0.03	<0.03	<0.03	<0.03	117	0.49	<0.03	0.17	mg/kg	A-T-019s
Phenanthrene$_{A}^{M\#}$	0.63	<0.03	<0.03	0.38	145	7.43	0.07	0.72	mg/kg	A-T-019s
Pyrene$_{A}^{M\#}$	0.76	<0.07	<0.07	5.14	95.2	7.92	0.30	0.58	mg/kg	A-T-019s
Total PAH-16MS$_{A}^{M\#}$	4.58	<0.08	0.17	24.1	690	34.5	2.71	3.73	mg/kg	A-T-019s

Envirolab Job Number: 18/07435

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/07435/1	18/07435/2	18/07435/3	18/07435/4	18/07435/5	18/07435/6	18/07435/7	18/07435/8	Units	Method ref
Client Sample No	1	1	1	1	1	2	1	2		
Client Sample ID	BH101	BH102	WS101	WS102	WS103	WS103	WS104	WS104		
Depth to Top	0.20	0.30	0.30	0.20	0.70	2.70	0.20	2.00		
Depth To Bottom	0.60	0.60	0.60	0.60	0.90	2.90	0.60	3.00		
Date Sampled	10-Sep-18	13-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18		
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES		
Sample Matrix Code	6A	4A	4A	4AB	1A	4	4A	5A		
PAH-16MS (leachable)										
Acenaphthene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Acenaphthylene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Anthracene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Benzo(a)anthracene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Benzo(a)pyrene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Benzo(b)fluoranthene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Benzo(ghi)perylene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Benzo(k)fluoranthene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Chrysene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Dibenzo(ah)anthracene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Fluoranthene (leachable)A	-	-	0.06	-	-	-	<0.01	-	µg/l	A-T-019w
Fluorene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Indeno(123-cd)pyrene (leachable)A	-	-	<0.01	-	-	-	<0.01	-	µg/l	A-T-019w
Naphthalene (leachable)A	-	-	0.02	-	-	-	<0.01	-	µg/l	A-T-019w
Phenanthrene (leachable)A	-	-	0.09	-	-	-	<0.01	-	µg/l	A-T-019w
Pyrene (leachable)A	-	-	0.05	-	-	-	<0.01	-	µg/l	A-T-019w
Total PAH-16MS (leachable)A	-	-	0.22	-	-	-	<0.01	-	µg/l	A-T-019w

Envirolab Job Number: 18/07435

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/07435/1	18/07435/2	18/07435/3	18/07435/4	18/07435/5	18/07435/6	18/07435/7	18/07435/8	Units	Method ref
Client Sample No	1	1	1	1	1	2	1	2		
Client Sample ID	BH101	BH102	WS101	WS102	WS103	WS103	WS104	WS104		
Depth to Top	0.20	0.30	0.30	0.20	0.70	2.70	0.20	2.00		
Depth To Bottom	0.60	0.60	0.60	0.60	0.90	2.90	0.60	3.00		
Date Sampled	10-Sep-18	13-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18	12-Sep-18		
Sample Type	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES	Soil - ES		
Sample Matrix Code	6A	4A	4A	4AB	1A	4	4A	5A		
TPH UKCWG										
Ali >C5-C6$_{A}^{\#}$	-	-	<0.01	-	<0.01	-	<0.01	-	mg/kg	A-T-022s
Ali >C6-C8$_{A}^{\#}$	-	-	<0.01	-	0.17	-	<0.01	-	mg/kg	A-T-022s
Ali >C8-C10$_{A}^{M\#}$	-	-	<1	-	131	-	<1	-	mg/kg	A-T-055s
Ali >C10-C12$_{A}^{M\#}$	-	-	<1	-	560	-	<1	-	mg/kg	A-T-055s
Ali >C12-C16$_{A}^{M\#}$	-	-	<1	-	1080	-	<1	-	mg/kg	A-T-055s
Ali >C16-C21$_{A}^{M\#}$	-	-	<1	-	470	-	2	-	mg/kg	A-T-055s
Ali >C21-C35$_{A}$	-	-	7	-	167	-	14	-	mg/kg	A-T-055s
Ali >C35-C44$_{A}$	-	-	4	-	<20	-	11	-	mg/kg	A-T-055s
Total Aliphatics >C5-C35$_{A}$	-	-	7	-	2410	-	15	-	mg/kg	A-T-055s
Total Aliphatics >C5-C44$_{A}$	-	-	11	-	2410	-	26	-	mg/kg	A-T-055s
Aro >C5-C7$_{A}^{\#}$	-	-	<0.01	-	<0.01	-	<0.01	-	mg/kg	A-T-022s
Aro >C7-C8$_{A}^{\#}$	-	-	<0.01	-	1.00	-	<0.01	-	mg/kg	A-T-022s
Aro >C8-C10$_{A}^{M\#}$	-	-	1	-	462	-	3	-	mg/kg	A-T-055s
Aro >C10-C12$_{A}^{M\#}$	-	-	<1	-	1450	-	2	-	mg/kg	A-T-055s
Aro >C12-C16$_{A}$	-	-	2	-	3080	-	6	-	mg/kg	A-T-055s
Aro >C16-C21$_{A}^{M\#}$	-	-	<1	-	2360	-	16	-	mg/kg	A-T-055s
Aro >C21-C35$_{A}^{M\#}$	-	-	15	-	1750	-	95	-	mg/kg	A-T-055s
Aro >C35-C44$_{A}$	-	-	5	-	54	-	18	-	mg/kg	A-T-055s
Total Aromatics >C5-C35$_{A}$	-	-	20	-	9090	-	120	-	mg/kg	A-T-055s
Total Aromatics >C5-C44$_{A}$	-	-	25	-	9150	-	137	-	mg/kg	A-T-055s
TPH (Ali & Aro >C5-C35)$_{A}$	-	-	27	-	11500	-	135	-	mg/kg	A-T-055s
TPH (Ali & Aro >C5-C44)$_{A}$	-	-	36	-	11600	-	162	-	mg/kg	A-T-055s
BTEX - Benzene$_{A}^{\#}$	-	-	<0.01	-	<0.01	-	<0.01	-	mg/kg	A-T-022s
BTEX - Toluene$_{A}^{\#}$	-	-	<0.01	-	1.00	-	<0.01	-	mg/kg	A-T-022s
BTEX - Ethyl Benzene$_{A}^{\#}$	-	-	<0.01	-	0.45	-	<0.01	-	mg/kg	A-T-022s
BTEX - m & p Xylene$_{A}^{\#}$	-	-	<0.01	-	2.24	-	<0.01	-	mg/kg	A-T-022s
BTEX - o Xylene$_{A}^{\#}$	-	-	<0.01	-	1.44	-	<0.01	-	mg/kg	A-T-022s
MTBE$_{A}^{\#}$	-	-	<0.01	-	<0.01	-	<0.01	-	mg/kg	A-T-022s

REPORT NOTES

General:
This report shall not be reproduced, except in full, without written approval from Envirolab.
All samples contained within this report, and any received with the same delivery, will be disposed of one month after the date of this report.
Analytical results reflect the quality of the sample at the time of analysis only.
Opinions and interpretations expressed are outside the scope of our accreditation.
If results are in italic font they are associated with an AQC failure, these are not accredited and are unreliable.
A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

Soil chemical analysis:
All results are reported as dry weight (<40°C).
For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.
For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any “A” subscripts
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

TPH analysis of water by method A-T-007:
Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

Electrical Conductivity of water by Method A-T-037:
Results greater than 12900µS/cm @ 25°C / 11550µS/cm @ 20°C fall outside the calibration range and as such are unaccredited.

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

Predominant Matrix Codes:
1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample.
Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.
Secondary Matrix Codes:
A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal, E = contains roots/twigs.

Key:
IS indicates Insufficient Sample for analysis.
US indicates Unsuitable Sample for analysis.
NDP indicates No Determination Possible.
NAD indicates No Asbestos Detected.
N/A indicates Not Applicable.
Superscript # indicates method accredited to ISO 17025.
Superscript "M" indicates method accredited to MCERTS.
Subscript "A" indicates analysis performed on the sample as received.
Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve

Please contact us if you need any further information.

envirolab
Units 7 & 8 Sandpits Business Park
Mottram Road, Hyde, Cheshire, SK14 3AR

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 18/08074
Issue Number: 1 **Date:** 12 October, 2018

Client: Sutcliffe
18-20 Harrington Street
Liverpool
L2 9QA

Project Manager: Alex Tosh; Kelly Davies, Adrian Lewis; David Bowen
Project Name: Bryn Awel, Mold
Project Ref: 29982LG
Order No: TBC
Date Samples Received: 02/10/18
Date Instructions Received: 03/10/18
Date Analysis Completed: 12/10/18

Prepared by:

Melanie Marshall
Laboratory Coordinator

Approved by:

Iain Haslock
Analytical Consultant

Envirolab Job Number: 18/08074

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/08074/1	18/08074/2	18/08074/3						Units	Method ref
Client Sample No	1	1	1							
Client Sample ID	HD101	HD105	HD106							
Depth to Top	0.20	0.30	0.20							
Depth To Bottom	0.60	0.60	0.60							
Date Sampled	01-Oct-18	01-Oct-18	01-Oct-18							
Sample Type	Soil - ES	Soil - ES	Soil - ES							
Sample Matrix Code	4AE	4AE	4A							
% Moisture at <40C$_{A}$	6.5	9.4	16.7						% w/w	A-T-044
% Stones >10mm$_{A}$	43.4	37.0	<0.1						% w/w	A-T-044
pH$_{D}^{M\#}$	8.63	8.34	8.34						pH	A-T-031s
Sulphate (water sol 2:1)$_{D}^{M\#}$	0.04	0.03	<0.01						g/l	A-T-026s
Sulphate (acid soluble)$_{D}^{M\#}$	440	610	520						mg/kg	A-T-028s
Cyanide (total)$_{A}^{M\#}$	<1	<1	<1						mg/kg	A-T-042sTCN
Phenols - Total by HPLC$_{A}$	<0.2	<0.2	<0.2						mg/kg	A-T-050s
Sulphide$_{A}$	<5	<5	<5						mg/kg	A-T-S2-s
Sulphur (elemental)$_{D}^{M\#}$	5	<5	<5						mg/kg	A-T-029s
Organic matter$_{D}^{M\#}$	2.5	7.4	4.3						% w/w	A-T-032 OM
Arsenic$_{D}^{M\#}$	3	4	4						mg/kg	A-T-024s
Boron (water soluble)$_{D}^{M\#}$	<1.0	<1.0	<1.0						mg/kg	A-T-027s
Cadmium$_{D}^{M\#}$	1.0	0.9	1.5						mg/kg	A-T-024s
Copper$_{D}^{M\#}$	19	30	26						mg/kg	A-T-024s
Chromium$_{D}^{M\#}$	8	10	12						mg/kg	A-T-024s
Chromium (hexavalent)$_{D}$	<1	<1	<1						mg/kg	A-T-040s
Chromium (trivalent)	8	10	12						mg/kg	Calc
Lead$_{D}^{M\#}$	132	164	285						mg/kg	A-T-024s
Mercury$_{D}$	0.31	0.28	<0.17						mg/kg	A-T-024s
Nickel$_{D}^{M\#}$	13	16	17						mg/kg	A-T-024s
Selenium$_{D}^{\#}$	<1	<1	<1						mg/kg	A-T-024s
Zinc$_{D}^{M\#}$	215	174	214						mg/kg	A-T-024s
Leachate Prep NRA (10:1)$_{A}$	*	*	-							A-T-001
pH (leachable)$_{A}^{\#}$	7.43	7.51	-						pH	A-T-031w
Sulphate (leachable)$_{A}^{\#}$	1.24	7.31	-						mg/l	A-T-026w
Cyanide (total) (leachable)$_{A}$	<0.005	<0.005	-						mg/l	A-T-042wTCN
Phenols (total by HPLC) (leachable)$_{A}$	<0.01	<0.01	-						mg/l	A-T-050w
Sulphide (leachable)$_{A}$	<0.1	<0.1	-						mg/l	A-T-S2-w
DOC (leachable)$_{A}^{\#}$	3.6	5.0	-						mg/l	A-T-032w
Arsenic (leachable)$_{A}^{\#}$	2	4	-						µg/l	A-T-025w
Boron (leachable)$_{A}^{\#}$	<10	<10	-						µg/l	A-T-025w
Cadmium (leachable)$_{A}^{\#}$	<1	<1	-						µg/l	A-T-025w
Copper (leachable)$_{A}^{\#}$	5	5	-						µg/l	A-T-025w

Envirolab Job Number: 18/08074

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/08074/1	18/08074/2	18/08074/3						Units	Method ref
Client Sample No	1	1	1							
Client Sample ID	HD101	HD105	HD106							
Depth to Top	0.20	0.30	0.20							
Depth To Bottom	0.60	0.60	0.60							
Date Sampled	01-Oct-18	01-Oct-18	01-Oct-18							
Sample Type	Soil - ES	Soil - ES	Soil - ES							
Sample Matrix Code	4AE	4AE	4A							
Chromium (leachable)$_{A}^{\#}$	2	<1	-						µg/l	A-T-025w
Chromium (hexavalent) (leachable)$_{A}$	<0.05	<0.05	-						mg/l	A-T-040w
Chromium (trivalent) (leachable)	<0.05	<0.05	-						mg/l	Calc
Lead (leachable)$_{A}^{\#}$	21	20	-						µg/l	A-T-025w
Mercury (leachable)$_{A}^{\#}$	<0.1	<0.1	-						µg/l	A-T-025w
Nickel (leachable)$_{A}^{\#}$	<1	<1	-						µg/l	A-T-025w
Selenium (leachable)$_{A}^{\#}$	<1	<1	-						µg/l	A-T-025w
Sulphur (elemental/free) (leachable)$_{A}$	<0.1	<0.1	-						mg/l	A-T-029w
Zinc (leachable)$_{A}^{\#}$	13	14	-						µg/l	A-T-025w
TPH total (>C6-C40) (leachable)$_{A}$	<80	<80	-						µg/l	A-T-007w

Envirolab Job Number: 18/08074

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/08074/1	18/08074/2	18/08074/3						Units	Method ref
Client Sample No	1	1	1							
Client Sample ID	HD101	HD105	HD106							
Depth to Top	0.20	0.30	0.20							
Depth To Bottom	0.60	0.60	0.60							
Date Sampled	01-Oct-18	01-Oct-18	01-Oct-18							
Sample Type	Soil - ES	Soil - ES	Soil - ES							
Sample Matrix Code	4AE	4AE	4A							
Asbestos in Soil (inc. matrix)										
Asbestos in soil$_{A}^{\#}$	NAD	NAD	NAD							A-T-045
Asbestos ACM - Suitable for Water Absorption Test?	N/A	N/A	N/A							

Envirolab Job Number: 18/08074

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/08074/1	18/08074/2	18/08074/3						Units	Method ref
Client Sample No	1	1	1							
Client Sample ID	HD101	HD105	HD106							
Depth to Top	0.20	0.30	0.20							
Depth To Bottom	0.60	0.60	0.60							
Date Sampled	01-Oct-18	01-Oct-18	01-Oct-18							
Sample Type	Soil - ES	Soil - ES	Soil - ES							
Sample Matrix Code	4AE	4AE	4A							
PAH-16MS										
Acenaphthene$_{A}^{M\#}$	<0.01	<0.01	0.02						mg/kg	A-T-019s
Acenaphthylene$_{A}^{M\#}$	0.01	<0.01	0.01						mg/kg	A-T-019s
Anthracene$_{A}^{M\#}$	<0.02	<0.02	0.05						mg/kg	A-T-019s
Benzo(a)anthracene$_{A}^{M\#}$	0.10	0.07	0.26						mg/kg	A-T-019s
Benzo(a)pyrene$_{A}^{M\#}$	0.11	0.09	0.28						mg/kg	A-T-019s
Benzo(b)fluoranthene$_{A}^{M\#}$	0.13	0.10	0.32						mg/kg	A-T-019s
Benzo(ghi)perylene$_{A}^{M\#}$	0.07	0.06	0.18						mg/kg	A-T-019s
Benzo(k)fluoranthene$_{A}^{M\#}$	<0.07	<0.07	0.11						mg/kg	A-T-019s
Chrysene$_{A}^{M\#}$	0.12	0.08	0.30						mg/kg	A-T-019s
Dibenzo(ah)anthracene$_{A}^{M\#}$	<0.04	<0.04	<0.04						mg/kg	A-T-019s
Fluoranthene$_{A}^{M\#}$	0.21	0.10	0.49						mg/kg	A-T-019s
Fluorene$_{A}^{M\#}$	<0.01	<0.01	0.01						mg/kg	A-T-019s
Indeno(123-cd)pyrene$_{A}^{M\#}$	0.09	0.07	0.20						mg/kg	A-T-019s
Naphthalene$_{A}^{M\#}$	<0.03	<0.03	<0.03						mg/kg	A-T-019s
Phenanthrene$_{A}^{M\#}$	0.10	0.04	0.26						mg/kg	A-T-019s
Pyrene$_{A}^{M\#}$	0.18	0.10	0.44						mg/kg	A-T-019s
Total PAH-16MS$_{A}^{M\#}$	1.12	0.71	2.93						mg/kg	A-T-019s

Envirolab Job Number: 18/08074

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/08074/1	18/08074/2	18/08074/3						Units	Method ref
Client Sample No	1	1	1							
Client Sample ID	HD101	HD105	HD106							
Depth to Top	0.20	0.30	0.20							
Depth To Bottom	0.60	0.60	0.60							
Date Sampled	01-Oct-18	01-Oct-18	01-Oct-18							
Sample Type	Soil - ES	Soil - ES	Soil - ES							
Sample Matrix Code	4AE	4AE	4A							
PAH-16MS (leachable)										
Acenaphthene (leachable)$_A$	0.04	0.05	-						µg/l	A-T-019w
Acenaphthylene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Anthracene (leachable)$_A$	0.02	0.03	-						µg/l	A-T-019w
Benzo(a)anthracene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Benzo(a)pyrene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Benzo(b)fluoranthene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Benzo(ghi)perylene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Benzo(k)fluoranthene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Chrysene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Dibenzo(ah)anthracene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Fluoranthene (leachable)$_A$	0.04	0.06	-						µg/l	A-T-019w
Fluorene (leachable)$_A$	0.03	0.03	-						µg/l	A-T-019w
Indeno(123-cd)pyrene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Naphthalene (leachable)$_A$	<0.01	<0.01	-						µg/l	A-T-019w
Phenanthrene (leachable)$_A$	0.09	0.12	-						µg/l	A-T-019w
Pyrene (leachable)$_A$	0.03	0.05	-						µg/l	A-T-019w
Total PAH-16MS (leachable)$_A$	0.25	0.34	-						µg/l	A-T-019w

Envirolab Job Number: 18/08074

Client Project Name: Bryn Awel, Mold

Client Project Ref: 29982LG

Lab Sample ID	18/08074/1	18/08074/2	18/08074/3						Units	Method ref
Client Sample No	1	1	1							
Client Sample ID	HD101	HD105	HD106							
Depth to Top	0.20	0.30	0.20							
Depth To Bottom	0.60	0.60	0.60							
Date Sampled	01-Oct-18	01-Oct-18	01-Oct-18							
Sample Type	Soil - ES	Soil - ES	Soil - ES							
Sample Matrix Code	4AE	4AE	4A							
TPH UKCWG										
Ali >C5-C6$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
Ali >C6-C8$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
Ali >C8-C10$_{A}^{M\#}$	<1	<1	<1						mg/kg	A-T-055s
Ali >C10-C12$_{A}^{M\#}$	<1	<1	<1						mg/kg	A-T-055s
Ali >C12-C16$_{A}^{M\#}$	<1	<1	<1						mg/kg	A-T-055s
Ali >C16-C21$_{A}^{M\#}$	<1	<1	<1						mg/kg	A-T-055s
Ali >C21-C35$_{A}$	4	2	5						mg/kg	A-T-055s
Ali >C35-C44$_{A}$	1	<1	<1						mg/kg	A-T-055s
Total Aliphatics >C5-C35$_{A}$	4	2	5						mg/kg	A-T-055s
Total Aliphatics >C5-C44$_{A}$	4	2	5						mg/kg	A-T-055s
Aro >C5-C7$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
Aro >C7-C8$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
Aro >C8-C10$_{A}^{M\#}$	<1	<1	1						mg/kg	A-T-055s
Aro >C10-C12$_{A}^{M\#}$	<1	<1	<1						mg/kg	A-T-055s
Aro >C12-C16$_{A}$	1	1	1						mg/kg	A-T-055s
Aro >C16-C21$_{A}^{M\#}$	3	2	5						mg/kg	A-T-055s
Aro >C21-C35$_{A}^{M\#}$	20	9	29						mg/kg	A-T-055s
Aro >C35-C44$_{A}$	3	1	12						mg/kg	A-T-055s
Total Aromatics >C5-C35$_{A}$	24	12	36						mg/kg	A-T-055s
Total Aromatics >C5-C44$_{A}$	28	14	48						mg/kg	A-T-055s
TPH (Ali & Aro >C5-C35)$_{A}$	28	14	41						mg/kg	A-T-055s
TPH (Ali & Aro >C5-C44)$_{A}$	32	15	53						mg/kg	A-T-055s
BTEX - Benzene$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - Toluene$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - Ethyl Benzene$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - m & p Xylene$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - o Xylene$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
MTBE$_{A}^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s

REPORT NOTES

General:
This report shall not be reproduced, except in full, without written approval from Envirolab.
All samples contained within this report, and any received with the same delivery, will be disposed of one month after the date of this report.
Analytical results reflect the quality of the sample at the time of analysis only.
Opinions and interpretations expressed are outside the scope of our accreditation.
If results are in italic font they are associated with an AQC failure, these are not accredited and are unreliable.
A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

Soil chemical analysis:
All results are reported as dry weight (<40°C).
For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.
For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any “A” subscripts
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

TPH analysis of water by method A-T-007:
Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

Electrical Conductivity of water by Method A-T-037:
Results greater than 12900µS/cm @ 25°C / 11550µS/cm @ 20°C fall outside the calibration range and as such are unaccredited.

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

Predominant Matrix Codes:
1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample.
Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.
Secondary Matrix Codes:
A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal, E = contains roots/twigs.

Key:
IS indicates Insufficient Sample for analysis.
US indicates Unsuitable Sample for analysis.
NDP indicates No Determination Possible.
NAD indicates No Asbestos Detected.
N/A indicates Not Applicable.
Superscript # indicates method accredited to ISO 17025.
Superscript "M" indicates method accredited to MCERTS.
Subscript "A" indicates analysis performed on the sample as received.
Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve

Please contact us if you need any further information.

Appendix E - Ground Gas & Groundwater Monitoring Data

Sutcliffe	**SUTCLIFFE INVESTIGATIONS**	**GAS MEASUREMENTS AND WATER LEVELS**	**Sheet No.: 1 of 1**
	TEL: 0151 227 3155		**Atmospheric Pressure: 1014mb**
	FAX: 0151 227 3156		**Weather: Clear/Cloudy**
			Pressure Trend: Faling
	VISIT No.: 1		
	CLIENT: Anwyl Construction	**SITE: Former Hotel, Bryn Awel, Mold**	
	Date of Fieldwork: 01.10.18	**Logged By: JS**	**Job No.: 29982LG**

B/H REF	CH_4		CO_2	O_2	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
BH102		0	0.6	19.9	-0.49	0		6.6	6.5	
		0	2.9	16.4						
		0.1	4.2	14.9						
		0.1	4.2	14.8						
WS101		0	0.9	20.2	-0.54	0		4	DRY	
		0	2.4	19.3						
		0.1	2.5	18.7						
		0.1	2.5	18.5						
WS102		0	0.6	20.4	-0.55	0		4	0.58	
		0	1.1	19.9						
		0.1	0.9	19.8						
		0.1	0.7	20.1						
WS104		0.1	0.7	20.5	-0.48	-0.3		2.1	1.7	
		0.1	4.6	18.2						
		0.1	6.8	12.3						
		0.1	7.2	10.5						

COMMENTS:

INSTRUMENT USED:	ACCURACY OF INSTRUMENT (% by volume)	CH_4	CO_2	O_2
		± 0.5% @ 5%	± 0.5% @ 5%	
		± 1.0% @15%	± 1.0% @15%	± 1.0%
		±3.0% @>15%	±3.0% @>15%	

A = Accumulated Type Sample
SS = Steady State Type Sample
P = Peak Type Sample
l/h = Litres per hour
mb = Millibar
mbgl = Metres Below Ground Level
%LEL = Lower Explosive Limit (for CH4 in air 100% = 5% by volume)

Sutcliffe	**SUTCLIFFE INVESTIGATIONS** TEL: 0151 227 3155 FAX: 0151 227 3156 **VISIT No.: 2**	**GAS MEASUREMENTS AND WATER LEVELS**	**Sheet No.: 1 of 1** **Atmospheric Pressure: 1000mb** **Weather: Overcast** **Pressure Trend: Steady**
	CLIENT: Anwyl Construction	**SITE: Former Hotel, Bryn Awel, Mold**	
	Date of Fieldwork: 16.10.18	**Logged By: JS**	**Job No.: 29982LG**

B/H REF	CH_4		CO_2	O_2	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
BH102		0	2.4	18.1	0.05	0		6.6	6.5	
		0	3.8	16.1						
		0.1	3.9	14.9						
		0.1	3.9	14.6						
WS101		0.1	1.5	19	0.07	0		4	DRY	
		0.1	2	18.5						
		0.1	2.1	18.7						
		0.1	2.2	18.7						
WS102		0	1.2	19	0.03	-0.3		4	0.52	
		0	0.2	19.7						
		0.1	0.1	20.7						
		0.1	0.1	20.7						
WS104		0	0.6	19.7	0.03	-0.1		2.1	1.67	
		0	5	16						
		0.1	5.2	14.8						
		0.1	5.5	14.3						

COMMENTS:

INSTRUMENT USED:	ACCURACY OF INSTRUMENT (% by volume)	CH_4	CO_2	O_2
		± 0.5% @ 5%	± 0.5% @ 5%	
		± 1.0% @15%	± 1.0% @15%	± 1.0%
		±3.0% @>15%	±3.0% @>15%	

A = Accumulated Type Sample
SS = Steady State Type Sample
P = Peak Type Sample
l/h = Litres per hour
mb = Millibar
mbgl = Metres Below Ground Level
%LEL = Lower Explosive Limit (for CH4 in air 100% = 5% by volume)

Sutcliffe	**SUTCLIFFE INVESTIGATIONS**	**GAS MEASUREMENTS AND WATER LEVELS**	**Sheet No.: 1 of 1**
	TEL: 0151 227 3155		**Atmospheric Pressure: 985mb**
	FAX: 0151 227 3156		**Weather: Overcast**
			Pressure Trend: Falling
	VISIT No.: 3		
	CLIENT: Anwyl Construction	**SITE: Former Hotel, Bryn Awel, Mold**	
	Date of Fieldwork: 30.10.18	**Logged By: JS**	**Job No.: 29982LG**

B/H REF	CH_4		CO_2	O_2	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
BH102		0	3.2	20.5	-0.26	0		6.6	6.2	
		0	3.5	19.8						
		0.1	3.6	15.4						
		0.1	3.6	14.7						
WS101		0	0	20.5	-0.33	0		4	DRY	
		0	3.5	19.3						
		0.1	3.8	18						
		0.1	3.8	17.4						
WS102		0	0.1	20.2	-0.31	0		4	0.56	
		0	1.2	20.3						
		0	0.5	20.1						
		0	0.2	20.1						
WS104		0.1	1.3	18.1	-0.29	0		2.1	1.75	
		0.1	5.8	16.2						
		0.1	6.1	13.6						
		0.1	6.1	13.6						

COMMENTS:

INSTRUMENT USED:	ACCURACY OF INSTRUMENT (% by volume)	CH_4	CO_2	O_2
		± 0.5% @ 5%	± 0.5% @ 5%	
		± 1.0% @15%	± 1.0% @15%	± 1.0%
		±3.0% @>15%	±3.0% @>15%	

A = Accumulated Type Sample
SS = Steady State Type Sample
P = Peak Type Sample
l/h = Litres per hour
mb = Millibar
mbgl = Metres Below Ground Level
%LEL = Lower Explosive Limit (for CH4 in air 100% = 5% by volume)

Appendix F – Geotechnical Laboratory Certificates

STRUCTURAL SOILS LTD

TEST REPORT

Report No. 783386 R1

1774

Date	28-September-2018	Contract	18/07436

Client Envirolab Ltd
Address Units 7 & 8 Sandpits Business Park
Mottram Road
Hyde
SK14 3AR

For the Attention of Iain Haslock

Samples submitted by client	18/09/2018	Client Reference	18/07436
Testing Started	19/09/2018	Client Order No.	P0739048
Testing Completed	28/09/2018	Instruction Type	Written

UKAS Accredited Tests Undertaken

Moisture Content (oven drying method) BS1377:Part 2:1990,clause 3.2 (superseded)**
Liquid Limit (definitive method) BS1377:Part 2:1990,clause 4.3
Plastic Limit BS1377:Part 2:1990,clause 5.3
Plasticity Index Derivation BS1377:Part 2:1990,clause 5.4
Particle Size Distribution wet sieve method BS1377:Part 2:1990,clause 9.2

* This clause of BS1377 is no longer the most up to date method due to the publication of ISO17892

Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of.
Test were undertaken on samples 'as received' unless otherwise stated.
Opinions and interpretations expressed in this report are outside the scope of accreditation for this laboratory.

Structural Soils Ltd, The Potteries, Pottery Street, Castleford, WF10 1NJ Tel.01977 552255. E-mail mark.athorne@soils.co.uk

SUMMARY OF SOIL CLASSIFICATION TESTS

In accordance with clauses 3.2,4.3,4.4,5.3,5.4,7.2,8.2,8.3 of BS1377:Part 2:1990

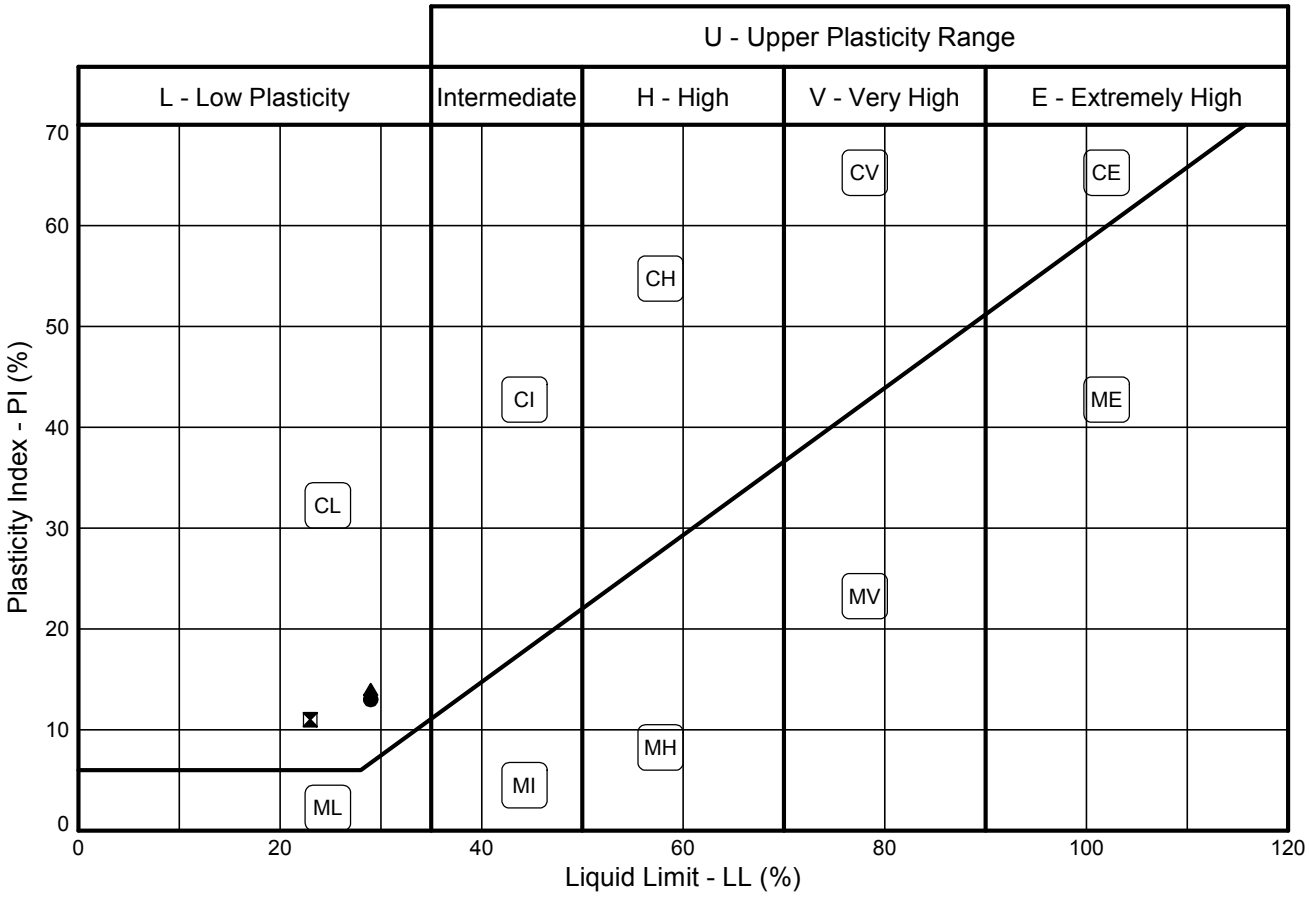
Exploratory Position ID	Sample Ref	Sample Type	Depth (m)	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	% <425um	Description of Sample
BH102	18/07436/1	U	4.00	14	29	16	13	76	Dark brown slightly sandy slightly gravelly CLAY
WS102	18/07436/2	U	2.00	8.9	23	12	11	72	Dark brown sandy slightly gravelly CLAY
WS104	18/07436/3	D	2.70	24	29	15	14	100	Brown slightly silty CLAY

STRUCTURAL SOILS LTD	Contract: 18/07436	Contract Ref: 783386

AGS

PLASTICITY CHART - PI Vs LL

In accordance with BS5930:2015
Testing in accordance with BS1377-2:1990



Sample Identification				BS Test Method #	Preparation Method +	MC %	LL %	PL %	PI %	<425um %	Lab location
Exploratory Position ID	Sample		Depth (m)								
● BH102	18/07436/1U		4.00	3.2/4.3/5.3/5.4	4.2.4	14	29	16	13	76	C
⊠ WS102	18/07436/2U		2.00	3.2/4.3/5.3/5.4	4.2.4	8.9	23	12	11	72	C
▲ WS104	18/07436/3D		2.70	3.2/4.3/5.3/5.4	4.2.3	24	29	15	14	100	C

Tested in accordance with the following clauses of BS1377-2:1990.

3.2 - Moisture Content
4.3 - Cone Penetrometer Method
4.4 - One Point Cone Penetrometer Method
4.6 - One Point Casagrande Method
5.3 - Plastic Limit Method
5.4 - Plasticity Index

+ Tested in accordance with the following clauses of BS1377-2:1990.

4.2.3 - Natural State
4.2.4 - Wet Sieved

Key: * = Non-standard test, NP = Non plastic.

Lab location: B = Bristol (BS3 4AG), C = Castleford (WF10 1NJ), H = Hemel Hempstead (HP3 9RT), T = Tonbridge (TN11 9HU)

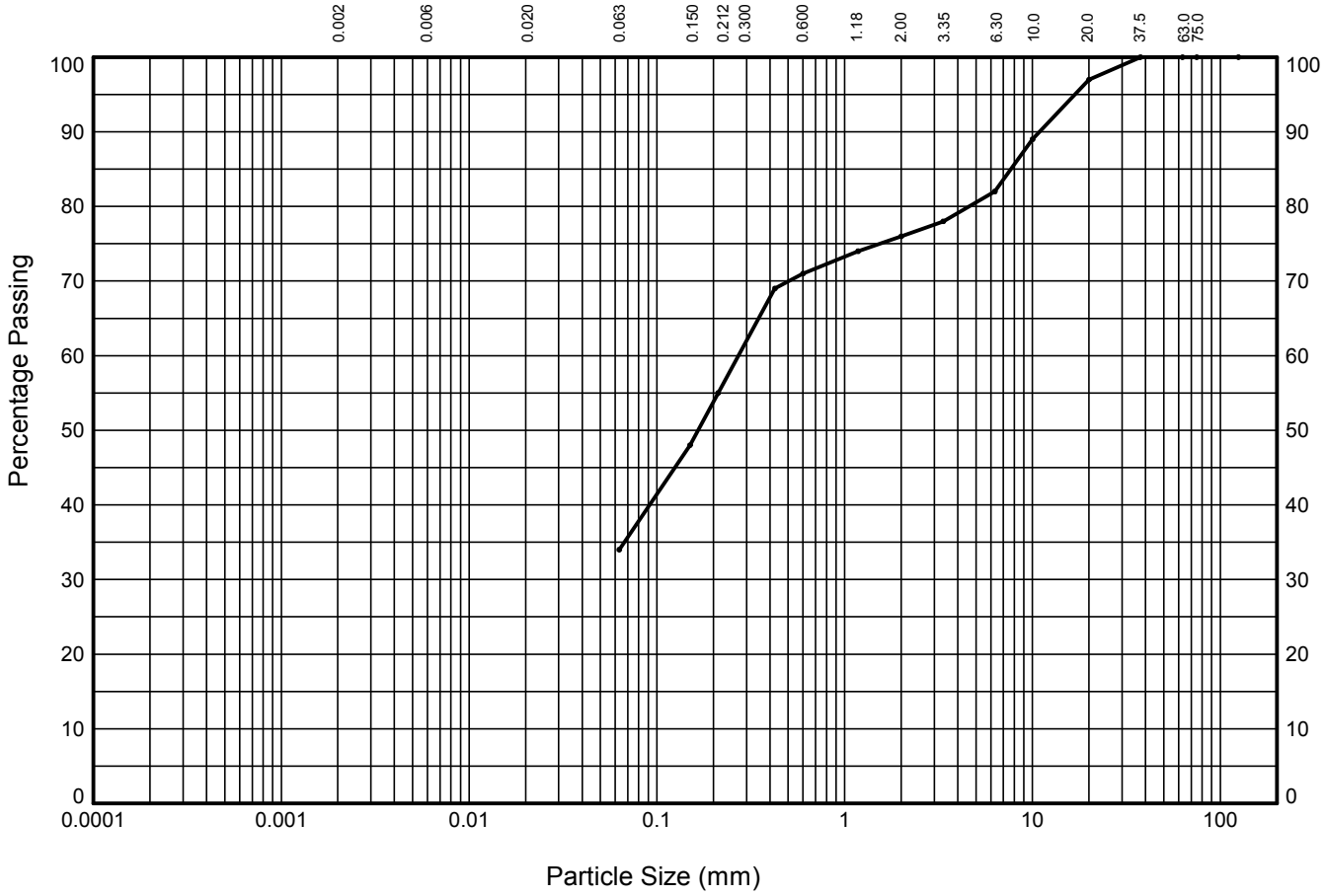
STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
M. Athorne	MARK ATHORNE	28/09/18
Contract: 18/07436	Contract Ref: 783386	

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2 of BS1377:Part 2:1990

Window Sample: **WS102** Sample Ref: **18/07436/2** Sample Type: **U** Depth (m): **2.00**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**97**
10.0	**89**
6.30	**82**
3.35	**78**
2.00	**76**
1.18	**74**
0.600	**71**
0.425	**69**
0.212	**55**
0.150	**48**
0.063	**34**

Particle Diameter (mm)	Percent Passing (%)

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**24**
SAND	**42**
SILT/CLAY	**34**

Soil Description:

Dark brown sandy slightly gravelly CLAY

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Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**28/09/18**
Contract **18/07436**	Contract Ref: **783386**	

AGS

SUMMARY OF HAND PENETROMETER & HAND VANE TEST RESULTS

Exploratory Position ID	Sample Ref	Sample Type	Depth (m)	Moisture Content (%)	Vane Type	Average Reading (kPa)	Sample Description	Lab location
BH102	18/07436/1	U	4.00	15	HVP	53	Dark brown slightly sandy slightly gravelly CLAY	**C**
WS102	18/07436/2	U	2.00	18	HVP	36	Dark brown sandy slightly gravelly CLAY	**C**

Lab location: B = Bristol (BS3 4AG), C = Castleford (WF10 1NJ), H = Hemel Hempstead (HP3 9RT), T = Tonbridge (TN11 9HU)

Key : HVP = Hand Vane (Peak), HVR = Hand Vane (Remoulded), PP = Pocket Penetrometer.

STRUCTURAL SOILS
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Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date	Contract Ref:
M. Athorne	**MARK ATHORNE**	**28.09.18**	**783386**
Contract: **18/07436**			

Appendix G - Soil Screening Tables

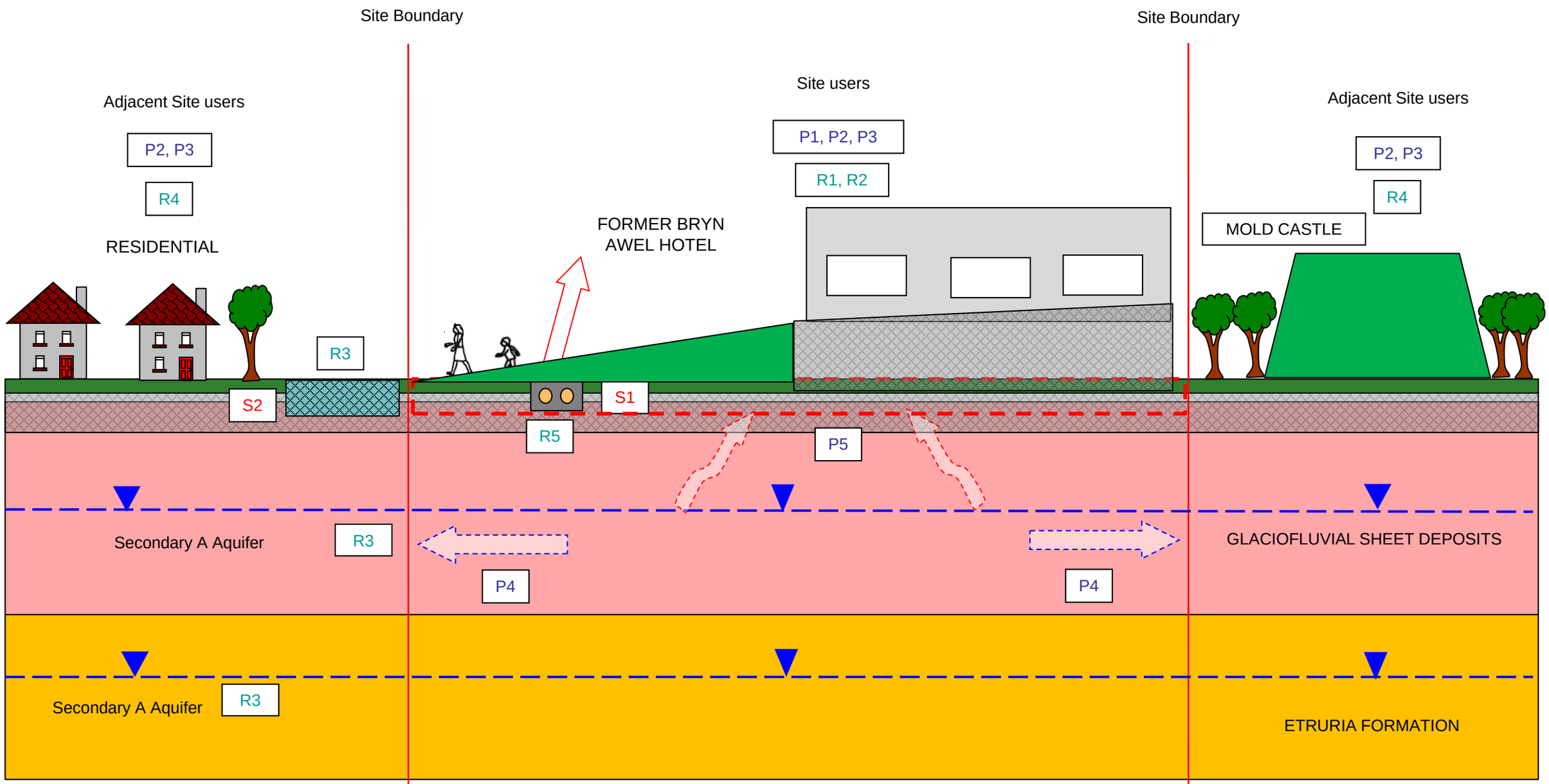
Job Name:	Bryn Awel
Job Number:	LG: 29982

Contaminant	Units	ATKINS REVISED 31/03/11, CATEGORY 4 - APRIL 2014, LQM JAN 2015					MG	MG	MG	MG	MG	NAT	MG	NAT	MG	MG	MG
		RESIDENTIAL WITHOUT PLANT UPTAKE					18/07435	18/07435	18/07435	18/07435	18/07435	18/07435	18/07435	18/07435	18/08074	18/08074	18/08074
							18/07435/1	18/07435/2	18/07435/3	18/07435/4	18/07435/5	18/07435/6	18/07435/7	18/07435/8	18/08074/1	18/08074/2	18/08074/3
		Category 4 Screening Levels (6%)	Atkins Atrisk	LQM			BH101	BH102	WS101	WS102	WS103	WS103	WS104	WS104	HD101	HD105	HD106
				SOM 1%	SOM 2.5%	SOM 5%	0.20 - 0.60m	0.30 - 0.60m	0.30 - 0.60m	0.20 - 0.60m	0.70 - 0.90m	2.70 - 2.90m	0.20 - 0.60m	2.00 - 3.00m	0.20 - 0.60m	0.30 - 0.60m	0.20 - 0.60m
Arsenic (Total)	mg/kg	40		40			8	3	2	15	<1	<1	2	3	3	4	4
Boron (Soluble)	mg/kg			11000			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cadmium (Total)	mg/kg	149		85			1.3	62.5	0.5	11.3	<0.5	<0.5	8.6	1.1	1	0.9	1.5
Chromium III	mg/kg			910			15	7	10	10	8	8	7	10	8	10	12
Chromium VI	mg/kg	21		6			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper (Total)	mg/kg			7100			21	40	7	35	3	6	14	17	19	30	26
Lead (Total)	mg/kg	310					293	22900	89	2220	18	40	1670	206	132	164	285
Mercury (Total)	mg/kg			56			<0.17	1.44	<0.17	0.33	<0.17	<0.17	0.5	<0.17	0.31	0.28	<0.17
Nickel (Total)	mg/kg			180			21	6	15	23	10	9	10	17	13	16	17
Selenium (Total)	mg/kg			430			2	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Zinc (Total)	mg/kg			40000			142	6570	56	1300	29	22	1320	143	215	174	214
Cyanide (Total)	mg/kg		34				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phenols (Total)	mg/kg			750	1300	2300	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Organic matter	%						2.1	1.4	<0.1	5.8	0.3	<0.1	<0.1	1.1	2.5	7.4	4.3
Sulphate (Acid Soluble)	mg/kg						570	820	<200	760	<200	<200	430	300	440	610	520
Sulphate as Water Soluble	g/l						0.05	0.02	0.02	0.03	<0.01	<0.01	0.03	0.05	0.04	0.03	<0.01
Sulphide	mg/kg						<5	<5	<5	410	9	31	<5	<5	<5	<5	<5
pH	pH units						8.05	8.49	8.69	8.19	8.15	8.57	7.94	7.91	8.63	8.34	8.34
Sulphur (Elemental)	mg/kg						<5	11	<5	81	7	23	<5	<5	5	<5	<5
Asbestos							NAD	NAD	NAD	NAD	NAD	NAD	NAD	NAD	NAD	NAD	NAD
>> TPH SUITE <<																	
Total Aliphatic																	
>C5 to C6 aliphatic	mg/kg			42	78	160	N/S	N/S	<0.01	N/S	<0.01	N/S	<0.01	N/S	<0.01	<0.01	<0.01
>C6 to C8 aliphatic	mg/kg			100	230	530	N/S	N/S	<0.01	N/S	0.17	N/S	<0.01	N/S	<0.01	<0.01	<0.01
>C8 to C10 aliphatic	mg/kg			27	65	150	N/S	N/S	<1	N/S	131	N/S	<1	N/S	<1	<1	<1
>C10 to C12 aliphatic	mg/kg			130	330	770	N/S	N/S	<1	N/S	560	N/S	<1	N/S	<1	<1	<1
>C12 to C16 aliphatic	mg/kg			1100	2400	4400	N/S	N/S	<1	N/S	1080	N/S	<1	N/S	<1	<1	<1
>C16 to C21 aliphatic	mg/kg			65000	92000	110000	N/S	N/S	<1	N/S	470	N/S	2	N/S	<1	<1	<1
>C21 to C35 aliphatic	mg/kg			65000	92000	110000	N/S	N/S	7	N/S	167	N/S	14	N/S	4	2	5
>C35 to C44 aliphatic	mg/kg			65000	92000	110000	N/S	N/S	4	N/S	<20	N/S	11	N/S	1	<1	<1
Total Aromatic																	
>C5 to C7 aromatic (Benzene)	mg/kg			370	690	1400	N/S	N/S	<0.01	N/S	<0.01	N/S	<0.01	N/S	<0.01	<0.01	<0.01
>C7 to C8 aromatic (Toluene)	mg/kg			860	1800	3900	N/S	N/S	<0.01	N/S	1	N/S	<0.01	N/S	<0.01	<0.01	<0.01
>C8 to C10 aromatic	mg/kg			47	110	270	N/S	N/S	1	N/S	462	N/S	3	N/S	<1	<1	1
>C10 to C12 aromatic	mg/kg			250	590	1200	N/S	N/S	<1	N/S	1450	N/S	2	N/S	<1	<1	<1
>C12 to C16 aromatic	mg/kg			1800	2300	2500	N/S	N/S	2	N/S	3080	N/S	6	N/S	1	1	1
>C16 to C21 aromatic	mg/kg			1900	1900	1900	N/S	N/S	<1	N/S	2360	N/S	16	N/S	3	2	5
>C21 to C35 aromatic	mg/kg			1900	1900	1900	N/S	N/S	15	N/S	1750	N/S	95	N/S	20	9	29
>C35 to C44 aromatic	mg/kg			1900	1900	1900	N/S	N/S	5	N/S	54	N/S	18	N/S	3	1	12
>> BTEX SUITE <<																	
benzene	mg/kg	3.3		0.38	0.7	1.4	N/S	N/S	<0.01	N/S	<0.01	N/S	<0.01	N/S	<0.01	<0.01	<0.01
toluene	mg/kg			880	1900	3900	N/S	N/S	<0.01	N/S	1	N/S	<0.01	N/S	<0.01	<0.01	<0.01
ethylbenzene	mg/kg			83	190	440	N/S	N/S	<0.01	N/S	0.45	N/S	<0.01	N/S	<0.01	<0.01	<0.01
m&p-xylene	mg/kg			79	180	430	N/S	N/S	<0.01	N/S	2.24	N/S	<0.01	N/S	<0.01	<0.01	<0.01
o-xylene	mg/kg			88	210	480	N/S	N/S	<0.01	N/S	1.44	N/S	<0.01	N/S	<0.01	<0.01	<0.01
>> PAH SUITE <<																	
naphthalene	mg/kg			2.3	5.6	13	<0.03	<0.03	<0.03	<0.03	117	0.49	<0.03	0.17	<0.03	<0.03	<0.03
acenaphthylene	mg/kg			2900	4600	6000	0.04	<0.01	<0.01	0.13	28.2	0.33	0.09	0.12	0.01	<0.01	0.01
acenaphthene	mg/kg			3000	4700	6000	0.01	<0.01	<0.01	0.08	56.5	0.67	0.02	0.21	<0.01	<0.01	0.02
fluorene	mg/kg			2800	3800	4500	0.06	<0.01	<0.01	0.03	50	1.24	0.02	0.2	<0.01	<0.01	0.01
phenanthrene	mg/kg			1300	1500	1500	0.63	<0.03	<0.03	0.38	145	7.43	0.07	0.72	0.1	0.04	0.26
anthracene	mg/kg			31000	35000	37000	0.12	<0.02	<0.02	0.28	46.7	2.75	0.1	0.23	<0.02	<0.02	0.05
fluoranthene	mg/kg			1500	1600	1600	0.97	<0.08	<0.08	5.59	65.9	6.09	0.18	0.4	0.21	0.1	0.49
pyrene	mg/kg			3700	3800	3800	0.76	<0.07	<0.07	5.14	95.2	7.92	0.3	0.58	0.18	0.1	0.44
benzo(a)anthracene	mg/kg			11	14	15	0.42	<0.04	<0.04	2.13	20.2	1.88	0.11	0.14	0.1	0.07	0.26
chrysene	mg/kg			30	31	32	0.42	<0.06	<0.06	2.08	18.6	1.69	0.2	0.16	0.12	0.08	0.3
benzo(b)fluoranthene	mg/kg			3.9	4	4	0.37	<0.05	0.06	2.45	10.5	0.96	0.36	0.17	0.13	0.1	0.32
benzo(k)fluoranthene	mg/kg			110	110	110	0.15	<0.07	<0.07	0.96	2.97	0.32	0.08	<0.07	<0.07	<0.07	0.11
benzo(a)pyrene	mg/kg	5.3		3.2	3.2	3.2	0.31	<0.04	0.06	2.16	16.9	1.51	0.39	0.22	0.11	0.09	0.28
dibenzo(ah)anthracene	mg/kg			0.31	0.32	0.32	<0.04	<0.04	<0.04	0.21	1.28	0.1	0.06	<0.04	<0.04	<0.04	<0.04
benzo(ghi)perylene	mg/kg			360	360	360	0.15	<0.05	<0.05	1.1	8.84	0.65	0.42	0.24	0.07	0.06	0.18
indeno(123cd)pyrene	mg/kg			45	46	46	0.17	<0.03	0.05	1.36	6.07	0.44	0.31	0.17	0.09	0.07	0.2

Job Name:	Bryn Awel, Mold
Job Number:	LG: 29982

	LEACHATES			18/07435	18/07435	18/08074	18/08074
CAS Number:	**Units**	**Site Specific Guidelines**		**18/07435/3**	**18/07435/7**	**18/08074/1**	**18/08074/2**
Sample Ref				**WS101**	**WS104**	**HD101**	**HD105**
Determinand Name		**EQS**	**UK DWS**	**0.30 - 0.6m**	**0.20 - 0.6m**	**0.20 - 0.60m**	**0.30 - 0.6m**
Leachate Prep (10:1 Std NRA)*							
Arsenic (Soluble)*	µg/l	50	10	<1	<1	2	4
Boron (Soluble)	µg/l	1000	1000	17	39	<10	<10
Cadmium (Soluble)	µg/l	0.45 - 1.5	5	<1	<1	<1	<1
Chromium Trivalent (Soluble)	µg/l	4.7	50	<50	<50	<50	<50
Chromium Hexavalent (Soluble)	µg/l	3.4	50	<50	<50	<50	<50
Copper (Soluble)	µg/l	1	2000	<1	2	5	5
Lead (Soluble)	µg/l	14	10	4	26	21	20
Mercury (Soluble)	µg/l	0.07	1	<0.1	<0.1	<0.1	<0.1
Nickel (Soluble)	µg/l	34	20	<1	<1	<1	<1
Selenium (Soluble)*	µg/l		10	<1	<1	<1	<1
Sulphur (Free)	mg/l			<0.1	<0.1	<0.1	<0.1
Zinc (Soluble)	µg/l	10.9	5000	2	22	13	14
Cyanide (Total)*	mg/l	1	50	<0.005	<0.005	<0.005	<0.005
Phenols (Total)	µg/l	7.7		<10	<10	<10	<10
Sulphate as SO3	mg/l	400	250	3.97	11.6	1.24	7.31
Sulphide as S	µg/l	0.25		<100	<100	<100	<100
pH	pH units			7.64	7.43	7.43	7.51
TPH Total C6-C40 (leachable)	µg/l			<80	<80	<80	<80
>> PAH SUITE <<*							
naphthalene*	µg/l	130		0.02	<0.01	<0.01	<0.01
acenaphthylene*	µg/l			<0.01	<0.01	<0.01	<0.01
acenaphthene*	µg/l			<0.01	<0.01	0.04	0.05
fluorene*	µg/l			<0.01	<0.01	0.03	0.03
phenanthrene*	µg/l			0.09	<0.01	0.09	0.12
anthracene*	µg/l	0.1		<0.01	<0.01	0.02	0.03
fluoranthene*	µg/l	0.12		0.06	<0.01	0.04	0.06
pyrene*	µg/l			0.05	<0.01	0.03	0.05
benzo(a)anthracene*	µg/l			<0.01	<0.01	<0.01	<0.01
chrysene*	µg/l			<0.01	<0.01	<0.01	<0.01
benzo(b)fluoranthene*	µg/l	0.017		<0.01	<0.01	<0.01	<0.01
benzo(k)fluoranthene*	µg/l	0.017		<0.01	<0.01	<0.01	<0.01
benzo(a)pyrene*	µg/l	0.27	0.01	<0.01	<0.01	<0.01	<0.01
dibenzo(ah)anthracene*	µg/l			<0.01	<0.01	<0.01	<0.01
benzo(ghi)perylene*	µg/l	0.0082		<0.01	<0.01	<0.01	<0.01
indeno(123cd)pyrene*	µg/l	0.002		<0.01	<0.01	<0.01	<0.01

Figure 3: Preliminary Conceptual Model



Key

S1 – Potentially Contaminated Soil – Onsite
S2 – Infilled Pond – Offsite

R1 Future site Users
R2 Construction Workers
R3 Controlled waters
R4 Adjacent Site Users
R5 Infrastructure & Buried services

P1 Direct Contact
P2 Ingestion
P3 Inhalation
P4 Leaching & Migration
P5 Vertical & lateral migration of ground gas

Infilled Land

Underground services

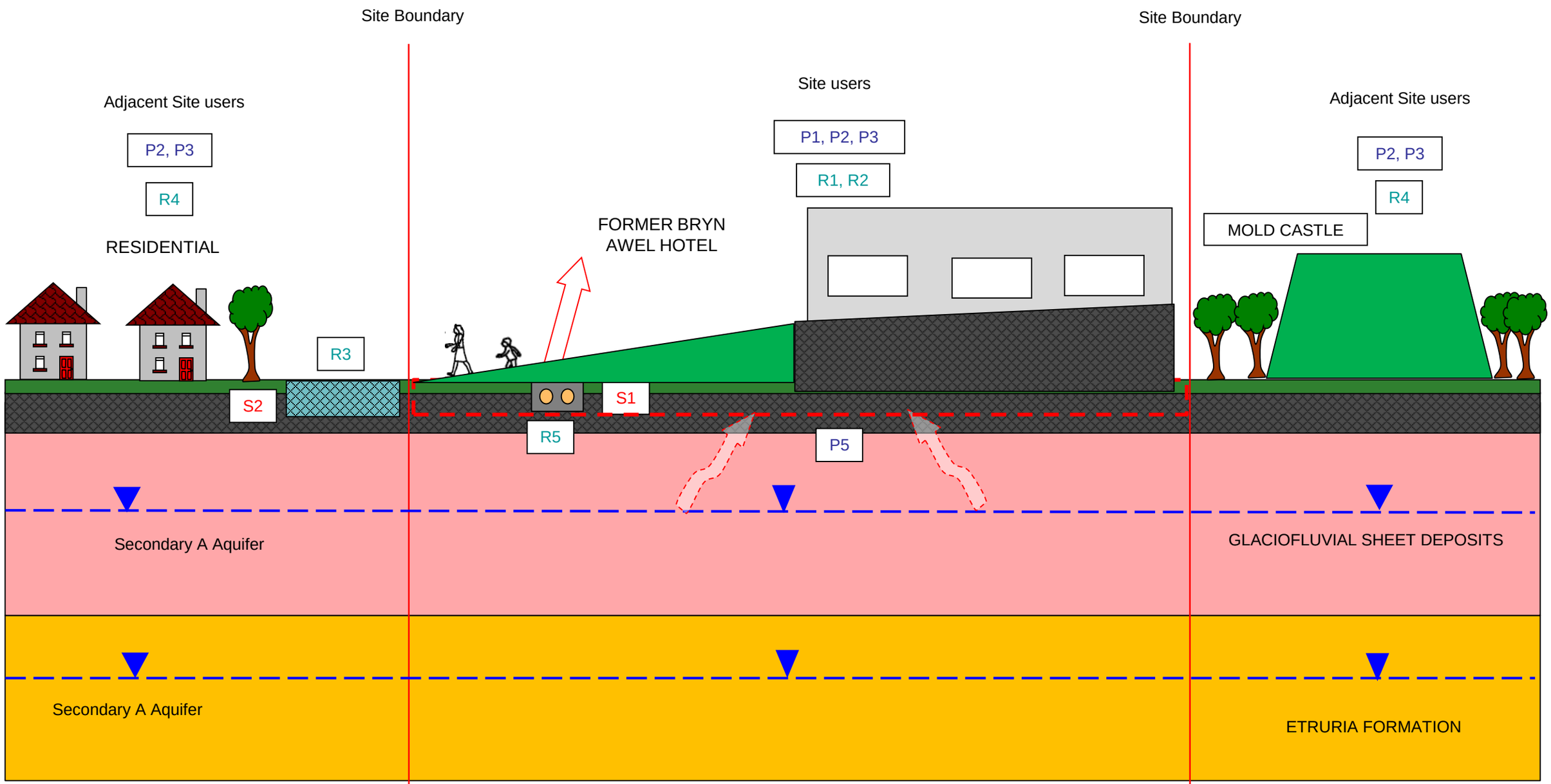
Ground gas migration

Leachate migration

Direct contact/ ingestion

Sutcliffe	Client: Anwyl Construction		
	Project: Bryn Awel Hotel		
	Title: Preliminary Conceptual Site Model (CSM)		
Purpose: Report	Draft		Scale (at A3)
	Issue	1	Not to scale
Issuing Office: Liverpool	Drawing number		Version
Telephone: 0151 227 3155	Fig 4.		A

Figure 4: Revised Conceptual Model



Key

S1 – Potentially Contaminated Soil – Onsite
S2 – Infilled Pond – Offsite

R1 Future site Users
R2 Construction Workers
R3 Controlled waters
R4 Adjacent Site Users
R5 Infrastructure & Buried services

P1 Direct Contact
P2 Ingestion
P3 Inhalation
P4 Leaching & Migration
P5 Vertical & lateral migration of ground gas

Infilled Land

Underground services

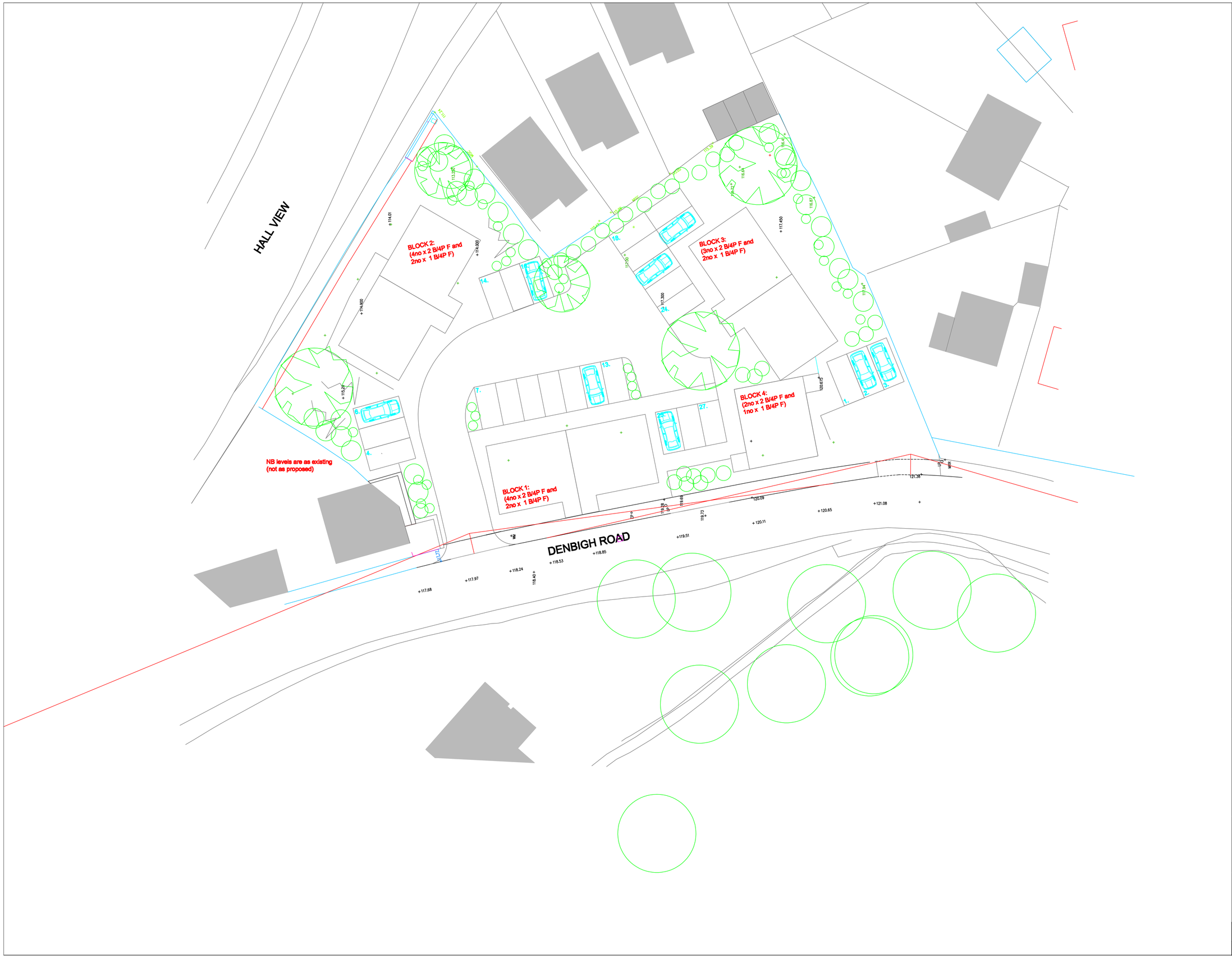
Ground gas migration

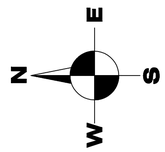
Leachate migration

Direct contact/ ingestion

Sutcliffe	Client: Anwyl Construction		
	Project: Bryn Awel Hotel		
	Title: Revised Conceptual Site Model (CSM)		
Purpose: Report	Draft		Scale (at A3)
	Issue	1	Not to scale
Issuing Office: Liverpool	Drawing number		Version
Telephone: 0151 227 3155	Fig 4.		A

Drawing No TEP / BA / SK 007 – Proposed Site Plan





Symbols/Abbreviations (Where Applicable):

AV:	AIR VALVE
BB:	BELISHA BEACON
BH:	BOREHOLE
BM:	BENCHMARK
BOL:	BOLLARD
B/S:	BUS STOP
CAM:	CAMERA
CS:	CABLE STAY
CATV:	C.A.T.V INSPECTION CHAMBER
CBOX:	ELECTRICITY BOX, CABLE BOX, ETC.
CCTV:	C.C.T.V CAMERA
C.PIT:	CATCH PIT
EP:	ELECTRICITY POLE
ER:	EARTH ROD
FH:	FIRE HYDRANT
FP:	FLAG POLE
G:	GULLY
G:	GULLY (ROUND)
GV:	GAS VALVE
IC:	INSPECTION COVER
IC:	INSPECTION COVER (ROUND)
IL:	INVERT LEVEL
KO:	KERB OUTLET
LB:	LETTER BOX
LC:	LIGHTING COLUMN
LP:	LAMP POST
LP/BS:	LAMP POST/BUS STOP
MH:	MANHOLE
MH:	MANHOLE (ROUND)
MKR:	MARKER
P:	POST
RE:	RODDING EYE
R/S:	ROAD SIGN
S/P:	SIGN POST
SNP:	STREET NAME PLATE
ST:	STOP TAP
SV:	STOP VALVE
TCB:	TELEPHONE CALL BOX
TL:	TRAFFIC LIGHT
TP:	TELEGRAPH POLE
TP/EP:	TELEGRAPH POLE/ELECTRIC POLE
WO:	WATER OUTLET
WM:	WATER METER
	GATE
	DEFINED POINT
	CONTROL POINT
	TREE (CONIFEROUS)
	TREE (DECIDUOUS)
	FOLIAGE
	HEDGE
SL 99.99m	SOFFIT LEVEL
EL 99.99m	EAVES LEVEL
RL 99.99m	RIDGE LEVEL
TL 99.99m	THRESHOLD LEVEL
DPC 99.99m	DAMP PROOF COURSE LEVEL

FENCE DESCRIPTIONS:

C/B:	CLOSE BOARDED FENCE
C/BARRIER:	CRASH BARRIER
C/P:	CHESTNUT PALING FENCE
CONC/P:	CONCRETE PANEL FENCE
I/R:	IRON RAILING FENCE
P/R:	POST AND RAIL FENCE
P/W:	POST AND WIRE FENCE
P/C:	POST AND CHAIN FENCE
S/PAL:	STEEL PALISADE FENCE
T/PAL:	TIMBER PALISADE FENCE
B/W:	BARBED WIRE FENCE

Revision Information

Rev	Date	Description

INFORMATION

1)
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NOTES

1) All co-ordinates are related to local grid.
2) All levels are related to O.S.B.M value: 123.76m

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Project

Site Layout
Flats Layout to DQR Space Standards
'Mount View'
(The Former Bryn Awel Hotel Mold CH7 1BL)

Project No	*Sheet:* A1	*Surveyed By:* —
	Scale: 1:200	*Drawn By:*
		Approved By:
Dwg TEP / BA / SK 007		*Issued:* 02/07/18

Drawing No 29982 – 700 – P1 – Existing Site Layout with Site Investigation Locations

DO NOT SCALE OFF THIS DRAWING

GENERAL NOTES

This drawing to read in conjunction with all relevant structural and architectural drawings and specifications.

All dimensions to be checked on site by the contractor / fabricator prior to commencement of works.

All dimensions are in millimetres unless stated otherwise.

All works to be carried out in strict accordance with the engineer's specifications, relevant British Standards and where applicable Local Authorities requirements.

For final setting out information relating to grid lines and wall positions refer to the architect's drawings.

Rev	Date	Checked	Description	By
P1	12.11.18	AT	PRELIMINARY ISSUE	DB

NOT WORKING DRAWING

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Client
ANWYL CONSTRUCTION

Project
BRYN AWEL HOTEL
DENBIGH ROAD
MOLD

Drawing title
SITE INVESTIGATION ON EXISTING LAYOUT

Scale at A3	NTS	Drawing number 29982-700
Drawn by	D.BOWEN	
Date	12.11.18	Revision suffix P1