

## Appendix A – Service Constraints Report Limitations & Planning Requirements

## **Service Constraints, Report Limitations & Planning Requirements**

This consultancy contract, report, and the site investigation (together comprise the "Services") were compiled and carried out by ByrneLooby Partners UK Limited (ByrneLooby) for the "client" (as detailed in Section 1.1 of the report) on the basis of a defined programme and scope of works and the terms of a contract between ByrneLooby and the "client." The Services were performed by ByrneLooby with all reasonable skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by ByrneLooby taking into account the limits of the scope of works required by the client, the prevailing site conditions, the time scale involved and the resources, including financial and manpower resources, agreed between ByrneLooby and the client. ByrneLooby Partners UK Limited cannot accept responsibility to any parties whatsoever, following the issue of this report, for any matters arising which may be considered out with the agreed scope of works.

Other than that, expressly contained in the above paragraph, ByrneLooby provides no other representation or warranty whether express or implied, is made in relation to the Services. Unless otherwise agreed this report has been prepared exclusively for the use and reliance of the client in accordance with generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon, or transferred to, by any other party without the written agreement of a Director of ByrneLooby. If a third party relies on this report, it does so wholly at its own and sole risk and ByrneLooby disclaims any liability to such parties.

It is ByrneLooby's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of, or reliance upon the report in those circumstances by the client without ByrneLooby's review and advice shall be at the client's sole and own risk.

The information contained in this report is protected by disclosure under Part 3 of the Environmental Information Regulations 2004 pursuant to the provisions of Regulation 12(5) without the consent in writing of a Director of ByrneLooby Partners UK Limited.

The report should be read in light of any subsequent changes in legislation, statutory requirements, and industry practices. Ground conditions can also change over time and further investigations, or assessment should be made if there is any significant delay in acting on the findings of this report. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of ByrneLooby. In the absence of such written advice of ByrneLooby, reliance on the report in the future shall be at the client's own and sole risk. Should ByrneLooby be requested to review the report in the future, ByrneLooby shall be entitled to additional payment at the then existing rate, or such other terms as may be agreed between ByrneLooby and the client.

The observations and conclusions described in this report are based solely upon the Services that were provided pursuant to the agreement between the client and ByrneLooby. ByrneLooby has not performed any observations, investigations, studies or testing not specifically set out or mentioned within this report. ByrneLooby is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, ByrneLooby did not seek to evaluate the presence on or off the site of electromagnetic fields or materials in buildings (i.e., materials inside or as part of the building fabric) such as asbestos, lead paint, radioactive or hazardous materials.

The Services are based upon ByrneLooby's observations of existing physical conditions at the site gained from a walkover survey of the site together with ByrneLooby's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The findings and recommendations contained in this report are based in part upon information provided by third parties, and whilst ByrneLooby Partners UK Limited have no reason to doubt the accuracy and that it has been provided in full from those it was requested from, the items relied on have not been verified. No responsibility can be accepted for errors within third party items presented in this report. Further ByrneLooby was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. ByrneLooby is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to ByrneLooby and including the doing of any independent investigation of the information provided to ByrneLooby save as otherwise provided in the terms of the contract between the client and ByrneLooby.

Where field investigations have been carried out these have been restricted to a level of detail required to achieve the stated objectives of the work. Ground conditions can also be variable and as investigation excavations only allow examination of the ground at discrete locations. The potential exists for ground conditions to be encountered which are different to those considered in this report. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and ByrneLooby based on an understanding of the available operational and historical information, and it should not be inferred that other chemical species are not present.

The groundwater conditions entered on the exploratory hole records are those observed at the time of investigation. The normal speed of investigation usually does not permit the recording of an equilibrium water level for any one water strike. Moreover, groundwater levels are subject to seasonal variation or changes in local drainage conditions and higher groundwater levels may occur at other times of the year than were recorded during this investigation.

Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site.

Throughout the report the term 'geotechnical' is used to describe aspects relating to the physical nature of the site (such as foundation requirements) and the term 'geo-environmental' is used to

describe aspects relating to ground-related environmental issues (such as potential contamination). However, it should be appreciated that this is an integrated investigation, and these two main aspects are inter-related. The geo-environmental sections are written in broad agreement with BS 10175:2011+A2 2017. For the geotechnical aspects of the report, the general requirements of Eurocode 7 (BS EN 1997-2:2007) are to produce a Ground Investigation Report (GIR) which shall form part of the Geotechnical Design Report (GDR). The geotechnical section of this report is intended to fulfil the general requirements of the GIR as outlined in BS EN 1997-2, Section 6. The GIR contains the factual information including geological features and relevant data, and a geotechnical evaluation of the information stating the assumptions made in the interpretation of the test results. This report shall not be considered as being a GDR.

### **Planning Requirements**

The National Planning Policy Framework (NPPF, 2019) emphasises the presumption in favour of sustainable development. Paragraph 11, which defines the presumption in favour of sustainable development, has two similar clauses which related to potentially contaminated land and sensitive receptors:

*11) Plans and decisions should apply a presumption in favour of sustainable development.*

*For **plan-making** this means that:*

*b) strategic policies should, as a minimum, provide for objectively assessed needs for housing and other uses, as well as any needs that cannot be met within neighbouring areas, unless:*

*i) the application of policies in this Framework that protect areas or assets of particular importance provides a strong reason for restricting the overall scale, type or distribution of development in the plan area;*

*For **decision-taking** this means:*

*d) where there are no relevant development plan policies, or the policies which are most important for determining the application are out-of-date, granting permission unless:*

*ii) the application of policies in this Framework that protect areas or assets of particular importance provides a clear reason for refusing the development proposed*

In accordance with the NPPF, areas or assets of particular importance are defined as:

*Habitats sites (and those sites listed in paragraph 176 – potential Special Protection Areas and Possible Areas of Conservation; listed or proposed Ramsar sites; and sites identified, or required, as compensatory measures for adverse effects on habitats sites, potential Special Protection Areas, possible Special Areas of Conservation, and listed or proposed Ramsar sites) and/or designated as Sites of Special Scientific Interest; land designated as Green Belt, Local Green Space, an Area of Outstanding Natural Beauty, a National Park (or within the Broads Authority) or defined as Heritage Coast; irreplaceable habitats; designated*

*heritage assets (and other heritage assets of archaeological interest referred to in footnote 63 (Non-designated heritage assets of archaeological interest, which are demonstrably of equivalent significance to scheduled monuments, should be considered subject to the policies for designated heritage assets.); and areas at risk of flooding or coastal change.*

Paragraph 118 states that planning policies and decisions should:

- *give substantial weight to the value of using suitable brownfield land within settlements for homes and other identified needs, and support appropriate opportunities to remediate despoiled, degraded, derelict, contaminated or unstable land;*

Paragraph 170 clarifies that enhancing the natural environment includes:

*Planning policies and decisions should contribute to and enhance the natural and local environment by:*

- *protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan);*
- *recognising the intrinsic character and beauty of the countryside, and the wider benefits from natural capital and ecosystem services – including the economic and other benefits of the best and most versatile agricultural land, and of trees and woodland;*
- *maintaining the character of the undeveloped coast, while improving public access to it where appropriate;*
- *minimising impacts on and providing net gains for biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures;*
- *preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and*
- *remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.*

Paragraph 180 of NPPF states that planning policies and decisions should ensure the following:

- *Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development.*

Paragraph 178 of NPPF states that planning policies and decisions for developments should also ensure that:

- a) a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);*
- b) after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and*
- c) adequate site investigation information, prepared by a competent person, is available to inform these assessments.*

Paragraph 179 states that where a site is affected by contamination or land stability issues, responsibility for securing a safe development rest with the developer and/or landowner.

This report has been prepared and authorised by staff that are competent as defined in the NPPF.

### **Unexploded Ordnance**

Clients have a legal duty under the CDM 2015 Regulations to provide designers and contractors with project-specific health and safety information needed to identify hazards and risks. This includes the possibility of unexploded ordnance (UXO) being encountered on the site. Further details are given in CIRIA Report C681 (Stone et al 2009). A non-UXO specialist screening exercise has been carried out for the site by considering any evidence of UK defence activities on or near the site evident from the gathered desk study information and the unexploded aerial delivered bomb (UXB) regional risk maps produced by Zetica. Other data sources are available, but as a first stage screening exercise the freely available Zetica maps have been used. The level of risk stated is that determined by Zetica, a company experience in the desk study, field investigation and clearance of UXO/UXB.

## Appendix B – Environmental Risk Assessment Methodology & Terminology

## **Environmental Risk Assessment Methodology & Terminology**

### **LEGISLATION OVERVIEW**

This report includes hazard identification and environmental risk assessment in line with the risk-based methods referred to in relevant UK legislation and guidance. Government environmental policy is based upon a “suitable for use approach,” which is relevant to both the current use of land and also to any proposed future use. The contaminated land regime is the statutory regime for remediation of contaminated land that causes an unacceptable level of risk and is set out in Part 2A of the Environmental Protection Act 1990 (“EPA 1990”). The main objective of introducing the Part IIA regime is to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health, or the wider environment given the current use and circumstances of the land. Part IIA provides a statutory definition of contaminated land under Section 78A(2) as:

“any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that:

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

or

b) Pollution of controlled waters is being, or is likely to be, caused.”

In order to assist in establishing if there is a “significant possibility of significant harm” there must be a “contaminant linkage” for potential harm to exist. That means there must be a source(s) of contamination, sensitive receptors present and a connection or pathway between the two. This combination of contaminant-pathway-receptor is termed a “contaminant linkage or CPR linkage.”

Part IIA of The Environmental Protection Act 1990 is supported by a substantial quantity of guidance and other Regulations. Key implementing legislation of the Part 2A regime includes the Contaminated Land (England) Regulations 2006 (SI 2006/1380) as amended by the overarching legislation for the contaminated land regime, which implements the provisions of Part IIA of the Environmental Protection Act 1990 (as inserted by section 57 of the Environment Act 1995), came into force on 14th July 2000 together with recent amended regulations: Contaminated Land (England) (Amendment) Regulations 2012 (SI 2012/263). Revised Contaminated Land Statutory Guidance was published by DEFRA in April 2012. Part IIA defines the duties of Local Authorities in dealing with it. Part IIA places contaminated land responsibility as a part of planning and redevelopment process rather than Local Authority direct action except in situations of very high pollution risk.

In the planning process guidance is provided by National Planning Policy Framework (NPPF) of July 2018 which requires that a site which has been developed shall not be capable of being determined “contaminated land” under Part IIA. In practice, Planning Authorities require sites being developed to have a lower level of risk post development than the higher level of risk that is required in order to determine a site as being contaminated in accordance with Part IIA. This is to ensure that there is a suitable zone of safety below the level for Part IIA determination and prevent

recently developed sites becoming reclassified as contaminated land if there are future legislative or technical changes (e.g., a substance is subsequently found to be more toxic than previously assessed this increases its hazard).

The criteria for assessing concentrations of contaminants and hence determining whether a site represents a hazard are based on a range of techniques, models and guidance. Within this context it is relevant to note that Government objectives are:

- a) to identify and remove unacceptable risks to human health and the environment;
- b) to seek to bring damaged land back into beneficial use;
- c) to seek to ensure that the cost burdens faced by individuals, companies and society as a whole are proportionate, manageable and economically sustainable.

These three objectives underlie the "suitable for use" approach to risk management and remediation of contaminated land. The "suitable for use" approach focuses on the risks caused by land contamination. The approach recognises that the risks presented by any given level of contamination will vary greatly according to the use of the land and a wide range of other factors, such as the underlying geology of the site. Risks therefore should be assessed on a site-by-site basis.

The "suitable for use" approach then consists of three elements:

- a) ensuring that land is suitable for its current use - in other words, identifying any land where contamination is causing unacceptable risks to human health and the environment, assessed on the basis of the current use and circumstances of the land, and returning such land to a condition where such risks no longer arise ("remediating" the land); the contaminated land regime provides the regulatory mechanisms to achieve this;
- b) ensuring that land is made suitable for any new use, as planning permission is given for that new use - in other words, assessing the potential risks from contamination, on the basis of the proposed future use and circumstances, before official permission is given for the development and, where necessary to avoid unacceptable risks to human health and the environment, remediating the land before the new use commences; this is the role of the town and country planning and building control regimes; and
- c) limiting requirements for remediation to the work necessary to prevent unacceptable risks to human health or the environment in relation to the current use or future use of the land for which planning permission is being sought - in other words, recognising that the risks from contaminated land can be satisfactorily assessed only in the context of specific uses of the land (whether current or proposed), and that any attempt to guess what might be needed at some time in the future for other uses is likely to result either in premature work (thereby running the risk of distorting social, economic and environmental priorities) or in unnecessary work (thereby wasting resources).

The mere presence of contaminants does not therefore necessarily warrant action, and consideration must be given to the scale of risk involved for the use that the site has and will have in the future.

**OVERALL METHODOLOGY**

The work presented in this report has been carried out in general accordance with recognised best practice as detailed in guidance documents such as in the EA online guidance: Land Contamination: Risk Management (LCRM) (Environment Agency, 2020), and BS10175:2011+A2 2017. Important aspects of the risk assessment process are transparency and justification. The particular rationale behind the risk assessments presented is given in this appendix.

The first stage of a two-staged investigation and assessment of a site is the Preliminary Investigation (BS 10175:2011), often referred to as the Phase 1 Study, comprising desk study and walk-over survey, which culminates in the Preliminary Risk Assessment. A preliminary conceptual site model (CSM) is developed which identifies potential geotechnical and geo-environmental hazards and the qualitative degree of risk associated with them. From the geo-environmental perspective, the Hazard Identification process uses professional judgement to evaluate all the hazards in terms of potential contaminant linkages (of contaminant source-pathway-receptor). Potential contaminant linkages are potentially unacceptable risks in terms of the current contaminated land regime legal framework and require either remediation or further assessment. These are normally addressed via intrusive ground investigation and generic risk assessment.

The second stage is the Ground Investigation, Generic Risk Assessment and Geotechnical Interpretation. This represents the further assessment mentioned above. The scope of the Ground Investigation is based on the findings of the Preliminary Risk Assessment and is designed to reduce uncertainty in the geotechnical and geo-environmental hazard identification. The Ground Investigation comprises fieldwork, laboratory testing and usually also on-site monitoring. The Ground Investigation may include the Exploratory, Main and Supplementary Investigations described in BS 10175:2011+A2 2017. The results of the Ground Investigation reduces uncertainty in the geotechnical and geo-environmental risks. Depending on the findings more detailed investigations or assessments may be required.

## **PRELIMINARY RISK ASSESSMENT**

Current practice recommends that the determination of potential liabilities that could arise from land contamination be carried out using the process of risk assessment, whereby “risk” is defined as:

- “(a) The probability, or frequency, or occurrence of a defined hazard; and
- (b) The magnitude (including the seriousness) of the consequences.”

The UK’s approach to the assessment of environmental risk is set out in by the Department of the Environment Transport and the Regions (2000) publication “A Guide to Risk Assessment and Risk Management for Environmental Protection” (also called Greenleaves II). This established an iterative, systematic staged process which comprises:

- a) Hazard identification;
- b) Hazard assessment;
- c) Risk estimation;
- d) Risk evaluation;
- e) Risk assessment;

At each stage during the development process, the above steps are repeated as more detailed information becomes available for the site.

For an environmental risk to be present, all three of the following elements must be present:

- Source/Contaminant: hazardous substance that has the potential to cause adverse impacts;
- Receptor: target that may be affected by contamination: examples include human occupants/users of site, water resources (rivers or groundwater), or structures;
- Pathway: a viable route whereby a hazardous substance may come into contact with the receptor.

The absence of one or more of each component (contaminant, pathway, receptor) would prevent a contaminant linkage being established and there would be no significant environmental risk.

The identification of potential contaminant linkages is based on a Conceptual Model of the site, which is subject to continual refinement as additional data becomes available. As part of a Preliminary Risk Assessment (Desk Study and site walk over) a Preliminary Conceptual Site Model (PCSM) is formed. Based on the PCSM, potential contaminant linkages can be assessed. If the PCSM and hazard assessment indicate that a contaminant linkage is not of significance then no further assessment or action is required for this linkage. For each significant and potential linkage, a risk assessment is carried out. The linkages which potentially pose significant risks may require a variety of responses ranging from immediate remedial action or risk management or, more commonly, further investigation and risk assessment. This next stage is termed a Phase II Main Site Investigation and should provide additional data to allow refinement of the Conceptual Site Model and assess the level of risk from each contaminant linkage.

## Definition of Risk Assessment Terminology

CIRIA Report C552, Contaminated Land Risk Assessment A Guide to Good Practice, 2001 sets out a methodology for estimating risk. The methodology for risk evaluation is a qualitative method for interpreting the output for the risk estimation stage of the assessment. It involves the classification of the:

- Magnitude of the potential consequence (severity) of risk occurring.
- Magnitude of the probability (likelihood) of the risk occurring.

The classification of consequence and probability are set out in table B1 and B2 below:

**Table B1 Classification of Consequence**

Classification	Definition	Examples
Severe (Sv)	Short term (acute) risk to human health likely to result in “significant harm” as defined by the Environment protection Act 1990, Part IIA. Short term risk of pollution of controlled waters. Catastrophic damage to buildings / property. A short-term risk to a particular ecosystem, or organism forming part of such ecosystem	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 (Md)	Chronic damage to Human Health (“significant harm”). Pollution of controlled waters. A significant change in a particular ecosystem, organism forming part such ecosystem.	Concentrations of contaminants from site exceeding generic or site-specific screening criteria. Leaching of contaminants into a major or minor aquifer. Death of species within a designated nature reserve.
Mild (Mi)	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures, and services. 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 (Mr)	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 measures such as 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 work. The loss of plants in a landscaping scheme. Discolouration of concrete.

The classification of consequence does not take into account the probability of the consequence being realised. Therefore there may be more than one consequence for a particular pollutant linkage. Both a severe and medium classification can result in death. Severe relates to short term (acute) risk while medium relates to long term (chronic) risk. Mild relates to significant harm but to

less sensitive receptors. Minor classification relates to harm which is not significant but could have a financial cost.

**Table B2 Classification of Probability**

Classification	Definition
High likelihood (Hi)	There is a pollutant linkage and an event that either appears very likely in the short term and almost inevitable in the long term, or there is evidence at the receptor or harm or pollution.
Likely (Li)	There is a pollutant 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 (Lw)	There is a pollutant 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 short term.
Unlikely (Ul)	There is a pollutant linkage, but circumstances are such that it is improbable that an event would occur even in the very long term.

The classification gives a guide as to the severity and consequence of identified risk when compared with other risk presented on the site. It should be noted that if a risk is identified it cannot be classified as “no risk” but as “very low risk”. Differing stakeholders may have a different view on the acceptability of a risk.

Once the consequence and probability have been classified these can be compared using a matrix (**Table B3**) to identify an overall risk category. These categories and the actions required are categorised in **Table B4**.

**Table B3 Risk Evaluation Matrix**

		Consequence			
		Severe (Sv)	Medium (Md)	Mild (Mi)	Minor (Mr)
Probability	High likelihood (Hi)	Very High Risk (VH)	High Risk (H)	Moderate Risk (M)	Mod/Low Risk (M/L)
	Likely (Li)	High Risk (H)	Moderate Risk (M)	Mod/Low Risk (M/L)	Low Risk (L)
	Low likelihood (Lw)	Moderate Risk (M)	Mod/Low Risk (M/L)	Low Risk (L)	Very Low Risk (VL)
	Unlikely (Ul)	Mod/Low Risk (M/L)	Low Risk (L)	Very Low Risk (VL)	Very Low Risk (VL)

**Table B4 Risk Categorisations**

<p>Very High Risk (VH)</p>	<p>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.</p>
<p>High Risk (H)</p>	<p>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.</p>
<p>Moderate Risk (M)</p>	<p>It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either 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.</p>
<p>Low Risk (L)</p>	<p>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.</p>
<p>Very Low Risk (VL)</p>	<p>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.</p>

## **GENERIC QUANTITATIVE RISK ASSESSMENT**

In the following sections the current UK guidance on risks to the following receptors are discussed: human health, plant life and controlled waters

### Human Health

The overall methodology for assessing the risk to human health from potential contaminants in soil is set out in the Environment Agency's guidance "Using Soil Guideline Values" SC050021/SGV Introduction, March 2009 and using the CLEA 1.06 model software (and CLEA 1.071 for nickel). The generic assessment criteria are in accordance with the following:

- Science Report SC050021/SR2: Human health toxicological assessment of contaminants in soil;
- Science Report SC050021/SR3: Updated technical background to the CLEA model;
- Science Report SC050021/SR4: CLEA Software (Version 1.071, 2014) & Handbook;
- Toxicological reports and SGV technical notes;
- Toxicological data published by LQM/CIEH (2009) and CL:AIRE/EIC/AGS (2009);
- DEFRA Development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010 (December 2013);
- LQM/CIEH Suitable 4 Use Levels (S4ULs) for Human Health Risk Assessment; and,
- Toxicology review published by the European Food Safety Authority for nickel (2015).

In March 2014 six 'proposed' Category 4 Screening Levels (pC4SL) were issued by Defra. These screening values are considered to be within Category 4 as defined in the Contaminated Land Statutory Guidance and indicate safe levels for new developments passing through the planning system. The SGV for lead has been withdrawn, and the pC4SL for lead has been derived using current best practice. In January 2015 LQM/CIEH published S4ULs for 89 contaminants in accordance with the C4SL methodology.

Note that groundwater contamination may pose a risk to human health but that there are no relevant generic assessment criteria available for comparison. ByrneLooby has derived our own assessment criteria for this.

### Phytotoxic Risks

Generic assessment of phytotoxicity is by comparison with guideline values presented in the British Standard for Topsoil and the MAFF document "Code of Good agricultural practice for the protection of soil", October 1998. This is in accordance with LCRM's reference to DEFRA notice CLAN 4/04.

### Controlled Waters

Risks to controlled waters (groundwater and surface waters) from contaminants are assessed in accordance with the EA documents "The Environment Agency's Approach to Groundwater Protection" (2017) and Remedial Targets Methodology (RTM, 2006). Pollutant inputs from

contaminated land sites are considered as passive inputs under the European Water Framework Directive (2000/60/EC) (WFD) and its daughter Directives, and as such are regulated under the Environment Agency's 'limit' pollution objective. Acceptable water quality targets (WQT) are defined for protection of human health (based on Drinking Water Standards (DWS)) and for protection of aquatic ecosystems (Environmental Quality Standards (EQS)). The risk posed to controlled waters from total soil concentrations cannot be directly assessed. The risk is assessed either by comparison of results of leachate tests carried out on soil samples, or from the direct testing of samples of groundwater to screening criteria. Leachate testing generally forms a conservative assessment and is not appropriate for organic contaminants.

## **CURRENT GUIDANCE ON INTERPRETATION OF CHEMICAL ANALYSIS OF SOILS**

Contaminated land is defined under law through Part IIA of the Environmental Protection Act 1990, implemented through Section 57 of the Environment Act 1995. This supports a 'suitable for use' based approach to the risk assessment of potentially contaminated land. The site-specific risk assessment is based upon assessment of plausible contaminant linkages, referred to as the contaminant-pathway- receptor model, based upon the current or proposed use of the site.

Before undertaking a risk assessment, a conceptual site model is devised in order to identify the potential contaminants, pathways and receptors. The individual contaminants, pathways and receptors then need to be further investigated in order to refine the initial assessment and risk assessment undertaken.

In March 2002, the Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency published the Contaminated Land Exposure Assessment (CLEA) Model and a series of related reports. These were designed to provide a scientifically based framework for the assessment of chronic risks to human health from contaminated land. These reports (CLR7-10) together with associated "SGV" documents were withdrawn and the following documents have been published as revised guidance to the CLEA assessment:

- Environment Agency : 2008: Using Soil Guideline Values SC050021/SGV Introduction, March 2008.
- Environment Agency : 2008: Science Report SC050021/SR2: Human health toxicological assessment of contaminants in soil.
- Environment Agency : 2008: Science Report SC050021/SR3: Updated technical background to the CLEA model.
- Environment Agency : 2008 : Compilation of Data for Priority Organic Contaminants for Derivation of Soil Guideline Values Science report SC050021/SR7
- Environment Agency : Science Report SC050021/SR4: CLEA Software (Version 1.071, 2015) & Handbook.
- DEFRA Development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010 (December 2013).
- LQM/CIEH Suitable 4 Use Levels for Human Health Risk Assessment.

Additional guidance on statistical assessment replacing CLR 7 is partly provided in:

- CL:AIRE: 2009: Guidance on Comparing Data With a Critical Concentration

A different approach to the statistical appraisal of data is required depending on whether the assessment of risk is to assess whether land is Contaminated Land in accordance with regulations, or whether the assessment is to assess whether the site is suitable for new development in according with Planning guidance. This is discussed further in CL:AIRE: 2009 "Guidance on Comparing Data With a Critical Concentration".

The introduction of the Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, 2012) reassessed the CLEA Model and the derived SGVs (and associated GACs calculated using the model). This re-assessment concluded that the SGVs/GACs were conservative screening criteria for determining the suitability of soil with regard to the risk to human health under the planning regime and defined a new upper limit for planning purposes which is the boundary between the new Category 3 and 4. In March and September 2014 DEFRA issued guidance on these new Category 4 Screening Levels (C4SL) and these are discussed further below.

### ***Soil Guideline Values***

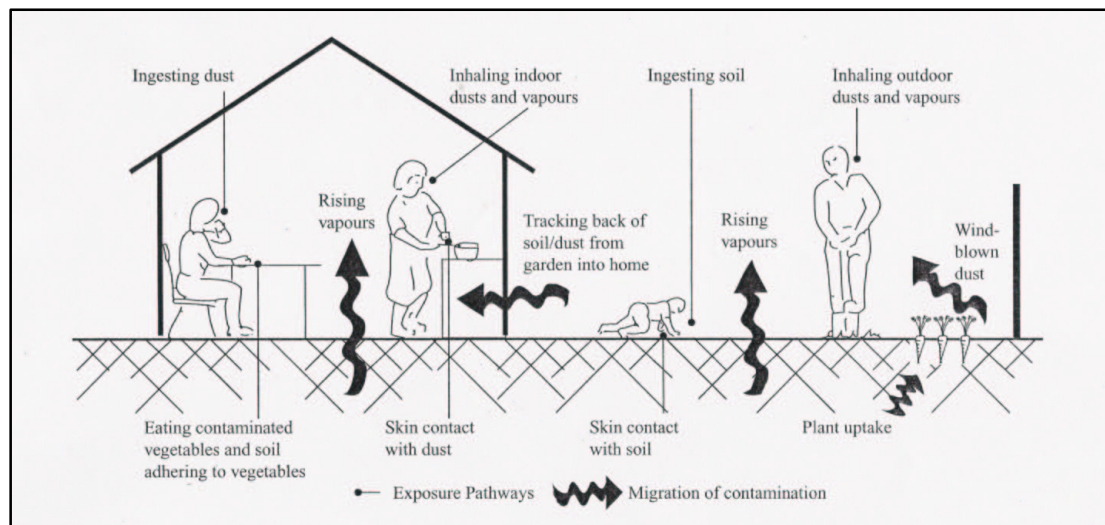
A program for the derivation of SGVs based on the above guidance is provided by the Environment Agency and is entitled “CLEA Software Version 1.06”. These reports, together with supporting toxicology reviews (“Tox” or Supplementary Information Reports) for individual substances (which will be gradually updated), Soil Guideline Value Reports and other guidance referred to in the above documents, provide guidance and the scientific basis for assessing the risk to human health from potential contaminants. Soil Guideline Value Reports (SGV Reports) have been published for a number of contaminants and these are published on the Environment Agency website. Eventually the reports will include SGVs for:

- heavy metals and other inorganic compounds: arsenic, cadmium, chromium, cyanide, lead (now withdrawn), mercury nickel (now withdrawn), and selenium;
- benzene, ethylbenzene, toluene, and xylenes;
- phenol;
- dioxins and dioxin-like polychlorinated biphenyls (PCBs);
- polycyclic aromatic hydrocarbons (PAHs) – 11 substances.

In September 2015, CLEA was re-issued as ‘CLEA Version 1.071’. Currently, the software has been used to produce an in-house GAC for nickel, following with withdrawal of the SGV.

In addition, CIEH through LQM and the EIC have published generic assessment criteria (GACs) for a wide variety of other parameters including metals, hydrocarbons, chlorinated aliphatic compounds, PAHs and explosive substances for three standard land uses. These have been produced to supplement the Environment Agency guidance. These GACs will be replaced by SGVs when or if the Environment Agency publishes any more SGVs.

The CLEA model has been developed to calculate an estimated tolerable daily soil intake (TDSI) for site users given a set ‘default’ exposure pathways. Ten human exposure pathways are covered in the CLEA model as presented below:



- Ingestion:
  - ingestion of outdoor soil;
  - ingestion of indoor dust;
  - ingestion of home-grown vegetables;
  - ingestion of soil attached to home grown vegetables.
- Dermal Contact:
  - dermal contact with outdoor soil;
  - dermal contact with indoor dust.
- Inhalation:
  - inhalation of outdoor dust;
  - inhalation of indoor dust;
  - inhalation of outdoor soil vapour;
  - inhalation of indoor soil vapour.

It should be noted that there are other potential exposure pathways on some sites not included in the CLEA model e.g., certain organic compounds can pass through plastic water pipes into drinking water supply.

The presence and/or significance of each of the above exposure pathways are dependent on the type of land use being considered and the nature of the contaminant under scrutiny. Accordingly, the CLEA model considers for principle 'default' land use types and makes a series of 'default' assumptions with regard to human exposure frequency, duration and critical human target groups for each land use considered:

- residential land use;
- allotments;
- commercial and industrial land use.

The land use categories defined in the CLEA are detailed below.

**Residential:** This land use category assumes that people live in a variety of dwellings including terraced, detached and semi-detached houses up to two storeys high. The structure of buildings varies. Default parameters for building materials and building design are included in CLEA documents to calculate the relevant multi-layer diffusion coefficients for vapour intrusion and to model indoor vapour intrusion. The CLEA model assumes that regardless of the style of housing the residents will have access to either a private garden or community open space nearby, and that soil tracked into the home will form indoor dust. It allows for the ingestion pathways from home grown vegetables.

**Allotments:** The CLEA model incorporates an assessment of land provided by local authorities specifically for people to grow fruit and vegetables for their own consumption. Consumption of such fruit and vegetables present several exposure pathways; plants absorb contaminants mainly via water uptake through roots, the contaminants move to edible portions of plants via translocation and contaminated soil particles become trapped in the skin and between leaves. At present the model fails to account for exposure through the consumption of animals, and their products (e.g., eggs), which have been reared on contaminated land.

**Commercial/Industrial:** Although there are a wide variety of workplaces and work-related activities, the CLEA assessment of this land-use assumes that work occurs in a permanent, three-storey structure, where employees spend most time indoors, conducting office-based or light physical work. The model assumes employees sit outside during breaks for most of the year. Limitations in applying this land-use to different industries is detailed in EA publication “Updated technical background to the CLEA model” (2011). The generic model assumes that the site would not be covered by hard standing. Risk of exposure to contaminants would be clearly less where commercial land is essentially all buildings and hard standing.

Based on the assumptions of each land use and the associated applicable exposure pathways, a ‘Soil Guideline Value’ (SGV) may be calculated for each contaminant under consideration for a particular land use in order to determine whether certain contaminant soil concentrations pose a significant risk to human health. The primary purpose of the CLEA SGVs are as ‘trigger values’ – indicators to a risk assessor that soil concentrations below this level require no further assessment as it can be assumed that the soil is suitable for the proposed use. Where soil concentrations occur above the SGV then further assessment of the results is required. The Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, 2012) which came into force in early April 2012 provides new clarity on the assessment of risk where soil concentrations exceed the SGV. The guidance introduces a four-stage classification system relating to concentration of contaminants and the assessed risk which indicates appropriate actions. Category 1 and 2 sites are classified as “Contaminated Land” as defined in Part IIA of The Environmental Protection Act (1990). Category 3 and 4 sites are not considered as “Contaminated Land” in accordance with the Act. This can be explained using the figure on the following page.

There are also difficulties in establishing soil concentrations of contaminants beyond which risks from exposure to these contaminants would be ‘unacceptable’ and that they would lead to “significant possibility of significant harm” as defined in Part IIA of The Environmental Protection Act (1990) and determine that the land is “contaminated.” This ultimately requires detailed ‘toxicological’ information of the health effects of individual contaminants and also a scientific judgement on what constitutes an ‘unacceptable’ risk. It is for local authorities or the

Environment Agency to determine whether a particular site is contaminated land, and it is for local Planning Authorities to determine whether land affected by contamination can be redeveloped.

Given the SGVs have been derived only for a limited number of contaminants and there was little prospect of further SGVs being published, two professional groupings have produced Generic Assessment Criteria (GACs) in accordance with the CLEA model for a large number of additional contaminants. These GACs were recognised in the new Contaminated Land Statutory Guidance (DEFRA, 2012) and have been produced as follows:

- *LQM/CIEH : 2009 Nathaniel CP, McCaffrey C, Ashmore MH, Cheng NPS GROUP, Gillett A, Ogden R & Scott D : 2009 . The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2<sup>nd</sup> edition). Land Quality Press, Nottingham.*
- *CL:AIRE/EIC/AGS: 2009 : Soil Generic Assessment Criteria (GAC) for Human Health Risk Assessment. Contaminated Land: Applications in Real Environments, Environment Industries Commission & Association of Geotechnical and Environmental Specialists. December 2009.*

#### ***Category 4 Screening Levels and LQM/CIEH Suitable 4 Use Levels***

For new developments progressing through the planning regime, it is desirable that the soil concentrations are within Category 4 where there is a valid contaminant linkage. The upper boundary between Category 4 and 3 is not defined in the guidance. This boundary can also be better defined by carrying out a Detailed Quantified Risk Assessment (DQRA) and this is discussed later in this appendix.

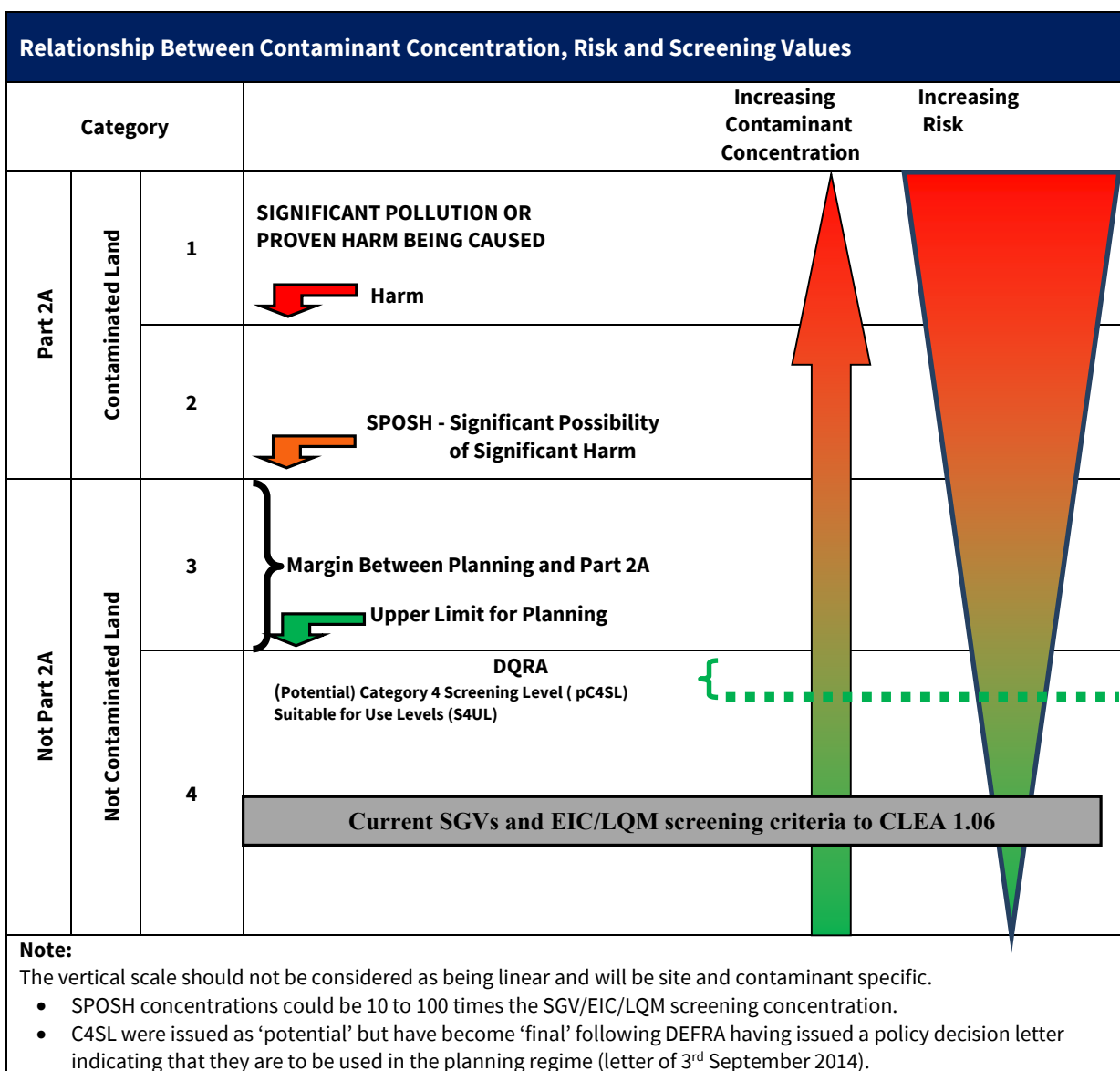
In December 2013 Defra issued the findings of a research project undertaken by CL:AIRE to set out the framework by which potential Category 4 Screening Levels (pC4SL) may be derived. The report was not designed to produce 'final' C4SL as the steering group producing the report believes that final C4SL should be set by a 'relevant authority' (e.g., Defra), the toxicological framework proposed has not been reviewed by the Committee on Toxicity and the document has yet to be subject to peer review.

In March 2014, appendices to the main Defra report were published detailing the derivation of pC4SL for 6 contaminants and other appendices regarding a review of the CIEH/CL:AIRE statistics guidance and sensitivity analysis. For each contaminant, a range of pC4SL have been produced relating to modifying toxicological parameters only, modifying exposure parameters only or by modifying both. It should be noted that the pC4SL produced for lead (the SGV was withdrawn in 2011) has undertaken a relatively large toxicological review in relation to modelling blood lead concentrations. pC4SL have been produced for:

- Arsenic;
- Benzene;
- Benzo(a)pyrene (as a surrogate marker for PAHs);
- Cadmium;
- Chromium (VI); and
- Lead

As previously discussed the values were initially published as 'potential' C4SL but have become 'final' following DEFRA having issued a policy decision letter indicating that they are to be used in the planning regime (letter of 3<sup>rd</sup> September 2014). It is considered that the pC4SL provide a

simple test for deciding whether land is suitable for use without any remediation. The pC4SL represent a new set of screening levels that are more pragmatic (but strongly precautionary) compared to the existing soil guideline values (SGVs and the other GACs calculate in accordance with the existing CLEA methodology). The pC4SL provide cautious estimates of contaminant concentrations in soil that are still considered to present an acceptable level of risk, within the context of Part 2A, by combining information on toxicology, exposure assessment and normal levels of exposure to these contaminants. pC4SL values should not be seen as ‘SPOH values.’ Exceeding a pC4SL means that further investigation is required, not that the land is necessarily contaminated. In January 2015, LQM published Suitable 4 Use Levels (S4ULs) for a further 89 contaminants using the Defra C4SL methodology. In a similar manner to the pC4SLs, no authoritative review has been undertaken although the approach and quality of the work undertaken is widely accepted as being of high quality.



**Lead:**

The SGV for lead was withdrawn in 2011 and is not used in this report. The pC4SL for lead provides a technically robust and conservative assessment tool using significantly updated toxicological modelling in line with current scientific understanding of lead toxicology.

**Nickel**

The SGV for nickel was withdrawn in 2015 and is not used in this report. In-house GACs for nickel have been produced using the updated toxicological review by the EFSA and the CLEA 1.071 software.

**Public Open Space**

The Defra report (December 2013) has also introduced exposure scenarios for two other commonly occurring land uses which require assessment (under the planning and Part 2A regimes) on a relatively frequent basis. These exposure scenarios are:

- Public Open Space – Space Near Residential Housing (POS<sub>resi</sub>); and,
- Public Open Space – Public Park (POS<sub>park</sub>).

Potential use of pC4SL relating to Public Open Space (POS) require care due to the significant variability in exposure characteristics. For example, POS may include:

- Children's play areas, public parks where children practise sport several times a week and teenagers only once a week;
- Grassed areas adjacent to residential properties which are rarely used;
- Dedicated sports grounds where exposure is only to players and groundworkers; and,
- Nature reserves or open ground with low level activity (for example, dog walking).

Within the Defra report (December 2013) the following exposure scenarios have been modelled as these are considered the most important for potential exposure for the critical receptor i.e., young children:

- Green open space close to housing, including tracking back of soil (POS<sub>resi</sub>); and
- Park-type scenario where distance is considered sufficient to discount tracking back of soil (POS<sub>park</sub>).

**Detailed Quantified Risk Assessment (DQRA)**

SGVs, GACs, pC4SL and S4ULs are based on a number of basic assumptions. There are two main options for developing Site Specific Assessment Criteria (SSAC) by adjusting the CLEA model so that they have greater relevance to the site:

- **Simple adjustment of the generic SGV / C4SL model.** Such adjustment is restricted to the choice of exposure routes selected for the generic land use, building type, soil type and soil organic matter content within the CLEA software.
- **Detailed adjustment.** It may be relevant to make greater modifications to the model due to the specific use of the land in question. This can include modification to any parameter value, including exposure assumptions, building parameters, and the choice and application of fate and transport models. This is equally relevant to site-specific modifications of existing generic land uses, the development of new land uses, and the inclusion of additional exposure pathways. Much of this can be undertaken using the CLEA software. Depending on the complexity of the detailed adjustments required, it may be necessary to use other tools either alone or in conjunction with the CLEA software. Both options should follow established protocols for DQRA and require sufficient justification and supporting information for the adjustments made. Detailed adjustments are likely to require substantially greater technical justification and supporting documentation, especially if modifications are based on information not contained within the SGV framework documents.

The two choices present the risk assessor with three options/decisions:

1. Use a published SGV/GAC/pC4SL/S4UL if it can be demonstrated that the assumptions inherent in the value are appropriate to the site in question. If they are not, proceed to either option 2 or 3 below.
2. Make simple site-specific adjustments to the generic exposure model used to derive the SSAC. Three examples of when this could be appropriate are:
  - a. High density residential development with no exposed contaminated soil at surface. It is appropriate in this case to consider the relevance of direct contact pathways and consumption of homegrown produce.
  - b. Soil type is significantly different (specifically when soil type is likely to be less protective e.g., made ground) to that assumed in the SGV/GAC/pC4SL/S4UL.
  - c. Soil organic matter content is significantly different to that assumed in the derivation of the SGV/GAC/pC4SL/S4UL.
3. If simple adjustments are not sufficient to reflect site conditions, undertake a DQRA. This may be undertaken using the CLEA software or by using an alternative risk assessment methodology that is relevant, appropriate, authoritative, and scientifically based. Changes to toxicological end points may also be considered, although this should only be undertaken by a toxicology expert. In the context of this guidance, simple adjustments of a generic land use scenario for soil type or SOM content for example are not considered sufficient to be classed as a DQRA.

DQRAs should be conducted with the agreement of the local authority (or the Environment Agency) since it is the authority that determines whether land is Contaminated Land or whether Planning Permission for a new development may be granted.

### **Representative Data**

The type, quantity and quality of the available soil data influence the method chosen to obtain a site representative soil concentration that is compared with an SGV/GAC/pC4SL/S4UL in the screening process. The soil data should be representative of the exposure scenario being considered. This can include factors such as:

- Averaging area over which exposure occurs;
- Sample depth; and,
- Heterogeneity of soil.

where the 'averaging area' is defined as:

*“That area (together with a consideration of depth) of soil to which a receptor is exposed or which otherwise contributes to the creation of hazardous conditions”.*

Site investigations take discrete samples from a given area (and to a certain depth). It has to be assumed that these samples are to some degree representative of the contaminant concentration throughout that volume of soil. The critical soil volume (taking into account area and depth) which might be usefully compared with an SGV/GAC/pC4SL/S4UL is a site-specific decision, but a starting point is the generic land use scenarios used in the derivation of the SGV/GAC/pC4SL/S4UL. The critical soil volume depends on two factors:

- Contaminant distribution and vertical profile (bands of highly contaminated material or lateral hot spots should not necessarily be averaged out with more extensive cleaner areas of soil without justification)
- Contribution to average exposure underpinning the SGV. Direct contact exposure pathways depend on the adult or child coming into contact with near-surface soils and the area over which that exposure occurs is usually important (i.e., the averaging area). Vapour pathways are less dependent on surface area, for example vapour intrusion may result from a highly concentrated hot spot beneath a building leading to elevated average indoor air concentrations. For the three standard land uses for which SGVs are derived, relevant considerations are:
  - For the standard **residential or allotment land use**, the critical soil volume is the area of an individual garden, communal play area or working plot from the surface to a depth of between 0.50m and 1.00m. This is the ground over which children are most likely to come into contact with soil or from which vegetable and fruit produce will be harvested. In the case of volatile contaminants, it may also be appropriate to consider the volume of soil underneath the footprint of the building although vapour intrusion may be driven by a soil volume much smaller than this if the contaminant source is highly concentrated.
  - For the standard **commercial land use**, the critical soil volume has to be decided on a case-by- case basis due to the wide range of possible site layouts. However, for non-volatile contaminants, landscaped and recreational areas around the perimeter of office buildings are likely to be most important. For volatile contaminants, the footprint occupied by the building itself should also be considered.

- For **most exposure pathways**, the contamination is assumed to be at or within one metre of the surface.

The use of averaging areas must be justified on the basis of relevance to the exposure scenario. SGVs are relevant only when the exposure assumptions inherent in them are appropriate for the identified exposure averaging area. Further guidance on critical soil volumes and the consideration of averaging exposure areas can be found in:

- *Secondary model procedure for the development of appropriate soil sampling strategies for land contamination (Environment Agency, 2000);*
- *Guidance on comparing soil contamination data with a critical concentration (CIEH/CL:AIRE, 2009); and*
- *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Appendix I (Defra December 2013, March 2014)*

It is the mean soil concentration for the individual contaminant within an individual averaging area, which is compared to the SGV. However, as contaminant concentrations vary across a site, and sampling and analysis will introduce measurement errors, the comparison between measured mean concentration and the SGV must take this uncertainty into account.

There are two principal options available to obtain site representative soil concentrations from a site investigation dataset; statistical and non-statistical methods. Data objectives, quality and quantity are likely to determine which approach is most appropriate. If statistical methods such as those presented in CIEH/CL:AIRE (2011) are to be used, sufficient data need to be available or obtained. No one single statistical approach is applicable to all sites and circumstances. The wider range of robust statistical techniques developed by organisations including the US Environmental Protection Agency (USEPA) are also important tools. Risk assessors should choose an appropriate statistical approach on the basis of the specific site and the decision that is being made. For further guidance on the appropriate use of statistical approaches, refer to USEPA 2006 or good environmental monitoring statistics textbooks.

When statistical approaches are inappropriate (this will depend on the objectives of the site investigation), individual or composite samples should be compared directly to the SGV. Guidance on use of alternative data handling approaches such as the use of composite sampling can be found in documents such as:

- *Verification of remediation of land contamination (Environment Agency, 2010);*
- *Sampling and testing of wastes to meet landfill Waste Acceptance Criteria (Environment Agency, 2005);*
- *Guidance on choosing a sampling design for environmental data collection (USEPA, 2002); and,*
- *Soil Quality – Sampling, ISO 10381 series (ISO, 2002–2007).*

The statistical tests should not be used as arbiters for decisions under Part 2A. They are an additional, useful line of evidence to assist in decision-making. The implications of the basis for the derivation of the site representative soil concentration must be taken into account in any decision-making process and clearly documented.

Where the statistical tests are conducted in accordance with the method described in CL:AIRE 2009:

- For the Planning situation, it has to be demonstrated that the concentration of contaminants is low compared to the pC4SL/S4UL or SSAC. All of the test data should be below the screening criteria and no statistical analysis is required or if there are exceedances of the criteria then a statistical assessment is required. For the statistical assessment this decision is based on whether there is at least a 95% confidence level that the true mean of the dataset is lower than the screening criteria.
- For the Part 2A scenario the regulator needs to determine whether the concentration of contaminants is greater than the SGV/GAC/pC4SL/S4UL or SSAC. This decision is based on whether there is at least a 95% confidence level that the true mean of the dataset is higher than the SSAC. However, the regulator may proceed with determination if there is just a 51% probability, “on the balance of probabilities.”

If the screening levels are exceeded then more sophisticated quantitative risk assessment can be undertaken or remedial action may be taken to break the contaminant linkages. The benefits of undertaking a quantitative risk assessment must be weighed against the likelihood that it will bring about cost savings in the proposed remediation. Further information about the use of soil guideline values is provided in Environment Agency : 2008: Using Soil Guideline Values SC050021/SGV Introduction, March 2008.

## **GENERIC RISK ASSESSMENT CRITERIA FOR RISK TO PLANTS**

Soil contaminants, if present at sufficient concentrations, can have an adverse effect on the plant population. Phytotoxic effects can be manifested by a variety of responses, such as growth inhibition, interference with plant processes, contaminant-induced nutrient deficiencies and chlorosis (yellowing of leaves). All chemicals are probably capable of causing phytotoxic effects. Thus, the phytotoxic potential of substances is dependent on the concentrations capable of having adverse effects on plants and the concentrations likely to be found at contaminated sites. Phytotoxicity is a difficult parameter to quantify given that experimental techniques vary widely, and variations exist in plant tolerances, soil effects and synergistic/antagonistic reactions between chemicals. Contaminants may be taken up and accumulated by plants through a range of mechanisms. The principal pathways are active and/or passive uptake through the plant root, adsorption to root surfaces and volatilisation from the soil surface followed by foliar uptake. After plant uptake, contaminants may be metabolised or excreted, or they may be bioaccumulated and this is highly species dependant. Many of the substances capable of adversely affecting vegetation exert this effect because of their water solubility, a characteristic that could result in their transport from contaminated sites into adjacent locations where the chemical may generate a phytotoxic response. This could be important if, for example, the adjacent site has important conservation status.

The concentration in soil at which substances become phytotoxic depend on a range of factors including plant type, soil type, pH, the form and availability of the contaminant and other vegetation stress factors that may be present (such as drought). Some plants (including some rare plants) will only grow in soils where there are relatively high concentrations which would be phytotoxic to other species. Whilst many contaminants may be phytotoxic, data are limited. Some heavy metals are essential as trace elements for plant growth but may become toxic at higher concentrations.

ByrneLooby has carried out a review of a number of current and former guidance documents and other texts on phytotoxicity. It is not possible to produce a definitive list of phytotoxic substances on account of the variables mentioned above. However, a number of metals are repeatedly cited as commonly occurring priority pollutants. As a result, the following list is adopted by ByrneLooby as indicators of the potential for phytotoxicity: As, Cr, Cu, Ni and Zn (note that Boron has been excluded from this list because the more modern studies do not assess this).

As the CLEA framework is a risk-based approach, applied to humans, an alternative strategy is required to assess the risk to plants from substances that are phytotoxic. Reference to published criteria and background concentrations can help put site data into context. Published assessment criteria for the protection of plant life from a number of countries are given in the following Table. The most authoritative source is the British Standard for topsoil, but this only lists three elements. LCRM states that the ICRL Guidance Note 70/90 can be used for initial screening criteria. This approach has been adopted by ByrneLooby where BS3882 is lacking, but where an ICRL 70/90 criterion is lacking, the lowest criterion in Table below from, firstly UK, and, secondly, European and then other worldwide criteria. The adopted criteria are highlighted in the table 3.8. The MAFF value of 250 mg/kg has been chosen for As over the ICRL value of 50 mg/kg as MAFF explains the 50 is applicable to vegetables and human health, whereas 250 is applicable to the plants themselves.

**Table B.5: Published Assessment Criteria for Phytotoxic Elements (mg/kg)**

Reference	As	CR (Total)	Cr (III)	Cr (VI)	Cu	Ni	Zn
British Standard for topsoil (BS3882:2007)	-	-	-	-	200 (pH >7)	110 (pH >7)	300 (pH >7)
					135 (pH 6-7)	75 (pH 6-7)	200 (pH 6-7)
					100 (pH 5.5-6.0)	60 (pH 5.5-6.0)	200 (pH 5.5-6.0)
MAFF Code of Good Agricultural Practice for the Protection of Soil (1998)	250	-	400 for sites containing sewage and sludge	-	500 (grass) but may fall to 250 for clover and sensitive species (at pH >6)	110 (pH >7) 75 (pH 6-7) 60 (pH 5.5-6.0)	1000 (clover & grass at pH 6), may fall to 300 for sensitive species (at pH 6-7)
ICRCL 59/83 (1987) now withdrawn for human health assessment	-	-	-	-	130	70	300
ICRCL 70/90 (1990) threshold trigger value	50	-	-	25 *	250	-	1000
Dutch ecotoxicological intervention value (Swartjes 1993 & 1994)	40	230	-	7	190	-	-
Australian Guideline B(1) (1999), Interim Urban Ecological Investigation Level (EIL). Soils not generally considered phytotoxic below these EILs.	20	-	400	1	100	60	200
New Zealand guidelines for timber treatment sites (1977), estimated based on Cu bioavailability *	-	-	-	-	500 - 1000 clay soils	-	-
New Zealand guidelines for timber treatment sites (1977), soil criteria for protection of plant life (residential/ agricultural setting)	10-20	-	600	25	130	-	-
<b>Note:</b> * Cr (VI) is only likely to be present in as a significant proportion of total Cr where pH >12 so this does not routinely need to be tested for regarding plant health.							

## CURRENT GUIDANCE FOR CONTROLLED WATERS RISK ASSESSMENT

### Summary of Regulatory Context

Government policy is based upon a “suitable for use approach,” which is relevant to both the current use of land and also to any proposed future use. When considering the current use of land, Part IIA of the Environment Protection Act 1990 <sup>[4]</sup> (EPA 1990) provides the regulatory regime, which was introduced by Section 57 of the Environment Act 1995 <sup>[5]</sup>, which came into force in England on 1 April 2000. The main objective of introducing the Part IIA regime is to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health, controlled waters or the wider environment given the current use and circumstances of the land. Part IIA provides a statutory definition of contaminated land under Section 78A(2) as:

*“any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that:*

- a) *Significant harm is being caused or there is a significant possibility of such harm being caused; or,*
- b) *Pollution of controlled waters is being, or is likely to be, caused.”*

Part IIA provides a statutory definition of the pollution of controlled waters under Section 78A(9) as:

*“the entry into controlled waters of **any** poisonous, noxious or polluting matter or **any** solid waste matter”*

Part IIA is supported by a substantial quantity of guidance and other Regulations, especially for England, The Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, 2012) which came into force in early April 2012. The document re-confirms the duties of Enforcing Authorities in dealing with contamination including the role of the Environment Agency which has powers under Part 7 of The Water Resources Act (1991) to take action to prevent or remedy the pollution of controlled waters, including circumstances where the pollution arises from contamination in the land.

Part IIA introduces the concept of a contaminant linkage; where for potential harm to exist, there must be a connection between the source of the hazard and the receptor via a pathway. Risk assessment in contaminated land is therefore directed towards identifying the contaminants, pathways and receptors that can provide contaminant linkages. This is known as the contaminant-pathway-receptor link (CPR or contaminant linkage).

Part IIA places contaminated land responsibility as a part of the planning and redevelopment process rather than Local Authority or Environment Agency taking direct action except in situations of very high pollution risk or where harm is occurring. In the planning process guidance is provided by National Planning Policy Framework (NPPF) of March 2012. This requires that a site which has been developed shall not be capable of being determined “contaminated land” under Part IIA. Therefore, appropriate risk-based investigation is required to identify the contaminant

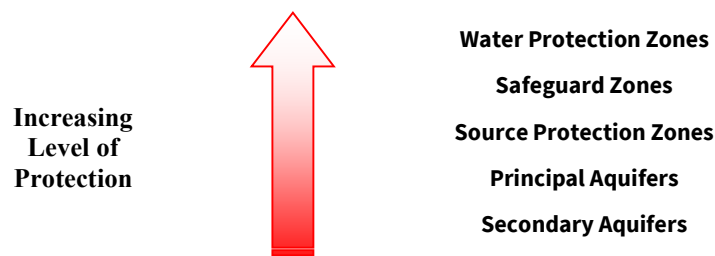
linkages that can then be assessed, and then mitigated using methods that can be readily agreed with the planners.

## **Environment Agency Guidance**

Legislation and guidance surrounding the protection of controlled waters in the UK is numerous and can be complex. The Environment Agency’s overall position on groundwater is “*To protect and manage groundwater resources for present and future generation in ways that are appropriate for the risks that we identify*” (The Environment Agency’s Approach to Groundwater Protection, 2017). In brief, the core objectives of the existing legislation serve to enforce this position.

In 1992, the National Rivers Authority published their Policy and Practice for the Protection of Groundwater (PPPG), this document was influential as it provided a focus for key developments such as Source Protection Zones (SPZs) and Groundwater Vulnerability Maps. The Policy was then revised in 1998, since which there have been substantial changes in legislation, driven by Europe. Key European Directives relating to groundwater include the Groundwater Directive (80/68/EEC) and the Water Framework Directive (2000/60/EC). Aspects of these directives are controlled by primary UK legislation such as the Water Resources Act 1991 as amended by the Water Act 2003. Further to legislative changes, gaps identified in the 1998 PPPG required addressing. These changes are reflected in the Environment Agency Policy document *The Environment Agency’s Approach to Groundwater Protection* of March 2017.

The Environment Agency follows a tiered, risk-based approach to drinking water protection, and this should be taken into account when carrying out controlled waters risk assessment:



## **Tools available for Risk Assessment of Controlled Waters**

In order for a developer of a potentially contaminated site to fulfil their obligations under the legislation, a site assessment would be required to be undertaken in order to identify any potential risks to controlled waters and to derive suitable clean-up criteria if necessary to ensure the protection of controlled waters. A number of tools are available for this purpose.

Three main stages apply to any risk assessment of controlled waters, these are:

- i. Risk Screening (devise Conceptual Site Model, making reference to groundwater vulnerability maps, site setting etc)
- ii. Generic Risk Assessment (using the EA Remedial Targets Methodology – Tier 1 - Comparison of groundwater data with relevant standards)
- iii. Detailed Quantitative Risk Assessment (Consideration of aquifer properties and site-specific parameters, using the EA Remedial Targets Methodology - Tiers 2 & 3)

The process is summarised below (Taken from the Environment Agency GP3 consultation document, 2006):

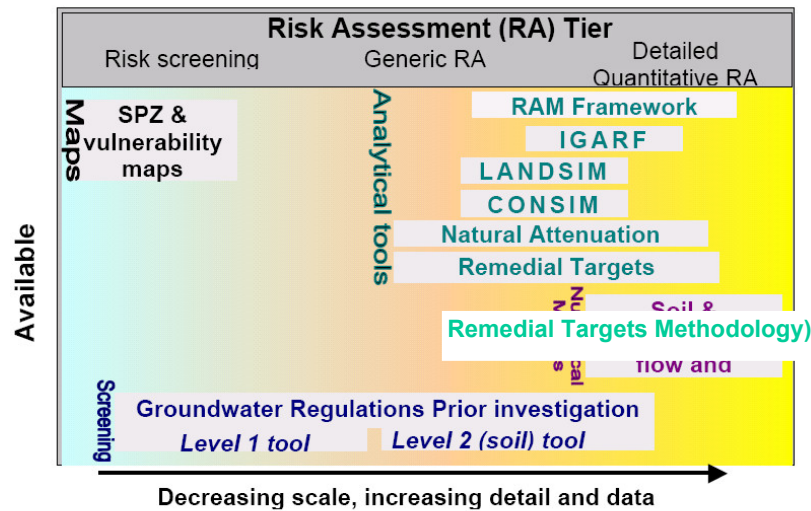


Figure 1-1 Environment Agency groundwater assessment tools, mapped against the different levels of risk assessment.

When assessing groundwater impact the Environment Agency advocate the application of their framework methodology “Remedial Targets Methodology – Hydrogeological Risk Assessment for Land Contamination” Environment Agency (2006). The methodology has four tiers of assessment:

**Tier 1** utilises either a soil concentration (calculation of pore water concentrations based on partitioning calculations), leaching test or pore-water concentration of perched water as a source concentration input and these are contrasted directly to water quality standards. No dilution or attenuation is considered at Level 1.

**Tier 2 (groundwater)** considers dilution of the contaminant within the underlying receiving groundwater or surface water body. To determine a dilution, factor the infiltration rate of pore water and the discharge of groundwater beneath the source must be determined. Level 2 Assessment comprises a comparison between measured groundwater concentrations with to water quality standards.

**Tier 3** considers natural attenuation in the form of dispersion, retardation and degradation of the contaminant. As the levels are progressed, the assessment becomes increasingly more detailed and less conservative as the data requirements are increased with each successive tier. The Environment Agency has released Excel Worksheets to carry out basic calculations using a conservative approach up to Tier 3. However, in this case the conceptual model is a simple one and assumes there is a simple migration of contaminants from the source zone into the aquifer receptor. Using these worksheets requires a sensitivity analysis showing how by varying each parameter, what effect it might have on the outcome of the assessment. Groundwater conceptual models are not always this simple.

**Tier 4** is for more complex conceptual models where multiple sources, multiple pathways, multiple receptors and complex water balances can be assessed.

The Environment Agency developed a spreadsheet-based code to support the Remedial Target Methodology, and the code is capable of undertaking assessments for Tiers 1 to 3. Tier 4 assessment is not supported by the spreadsheet-based code.

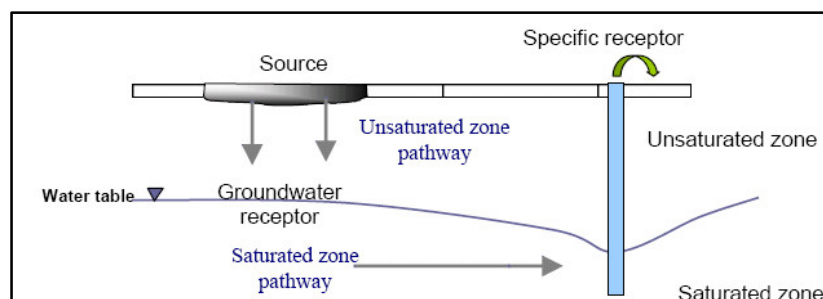
A more advanced code, ConSim 2, developed on behalf of the Environment Agency to support the Remedial Targets Methodology, allows for the introduction of additional geological horizons and is used mainly to determine the concentrations reaching a receptor and the timescales over which this may happen.

The codes assess only the dissolved phase contaminants. There are many further codes commercially available for use in controlled waters risk assessment, particularly for more complex situations, however, these should be used with caution and only once agreement has been obtained from the Environment Agency. All have the overall aim of the estimation of risk from contaminant linkages and the protection of controlled waters.

## **General notes on each stage of the controlled waters risk assessment process**

### **Risk Screening**

The understanding of the Conceptual Site Model (CSM) is the key to assessing any site. Using a robust CSM, potential pathways or receptors may be screened out from any further assessment at an early stage. For example, if the pathway through the unsaturated zone is blocked by the presence of a significant thickness of low permeability clay. A greater understanding of the CSM is achieved with each tier of risk assessment. An example of a basic Source-Pathway-Receptor concept is given below (taken from the Environment Agency GP3, 2006):



### **Generic Risk Assessment**

When undertaking the Generic Hydrogeological Risk Assessment (EA Remedial Targets Methodology Tier 1), comparison of chemical analytical results is made with screening criteria. Published values of screening criteria with which chemical test results can be compared are published in the following guidance:

There is a hierarchy of screening criteria which is as follows:

- Updated Recommendations on Environmental Technical Standards, River Basin Management (2015-21), April 2012 by the UK Technical Advisory Group on the Water Framework Directive;
- Environmental Quality Standards (EQS) for freshwaters based on The EC Dangerous Substances Directive (76/464/EEC and Daughter Directives);

- Surface Waters (Abstraction for Drinking Water)(Classification) Regulations (1996)
- Surface Waters (Fishlife) (Classification) Regulations (1997)
- UK Drinking Water Standards (DWS) (Water Supply (Water Quality) Regulations 2000);
- Dutch Ministry of Housing, Spatial Planning and Environment (2001) Intervention Values and Target Values – soil quality standards;
- World Health Organisation Guidelines for Drinking Water (2004)

Should the Level 1 or 2 assessments indicate threshold levels to be exceeded, then there are three alternative ways in which to proceed:

- To devise suitable remedial solutions;
- To carry out more investigation, sampling and analysis;
- To conduct a site-specific Detailed Quantitative Risk Assessment (DQRA) to whether or not the soil materials are suitable for their site-specific intended use or to devise a site-specific clean-up level.

### **Detailed Quantitative Risk Assessment (DQRA)**

The decision to carry out a DQRA will be dependent on the extent and implications of the initial qualitative and generic assessment. The scope of any such assessment will be accurately defined by the outcomes of the former two stages. The CSM will be sufficiently refined by this stage that only certain contaminants of concern, certain pathways and certain receptors will require further assessment, the remainder having been screened out.

Additional site-specific data is normally required for this stage of assessment, as explained above, more processes that are capable of affecting contaminant concentrations are considered (such as dilution and attenuation).

Remediation criteria derived will therefore be specific to each site and will be based on a detailed assessment of the potential impact at the identified receptor or *compliance point*. A greater level of confidence can be placed on the predicted impact on the compliance point following a DQRA.

### **Definition of Controlled Waters**

The term 'controlled waters' is defined in Section 104 of the Water Resources Act 1991 as:

*“Territorial Waters...which extend seawards for three miles..., coastal waters..., inland freshwaters, waters in any relevant lake or pond or of so much of any relevant river or watercourse as is above the freshwater limit, and ground waters, that is to say, any waters contained in underground strata.”*

Note that the definition of groundwater under the Water Resources Act 1991 includes all water within underground strata (including soil / pore water in the unsaturated zone). The definition of groundwater under the Groundwater Directive however is limited to water in the saturated zone. For the purposes of Part IIA of the Environmental Protection Act 1990, the Environment Agency

recommends that the groundwater within the saturated zone only is considered as the receptor (rather than soil / pore water).

### **Environment Agency's Aquifer Designations**

The Environment Agency have classified different types of aquifers from which groundwater can be extracted. The aquifer designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetland ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey.

The maps are split into two different types of aquifer designation:

- **Superficial (Drift)** – permeable unconsolidated (loose) deposits.
- **Bedrock (Solid)** – solid permeable formations e.g., sandstone, chalk, limestone.

The aquifer designations displayed on the Environment Agency maps are as follows:

- **Principal Aquifers (formerly termed Major Aquifers)** – These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as a major aquifer.
- **Secondary Aquifers (formerly termed Minor Aquifers)** – These include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types:
  - **Secondary A** - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers;
  - **Secondary B** - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
  - **Secondary Undifferentiated** - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
- **Unproductive Strata (formerly termed Non-Aquifer)** – These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

### **Hazardous and Non-Hazardous Substances**

The Groundwater (England and Wales) Regulations 2009 control the disposal to the hydrogeological environment of potentially polluting substances which are divided into Hazardous Substances and Non-hazardous Contaminants (this roughly approximates to the former List 1 and List 2 substances).

Hazardous Substances are the most damaging and toxic and must be prevented from directly or indirectly entering the groundwater environment. Hazardous Substances include mineral oils and hydrocarbons, pesticides, biocides, herbicides, solvents and some metals. Discharge of Hazardous Substances to Controlled Waters must be prevented.

Non-hazardous Pollutants are any contaminants other than Hazardous Substances. Non-hazardous Pollutants are potentially toxic but are less harmful than Hazardous Substances, but their direct discharge to groundwater is generally not permitted and any indirect discharge to groundwater must be limited and be controlled by technical precautions in order to prevent pollution. Non-hazardous Pollutants include ammonia and nitrites, many metals and fluorides.

**MANAGEMENT OF CONTAMINATED LAND**

When risk assessment of the site has been completed and this indicates that remedial works are required, the main guidance in managing this process is set out in the DEFRA/EA online guidance LCRM (2020) “Land Contamination: Risk Management” The stages of managing remediation are as follows:

- (a) Options Appraisal and develop Remediation Strategy;
- (b) Develop Implementation Plan and Verification Plan;
- (c) Remediation, Verification and Monitoring.

The Remediation Strategy sets out the remediation targets, identifies technically feasible remedial solutions and presents an evaluation of the options so that these can be assessed enabling that the most suitable solution is adopted. An outline of the proposed remedial method should be presented. Agreement should be sought of the appropriate statutory bodies for the Remediation Strategy before proceeding to the next stage.

The Implementation Plan is a detailed method statement setting out how the remediation is to be carried out including stating how the site will be managed, welfare procedures, health and safety considerations together with practical measures such as details of temporary works, programme of works, waste management licences and regulatory consents required. Agreement should again be sought of the appropriate statutory bodies for this Plan.

The Verification Plan sets out the requirements for gathering data to demonstrate that the remediation has met the required remediation objectives and criteria. The Verification Plan presents the requirements for a wide range of issues including the level of supervision, sampling and testing regimes for treated materials, waste and imported materials, required monitoring works during and post remediation, how compliance with all licenses and consents will be checked etc. Agreement should again be sought of the appropriate statutory bodies for the Verification Plan. On completion of the remediation a Verification Report should be produced to provide a complete record of all remediation activities on-site and the data collected as required in the Verification Plan. The Verification Report should demonstrate that the remediation has met the remedial targets to show that the site is suitable for the proposed use.

## GLOSSARY

TERMS		UNITS	
AST	Above Ground Storage Tank	m	Metres
BGS	British Geological Survey	km	Kilometres
BSI	British Standards Institute	%	Percent
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes	%v/v	Percent volume in air
CIEH	Chartered Institute of Environmental Health	mb	Milli Bars (atmospheric pressure)
CIRIA	Construction Industry Research Association	l/hr	Litres per hour
CLEA	Contaminated Land Exposure Assessment	ha	Hectare (10,000m <sup>2</sup> )
CSM	Conceptual Site Model	µg/l	Micrograms per Litre (parts per billion)
DNAPL	Dense Non-Aqueous Phase Liquid (chlorinated solvents, PCB)	ppb	Parts Per Billion
DWS	Drinking Water Standard	mg/kg	Milligrams per kilogram (parts per million)
EA	Environment Agency	ppm	Parts Per Million
EQS	Environmental Quality Standard	mg/m <sup>3</sup>	Milligram per metre cubed
GAC	General Assessment Criteria	Mg/m <sup>3</sup>	Megagram per metre cubed
GL	Ground Level	µg/m <sup>3</sup>	Microgram per metre cubed
GSV	Gas Screening Value	m bgl	Metres Below Ground Level
HCV	Health Criteria Value	m bcl	Metre Below Cover Level
LNAPL	Light Non-Aqueous Phase Liquid (petrol, diesel)	mOD	Metres Above Ordnance Datum (sea level)
ND	Not Detected	kN/m <sup>2</sup>	Kilo Newtons per metre squared
LMRL	Lower Method Reporting Limit	kPa	Kilo Pascal – same as kN/m <sup>2</sup>
NR	Not Recorded	µm	Micro metre
OD	Ordnance Datum		
PAH	Poly Aromatic Hydrocarbon		
PCB	Poly-Chlorinated Biphenyl		
PID	Photo Ionisation Detector		
PCSM	Preliminary Conceptual Site Model		
SGV	Soil Guideline Value		
TPH (CWG)	Total Petroleum Hydrocarbon (Criteria Working Group)		
SPT	Standard Penetration Test		
SVOC	Semi Volatile Organic Compound		
UST	Underground Storage Tank		
VCCs	Vibro Concrete Columns	VSCs	Vibro Stone Columns
VOC	Volatile Organic Compound		

## Appendix C – Photographs



Photograph 1: WS01 Inspection pit



Photograph 2: WS02 sample runs 1.2m to 3.0m bgl



Photograph 3: WS01 samples runs 3.0m to 5.0m bgl



Photograph 4: WS02 inspection pit.



Photograph 5: WS02 sample runs 1.2m to 5.0m bgl



Photograph 6: WS03 inspection pit



Photograph 7: WS03 sample runs 1.2m to 5.0m bgl



Photograph 8: WS04 inspection pit



Photograph 9: WS04 sample runs 1.2m to 6.0m bgl.



Photograph 10: WS05 sample runs 1.2m to 6.0m bgl.



Photograph 11: TP01 extracted soils GL to 0.5m bgl



Photograph 12: TP01 extracted soils 0.5m to 3.4m bgl



Photograph 13: TP01, base 3.4m bgl.



Photograph 14: TP02 extracted soils GL to 0.5m bgl.



Photograph 15: TP02 extracted soil 0.5m to 3.5m bgl



Photograph 16: TP02, base at 3.5m bgl.



Photograph 17: TP03 extracted soils GL to 0.5m bgl



Photograph 18: TP03 extracted soils 0.5m to 4.0m bgl



Photograph 19: TP03, base at 4.0m bgl



Photograph 20: TP05 extracted soils GL to 2.5m bgl



Photograph 21: TP05 soakaway test



Photograph 22: TP06 extracted soils GL to 3.0m bgl



Photograph 23: TP06, bast at 3.0m bgl



Photograph 24: TP07 extracted soils GL to 2.8m bgl.



Photograph 25: TP07, base at 2.8m bgl

Appendix D – Exploratory Hole Records and SPT Calibration  
Certificate

# Dynamic Sample Log

### Borehole formation details:

Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Sampling PM Sampling	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:
WS	0.00	5.45	08-11-21	08-11-21		Terrier Rig	HW	08-11-21	Saturated at 4.1m bgl.

### Location details:

mE:	432172.00
mN:	408362.00
Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
				0.10	MADE GROUND: Brown silty sandy, sub-angular to sub-rounded, fine to coarse GRAVEL of concrete, brick and limestone					
				0.15	MADE GROUND: Black TARMAC					
				0.25	MADE GROUND: Medium strength grey CONCRETE.					
				(0.45)	MADE GROUND: Brown silty gravelly SAND. Gravel is sub-angular to sub-rounded, fine to coarse of brick, concrete and coal fragments.			0.50	ES1	
				0.70	MADE GROUND: Soft brown slightly sandy gravelly CLAY. Gravel is sub-angular, fine to coarse of brick and mudstone.					
				(0.30)						
				1.00	MADE GROUND: Firm brown mottled grey slightly sandy slightly gravelly CLAY. Gravel is sub-angular, fine to coarse of mudstone. (Reworked Natural).			1.00	ES2	
				(1.00)		Dry		1.20 - 1.65 1.20 1.30	SPT D3 D4	N=8 (1,2/2,2,2,2)
				2.00	MADE GROUND: Soft black sand gravelly SILT. Gravel is sub-angular, fine to coarse of brick, concrete, limestone, mudstone, coal with ash and pockets of silty sand. (Colliery Fill)			2.00 - 2.45 2.00 2.00 - 4.00	SPT D6 B5	N=24 (10,6/6,5,5,8)
				(1.00)		Dry				
				(3.45)		Dry		3.00 - 3.45 3.00	SPT D7	N=24 (5,6/6,6,6,6)
				(51)		Dry		4.00 - 4.45	SPT	N=8 (1,2/2,2,2,2)
				(51)		Dry		5.00 - 5.45 5.00	SPT D8	N=6 (0,0/0,2,2,2)

Groundwater entries:	Casing:	Depth related remarks:	Run details:
Struck: 4.10 Rose to: 4.10 Casing: Sealed:	Cased to: Diameter (mm):	From: to: Remarks	From: to: Ø Duration: Recovery:

 Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres. Log issue: DRAFT Scale: 1:25	Project: Whaley Rd, Barugh Green Project No: K0030 Client: Melia Smith & Jones Limited	Exploratory position reference: <h1>WS01</h1> Sheet 1 of 2
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# Dynamic Sample Log

Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Sampling	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432172.00	mN: 408362.00
WS	0.00	5.45	08-11-21	08-11-21	PM Sampling	Terrier Rig	HW	08-11-21	Saturated at 4.1mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
			5.45		MADE GROUND: Soft black sand gravelly SILT. Gravel is sub-angular, fine to coarse of brick, concrete, limestone, mudstone, coal with ash and pockets of silty sand. (Colliery Fill)					
					Dynamic sample ends at 5.45 m (Reach required depth)					

Groundwater entries:	Casing:	Depth related remarks:	Run details:
Struck: Rose to: Casing: Sealed:	Cased to: Diameter (mm):	From to: Remarks	From: to: Ø Duration: Recovery:

<p>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</p> <p>Log issue: DRAFT</p> <p>Scale: 1:25</p>	<p>Project: Whaley Rd, Barugh Green</p> <p>Project No: K0030</p> <p>Client: Melia Smith &amp; Jones Limited</p>	<p>Exploratory position reference:</p> <h1>WS01</h1>
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# Dynamic Sample Log

Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Sampling	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432193.00	mN: 408329.00
WS	0.00	4.25	08-11-21	08-11-21	g PM Sampling	Terrier Rig	HW	08-11-21	Saturated at 4.1mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing					
						Water	Casing	Depth	Type & No	Results	
				0.20	MADE GROUND: Brown silty gravelly SAND. Gravel is sub-angular, fine to coarse of brick, concrete, limestone and coal fragments.						
				0.40	MADE GROUND: Weak red BRICKS						
				(0.80)	MADE GROUND: Black silty gravelly SAND. Gravel is sub-angular to angular, fine to coarse of brick and coal. (Colliery Fill).						
				1.20	MADE GROUND: Soft sandy gravelly CLAY. Gravel is sub-angular to angular, fine to coarse of coal, brick and ash. (Colliery Fill).	Dry		1.20 - 1.65 1.20 1.20 1.20 - 3.00	SPT D2 D3 B4	N=7 (1,1/1,2,2,2)	
				(2.80)		Dry		2.00 - 2.45 2.00	SPT D5	N=22 (3,3/3,6,6,7)	
						Dry		2.50	ES6		
						Dry		3.00 - 3.45 3.00	SPT D7	N=6 (2,1/1,2,1,2)	
						Dry		4.00 - 4.45 4.00 4.10	SPT D8 D9	N=17 (2,2/3,3,4,7)	
						Dry	(0.93)		4.50 - 4.92 4.50	SPT D10	50 (10,9/50 for 275mm)
							4.93	Dynamic sample ends at 4.93 m (Refusal)			

Groundwater entries:	Casing:	Depth related remarks:	Run details:
Struck: 4.10 Rose to: 4.10 Casing: Sealed:	Cased to: Diameter (mm):	From: to: Remarks	From: to: Ø Duration: Recovery:


<p>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</p> <p>Log issue: DRAFT Scale: 1:25</p>	<p>Project: Whaley Rd, Barugh Green Project No: K0030 Client: Melia Smith &amp; Jones Limited</p>	<p>Exploratory position reference: <b>WS02</b></p>
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# Dynamic Sample Log

Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Sampling	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432202.00	mN: 408356.00
WS	0.00	5.45	08-11-21	08-11-21	g PM Sampling	Terrier Rig	HW	08-11-21	Saturated at 2.0mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
				0.15	MADE GROUND: Brown silty sandy, sub-angular to sub-rounded, fine to coarse GRAVEL of concrete, brick and limestone.					
				0.30	MADE GROUND: Medium strength grey CONCRETE.					
				(1.20)	MADE GROUND: Firm brown sandy gravelly CLAY. Gravel is sub-angular, fine to coarse of brick concrete, limestone and coal fragments.					
				1.50	MADE GROUND: Soft black slightly sandy slightly gravelly CLAY. Gravel is sub-angular, fine to medium of brick, tile, coal with ash. (Colliery Fill).					
				(3.10)		Dry		1.00	D1	
								1.20 - 1.65	SPT D2	N=13 (4,3/3,4,3,3)
								1.20		
								1.50	ES3	
								1.70	D4	
						Dry		2.00 - 2.45	SPT D5	N=5 (1,1/1,1,2,1)
								2.00		
								3.00 - 3.45	SPT D6	N=13 (2,3/4,3,3,3)
								3.00		
								3.50	D7	
								4.00 - 4.45	SPT	N=8 (1,1/2,2,2,2)
						Dry		4.70	ES8	
				4.60	Stiff to very stiff brown mottled grey slightly gravelly CLAY. Gravel is sub-angular, fine to medium of mudstone. Becoming weak weathered MUDSTONE at base. (PMCM)					
				(0.85)		Dry		5.00 - 5.45	SPT D9	N=19 (3,3/4,4,4,7)
								5.00		

Groundwater entries:		Casing:		Depth related remarks:		Run details:	
Struck: 2.00	Rose to: 2.00	Casing: Sealed:	Cased to: Diameter (mm):	From: to: Remarks	From: to: Ø	Duration: Recovery:	

 Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres. Log issue: DRAFT Scale: 1:25	Project: Whaley Rd, Barugh Green Project No: K0030 Client: Melia Smith & Jones Limited	Exploratory position reference: <h1>WS03</h1> Sheet 1 of 2
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# Dynamic Sample Log

Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Sampling	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432202.00	mN: 408356.00
WS	0.00	5.45	08-11-21	08-11-21	PM Sampling	Terrier Rig	HW	08-11-21	Saturated at 2.0mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
			5.45		Stiff to very stiff brown mottled grey slightly gravelly CLAY. Gravel is sub-angular, fine to medium of mudstone. Becoming weak weathered MUDSTONE at base. (PMCM)					
					Dynamic sample ends at 5.45 m (Reached required depth)					

Groundwater entries:	Casing:	Depth related remarks:	Run details:
Struck: Rose to: Casing: Sealed:	Cased to: Diameter (mm):	From to: Remarks	From: to: Ø Duration: Recovery:

<p>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</p> <p>Log issue: DRAFT</p> <p>Scale: 1:25</p>	<p>Project: Whaley Rd, Barugh Green</p> <p>Project No: K0030</p> <p>Client: Melia Smith &amp; Jones Limited</p>	<p>Exploratory position reference:</p> <h1>WS03</h1>
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# Dynamic Sample Log

Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Sampling	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432218.00	mN: 408343.00
WS	0.00	5.94	08-11-21	08-11-21	PM Sampling	Terrier Rig	HW	08-11-21	Saturated at 3.8mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
				(1.00)	MADE GROUND: Stiff brown sandy gravelly CLAY. Gravel is sub-angular, fine to coarse of concrete, brick, limestone and coal fragments.					
				1.00	MADE GROUND: Weak red BRICKS					
				1.20	MADE GROUND: Soft dark brown to black sandy gravelly CLAY. Gravel is sub-angular, fine to coarse, brick concrete and coal with ash. (Colliery Fill). <i>1.20 - 1.50 m: Low recovery.</i>	Dry		1.20 - 1.65 1.20	SPT D1	N=41 (1,2/2,25,6,8)
					<i>2.00 - 3.80 m: Becomes very sandy.</i>			1.70	ES2	
						Dry		2.00 - 2.45 2.00 2.10	SPT D3 D4	N=6 (2,2/1,1,1,3)
				(3.40)		Dry		3.00 - 3.45 3.00 3.10	SPT D5 D6	N=8 (2,2/2,2,2,2)
						Dry		4.00 - 4.45 4.00	SPT D7	N=13 (2,3/3,3,3,4)
				4.60	Stiff to very stiff brown mottled grey slightly gravelly CLAY. Gravel is angular, fine to medium of mudstone. Becoming weak MUDSTONE at 5.8m. (PCMC)	Dry		4.70	D8	
						Dry		5.00 - 5.42 5.00	SPT D9	50 (4,6/50 for 275mm)

Groundwater entries:		Casing:		Depth related remarks:		Run details:	
Struck: 3.80	Rose to: 3.80	Casing: Sealed:	Cased to: Diameter (mm):	From: to: Remarks	From: to: Ø	Duration: Recovery:	

<p>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</p> <p>Log issue: DRAFT</p> <p>Scale: 1:25</p>	<p>Project: Whaley Rd, Barugh Green</p> <p>Project No: K0030</p> <p>Client: Melia Smith &amp; Jones Limited</p>	<p>Exploratory position reference:</p> <h2>WS04</h2> <p>Sheet 1 of 2</p>
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# Dynamic Sample Log

Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Samplin	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432218.00	mN: 408343.00
WS	0.00	5.94	08-11-21	08-11-21	g PM Samplin	Terrier Rig	HW	08-11-21	Saturated at 3.8mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
			(1.34)		Stiff to very stiff brown mottled grey slightly gravelly CLAY. Gravel is angular, fine to medium of mudstone. Becoming weak MUDSTONE at 5.8m. (PCMC)			5.50	D10	
						Dry			SPT	50 (14,11/50 for 90mm)
			5.94		Dynamic sample ends at 5.94 m (Refusal)			6.00	D11	

Groundwater entries:		Casing:		Depth related remarks:		Run details:	
Struck: Rose to:	Casing: Sealed:	Cased to:	Diameter (mm):	From:	to: Remarks	From:	to: Ø Duration: Recovery:

 <small>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</small> Log issue: DRAFT Scale: 1:25	Project: Whaley Rd, Barugh Green Project No: K0030 Client: Melia Smith & Jones Limited	Exploratory position reference: <h1>WS04</h1>
---	--	--

# Dynamic Sample Log

Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Samplin g PM Samplin	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432190.00	mN: 408378.00
WS	0.00	6.45	08-11-21	08-11-21		Terrier Rig	HW	08-11-21	Saturated from 4.7mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
				(0.50)	MADE GROUND: Brown silty gravelly SAND. Gravel is sub-angular, fine to coarse of brick concrete, limestone and coal fragments.					
				0.50 (0.50)	MADE GROUND: Soft to firm, brown sandy gravelly CLAY. Gravel is sub-rounded to sub-angular, fine to coarse of brick, concrete, limestone and coal fragments.					
				1.00 (3.50)	MADE GROUND: Soft dark brown, slightly sandy, slightly gravelly CLAY. Gravel is sub-rounded to sub-angular, fine to medium of brick, limestone, coal and clinker.	Dry		1.10 1.20 - 1.65 1.20	ES1 SPT D2	N=6 (1,1/1,2,2,1)
						Dry		2.00 - 2.45 2.00	SPT D3	N=6 (1,1/1,1,2,2)
								2.50	D4	
						Dry		3.00 - 3.45 3.00	SPT D5	N=8 (3,2/2,2,2,2)
				4.50 (1.00)	MADE GROUND: Brown sandy clayey sub-angular, fine to coarse GRAVEL of brick and concrete.	Dry		4.00 - 4.45 4.00	SPT D6	N=11 (1,2/2,3,3,3)
						Dry		5.00 - 5.45	SPT	N=10 (3,1/3,3,2,2)

Groundwater entries:		Casing:		Depth related remarks:			Run details:			
Struck: 4.70	Rose to: 4.70	Casing: Sealed:	Cased to: Diameter (mm):	From:	to:	Remarks:	From:	to:	Ø	Duration: Recovery:
Log issue: DRAFT		Project: Whaley Rd, Barugh Green		Exploratory position reference:			<b>WS05</b>			
Scale: 1:25		Project No: K0030		Client: Melia Smith & Jones Limited						

# Dynamic Sample Log

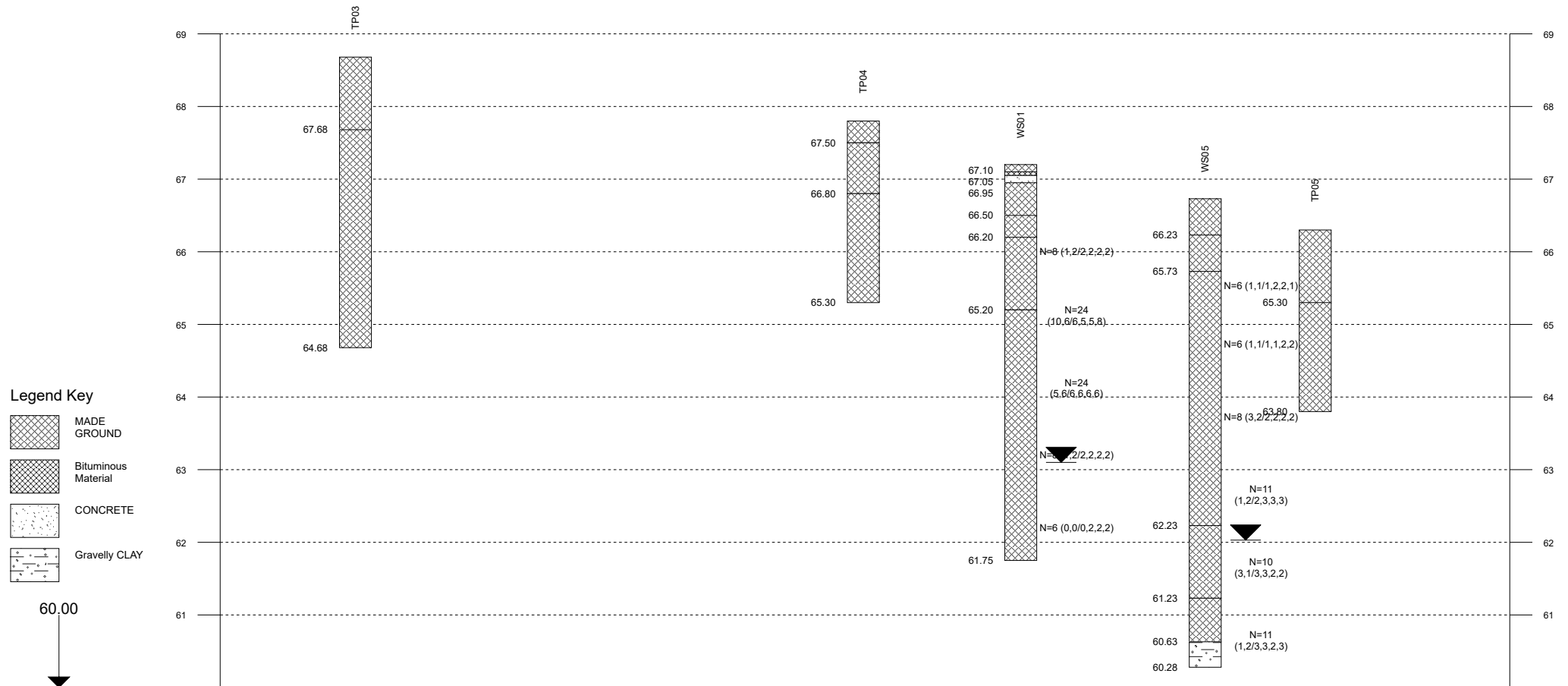
Borehole formation details:										Location details:	
Type: IP	From: 0.00	To: 1.20	Start date: 08-11-21	End date: 08-11-21	Crew: PM Sampling	Plant: Hand Tools	Logger: HW	Logged: 08-11-21	Remarks:	mE: 432190.00	mN: 408378.00
WS	0.00	6.45	08-11-21	08-11-21	g PM Sampling	Terrier Rig	HW	08-11-21	Saturated from 4.7mbgl.	Grid:	

Backfill/Instaln	Water-strike	Legend	Level	Depth (thickness)	Stratum Description	Samples & In Situ Testing				
						Water	Casing	Depth	Type & No	Results
				5.50	MADE GROUND: Brown sandy clayey sub-angular, fine to coarse GRAVEL of brick and concrete.					
				(0.60)	MADE GROUND: Brown mottled grey sandy gravelly, CLAY. Gravel is sub-angular, fine to coarse of brick and concete.					
				6.10	Firm to stiff brown mottled grey slightly gravelly CLAY. Gravel is sub-angular fine to medium of weathered mudstone.	Dry		6.00 - 6.45 6.00	SPT D7	N=11 (1,2/3,3,2,3)
				(0.35)						
				6.45	Dynamic sample ends at 6.45 m (Reached required depth)					

Groundwater entries:	Casing:	Depth related remarks:	Run details:
Struck: Rose to: Casing: Sealed:	Cased to: Diameter (mm):	From to: Remarks	From: to: Ø Duration: Recovery:

<p>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</p> <p>Log issue: DRAFT</p> <p>Scale: 1:25</p>	<p>Project: Whaley Rd, Barugh Green</p> <p>Project No: K0030</p> <p>Client: Melia Smith &amp; Jones Limited</p>	<p>Exploratory position reference:</p> <h1>WS05</h1>
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# Geological Section A - A'



Chainage (m)	0.00	4.12	70.52	74.69	91.10	97.27	115.22	129.60	134.09
Elevation (mAOD)	68.68		67.80		67.20		66.73	66.30	
Offset (m)	0.50		0.21		0.15		0.50	0.60	

Notes: For explanation of symbols and abbreviations see Key Sheet.  
All depths and reduced levels are in meters.

Remarks:  
None

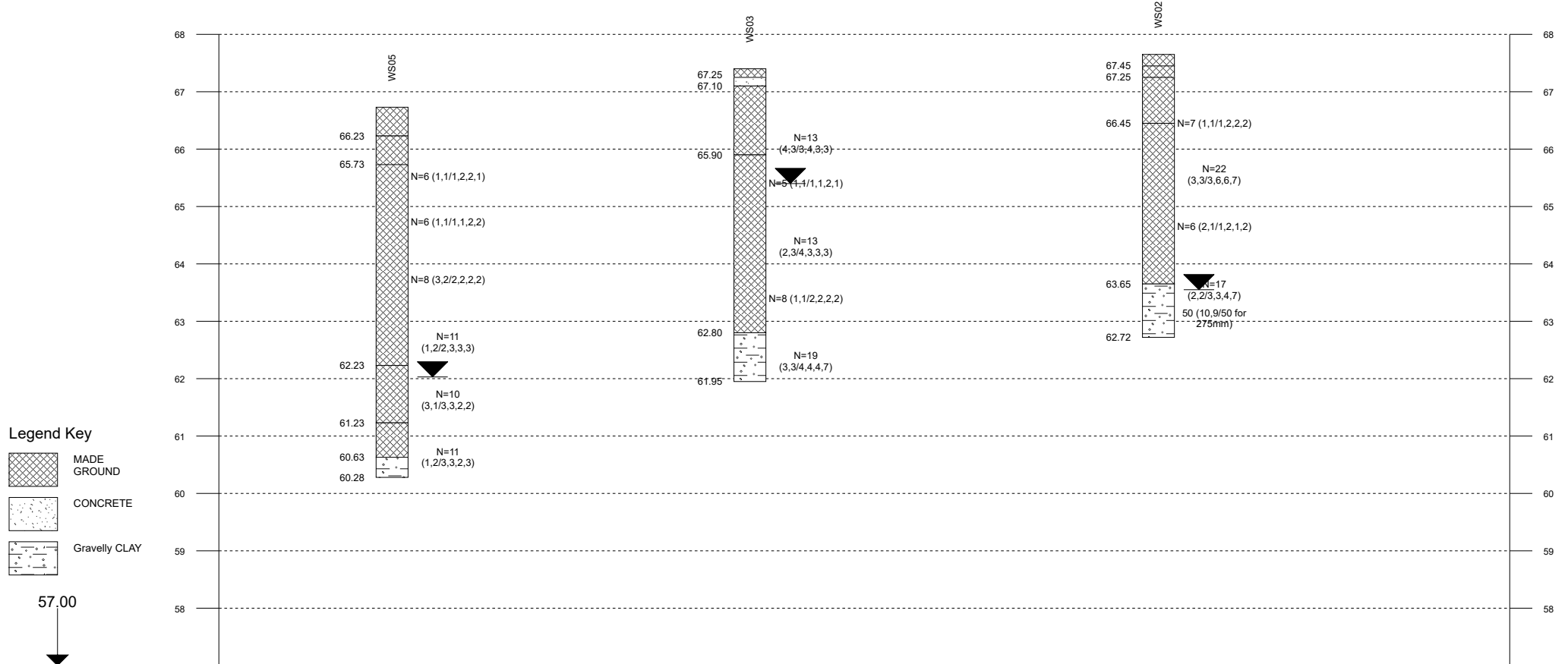
Description:  
Section description

Issue:  
Drawn by: Open Geo  
Vertical scale: 1:79  
Horizontal scale: 1:750

Project: Whaley Rd, Barugh Green  
Project No: K0030  
Client: Melia Smith & Jones Limited

Drawing No:  
**Section 1**

# Geological Section B - B'



57.00

Chainage (m)	0.00	4.83	29.78	58.22	62.52
Elevation (mAOD)		66.73	67.40	67.65	
Offset (m)		0.59	0.19	0.23	

Notes: For explanation of symbols and abbreviations see Key Sheet.  
All depths and reduced levels are in meters.

Remarks:  
None

Description:  
Section description

Issue: Open  
Drawn by: Geo  
Vertical scale: 1:100  
Horizontal scale: 1:400

Project: Whaley Rd, Barugh Green  
Project No: K0030  
Client: Melia Smith & Jones Limited

Drawing No:  
**Section 2**

# SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

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

SPT Hammer Ref: DART478  
Test Date: 29/10/2020  
Report Date: 29/10/2020  
File Name: DART478.spt  
Test Operator: JL

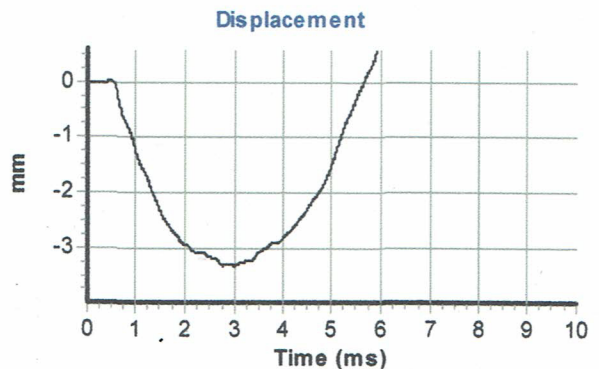
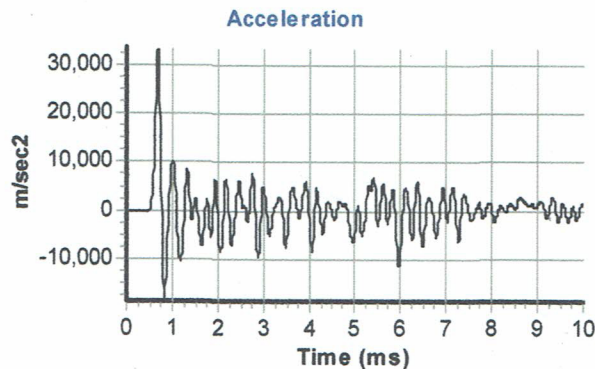
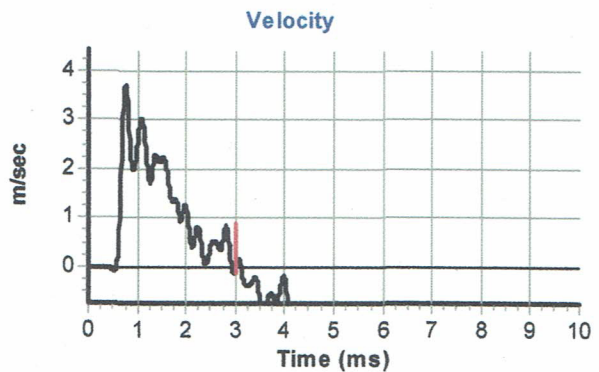
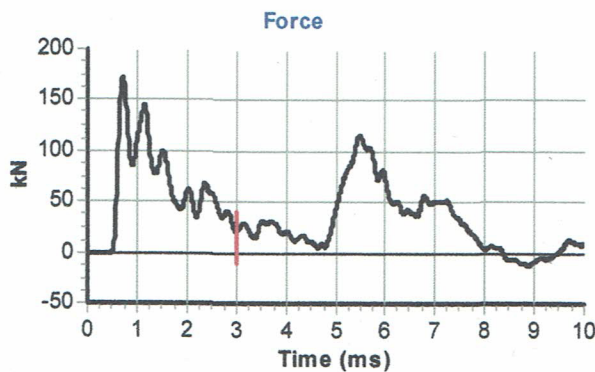
## Instrumented Rod Data

Diameter  $d_r$  (mm): 54  
Wall Thickness  $t_r$  (mm): 6.2  
Assumed Modulus  $E_a$  (GPa): 210  
Accelerometer No.1: 7080  
Accelerometer No.2: 11609

## SPT Hammer Information

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

## Comments / Location



## Calculations

Area of Rod A ( $\text{mm}^2$ ): 931  
Theoretical Energy  $E_{\text{theor}}$  (J): 473  
Measured Energy  $E_{\text{meas}}$  (J): 352

**Energy Ratio  $E_r$  (%):** **74**

Signed: S. HOWARTH  
Title: FITTER

The recommended calibration interval is 12 months


Appendix E – Trial Pit Logs

# Trial Pit Log

<b>Personnel:</b>		<b>Equipment &amp; methods:</b>		<b>Dimensions:</b>		<b>Coordinates &amp; level:</b>		<b>Dates:</b>	
Logged by:	HW	Method:	Machine Excavated	Width:	1.00	Easting:	432119.00 m E	Start:	09/11/2021
Checked by:	JT	Plant:	Doosan Midi DX85	Length:	3.00	Northing:	408288.00 m N	End:	09/11/2021
Approved by:		Shoring:	None used	<b>Orientation:</b>		Level:		Logged:	09/11/2021
				Strike A - C = °		Grid:			

Backfill/ Instal'n	Water- strike	Legend	Level & Depth (Thickness)	Stratum Description	Samples & In Situ Testing		
					Depth	Type & No	Results
			(0.50)	MADE GROUND: Brown sandy clayey, sub-angular, fine to coarse GRAVEL of brick, concrete, limestone and coal.			
			0.50	MADE GROUND: Black silty gravelly SAND. Gravel is sub-angular to angular, fine to coarse of brick, mudstone and coal with pyrite. (Colliery Fill).			
			(2.50)		1.20	ES1	
					1.50	D2	
					2.00	B3	
			3.00	Stiff brown mottled grey CLAY.	3.00	HV	95 kPa
			(0.40)		3.00	HV	92 kPa
					3.00	HV	110 kPa
					3.10	D4	
			3.40	Trial pit ends at 3.40 m (Refusal)	3.30	ES5	
					Depth	Type & No	Results

<b>Groundwater entries:</b>	<b>Depth related remarks:</b>	<b>General remarks:</b>
Depth:      Rose      After to:        (mins):      Remarks:	From    to:      Remarks:	Weather: Stability:      Stable Remarks:


 <small>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</small> Log issue:      DRAFT Scale:            1:25	Project:      Whaley Rd, Barugh Green Project No:    K0030 Client:        Melia Smith & Jones Limited	Exploratory position reference: <h2 style="text-align: center;">TP01</h2> <p style="text-align: right;">Sheet 1 of 1</p>
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# Trial Pit Log

<b>Personnel:</b>		<b>Equipment &amp; methods:</b>		<b>Dimensions:</b>		<b>Coordinates &amp; level:</b>		<b>Dates:</b>	
Logged by:	HW	Method:	Machine Excavated	Width:	1.00	Easting:	432131.00 m E	Start:	09/11/2021
Checked by:	JT	Plant:	Doosan Midi DX85	Length:	2.50	Northing:	408261.00 m N	End:	09/11/2021
Approved by:		Shoring:	None used	<b>Orientation:</b>		Level:		Logged:	09/11/2021
				Strike A - C = °		Grid:			

Backfill/ Instal'n	Water- strike	Legend	Level & Depth (Thickness)	Stratum Description	Samples & In Situ Testing		
					Depth	Type & No	Results
			(0.50)	MADE GROUND: Brown sandy clayey, sub-angular, fine to coarse GRAVEL of brick, concrete, limestone and coal.	0.40	ES1	
			0.50	MADE GROUND: Black silty gravelly SAND. Gravel is sub-angular to angular, fine to coarse of brick, mudstone, ash and coal with pyrite. (Colliery Fill).	1.00	D2	
			(1.50)				
			2.00	Stiff brown mottled grey CLAY. Becoming weak MUDSTONE at 3.4m.	2.00 2.00 2.00 2.00	D3 HV HV HV	91 kPa 105 kPa 102 kPa
			(1.50)				
					3.00 3.00 3.00 3.00	D4 HV HV HV	>120 kPa >120 kPa >120 kPa
			3.50	Trial pit ends at 3.50 m (Refusal)			
					Depth	Type & No	Results

<b>Groundwater entries:</b> Depth:      Rose      After to:        (mins):      Remarks:	<b>Depth related remarks:</b> From      to:        Remarks:	<b>General remarks:</b> Weather: Stability:      Stable Remarks:
--	--	---


 Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres. Log issue:      DRAFT Scale:            1:25	Project:      Whaley Rd, Barugh Green Project No:    K0030 Client:        Melia Smith & Jones Limited	Exploratory position reference: <h1>TP02</h1> Sheet 1 of 1
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# Trial Pit Log

<b>Personnel:</b>		<b>Equipment &amp; methods:</b>		<b>Dimensions:</b>		<b>Coordinates &amp; level:</b>		<b>Dates:</b>	
Logged by:	HW	Method:	Machine Excavated	Width:	1.00	Easting:	432104.00 m E	Start:	09/11/2021
Checked by:	JT	Plant:	Doosan Midi DX85	Length:	2.50	Northing:	408308.00 m N	End:	09/11/2021
Approved by:		Shoring:	None used	<b>Orientation:</b>	Strike A - C = °	Level:		Logged:	09/11/2021

Backfill/ Instal'n	Water- strike	Legend	Level & Depth (Thickness)	Stratum Description	Samples & In Situ Testing		
					Depth	Type & No	Results
			(1.00)	MADE GROUND Brown slightly clayey sandy GRAVEL. Gravel is sub-angular, fine to coarse, concrete brick, limestone and coal with high cobble content of concrete.	0.40 0.50	D1 B2	
			1.00	MADE GROUND: Black silty gravelly SAND. Gravel is sub-angular to angular, fine to coarse of brick, mudstone, ash and coal with pyrite. (Colliery Fill).	1.00	ES3	
			(3.00)		1.50	B4	
			4.00	Trial pit ends at 4.00 m (Reached required depth)			
					Depth	Type & No	Results

<b>Groundwater entries:</b> Depth:      Rose      After to:        (mins):      Remarks:	<b>Depth related remarks:</b> From      to:      Remarks:	<b>General remarks:</b> Weather: Stability:      Stable Remarks:
--	--	---

 Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres. Log issue:      DRAFT Scale:            1:25	Project:      Whaley Rd, Barugh Green Project No:    K0030 Client:        Melia Smith & Jones Limited	Exploratory position reference: <h1 style="text-align: center;">TP03</h1>
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# Trial Pit Log

<b>Personnel:</b>		<b>Equipment &amp; methods:</b>		<b>Dimensions:</b>		<b>Coordinates &amp; level:</b>		<b>Dates:</b>	
Logged by:	HW	Method:	Machine Excavated	Width:	1.00	Easting:	432191.00 m E	Start:	09/11/2021
Checked by:	JT	Plant:	Doosan Midi DX85	Length:	2.50	Northing:	408355.00 m N	End:	09/11/2021
Approved by:		Shoring:	None used.	<b>Orientation:</b>	Strike A - C = °	Level:		Logged:	09/11/2021

Backfill/ Instal'n	Water- strike	Legend	Level & Depth (Thickness)	Stratum Description	Samples & In Situ Testing		
					Depth	Type & No	Results
			(1.20)	MADE GROUND: Soft brown sandy gravelly CLAY. Gravel is sub-angular, fine to coarse of brick, concrete, wood, coal, clinker and rare plastics.			
			1.20	MADE GROUND: Black sandy gravelly CLAY. Gravel is sub-angular, fine to coarse of brick, concrete, coal, clinker, metal, plastic, demolition rubble and ash with high cobble content of brick and concrete. (Colliery Fill).	1.50	ES1	
			(1.80)		2.00	B2	
			3.00		2.50	D3	
				Trial pit ends at 3.00 m (Refusal)			
					Depth	Type & No	Results

<b>Groundwater entries:</b> Depth:      Rose      After to:        (mins):      Remarks:	<b>Depth related remarks:</b> From      to:        Remarks:	<b>General remarks:</b> Weather: Stability:        Stable Remarks:
--	--	---


 <small>Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres.</small> Log issue:      DRAFT Scale:            1:25	Project:      Whaley Rd, Barugh Green Project No:    K0030 Client:        Melia Smith & Jones Limited	Exploratory position reference: <h2 style="text-align: center;">TP06</h2>
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# Trial Pit Log

<b>Personnel:</b>		<b>Equipment &amp; methods:</b>		<b>Dimensions:</b>		<b>Coordinates &amp; level:</b>		<b>Dates:</b>	
Logged by:	HW	Method:	Machine Excavated	Width:	1.00	Easting:	432241.00 m E	Start:	09/11/2021
Checked by:	JT	Plant:	Doosan Midi DX85	Length:	2.50	Northing:	408358.00 m N	End:	09/11/2021
Approved by:		Shoring:	None used.	<b>Orientation:</b>	Strike A - C = °	Level:		Logged:	09/11/2021

Backfill/ Instal'n	Water- strike	Legend	Level & Depth (Thickness)	Stratum Description	Samples & In Situ Testing		
					Depth	Type & No	Results
			(2.70)	MADE GROUND: Brown sandy gravelly CLAY. Gravel is sub-angular fine to coarse of concrete, brick, limestone, coal, rebar, demolition rubble with high cobble content of brick and concrete.	0.50	ES1	
			2.70		1.50	B2	
			2.70	Trial pit ends at 2.70 m (Refusal)			
					Depth	Type & No	Results

<b>Groundwater entries:</b> Depth:      Rose      After to:        (mins):      Remarks:	<b>Depth related remarks:</b> From    to:        Remarks:	<b>General remarks:</b> Weather: Stability:      Stable Remarks:
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 Notes: For explanation of symbols and abbreviations see Key Sheet. All depths and reduced levels are in metres. Log issue:      DRAFT Scale:            1:25	Project:      Whaley Rd, Barugh Green Project No:    K0030 Client:        Melia Smith & Jones Limited	Exploratory position reference: <h1 style="text-align: center;">TP07</h1>
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## Appendix F – Soakaway Test Results

# Infiltration Test Report

Carried out by:	Date:	Method:			Trial pit dimensions:	Before:	After:	Location:	Grid: OSGB	
HW	09/11/21	BRE Digest DG 365: 2016 & BS6297:2007+A1:2008			Length (m):	1.30	1.30	mE:	432157.00	
Chkd by:	Test no:	Granular infill:	Datum height (m agl):	Depth to water: Start: End:		Width (m):	0.60	0.60	mN:	408348.00
JT	1	No	0.00	1.19	1.70	Depth (m):	2.50	2.50	m OD:	-

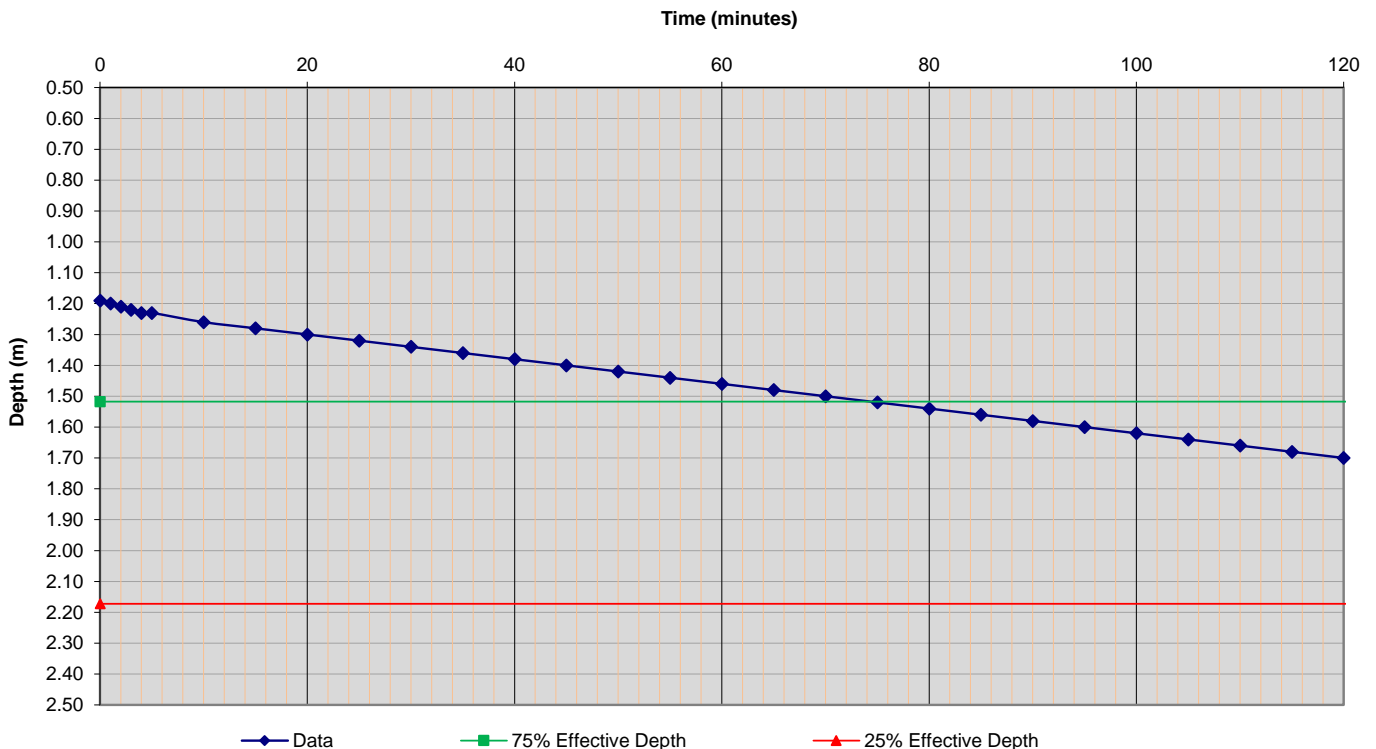
Elapsed time (mins):	Water depth (m below datum):	Elapsed time (mins):	Water depth (m below datum):
0	1.19	95	1.60
1	1.20	100	1.62
2	1.21	105	1.64
3	1.22	110	1.66
4	1.23	115	1.68
5	1.23	120	1.70
10	1.26		
15	1.28		
20	1.30		
25	1.32		
30	1.34		
35	1.36		
40	1.38		
45	1.40		
50	1.42		
55	1.44		
60	1.46		
65	1.48		
70	1.50		
75	1.52		
80	1.54		
85	1.56		
90	1.58		

Effective depth (m):		Elapsed time (mins) (from graph):	
75%	1.52	75%	35.00
50%	1.85	50%	100.00
25%	2.17	25%	190.00

Base area of pit	0.78	m <sup>2</sup>
Mean surface area through which outflow occurs	3.27	m <sup>2</sup>
Volume outflow between 75 and 25% effective depth	0.51	m <sup>3</sup>

Soil infiltration rate, f	1.68E-05	m <sup>3</sup> /m <sup>2</sup> /s
Soil infiltration rate, f	6.05E-02	m/hr
Percolation Value, vp	1.42E+01	s/mm

Notes: Coordinates are approximate  
Located at TP04



# Infiltration Test Report

Carried out by:	Date:	Method:			Trial pit dimensions:	Before:	After:	Location:	Grid: OSGB	
HW	09/11/21	BRE Digest DG 365: 2016 & BS6297:2007+A1:2008			Length (m):	0.60	0.60	mE:	432202.00	
Chkd by:	Test no:	Granular infill:	Datum height (m agl):	Depth to water: Start:      End:		Width (m):	1.50	1.50	mN:	408386.00
JT	1	No	0.00	1.46	1.47	Depth (m):	2.50	1.25	m OD:	-

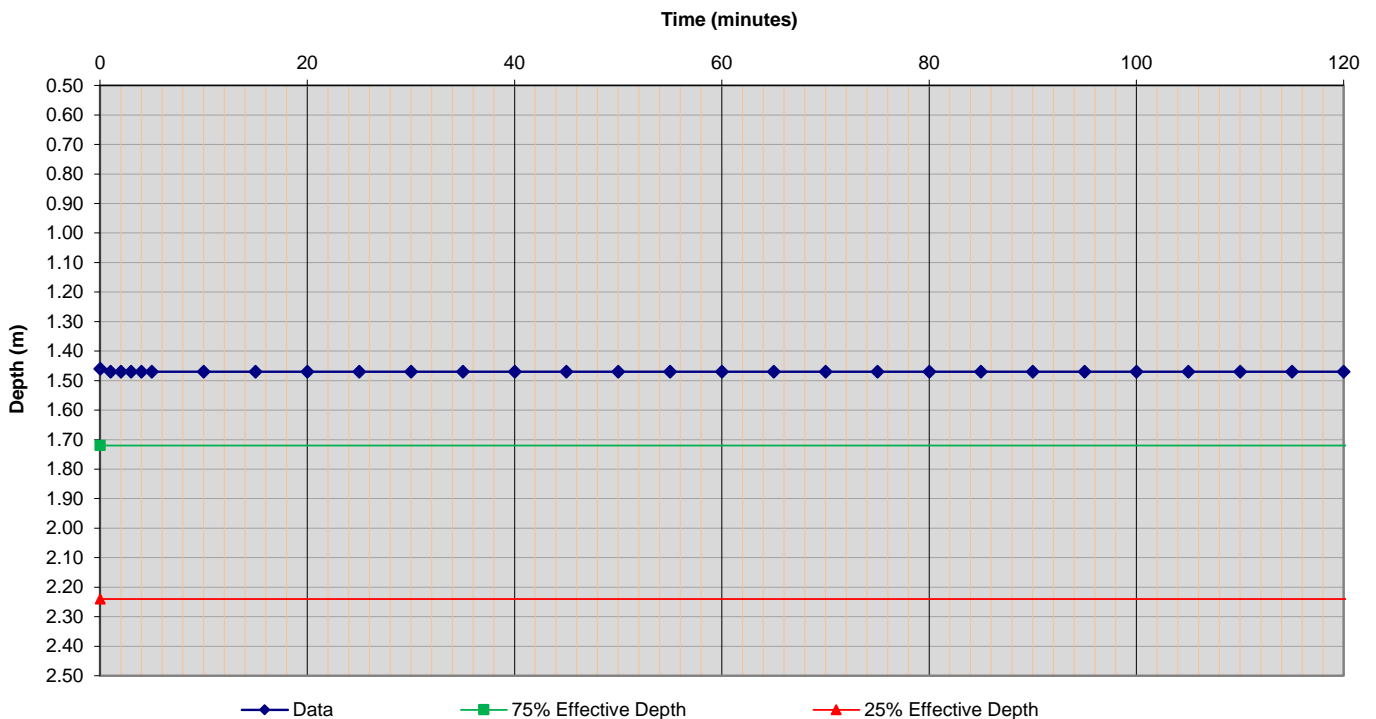
Elapsed time (mins):	Water depth (m below datum):	Elapsed time (mins):	Water depth (m below datum):
0	1.46	95	1.47
1	1.47	100	1.47
2	1.47	105	1.47
3	1.47	110	1.47
4	1.47	115	1.47
5	1.47	120	1.47
10	1.47		
15	1.47		
20	1.47		
25	1.47		
30	1.47		
35	1.47		
40	1.47		
45	1.47		
50	1.47		
55	1.47		
60	1.47		
65	1.47		
70	1.47		
75	1.47		
80	1.47		
85	1.47		
90	1.47		

Effective depth (m):		Elapsed time (mins) (from graph):	
75%	1.72	75%	12.00
50%	1.98	50%	40.00
25%	2.24	25%	75.00

Base area of pit	0.90	m <sup>2</sup>
Mean surface area through which outflow occurs	3.08	m <sup>2</sup>
Volume outflow between 75 and 25% effective depth	0.47	m <sup>3</sup>

Soil infiltration rate, f	4.01E-05	m <sup>3</sup> /m <sup>2</sup> /s
Soil infiltration rate, f	1.45E-01	m/hr
Percolation Value, vp	7.27E+00	s/mm

Notes: Coordinates are approximate  
Located at TP05



## Appendix G – Gas and Groundwater Monitoring

No: K0030

**GROUNDWATER AND GROUND GAS MONITORING**



Site: Whaley Road, Barugh Green

Location	Date	Monitored by	Well Details		Groundwater		Gas														Weather
			Standpipe diameter (mm)	Depth to Base (m bgl)	Water Depth (m bgl)	Water Sample Taken?	Atmospheric Pressure (mbar)	Atmospheric Pressure Comment	Relative Pressure (mb)	Flow - Peak (l/h)	Flow - Steady (l/h)	CH <sub>4</sub> (% v/v)	GSV CH <sub>4</sub> (l/hr)	CO <sub>2</sub> (% v/v)	GSV CO <sub>2</sub> (l/hr)	O <sub>2</sub> (% v/v)	CO (ppm)	H <sub>2</sub> S (ppm)	VOC	GFM	Conditions
WS01	18/11/21	MW	51	3.87	Dry	N	1019	Steady	1	0.0	0.0	0.0	0.0000	1.7	0.0000	18.3	0	0	0 / 0	13387	Cloudy
	26/11/21	HW	51	3.86	Dry	N	983	Steady	1	0.0	0.0	0.0	0.0000	6.9	0.0000	13.8	0	0	0 / 0	13387	Overcast
	01/12/21	MW	51	3.79	Dry	N	993	Falling	1	0.0	0.0	0.0	0.0000	0.3	0.0000	20.0	0	0	0 / 0	13387	Overcast
	17/01/22	OS	51	3.80	3.79	N	1031	Steady	1	0.0	0.0	0.0	0.0000	0.0	0.0000	20.0	0	0	0 / 0	12417	Sunny
	31/01/22	OS	51	3.70	Dry	N	1015	Falling	1	0.0	0.0	0.0	0.0000	1.9	0.0000	3.2	0	0	0 / 0	13387	Sunny
	09/02/22	OS	51	3.69	Dry	N	1011	Steady	1	0.0	0.0	0.0	0.0000	2.7	0.0000	2.4	0	0	0	13387	Overcast
WS02	18/11/21	MW	51	2.70	Dry	N	1019	Steady	1	0.0	0.0	0.0	0.0000	0.0	0.0000	20.2	0	0	0 / 0	13387	Cloudy
	26/11/21	HW	51	2.74	2.51	N	983	Steady	1	0.0	0.0	4.4	0.0000	1.4	0.0000	1.3	0	0	0 / 0	13387	Overcast
	01/12/21	MW	51	2.68	2.42	N	992	Falling	1	0.0	0.0	2.1	0.0000	0.4	0.0000	6.3	0	0	0 / 0	13387	Overcast
	17/01/22	OS	51	2.73	Dry	N	1028	Steady	1	0.0	0.0	2.3	0.0000	0.7	0.0000	10.8	0	0	0 / 0	12417	Sunny
	31/01/22	OS	51	2.70	Dry	N	1017	Falling	1	0.0	0.0	0.0	0.0000	1.3	0.0000	0.4	0	0	0 / 0	13387	Sunny
	09/02/22	OS	51	2.71	2.56	N	1012	Steady	1	0.0	0.0	5.7	0.0000	1.2	0.0000	0.2	0	0	0 / 0	13387	Overcast
WS03	18/11/21	MW	51	3.99	3.37	Y*	1019	Steady	1	0.0	0.0	0.0	0.0000	0.6	0.0000	19.8	0	0	0 / 0	13387	Cloudy
	26/11/21	HW	51	3.99	3.21	N	998	Steady	1	0.0	0.0	0.0	0.0000	2.5	0.0000	0.1	0	0	0 / 0	13387	Overcast
	01/12/21	MW	51	3.92	3.28	N	992	Falling	1	0.0	0.0	0.0	0.0000	1.0	0.0000	17.3	0	0	0 / 0	13387	Overcast
	17/01/22	OS	51	3.99	3.38	N	1028	Steady	1	0.0	0.0	0.0	0.0000	0.2	0.0000	19.0	0	0	0 / 0	12417	Sunny
	31/01/22	OS	51	3.98	3.37	N	1015	Falling	1	0.0	0.0	0.0	0.0000	1.9	0.0000	3.2	0	0	0 / 0	13387	Sunny
	09/02/22	OS	51	3.98	3.36	N	1011	Steady	1	0.0	0.0	0.0	0.0000	0.9	0.0000	12.9	0	0	0 / 0	13387	Overcast

**Notes:**

Groundwater sample taken from WS02 18/11/2021  
 Volume purged prior to sampling: 6 ltrs (very slow recharge rate).  
 Description: Cloudy, brown, sediment present.  
 Containers: 1 x 1 ltr glass bottle, 1 x 1 ltr plastic bottle, 4 x 60 ml glass vials

Monitoring visit 17/01/22:  
 WS01 below excavator, cover is now crushed but installation still intact- see photos

Ground gas monitoring visit 26/12/2021: 01/11/2021  
 WS02 - Peak CH<sub>4</sub> (% LEL) - >>> (above detection limit) 48.9

Monitoring Visit 31/02/22:  
 WS01 had been crushed by excavator again

**NOTES:**

NM = Not Measured.  
 (x) = Peak value recorded.  
 [grey] = Below detection limit.

$$GSV (l/hr) = [\text{gas concentration (\%v/v)}] \times [\text{gas well flow rate (l/hr)}]$$

## Instrumentation Specifications

### Gas Monitoring – Permanent Gases

Gas monitoring for permanent gases (e.g., methane, carbon dioxide, oxygen etc) at ByrneLooby is carried out using a GasData GFM 400 series gas analyser with flow meter which measures borehole flow rates, bulk gas concentrations (methane, carbon dioxide and oxygen), barometric and differential pressure.

The specification range of the GFM 400 series is as follows:

Feature	Method/Type	Range	Resolution
Methane	Infrared	0 - 100%v/v	0.1%
Lower Detection Limit (LEL)	Infrared	0 - 100%v/v	0.1%
Carbon Dioxide	Infrared	0 - 100%v/v	0.1%
Oxygen	Electrochemical	0 - 25%v/v	0.1%
Hydrogen Sulphide	Electrochemical	0 - 5,000ppm	1ppm
Carbon monoxide	Electrochemical	0 - 2,000ppm	1ppm
Atmospheric Pressure	Absolute Pressure Sensor	800 – 1,200mb	1mb
Differential Pressure	Thermal Dissipation	±1,250Pa	0.1Pa
Temperature	Bi-metal	-10°C to +100°C	1°C
Flow	Thermal Dissipation	-60 – 100 l/hr	0.1 l/hr

### Volatile Organic Compounds

ByrneLooby uses a PhoCheck Tiger Photo Ionisation Detector (PID) to detect a large range of Volatile Organic Compounds (VOCs) which are potentially dangerous from both a poisoning and/or an explosive perspective.

The sensor specification is as follows:

Feature	Method/Type	Range	Resolution
Total VOCs	PID	1ppb – 10,000ppm & 1ppb to 20,000ppm for specific gases	+/- 5% displayed reading +/- one digit

### Calibration

Measuring equipment owned by ByrneLooby is maintained in good condition and regularly inspected to ensure that it is capable of accurate and effective operation and is calibrated in line with the manufacturer’s recommendations. When equipment is hired for use, the hirer will be required to provide a calibration certificate with the equipment.

In accordance with ByrneLooby’s ISO 9001:2015 accreditation, the process of calibrating and maintenance of ByrneLooby’s own measuring equipment is carried out in accordance with our quality system procedures and a register of all measuring equipment is maintained and calibration certificates collated and stored accordingly.

## Appendix H – Laboratory Chemical Testing Results

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## THE ENVIRONMENTAL LABORATORY LTD

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**Analytical Report Number:** 21-37105

**Issue:** 1

**Date of Issue:** 19/11/2021

**Contact:** Harry Wrigley

**Customer Details:** Byrne Looby Partners (UK) Limited  
Suite 104  
Mere Grange Business Park  
St Helens  
WA9 5GG

**Quotation No:** Q21-02252


**Order No:** 140696

**Customer Reference:** K0030

**Date Received:** 12/11/2021

**Date Approved:** 19/11/2021

**Details:** Whaley Road

**Approved by:** 

Mike Varley, General Manager

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Any comments, opinions or interpretations expressed herein are outside the scope of UKAS accreditation (Accreditation Number 2683)

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## Sample Summary

Report No.: 21-37105, issue number 1

Elab No.	Client's Ref.	Date Sampled	Date Scheduled	Description	Deviations
257492	WS01 1 0.50	08/11/2021	12/11/2021		
257493	WS01 2 1.00 - 1.20	08/11/2021	12/11/2021	Silty clayey loam	
257494	WS02 1 0.70	08/11/2021	12/11/2021		
257495	WS02 2 2.50	08/11/2021	12/11/2021	Sandy silty loam	
257496	WS03 1 1.50	08/11/2021	12/11/2021	Silty clayey loam	
257497	WS03 2 4.70	08/11/2021	12/11/2021	Silty clayey loam	
257498	WS04 1 1.70	08/11/2021	12/11/2021		
257499	WS05 1 1.10	08/11/2021	12/11/2021	Silty loam	
257500	TP01 1 1.20	09/11/2021	12/11/2021	Sandy silty loam	
257501	TP01 1 3.30	09/11/2021	12/11/2021	Silty clayey loam	
257502	TP02 1 0.40	09/11/2021	12/11/2021	Sandy silty loam	
257503	TP03 1 1.00	09/11/2021	12/11/2021		
257504	TP04 1 1.00	09/11/2021	12/11/2021	Sandy silty loam	
257505	TP06 1 1.50	09/11/2021	12/11/2021		
257506	TP07 1 0.50	09/11/2021	12/11/2021	Sandy silty loam	c



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# Results Summary

Report No.: 21-37105, issue number 1

ELAB Reference	257493	257495	257496	257497	257499	257500	257501	257502	257504	257506
Customer Reference	2	2	1	2	1	1	1	1	1	1
Sample ID										
Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Sample Location	WS01	WS02	WS03	WS03	WS05	TP01	TP01	TP02	TP04	TP07
Sample Depth (m)	1.00 - 1.20	2.50	1.50	4.70	1.10	1.20	3.30	0.40	1.00	0.50
Sampling Date	08/11/2021	08/11/2021	08/11/2021	08/11/2021	08/11/2021	09/11/2021	09/11/2021	09/11/2021	09/11/2021	09/11/2021

Determinand	Codes	Units	LOD										
<b>Soil sample preparation parameters</b>													
Moisture Content	N	%	0.1	14.5	8.2	19.8	22.9	16.2	8.5	19.5	7.9	13.8	12.2
Stones Content	N	%	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	49.3	< 0.1	35.3
Material removed	N	%	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	49.3	< 0.1	35.3
Description of Inert material removed	N		0	None	None	None	None	None	None	None	Stones,clinker	None	Stones,brick,clinker
<b>Metals</b>													
Arsenic	M	mg/kg	1	22.2	111	33.7	10.0	39.9	157	9.9	112	242	38.2
Cadmium	M	mg/kg	0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	1.2	< 0.5	0.7	< 0.5	0.7
Chromium	M	mg/kg	5	28.5	10.9	27.7	19.3	27.1	11.7	23.9	102	27.0	63.6
Copper	M	mg/kg	5	42.1	74.7	59.5	21.9	57.2	93.9	23.0	59.4	60.0	121
Lead	M	mg/kg	5	73.3	60.7	108	24.1	49.1	87.2	15.7	105	75.1	153
Mercury	M	mg/kg	0.5	0.6	< 0.5	< 0.5	< 0.5	< 0.5	0.9	< 0.5	0.6	0.7	< 0.5
Nickel	M	mg/kg	5	34.9	48.6	31.1	20.2	31.5	49.4	19.2	34.2	17.5	33.0
Selenium	M	mg/kg	1	< 1.0	3.4	1.0	< 1.0	1.1	4.5	< 1.0	2.5	4.4	< 1.0
Zinc	M	mg/kg	5	134	150	151	78.2	123	239	75.8	171	105	213
<b>Anions</b>													
Water Soluble Sulphate	M	g/l	0.02	0.06	2.14	0.15	0.47	1.59	1.52	0.62	1.81	1.66	1.46
<b>Inorganics</b>													
Hexavalent Chromium	N	mg/kg	0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Total Cyanide	M	mg/kg	1	7.3	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acid Soluble Sulphate (SO4)	U	%	0.02	0.05	n/t	0.06	n/t	1.20	3.36	n/t	n/t	7.26	n/t
<b>Miscellaneous</b>													
pH	M	pH units	0.1	7.8	7.5	7.9	7.3	7.5	8.9	7.8	9.3	7.7	9.4
Soil Organic Matter	U	%	0.1	6.5	6.5	3.7	2.0	3.0	6.3	1.8	5.6	7.0	4.4
Total Organic Carbon	N	%	0.01	4.0	12	3.9	1.0	3.8	20	1.3	11	9.4	5.1



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# Results Summary

Report No.: 21-37105, issue number 1

ELAB Reference	257493	257495	257496	257497	257499	257500	257501	257502	257504	257506			
Customer Reference	2	2	1	2	1	1	1	1	1	1			
Sample ID													
Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL			
Sample Location	WS01	WS02	WS03	WS03	WS05	TP01	TP01	TP02	TP04	TP07			
Sample Depth (m)	1.00 - 1.20	2.50	1.50	4.70	1.10	1.20	3.30	0.40	1.00	0.50			
Sampling Date	08/11/2021	08/11/2021	08/11/2021	08/11/2021	08/11/2021	09/11/2021	09/11/2021	09/11/2021	09/11/2021	09/11/2021			
Determinand	Codes	Units	LOD										
<b>Organics</b>													
>C8-C10 BCB (EH_1D_Total)	N	mg/kg	1	1.4	n/t	< 1.0	n/t	< 1.0	< 1.0	n/t	n/t	< 1.0	n/t
>C10-C12 BCB (EH_1D_Total)	N	mg/kg	1	21.6	n/t	< 1.0	n/t	< 1.0	< 1.0	n/t	n/t	< 1.0	n/t
>C12-C16 BCB (EH_1D_Total)	N	mg/kg	1	179	n/t	1.7	n/t	< 1.0	< 1.0	n/t	n/t	5.3	n/t
>C16-C21 BCB (EH_1D_Total)	N	mg/kg	1	204	n/t	4.4	n/t	< 1.0	< 1.0	n/t	n/t	12.9	n/t
Diesel Range Organics (>C8-C21) (EH_1D_Total)	N	mg/kg	1	406	n/t	6	n/t	< 1	1	n/t	n/t	18	n/t
<b>Phenols</b>													
Total Monohydric Phenols	N	mg/kg	5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	c < 5
<b>Polyaromatic hydrocarbons</b>													
Naphthalene	M	mg/kg	0.1	2.0	1.4	3.4	< 0.1	< 0.1	0.3	< 0.1	0.8	1.1	c 0.9
Acenaphthylene	M	mg/kg	0.1	1.3	< 0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	c 0.1
Acenaphthene	M	mg/kg	0.1	3.6	< 0.1	8.9	< 0.1	< 0.1	0.3	< 0.1	0.5	1.1	c 0.7
Fluorene	M	mg/kg	0.1	3.4	0.1	19.4	< 0.1	< 0.1	0.3	< 0.1	0.1	0.6	c 0.6
Phenanthrene	M	mg/kg	0.1	11.1	1.1	62.0	< 0.1	< 0.1	2.2	< 0.1	1.1	3.8	c 4.0
Anthracene	M	mg/kg	0.1	4.0	0.1	32.9	< 0.1	< 0.1	0.7	< 0.1	0.1	0.7	c 1.4
Fluoranthene	M	mg/kg	0.1	12.1	0.5	49.1	< 0.1	< 0.1	4.0	< 0.1	0.8	2.5	c 6.9
Pyrene	M	mg/kg	0.1	9.5	0.4	36.2	< 0.1	< 0.1	3.2	< 0.1	0.9	2.1	c 6.0
Benzo(a)anthracene	M	mg/kg	0.1	6.6	0.2	19.1	< 0.1	< 0.1	2.1	< 0.1	0.5	0.9	c 3.3
Chrysene	M	mg/kg	0.1	7.3	0.3	20.7	< 0.1	< 0.1	2.6	< 0.1	0.8	1.2	c 3.7
Benzo(b)fluoranthene	M	mg/kg	0.1	4.2	0.2	14.9	< 0.1	< 0.1	2.1	< 0.1	0.7	0.9	c 3.4
Benzo(k)fluoranthene	M	mg/kg	0.1	5.7	0.2	16.6	< 0.1	< 0.1	2.1	< 0.1	0.8	0.9	c 3.4
Benzo(a)pyrene	M	mg/kg	0.1	5.8	0.2	18.5	< 0.1	< 0.1	2.0	< 0.1	0.7	0.9	c 3.6
Indeno(1,2,3-cd)pyrene	M	mg/kg	0.1	2.8	0.1	12.5	< 0.1	< 0.1	1.4	< 0.1	0.7	0.6	c 2.4
Dibenzo(a,h)anthracene	M	mg/kg	0.1	0.5	< 0.1	1.7	< 0.1	< 0.1	0.3	< 0.1	0.3	< 0.1	c 0.5
Benzo[g,h,i]perylene	M	mg/kg	0.1	2.4	0.1	9.8	< 0.1	< 0.1	1.2	< 0.1	0.8	0.5	c 2.0
Coronene	N	mg/kg	0.1	0.7	< 0.1	3.7	< 0.1	< 0.1	0.5	< 0.1	0.3	0.2	c 0.7
Total PAH(16)	M	mg/kg	0.4	82.3	5.0	326	< 0.4	< 0.4	24.7	< 0.4	9.7	18.0	c 42.8



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# Results Summary

Report No.: 21-37105, issue number 1

ELAB Reference	257493	257495	257496	257497	257499	257500	257501	257502	257504	257506			
Customer Reference	2	2	1	2	1	1	1	1	1	1			
Sample ID													
Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL			
Sample Location	WS01	WS02	WS03	WS03	WS05	TP01	TP01	TP02	TP04	TP07			
Sample Depth (m)	1.00 - 1.20	2.50	1.50	4.70	1.10	1.20	3.30	0.40	1.00	0.50			
Sampling Date	08/11/2021	08/11/2021	08/11/2021	08/11/2021	08/11/2021	09/11/2021	09/11/2021	09/11/2021	09/11/2021	09/11/2021			
Determinand	Codes	Units	LOD										
<b>BTEX</b>													
Benzene	M	ug/kg	10	25.4	n/t	< 10.0	n/t	< 10.0	< 10.0	n/t	n/t	< 10.0	n/t
Toluene	M	ug/kg	10	< 10.0	n/t	< 10.0	n/t	< 10.0	< 10.0	n/t	n/t	< 10.0	n/t
Ethylbenzene	M	ug/kg	10	< 10.0	n/t	< 10.0	n/t	< 10.0	< 10.0	n/t	n/t	< 10.0	n/t
Xylenes	M	ug/kg	10	< 10.0	n/t	< 10.0	n/t	< 10.0	< 10.0	n/t	n/t	< 10.0	n/t
MTBE	N	ug/kg	10	< 10.0	n/t	< 10.0	n/t	< 10.0	< 10.0	n/t	n/t	< 10.0	n/t
<b>TPH CWG</b>													
>C5-C6 Aliphatic (HS_1D_MS)	N	mg/kg	0.01	< 0.01	n/t	< 0.01	n/t	< 0.01	< 0.01	n/t	n/t	< 0.01	n/t
>C6-C8 Aliphatic (HS_1D_MS)	N	mg/kg	0.01	< 0.01	n/t	< 0.01	n/t	< 0.01	< 0.01	n/t	n/t	< 0.01	n/t
>C8-C10 Aliphatic (EH_CU_1D_AL)	N	mg/kg	1	3.9	n/t	< 1.0	n/t	< 1.0	< 1.0	n/t	n/t	< 1.0	n/t
>C10-C12 Aliphatic (EH_CU_1D_AL)	N	mg/kg	1	26.1	n/t	1.5	n/t	< 1.0	< 1.0	n/t	n/t	< 1.0	n/t
>C12-C16 Aliphatic (EH_CU_1D_AL)	N	mg/kg	1	217	n/t	6.2	n/t	< 1.0	< 1.0	n/t	n/t	1.0	n/t
>C16-C21 Aliphatic (EH_CU_1D_AL)	N	mg/kg	1	237	n/t	11.9	n/t	< 1.0	< 1.0	n/t	n/t	2.4	n/t
>C21-C35 Aliphatic (EH_CU_1D_AL)	N	mg/kg	1	128	n/t	53.3	n/t	< 1.0	< 1.0	n/t	n/t	36.4	n/t
>C35-C40 Aliphatic (EH_CU_1D_AL)	N	mg/kg	1	4.6	n/t	35.4	n/t	< 1.0	< 1.0	n/t	n/t	12.3	n/t
>C5-C7 Aromatic (HS_1D_MS)	N	mg/kg	0.01	0.03	n/t	< 0.01	n/t	< 0.01	< 0.01	n/t	n/t	< 0.01	n/t
>C7-C8 Aromatic (HS_1D_MS)	N	mg/kg	0.01	< 0.01	n/t	< 0.01	n/t	< 0.01	< 0.01	n/t	n/t	< 0.01	n/t
>C8-C10 Aromatic (EH_CU_1D_AR)	N	mg/kg	1	1.3	n/t	< 1.0	n/t	< 1.0	< 1.0	n/t	n/t	< 1.0	n/t
>C10-C12 Aromatic (EH_CU_1D_AR)	N	mg/kg	1	19.7	n/t	< 1.0	n/t	< 1.0	< 1.0	n/t	n/t	< 1.0	n/t
>C12-C16 Aromatic (EH_CU_1D_AR)	N	mg/kg	1	199	n/t	20.6	n/t	< 1.0	< 1.0	n/t	n/t	3.9	n/t
>C16-C21 Aromatic (EH_CU_1D_AR)	N	mg/kg	1	225	n/t	43.0	n/t	< 1.0	< 1.0	n/t	n/t	9.9	n/t
>C21-C35 Aromatic (EH_CU_1D_AR)	N	mg/kg	1	195	n/t	149	n/t	< 1.0	5.3	n/t	n/t	98.0	n/t
>C35-C40 Aromatic (EH_CU_1D_AR)	N	mg/kg	1	33.2	n/t	94.2	n/t	< 1.0	1.5	n/t	n/t	57.5	n/t
Total (>C5-C40) Ali/Aro (HS_1D_MS+EH_CU_1D_Total)	N	mg/kg	1	1290	n/t	416	n/t	< 1.0	6.8	n/t	n/t	222	n/t
<b>Total Petroleum Hydrocarbons</b>													
Mineral Oil (>C8-C40) (EH_1D_Total)	M	mg/kg	5	913	n/t	63	n/t	11	26	n/t	n/t	316	n/t



Unit A2, Windmill Road, Ponswood Industrial Estate, St Leonards on Sea, East Sussex, TN38 9BY

Tel: +44 (0)1424 718618, Email: info@elab-uk.co.uk, Web: www.elab-uk.co.uk

## Results Summary

Report No.: 21-37105, issue number 1

### Asbestos Results

Analytical result only applies to the sample as submitted by the client. Any comments, opinions or interpretations (marked #) in this report are outside UKAS accreditation (Accreditation No2683). They are subjective comments only which must be verified by the client.

Elab No	Depth (m)	Clients Reference	Description of Sample Matrix #	Asbestos Identification	Gravimetric Analysis Total (%)	Gravimetric Analysis by ACM Type (%)	Free Fibre Analysis (%)	Total Asbestos (%)
257493	1.00 - 1.20	WS01 2	Grey soil, stones, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257494	0.70	WS02 1	Grey sandy soil, stones, brick, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257496	1.50	WS03 1	Brown sandy soil, stones, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257498	1.70	WS04 1	Grey sandy soil, stones, brick, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257499	1.10	WS05 1	Brown sandy soil, stones, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257500	1.20	TP01 1	Brown sandy soil, stones, concrete, brick, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257502	0.40	TP02 1	Brown sandy soil, stones, concrete, brick, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257503	1.00	TP03 1	Grey sandy soil, stones, concrete, brick, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257504	1.00	TP04 1	Brown sandy soil, stones, brick, clinker	No asbestos detected	n/t	n/t	n/t	n/t
257506	0.50	TP07 1	Brown sandy soil, stones, concrete, brick, clinker, glass	No asbestos detected	n/t	n/t	n/t	n/t

## Method Summary

Report No.: 21-37105, issue number 1

Parameter	Codes	Analysis Undertaken On	Date Tested	Method Number	Technique
<b>Soil</b>					
Hexavalent chromium	N	As submitted sample	16/11/2021	110	Colorimetry
pH	M	Air dried sample	18/11/2021	113	Electromeric
Acid Soluble Sulphate	U	Air dried sample	17/11/2021	115	Ion Chromatography
Total Petroleum Hydrocarbons in solids	M	As submitted sample	16/11/2021	117	GC-FID
Aqua regia extractable metals	M	Air dried sample	16/11/2021	118	ICPMS
Phenols in solids	N	As submitted sample	16/11/2021	121	HPLC
PAH (GC-FID)	M	As submitted sample	16/11/2021	133	GC-FID
Water soluble anions	M	Air dried sample	16/11/2021	172	Ion Chromatography
Low range Aliphatic hydrocarbons soil	N	As submitted sample	16/11/2021	181	GC-MS
Low range Aromatic hydrocarbons soil	N	As submitted sample	16/11/2021	181	GC-MS
BTEX in solids	M	As submitted sample	16/11/2021	181A	GC-MS
Total cyanide	M	As submitted sample	16/11/2021	204	Colorimetry
Total organic carbon/Total sulphur	N	Air dried sample	17/11/2021	210	IR
Aliphatic hydrocarbons in soil	N	As submitted sample	16/11/2021	214	GC-FID
Aliphatic/Aromatic hydrocarbons in soil	N	As submitted sample	17/11/2021	214	GC-FID
Aromatic hydrocarbons in soil	N	As submitted sample	16/11/2021	214	GC-FID
Basic carbon banding in soil	N	As submitted sample	16/11/2021	218	GC-FID
Diesel range organics in soil	N	As submitted sample	17/11/2021	257	GC-FID
Asbestos identification	U	Air dried sample	17/11/2021	280	Microscopy
Soil organic matter	U	Air dried sample	16/11/2021	BS1377:P3	Titrimetry

Tests marked N are not UKAS accredited

## Report Information

Report No.: 21-37105, issue number 1

### Key

---

U	hold UKAS accreditation
M	hold MCERTS and UKAS accreditation
N	do not currently hold UKAS accreditation
^	MCERTS accreditation not applicable for sample matrix
*	UKAS accreditation not applicable for sample matrix
S	Subcontracted to approved laboratory UKAS Accredited for the test
SM	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
NS	Subcontracted to approved laboratory. UKAS accreditation is not applicable.
I/S	Insufficient Sample
U/S	Unsuitable sample
n/t	Not tested
<	means "less than"
>	means "greater than"

LOD LOD refers to limit of detection, except in the case of pH soils and pH waters where it means limit of discrimination.  
Soil sample results are expressed on an air dried basis (dried at < 30°C), and are uncorrected for inert material removed.  
ELAB are unable to provide an interpretation or opinion on the content of this report.  
The results relate only to the sample received.  
PCB congener results may include any coeluting PCBs  
Uncertainty of measurement for the determinands tested are available upon request  
Unless otherwise stated, sample information has been provided by the client. This may affect the validity of the results.

### Deviation Codes

---

a	No date of sampling supplied
b	No time of sampling supplied (Waters Only)
c	Sample not received in appropriate containers
d	Sample not received in cooled condition
e	The container has been incorrectly filled
f	Sample age exceeds stability time (sampling to receipt)
g	Sample age exceeds stability time (sampling to analysis)

Where a sample has a deviation code, the applicable test result may be invalid.

### Sample Retention and Disposal

---

All soil samples will be retained for a period of one month  
All water samples will be retained for 7 days following the date of the test report  
Charges may apply to extended sample storage

### TPH Classification - HWOL Acronym System

---

HS	Headspace analysis
EH	Extractable Hydrocarbons - i.e. everything extracted by the solvent
CU	Clean-up - e.g. by florisil, silica gel
1D	GC - Single coil gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics only
AR	Aromatics only
2D	GC-GC - Double coil gas chromatography
#1	EH_Total but with humics mathematically subtracted
#2	EH_Total but with fatty acids mathematically subtracted
_	Operator - underscore to separate acronyms (exception for +)
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total
MS	Mass Spectrometry

---

## THE ENVIRONMENTAL LABORATORY LTD

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**Analytical Report Number:** 21-37250

**Issue:** 1

**Date of Issue:** 26/11/2021

**Contact:** Harry Wrigley

**Customer Details:** Byrne Looby Partners (UK) Limited  
Suite 104  
Mere Grange Business Park  
St Helens  
WA9 5GG

**Quotation No:** Q21-02252

**Order No:** 140761

**Customer Reference:** K0030

**Date Received:** 22/11/2021

**Date Approved:** 26/11/2021

**Details:** Whaley Rd, Barugh Green

**Approved by:** 

Mike Varley, General Manager

---

Any comments, opinions or interpretations expressed herein are outside the scope of UKAS accreditation (Accreditation Number 2683)

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This report may only be reproduced in full

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## Sample Summary

Report No.: 21-37250, issue number 1

Elab No.	Client's Ref.	Date Sampled	Date Scheduled	Description	Deviations
258524	WS02 3.60	18/11/2021	22/11/2021		c

# Results Summary

Report No.: 21-37250, issue number 1

ELAB Reference	258524
Customer Reference	
Sample ID	
Sample Type	WATER
Sample Location	WS02
Sample Depth (m)	3.60
Sampling Date	18/11/2021

Determinand	Codes	Units	LOD	
<b>Dissolved Metals</b>				
Arsenic	U	ug/l	5	13
Calcium	U	ug/l	100	577000
Cadmium	U	ug/l	1	< 1
Chromium	U	ug/l	5	< 5
Copper	U	ug/l	5	< 5.0
Mercury	U	ug/l	0.1	< 0.1
Magnesium	U	ug/l	100	313000
Nickel	U	ug/l	5	10
Lead	U	ug/l	1	< 1
Selenium	U	ug/l	5	< 5
Zinc	U	ug/l	5	24
<b>Anions</b>				
Chloride	U	mg/l	0.5	57.0
Nitrate	U	mg/l	0.5	0.9
Sulphate	U	mg/l	0.5	1710
<b>Inorganics</b>				
Ammonia as NH4	N	mg/l	0.1	1.3
Total Cyanide	U	ug/l	5	c < 5
<b>Miscellaneous</b>				
Electrical Conductivity	U	uS/cm	50	4080
Hardness ( CaCO3)	N	mg/l CaCO3	0.1	2730
pH	U	pH units	0.1	6.5
<b>Phenols</b>				
Total Monohydric Phenols	N	ug/l	1	< 1

# Results Summary

Report No.: 21-37250, issue number 1

ELAB Reference	258524
Customer Reference	
Sample ID	
Sample Type	WATER
Sample Location	WS02
Sample Depth (m)	3.60
Sampling Date	18/11/2021

Determinand	Codes	Units	LOD	
<b>Polyaromatic hydrocarbons</b>				
Naphthalene GCMS	N	ug/l	0.01	0.38
Acenaphthylene GCMS	N	ug/l	0.01	0.07
Acenaphthene GCMS	N	ug/l	0.01	0.19
Fluorene GCMS	N	ug/l	0.01	0.23
Phenanthrene GCMS	N	ug/l	0.01	2.23
Anthracene GCMS	N	ug/l	0.01	0.50
Fluoranthene GCMS	N	ug/l	0.01	1.84
Pyrene GCMS	N	ug/l	0.01	1.58
Benzo (a) anthracene GCMS	N	ug/l	0.01	0.78
Chrysene GCMS	N	ug/l	0.01	0.93
Benzo (b) fluoranthene GCMS	N	ug/l	0.01	0.57
Benzo (k) fluoranthene GCMS	N	ug/l	0.01	0.74
Benzo (a) pyrene GCMS	N	ug/l	0.01	0.99
Indeno (1,2,3-cd) pyrene GCMS	N	ug/l	0.01	0.63
Dibenzo(a,h)anthracene GCMS	N	ug/l	0.01	0.29
Benzo(ghi)perylene GCMS	N	ug/l	0.01	0.84
Total PAH(16) GCMS	N	ug/l	0.01	12.8
<b>BTEX</b>				
Benzene	N	ug/l	1	< 1.00
Toluene	N	ug/l	1	< 1.00
Ethylbenzene	N	ug/l	1	< 1.00
Xylenes	N	ug/l	1	< 1.00
MTBE	N	ug/l	1	< 1.00
<b>TPH CWG</b>				
>C5-C6 Aliphatic (HS_1D_MS)	N	ug/l	1	< 1.0
>C6-C8 Aliphatic (HS_1D_MS)	N	ug/l	1	< 1.0
>C8-C10 Aliphatic (EH_CU_1D_AL)	N	ug/l	5	< 5.0
>C10-C12 Aliphatic (EH_CU_1D_AL)	N	ug/l	5	< 5.0
>C12-C16 Aliphatic (EH_CU_1D_AL)	N	ug/l	5	5.0
>C16-C21 Aliphatic (EH_CU_1D_AL)	N	ug/l	5	< 5.0
>C21-C35 Aliphatic (EH_CU_1D_AL)	N	ug/l	5	269
>C35-C40 Aliphatic (EH_CU_1D_AL)	N	ug/l	5	22.4
Total (>C5-C40) Aliphatic (HS_1D_MS+EH_CU_1D_AL)	N	ug/l	5	297
>C5-C7 Aromatic (HS_1D_MS)	N	ug/l	1	< 1.0
>C7-C8 Aromatic (HS_1D_MS)	N	ug/l	1	< 1.0
>C8-C10 Aromatic (EH_CU_1D_AR)	N	ug/l	5	< 5.0
>C10-C12 Aromatic (EH_CU_1D_AR)	N	ug/l	5	< 5.0
>C12-C16 Aromatic (EH_CU_1D_AR)	N	ug/l	5	< 5.0
>C16-C21 Aromatic (EH_CU_1D_AR)	N	ug/l	5	< 5.0
>C21-C35 Aromatic (EH_CU_1D_AR)	N	ug/l	5	326
>C35-C40 Aromatic (EH_CU_1D_AR)	N	ug/l	5	59.2
Total (>C5-C40) Aromatic (HS_1D_MS+EH_CU_1D_AR)	N	ug/l	5	386
Total (>C5-C40) Ali/Aro (HS_1D_MS+EH_CU_1D_Total)	N	ug/l	5	682
<b>Total Petroleum Hydrocarbons</b>				
Total TPH (C10-C40) (EH_1D_Total)	U	ug/l	100	909

## Method Summary

Report No.: 21-37250, issue number 1

Parameter	Codes	Analysis Undertaken On	Date Tested	Method Number	Technique
<b>Water</b>					
Aliphatic/Aromatic hydrocarbons in water	N		24/11/2021		GC-FID
Aromatic hydrocarbons in water	N		24/11/2021		GC-FID
Phenols in waters	N		23/11/2021		HPLC
Dissolved metals by ICP in waters	U		23/11/2021	101	ICPMS
pH of waters	U		23/11/2021	113	Electromeric
PAHs and/or PCBs in waters	N		23/11/2021	135	GC-MS
Electrical conductivity of water	U		23/11/2021	136	Electromeric
Ammonia in waters	N		23/11/2021	151	Colorimetry
Total Petroleum Hydrocarbons in waters	U		24/11/2021	178	GC-FID
BTEX in waters	N		24/11/2021	200	GC-MS
Low range Aliphatic hydrocarbons water	N		24/11/2021	200	GC-MS
Low range Aromatic hydrocarbons water	N		24/11/2021	200	GC-MS
Cyanide in waters	U		23/11/2021	205	Colorimetry
Aliphatic hydrocarbons in water	N		23/11/2021	215	GC-FID
Aromatic hydrocarbons in water	N		23/11/2021	215	GC-FID
Anions	U		23/11/2021	270	Ion Chromatography
Hardness in waters	N		24/11/2021	APHA	ICPMS

Tests marked N are not UKAS accredited

## Report Information

Report No.: 21-37250, issue number 1

### Key

---

U	hold UKAS accreditation
M	hold MCERTS and UKAS accreditation
N	do not currently hold UKAS accreditation
^	MCERTS accreditation not applicable for sample matrix
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S	Subcontracted to approved laboratory UKAS Accredited for the test
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NS	Subcontracted to approved laboratory. UKAS accreditation is not applicable.
I/S	Insufficient Sample
U/S	Unsuitable sample
n/t	Not tested
<	means "less than"
>	means "greater than"
LOD	<p>LOD refers to limit of detection, except in the case of pH soils and pH waters where it means limit of discrimination.</p> <p>Soil sample results are expressed on an air dried basis (dried at &lt; 30°C), and are uncorrected for inert material removed.</p> <p>ELAB are unable to provide an interpretation or opinion on the content of this report. The results relate only to the sample received.</p> <p>PCB congener results may include any coeluting PCBs</p> <p>Uncertainty of measurement for the determinands tested are available upon request Unless otherwise stated, sample information has been provided by the client. This may affect the validity of the results.</p>

### Deviation Codes

---

a	No date of sampling supplied
b	No time of sampling supplied (Waters Only)
c	Sample not received in appropriate containers
d	Sample not received in cooled condition
e	The container has been incorrectly filled
f	Sample age exceeds stability time (sampling to receipt)
g	Sample age exceeds stability time (sampling to analysis)

Where a sample has a deviation code, the applicable test result may be invalid.

### Sample Retention and Disposal

---

All soil samples will be retained for a period of one month  
 All water samples will be retained for 7 days following the date of the test report  
 Charges may apply to extended sample storage

### TPH Classification - HWOL Acronym System

---

HS	Headspace analysis
EH	Extractable Hydrocarbons - i.e. everything extracted by the solvent
CU	Clean-up - e.g. by florisil, silica gel
1D	GC - Single coil gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics only
AR	Aromatics only
2D	GC-GC - Double coil gas chromatography
#1	EH_Total but with humics mathematically subtracted
#2	EH_Total but with fatty acids mathematically subtracted
_	Operator - underscore to separate acronyms (exception for +)
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total
MS	Mass Spectrometry

## Appendix I – Laboratory Geotechnical Testing Results



5

# LABORATORY REPORT



4043

**Contract Number: PSL21/9205**

Report Date: 13 December 2021  
Client's Reference: K0030  
Client Name: Byrne Looby  
Bold Business Centre  
Bold Lane  
Sutton  
St Helens  
WA9 4TX

**For the attention of: Harry Wrigley/Byrne Looby**

Contract Title: K0030 Whaley Road

Date Received: 23/11/2021  
Date Commenced: 23/11/2021  
Date Completed: 13/12/202

**Notes: Opinions and Interpretations are outside the UKAS Accreditation**

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

Checked and Approved Signatories:

A Watkins  
(Director)

R Berriman  
(Quality Manager)

S Royle  
(Laboratory Manager)

L Knight  
(Assistant Laboratory Manager)

S Eyre  
(Senior Technician)

M Fennell  
(Senior Technician)

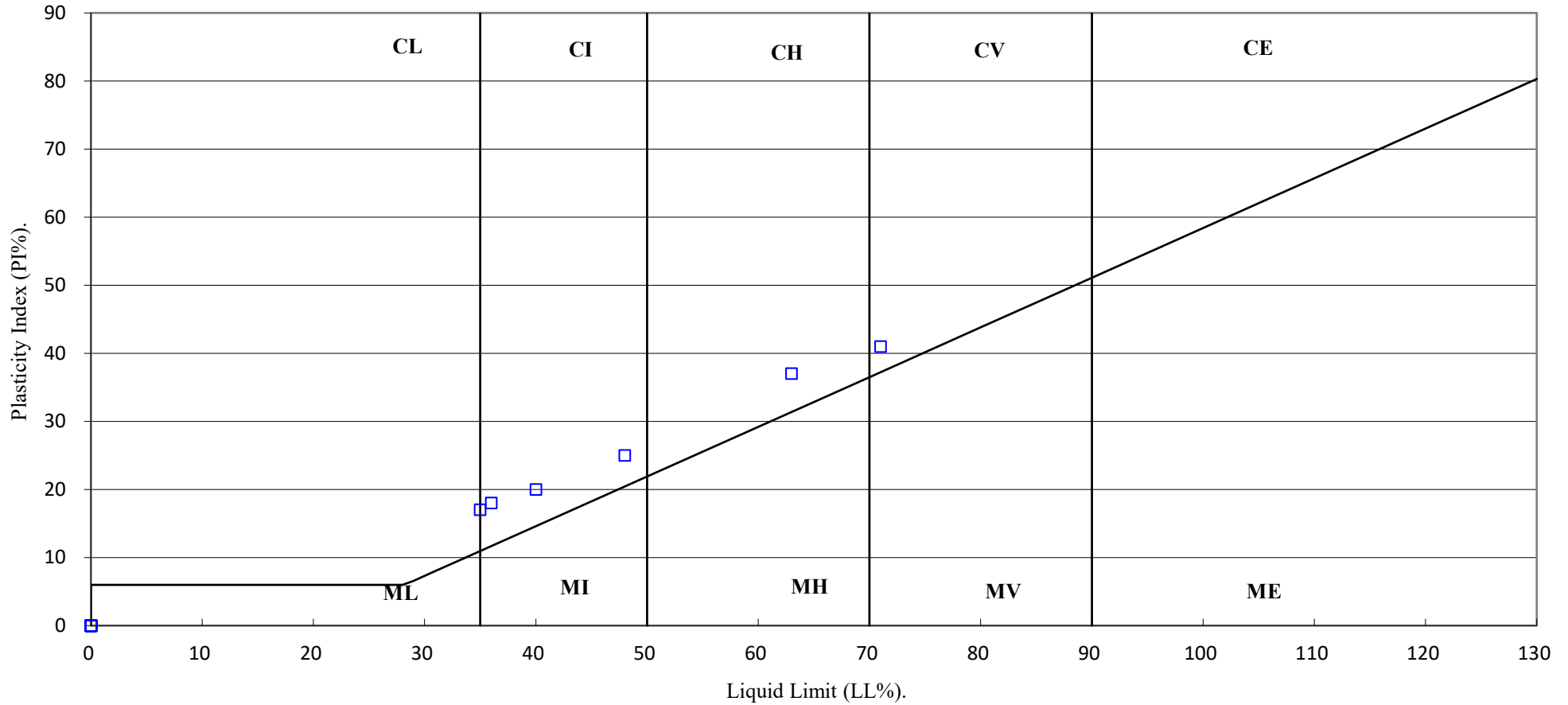
5 – 7 Hexthorpe Road, Hexthorpe,  
Doncaster DN4 0AR  
tel: +44 (0)844 815 6641  
fax: +44 (0)844 815 6642  
e-mail: rberriman@prosoils.co.uk  
awatkins@prosoils.co.uk

Page 1 of





# PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.



4043

**PSL**  
Professional Soils Laboratory

K0030 Whaley Road

**Contract No:**

PSL21/9205

**Client Ref:**

140697

# PARTICLE SIZE DISTRIBUTION TEST

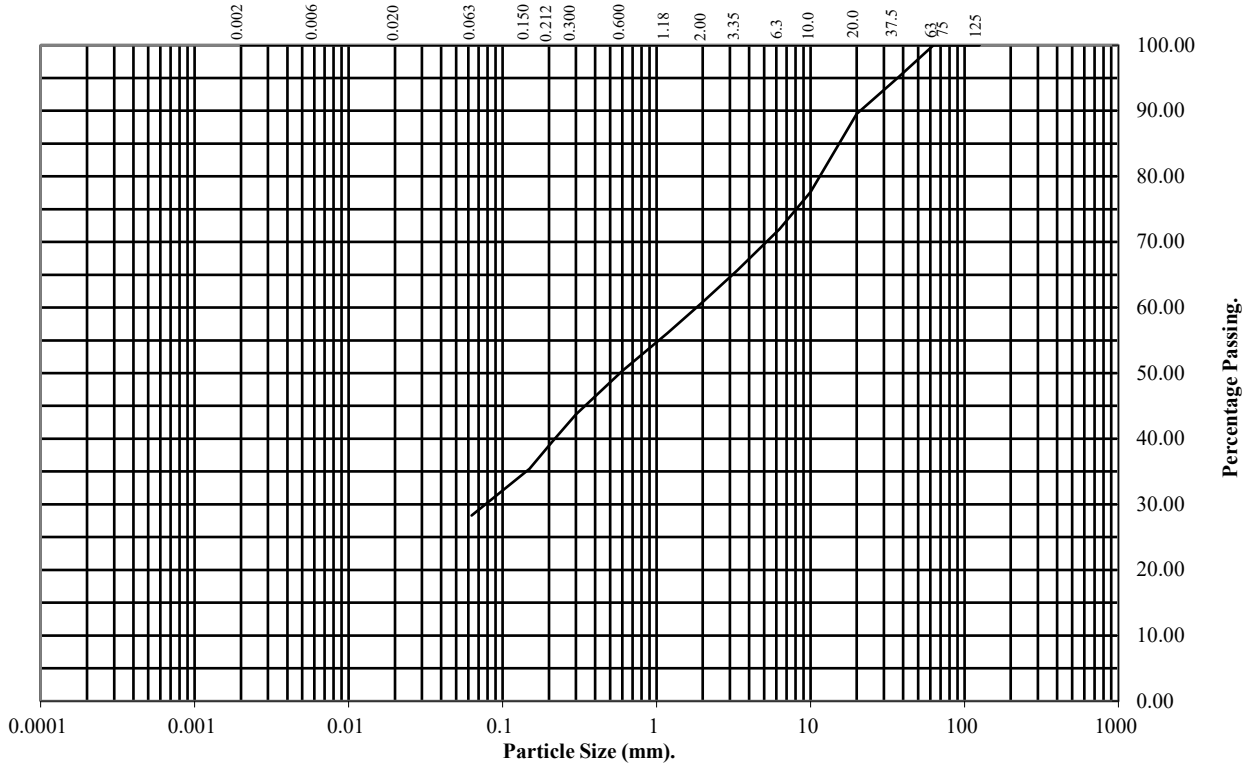
**BS1377 : Part 2 : 1990**

Wet Sieve, Clause 9.2

**Hole Number:** TP06 **Top Depth (m):** 2.00

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

**Sample Type:** B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	95
20	90
10	78
6.3	72
3.35	66
2	61
1.18	56
0.6	50
0.3	44
0.212	40
0.15	35
0.063	28

Soil Fraction	Total Percentage
Cobbles	0
Gravel	39
Sand	33
Silt/Clay	28

**Remarks:**  
See Summary of Soil Descriptions



K0030 Whaley Road

<b>Contract No:</b>
<b>PSL21/9205</b>
<b>Client Ref:</b>
<b>140697</b>

# PARTICLE SIZE DISTRIBUTION TEST

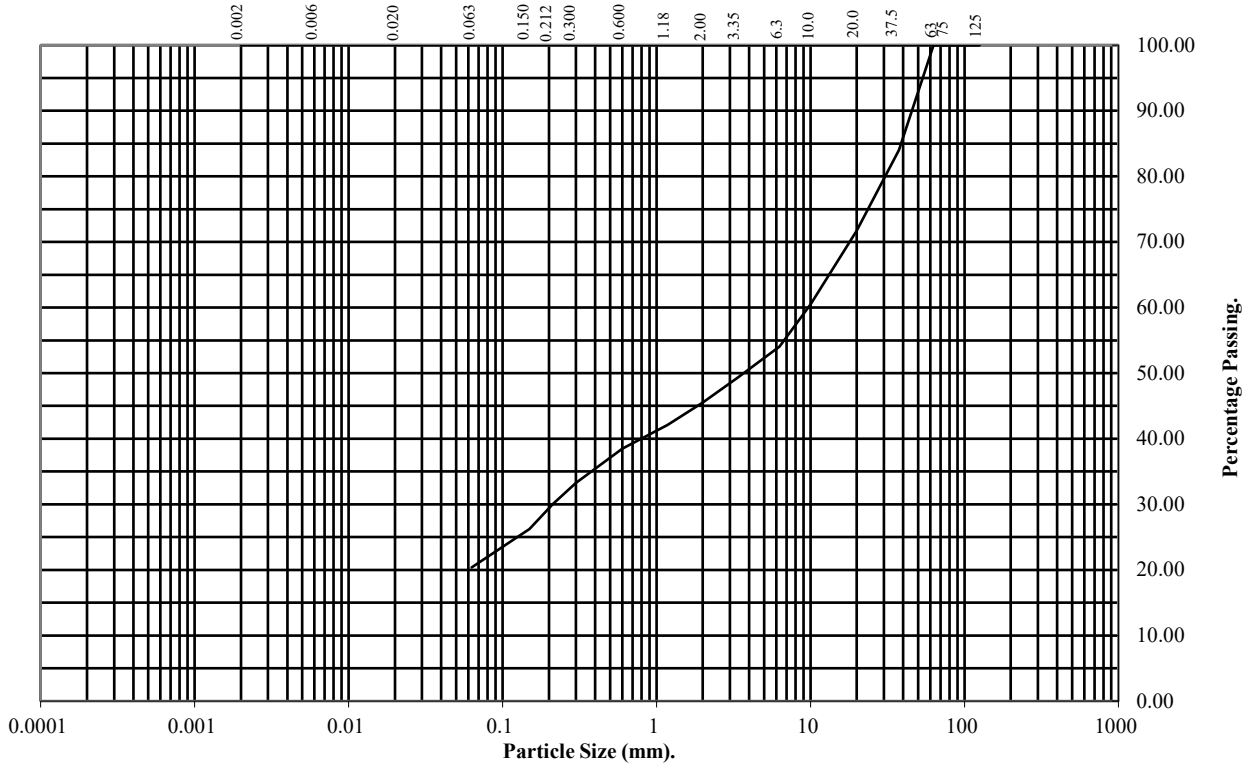
**BS1377 : Part 2 : 1990**

Wet Sieve, Clause 9.2

**Hole Number:** TP07 **Top Depth (m):** 1.50

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

**Sample Type:** B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	84
20	72
10	61
6.3	54
3.35	49
2	46
1.18	42
0.6	38
0.3	33
0.212	30
0.15	26
0.063	20

Soil Fraction	Total Percentage
Cobbles	0
Gravel	54
Sand	26
Silt/Clay	20

**Remarks:**  
See Summary of Soil Descriptions



K0030 Whaley Road

<b>Contract No:</b>
<b>PSL21/9205</b>
<b>Client Ref:</b>
<b>140697</b>

# PARTICLE SIZE DISTRIBUTION TEST

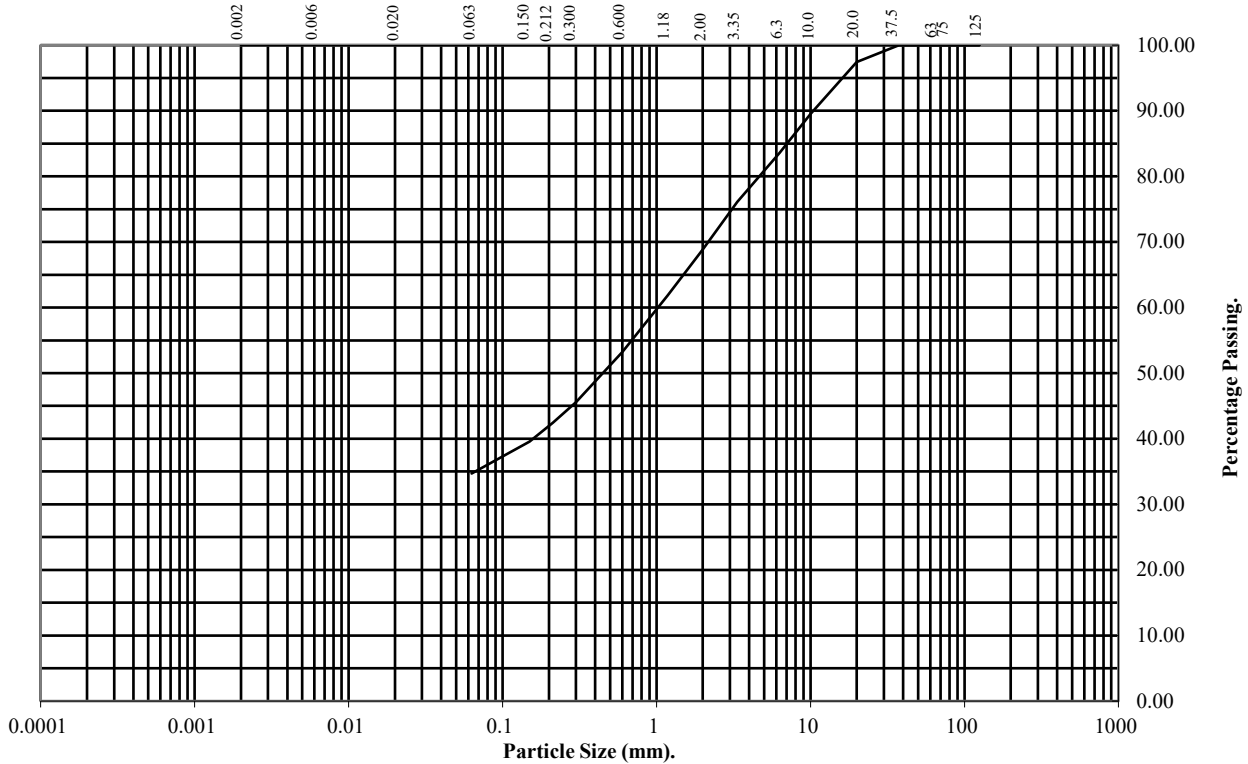
BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number: **WS02** Top Depth (m): **1.20**

Sample Number: Base Depth(m): **3.00**

Sample Type: **B**



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	97
10	90
6.3	84
3.35	76
2	69
1.18	62
0.6	53
0.3	46
0.212	42
0.15	40
0.063	35

Soil Fraction	Total Percentage
Cobbles	0
Gravel	31
Sand	34
Silt/Clay	35

**Remarks:**  
See Summary of Soil Descriptions



K0030 Whaley Road

Contract No:  
PSL21/9205  
Client Ref:  
140697



## ANALYTICAL TEST REPORT

**Contract no:** 103753

**Contract name:** K0030 - Whaley Road

**Client reference:** PSL21/9205

**Clients name:** Professional Soils Laboratory

**Clients address:** 5/7 Hexthorpe Road  
Doncaster  
DN4 0AR

**Samples received:** 10 December 2021

**Analysis started:** 10 December 2021

**Analysis completed:** 20 December 2021

**Report issued:** 20 December 2021

**Key**

U UKAS accredited test

M MCERTS & UKAS accredited test

\$ Test carried out by an approved subcontractor

I/S Insufficient sample to carry out test

N/S Sample not suitable for testing

**Approved by:**

Rachael Burton

Reporting Team Lead

# Chemtech Environmental Limited

## SOILS

Lab number			103753-1	103753-2	103753-3	103753-4	103753-5
Sample id			WS01	WS02	WS03	WS03	TP01
Depth (m)			2.00	1.20	3.50	5.00	1.50
Sample Type			SPT	D	D	SPT	D
Date sampled			-	-	-	-	-
Test	Method	Units					
pH	CE004 <sup>u</sup>	units	7.3	7.2	7.1	7.2	7.3
Magnesium (2:1 water soluble)	CE061	mg/l Mg	89	141	111	90	97
Chloride (2:1 water soluble)	CE049 <sup>u</sup>	mg/l Cl	9.8	13	21	22	15
Nitrate (2:1 water soluble)	CE049 <sup>u</sup>	mg/l NO <sub>3</sub>	<1	<1	<1	<1	1.4
Sulphate (2:1 water soluble)	CE061 <sup>u</sup>	mg/l SO <sub>4</sub>	2083	2276	1997	830	1932
Sulphate (total)	CE062 <sup>u</sup>	mg/kg SO <sub>4</sub>	14159	52449	36645	2500	37533
Sulphur (total)	CE119	mg/kg S	6432	36192	26490	<100	52754
Sulphur (total)	CE119	% w/w S	0.64	3.62	2.65	<0.01	5.28

# Chemtech Environmental Limited

## METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE004	pH	Based on BS 1377, pH Meter	As received	U	-	units
CE061	Magnesium (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry		1	mg/l Mg
CE049	Chloride (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l Cl
CE049	Nitrate (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l NO <sub>3</sub>
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry	U	10	mg/l SO <sub>4</sub>
CE062	Sulphate (total)	Acid extraction, ICP-OES	Dry	U	100	mg/kg SO <sub>4</sub>
CE119	Sulphur (total)	Acid extraction, ICP-OES	Dry		100	mg/kg S
CE119	Sulphur (total)	Acid extraction, ICP-OES	Dry		0.01	% w/w S

# Chemtech Environmental Limited

## DEVIATING SAMPLE INFORMATION

### Comments

Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.

For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.

Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

### Key

N	No (not deviating sample)
Y	Yes (deviating sample)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
103753-1	WS01	2.00	Y	All (NSD)
103753-2	WS02	1.20	Y	All (NSD)
103753-3	WS03	3.50	Y	All (NSD)
103753-4	WS03	5.00	Y	All (NSD)
103753-5	TP01	1.50	Y	All (NSD)

# Chemtech Environmental Limited

## ADDITIONAL INFORMATION

### Notes

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

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

All testing carried out at Unit 6 Parkhead, Stanley, DH9 7YB, except for subcontracted testing.

Methods, procedures and performance data are available on request.

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

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

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

For soils and solids, all results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.

Analytical results are inclusive of stones, where applicable.



## ANALYTICAL TEST REPORT

**Contract no:** 103753

**Contract name:** K0030 - Whaley Road

**Client reference:** PSL21/9205

**Clients name:** Professional Soils Laboratory

**Clients address:** 5/7 Hexthorpe Road  
Doncaster  
DN4 0AR

**Samples received:** 10 December 2021

**Analysis started:** 10 December 2021

**Analysis completed:** 20 December 2021

**Report issued:** 20 December 2021

**Key**

U UKAS accredited test

M MCERTS & UKAS accredited test

\$ Test carried out by an approved subcontractor

I/S Insufficient sample to carry out test

N/S Sample not suitable for testing

**Approved by:**

Rachael Burton

Reporting Team Lead

# Chemtech Environmental Limited

## SOILS

Lab number			103753-1	103753-2	103753-3	103753-4	103753-5
Sample id			WS01	WS02	WS03	WS03	TP01
Depth (m)			2.00	1.20	3.50	5.00	1.50
Sample Type			SPT	D	D	SPT	D
Date sampled			-	-	-	-	-
Test	Method	Units					
pH	CE004 <sup>u</sup>	units	7.3	7.2	7.1	7.2	7.3
Magnesium (2:1 water soluble)	CE061	mg/l Mg	89	141	111	90	97
Chloride (2:1 water soluble)	CE049 <sup>u</sup>	mg/l Cl	9.8	13	21	22	15
Nitrate (2:1 water soluble)	CE049 <sup>u</sup>	mg/l NO <sub>3</sub>	<1	<1	<1	<1	1.4
Sulphate (2:1 water soluble)	CE061 <sup>u</sup>	mg/l SO <sub>4</sub>	2083	2276	1997	830	1932
Sulphate (total)	CE062 <sup>u</sup>	mg/kg SO <sub>4</sub>	14159	52449	36645	2500	37533
Sulphur (total)	CE119	mg/kg S	6432	36192	26490	<100	52754
Sulphur (total)	CE119	% w/w S	0.64	3.62	2.65	<0.01	5.28

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## METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE004	pH	Based on BS 1377, pH Meter	As received	U	-	units
CE061	Magnesium (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry		1	mg/l Mg
CE049	Chloride (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l Cl
CE049	Nitrate (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l NO <sub>3</sub>
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry	U	10	mg/l SO <sub>4</sub>
CE062	Sulphate (total)	Acid extraction, ICP-OES	Dry	U	100	mg/kg SO <sub>4</sub>
CE119	Sulphur (total)	Acid extraction, ICP-OES	Dry		100	mg/kg S
CE119	Sulphur (total)	Acid extraction, ICP-OES	Dry		0.01	% w/w S

# Chemtech Environmental Limited

## DEVIATING SAMPLE INFORMATION

### Comments

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103753-4	WS03	5.00	Y	All (NSD)
103753-5	TP01	1.50	Y	All (NSD)

# Chemtech Environmental Limited

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Analytical results are inclusive of stones, where applicable.

## Appendix J – Summary of Chemical Analysis of Soils



## Appendix K – Summary of Chemical Analysis of Water and Leachate

Observed Contamination		Strata	
Sample Description		WATER	
Date	-	18/11/2021	
Sample ID	-	WS02	
Depth	m	3.60	
Screening Level	Substance	Units	
-	pH (pH units)	pH units	6.5
10	Arsenic	µg/l	13
5	Cadmium	µg/l	< 1
50	Total Chromium	µg/l	< 5
2000	Copper	µg/l	< 5.0
10	Lead	µg/l	< 1
1	Mercury	µg/l	< 0.1
20	Nickel	µg/l	10
10	Selenium	µg/l	< 5
-	Zinc	µg/l	24
-	Total Cyanide	µg/l	c < 5
250	Sulphate	mg/l	1710
250	Chloride	mg/l	57
0.5	Ammonia expressed as NH4	mg/L	1.3
-	Total Alkalinity as CaCO3	mgCaCO3/l	2730
-	Naphthalene	µg/l	0.38
-	Acenaphthylene	µg/l	0.07
-	Acenaphthene	µg/l	0.19
-	Fluorene	µg/l	0.23
-	Phenanthrene	µg/l	2.23
-	Anthracene	µg/l	0.5
-	Fluoranthene	µg/l	1.84
-	Pyrene	µg/l	1.58
-	Benzo(a)anthracene	µg/l	0.78
-	Chrysene	µg/l	0.93
-	Benzo(b)fluoranthene	µg/l	0.57
-	Benzo(k)fluoranthene	µg/l	0.74
0.7	Benzo(a)pyrene	µg/l	0.99
-	Indeno(1,2,3-cd)pyrene	µg/l	0.63
-	Di-benz(a,h,)anthracene	µg/l	0.29
-	Benzo(g,h,i)perylene	µg/l	0.84
-	Total PAH (16)	µg/l	12.8
10	Aliphatics C5-C6	µg/l	< 1.0
10	Aliphatics >C6-C8	µg/l	< 1.0
10	Aliphatics >C8-C10	µg/l	< 5.0
10	Aliphatics >C10-C12	µg/l	< 5.0
10	Aliphatics >C12-C16	µg/l	5
10	Aliphatics >C16-C21	µg/l	< 5.0
10	Aliphatics >C21-C35	µg/l	269
10	Aliphatics >C35-C44	µg/l	22.4
10	Total Aliphatics >C5-44 Aqueous	µg/l	386
-	Aromatics C5-7	µg/l	< 1.0
10	Aromatics >C7-C8	µg/l	< 1.0
10	Aromatics >EC8-EC10	µg/l	< 5.0
10	Aromatics >EC10-EC12	µg/l	< 5.0
10	Aromatics >EC12-EC16	µg/l	< 5.0
10	Aromatics >EC16-EC21	µg/l	< 5.0
10	Aromatics >EC21-EC35	µg/l	326
10	Aromatics >EC35-EC44	µg/l	59.2
-	TPH (Total Aliphatics + Total Aromatics) >C5-C44	µg/l	909
-	Methyl Tertiary Butyl Ether	µg/l	< 1.00
1	Benzene	µg/l	< 1.00
700	Toluene	µg/l	< 1.00
300	Ethylbenzene	µg/l	< 1.00
-	p/m-Xylene	µg/l	
-	o-Xylene	µg/l	
500	Sum of xylenes	µg/l	< 1.00
-	Total Phenols	mg/l	< 1
-	Nitrate	mg/l	0.9

## Appendix L – Source Signature Double Ratio Plot Risk Assessment

## Source Signature Double Ratio Plot Explanation Sheet

When coal forms, organic matter is converted to coal via low grade metamorphism. The geological process which converts the fresh organic matter to a carbon based strata is noted to comprise carbonisation as well as dehydrogenation. The carbonisation process forms methane gases as well as partially converts the material into hydrocarbon based products. As carbonisation progresses, the volume of volatile gases diminish as these are driven from the strata and complex organic compounds are formed. The slow cracking of the organic material over many millions of years, where a constant heat flow is present will eventually strip the material of hydrogen, nitrogen and oxygen, producing purer carbon products. The presence of the PAH concentrations encountered to date within the samples analysed are not beyond what may be expected for a coal. Other methods of PAH formation comprise the partial combustion of fuel such as coal and petroleum.

To determine whether the source of the PAH compounds are petroleum or pyrogenically (from coal fragments) formed, a source signature double ratio plot assessment was undertaken. This method of appraisal compares a ratio of comparative compound pairs for 4 No. PAH compounds. This means that the properties of the comparative PAH compounds are similar (such as aqueous solubility, molecular weight, Kow) and have diagnostic source ratios which should retain their relative concentrations and hence their ratio remain constant. ByrneLooby have adopted a classification of double ratio PAH compounds fluoranthene/pyrene and benzo(a)anthracene/chrysene in accordance with Costa and Sauer 2005. These have been considered the most appropriate pairing to determine a differentiation between petroleum fuels, coal, coal derived products, combustion products and natural plant matter (such as peat and lignin).

The method for differentiating petroleum based hydrocarbon concentrations from natural organic units is by determining the rates of combustion and the relative losses of PAH compounds within samples analysed. Forensic environmental scientists, situated predominately within the United States, have investigated the relationships between many combinations of PAH compounds and it is generally considered the 4 No. compounds mentioned above have a suitable and representative correlation for this assessment.

The method of assessment requires the 2 ratios of the 2 pairs of diagnostic source ratio compounds to be calculated, and the results plotting on a graph. The graph has areas compartmentalised into petroleum, combustion and coal derived sources, with plant derived sources situated in the bottom right hand corner. These designations have been derived from ALcontrol Geochem's extensive knowledge with regards to PAH signatures as well as the extensive work completed by Environmental Forensic scientists such as H J Costa and T C Sauer. ALcontrol Geochem have been using this method for tracing hydrocarbon sources for many years and have pooled their extensive database of material type traces for their graphic representation (refer to Figure 1 below).

PAH compounds can be both created and lost through combustion. With regards to petroleum derived products, the fresh compounds tend to be situated on the mid left hand side of the graph, with combusted and heavier fuels moving north east across the graph. Coal is generally positioned in the top right area of the graph, with combustion products such as ash and clinker, soot and burnt coal being situated between coal and petroleum sections. It should be noted that smokeless fuels appear within the mid petroleum derived column as the processes involved in the formation of this fuel includes the removal of certain PAH compounds.

Peat forms PAH compounds due to the degradation of organic matter and is represented in the bottom right hand corner of the graph. Asphalt and coal tar derived tarmac can also be determined from this form of analysis.

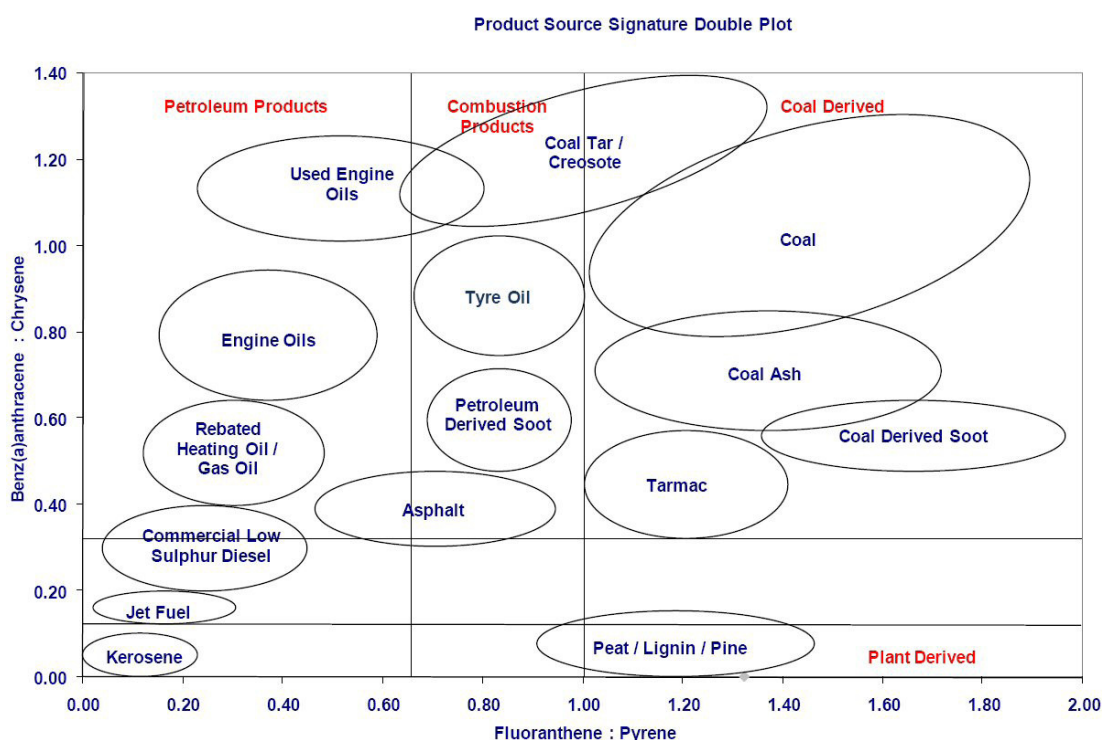


Figure 1: Key to source signature double ratio plots based on conjectured source.

### Double ratio plots – references

Double ratio plots have been developed as a result of expanding our Environment Forensic capabilities and is based on the following references amongst others.

Yunker, M. B., Macdonald, R. W., Vingarzin, R., Mitchell, R. H., Goyette, D., and Sylvestre, S. 2002. PAH in the Fraser River basin: A critical appraisal of PAH ratios as indicators of PAH source and composition. *Organic Geochemistry* 33:489-515.

Costa, H. J., and Sauer, T. C., Jr. 2005. Technical Note - Forensic Approaches and Considerations in Identifying PAH Background. *Environmental Forensics*, 6:9-16.

As for how robust the technique is, for low concentrations, or where the PAHs being used to determine the ratios are very similar it will not be completely reliable, but we have found that in most cases it offers a very good correlation with visual and/or site histories. Ratios other than those on the flier can also be used.

Environmental forensics is basically a matter of using the most appropriate ratios to identify sources and correlate spills. There are hundreds of possible combinations, and it is very much a case of experience and knowledge as to which will give the most meaningful answers, as no two sites are the same.

The Fluoranthene:Pyrene vs Benz(a)anthracene:chrysene ratios have been found to be the best in identifying the sources of PAH compounds with regard to petroleum, petrogenic (coal), combustion (ash and clinker) or recently formed (peat).

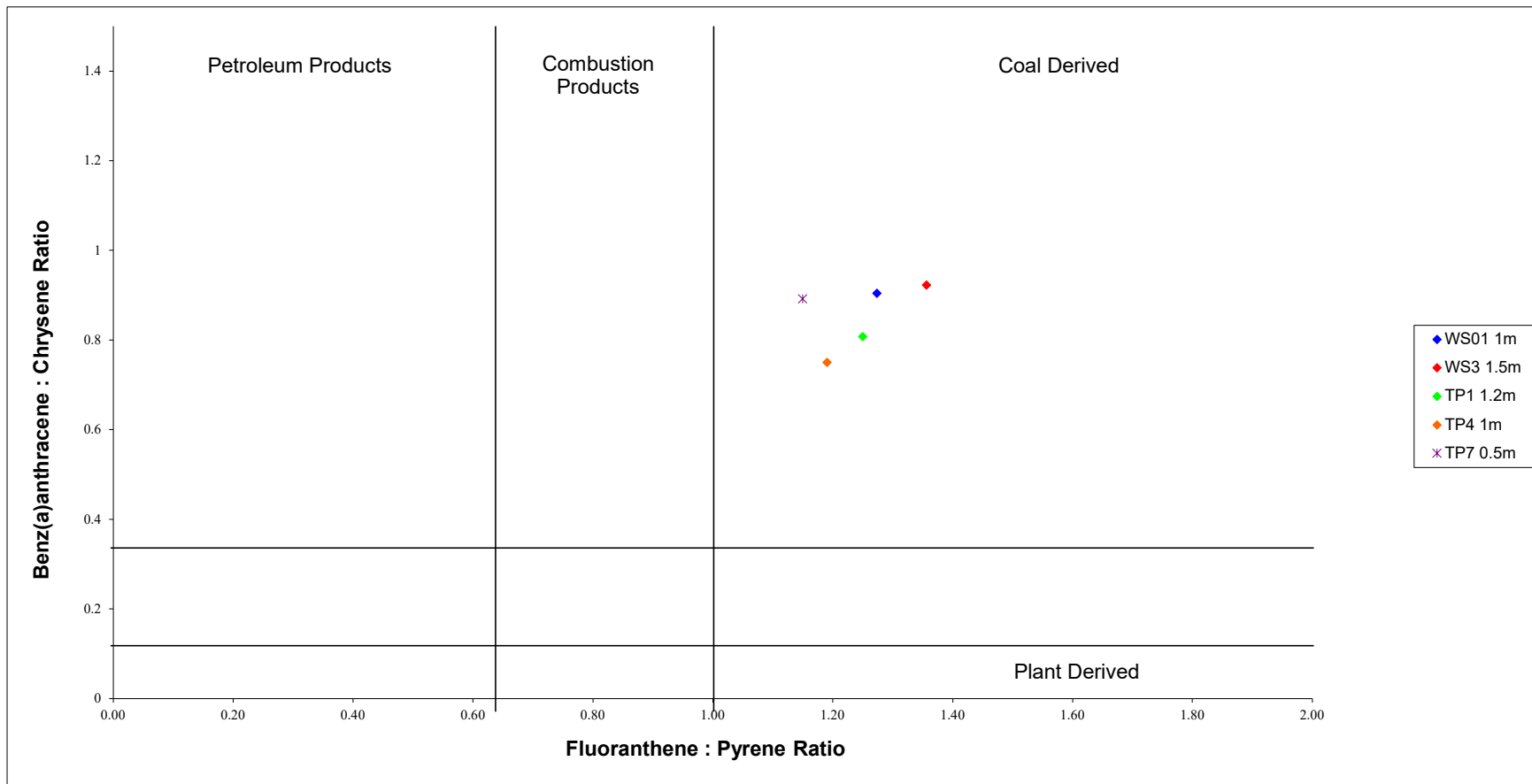
## Source Signature Double Ratio Plot

Project Number:	K0030
Laboratory Reference Number:	21-37105

Sample Type:	Madeground (colliery fill)
Laboratory:	Elab

Sample No.	WS01 1m	WS3 1.5m	TP1 1.2m	TP4 1m	TP7 0.5m
Benzo(a)anthracene	6.6	19.1	2.1	0.9	3.3
Chrysene	7.3	20.7	2.6	1.2	3.7
Fluoranthene	12.1	49.1	4	2.5	6.9
Pyrene	9.5	36.2	3.2	2.1	6

All concentrations are in mg/kg



## Appendix M – Current Guidance for Ground Gas Risk Assessment

## Current Guidance for Ground Gas Risk Assessment

### Origin of Ground and Landfill Gases

When carrying out a ground gas risk assessment for permanent ground gases (e.g., methane and carbon dioxide), the origin or source of the gases is important as potential risks will vary depending on the source. This Appendix relates to the risk of the two main ground gases of concern: methane and carbon dioxide and does not apply to other ground gases (e.g., radon or vapours from hydrocarbon spills). Methane and carbon dioxide are major constituents of landfill gas but can also occur from a variety of anthropogenic and natural sources, as summarised in Table G1 below:

Table G1. Potential Sources of Ground Gases		
Gas	Source	Comments
Landfill Gas	Anaerobic decomposition of degradable waste within landfill sites. Typically, 60% methane and 40% carbon dioxide during methanogenic phase.	Composition varies over time, particularly in early stages. Contains a range of minor constituents (particularly carbon monoxide and hydrogen sulphide).
Landfill Associated Gases	<ul style="list-style-type: none"> <li>- Anaerobic degradation of leachate external to the site;</li> <li>- Degassing of dissolved gases in groundwater;</li> <li>- Evolution of gases following interaction between leachate and groundwater</li> </ul>	Can result in secondary (external) production of methane or carbon dioxide.
Made Ground	Anaerobic degradation of organic components	Very variable depending on source
Sewer Gas, Cess Pits	Anaerobic degradation of organic components of sewage producing methane and carbon dioxide.	Often characterised by hydrogen sulphide odour.
Mains Gas	Leakage from underground pipework or storage tanks. Mainly methane but often contains higher alkanes.	An odouriser is added to permit detection of leaks. Typically, 90% CH <sub>4</sub> , but 1 to 27% C <sub>2</sub> -C <sub>4</sub> alkanes, May also contain other trace gases e.g., CO, helium and CO <sub>2</sub> (from degradation of CH <sub>4</sub> in the ground).
Other Anthropogenic Sources	<ul style="list-style-type: none"> <li>- Degradation of leaked or spilled hydrocarbons or other industrial chemicals;</li> <li>- Anaerobic degradation of organic contaminants in groundwaters (e.g., silage liquor);</li> <li>- Reactions between monitoring well construction components and environment;</li> <li>- Burial grounds/cemeteries.</li> </ul>	Hydrocarbon spillages often have an 'oily' odour. Fuel spillages common – Petrol or Diesel and can contain a wide range of VOC's. Can degrade to produce methane / carbon dioxide.
Alluvium / Marsh / Peat Gas	Anaerobic microbial degradation of organic material (usually waterlogged vegetation / peat). Often associated with the presence of alluvial deposits or dredgings.	
Geogenic Gas	Natural seepages of carbon dioxide and hydrocarbon gases derived from geologic sources such as coal seams and deep oil / gas source formations. Can be present in solution in groundwaters.	Methane most common but can contain carbon dioxide and higher alkanes.
Mine Gases	Various types. Most common is "fire damp" with high methane, produced by the desorption of gas trapped in coal. "Black damp" (Stythe gas) with high carbon dioxide and denser than air. "White damp" is high in carbon monoxide.	Methane most common. Can contain higher alkanes, carbon dioxide and carbon monoxide. Often low in oxygen.
Natural Shallow Ground Gas	<ul style="list-style-type: none"> <li>- Various types</li> <li>- high carbon dioxide formed by subsurface aerobic activity leading to depleted oxygen and elevated carbon dioxide;</li> <li>- chemical degradation of rocks (e.g., carbonates) producing carbon dioxide;</li> <li>- carbon dioxide production in root zone of soils by plants.</li> </ul>	Gases can be emitted from ground under falling barometric pressure conditions.

This Appendix concentrates on the assessment of risk from methane and carbon dioxide. This Appendix does not provide guidance for the assessment of risk when other gases are present due to 'Other Sources' from the above table (particularly organic compounds such as BTEX and VOC's or for the risk from radon or hydrogen sulphide).

To determine the origin of the gas a range of factors must be considered together, including;

1. Proximity of likely sources;
2. Ground conditions (geology, hydrogeology, anthropogenic pathways etc);
3. Properties of gases present including:
  - a. Chemical composition;
  - b. Physical properties;
  - c. Ratios of components e.g., methane : carbon dioxide.
4. Timeframe of activities such as infilling periods, capping works, installation of gas control systems etc.

Identification of the originating source may be problematic given that there may be more than one source present and trace gas analysis may be required. Identification of the sources of the gases encountered during monitoring is usually carried out through a process of eliminating the most unlikely potential sources (given the site setting) and selecting those which are the more likely candidates.

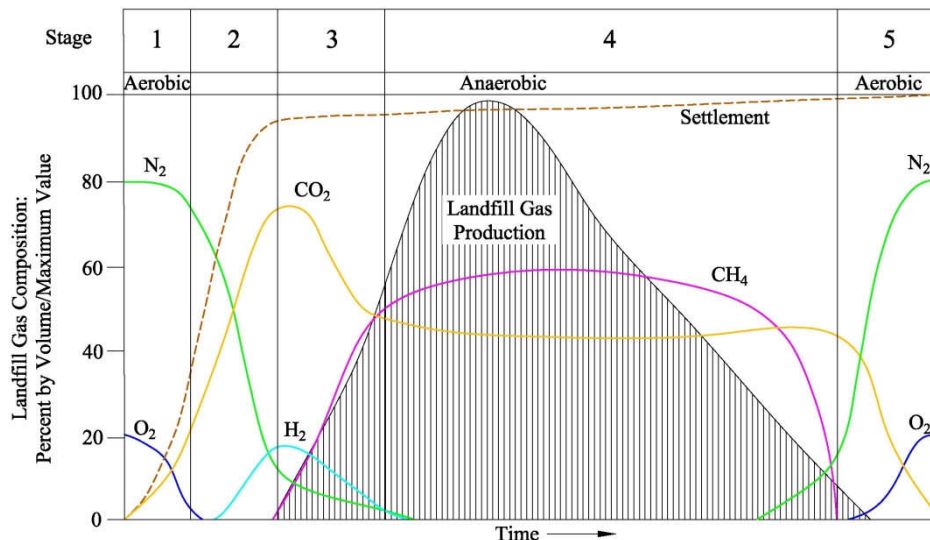
### **Hazards Associated with Presence of Ground Gases**

Methane gas is combustible and potentially explosive. When the concentration of methane in air is between the limits of 5.0%v/v and 15.0%v/v an explosive mixture is formed. The Lower Explosive Limit (LEL) of methane is 5.0%v/v, which is equivalent to 100% LEL. The 15.0%v/v limit is known as the Upper Explosive Limit (UEL), but concentrations above this level cannot be assumed to represent safe concentrations. Further, the LEL and UEL will vary (up and down) depending upon the proportion of other gases (including oxygen). However, the fact that methane is a colourless, odourless gas means that there is no simple indicator of the presence of the gas until such a time as explosive limits are reached, and an incident occurs. Methane is lighter than air and has a low toxicity. However, at high concentrations it can result in asphyxiation due to oxygen displacement.

Carbon dioxide is a colourless, odourless gas, which, although non-flammable, is both toxic and an asphyxiant. As carbon dioxide is denser than air, it will collect in low points and depressions. The UK Health & Safety Executive (HSE) has published information relating to concentrations of carbon dioxide that humans may be exposed to, which uses concentrations contained in the Control of Substances Hazardous to Health Regulations 2002 (as amended). These are the Long-Term Occupational Exposure Limit (LTOEL, 8-hour period) and the Short-Term Occupational Exposure Limit (STOEL, 15-minute period), which are 0.5% and 1.5% carbon dioxide, respectively.

### Parameters Influencing the Rate of Ground Gas Production

Figure G2 is taken from EA guidance document LFTGN 03 illustrates typical ground gas generation curves from biodegradable materials:



**Figure G2. Idealised Representation of Landfill Gas Generation.**

The production of methane and carbon dioxide at a landfill site may be expected to be considerable and ongoing. Concentrations of methane will eventually decrease, followed by concentrations of carbon dioxide, but the duration and rate of gas production can vary markedly between sites. Five distinct phases of gas production occur during the process which are, in order of event (as marked on Figure G2), as follows:

1. An aerobic phase involving oxygen depletion and temperature increase through aerobic respiration;
2. The establishment of anaerobic conditions and the evolution of carbon dioxide and hydrogen through acidogenic activity;
3. Commencement of methanogenic activity; the establishment of populations of methanogenic bacteria;
4. A phase of stable methanogenic activity, which may go on for many tens of years;
5. A phase of decreasing methanogenic activity, representing depletion of the organic material and a return to aerobic conditions.

The time scale for the return to the normal ground gas concentrations will be highly variable, depending upon the types and quantities of materials present. In addition, the optimum parameters influencing the rate of decomposition and ground gas production within the ground at a site are as follows:

- High water content with adequate rainfall and water infiltration to provide moisture content between approximately 20 to 26%;

- Conditions that either are or are very close to anaerobic;
- High proportion of biodegradable materials;
- A pH between 6.5 and 8.5, ideally verging slightly on the acidic between pH 6 to 7;
- Temperature between 25°C and 55°C;
- The ratio of the biochemical and chemical oxygen demands (BOD:COD);
- High permeability;
- Small particle size, as finer subsurface materials possess a greater surface area to provide a growing 'face' for the micro-organisms but high fines levels reduces permeability and reduces decomposition rate.

For this reason, it is vital that sources of methane and carbon dioxide are identified prior to the commencement of any work on a construction site, and that the ground gas regime is characterised at the worst temporal conditions a site may experience. From this, a risk assessment is carried out to identify the risk at the site from ground gases so that suitable protection measures can be designed and incorporated into a development to prevent a dangerous build-up of gas occurring.

### **Factors Influencing the Migration and Behaviour of Ground Gases**

There are many factors that influence the migration of ground gases which can affect the risk from a gassing source:

- driving force – pressure differential along a pathway, diffusion and dissolved in solution;
- meteorological conditions – short term and seasonal conditions including atmospheric pressure changes (e.g., rapidly falling pressure causes gas to expand increasing emission rates), rainfall, frozen ground and thawing, temperature;
- geological and groundwater conditions – these can have the over-riding influence on the direction/pathways and quantity of migrating gas;
- anthropogenic influences – man-made pathways include mine shafts, service runs/drains, foundation piles, underground voids/pits/basements, foundation/building design/construction

### **Guidance Documents**

Currently in the UK, there are no statutory threshold limits for hazardous gases in the ground as site specific variables mean that standard threshold values cannot be applied. The published guidance relating to development of sites where methane and carbon dioxide are present has been produced in response to building projects on or close to landfill sites, as both gases are principal constituents of landfill gas. Much of the historic guidance that has been produced on gas risk assessment focused on landfill sites and as a result there has previously been a lack of clarity when relating the process to gas conditions on non-landfill sites.

Statutory guidance regarding methane in the ground has previously taken a limiting concentration of 1.0 % by volume methane (equal to 20% of the lower explosive limit of methane in air) above which necessary actions will be appropriate. For carbon dioxide the limiting recommended trigger was 1.5 % by volume (the Long-Term Exposure Limit for carbon dioxide). Above these concentrations the Building Regulations Approved Document C (1992) stated that consideration should be given to whether actions may be appropriate, whilst more specific solutions would be likely to be necessary at concentrations greater than 5% by volume of carbon dioxide (Building Regulations Approved Document C, 1992). However, the latest fully revised version of Approved Document C (DoE, 2004) no longer endorses this approach and instead requires the use of a risk-based approach in interpreting the findings of a gas monitoring survey. Further, the latest EA documentation on landfill gas (LFTGN 03, 2004) continues to sanction the use of a risk-based approach through a structured approach to the assessment of ground gases and links with the risk assessment process outlined within CLR 11 for soil contaminants.

With the above in mind, recent guidance has been produced in 2006 and 2007 with the aim of providing up to date advice in relation to residential and commercial development. The guidance does not address issues associated with gas derived from landfills, for this refer to “*Guidance on the Management of Landfill Gas*” (Environment Agency 2004) for an overview.

Recent guidance relevant to gas assessments for residential and commercial development includes;

- **Wilson et al. (CIRIA C665, December 2007) “Assessing Risks Posed by Hazardous Ground Gases for Buildings.”**

This document provides up to date advice on all aspects of ground gas risk assessment such as investigation, monitoring programmes, data collection and interpretation. The guidance presents separate methodologies for the characterisation of:

- **All development types except low rise housing with gardens and for Low Rise Buildings without a 150mm void** (Situation A) (Table 8.5 CIRIA C665)
- and;
- **Low rise housing with gardens with a 150mm ventilated sub-floor void** (Situation B) (Table 8.7 CIRIA C665)
- (See below for further explanation of the methods of characterisation)

- **Boyle and Witherington (NHBC / RSK Group, Report 10627-R01(04) January 2007) “Guidance on the Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present.”**

This document presents the “Traffic Lights System” detailed below and is relevant only for low rise properties (e.g., bungalows and town houses) that have a ventilated sub-floor void (i.e., Situation B as described in CIRIA C665).

- **Wilson and Card (CIEH, expected 2011) “Ground Gas Handbook for Designers and Regulators”**

This document is expected to provide practical guidance on ground gas assessments and the design and evaluation of protection measures.

- **British Standard (BS 8485+A1, January 2019) “Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings”**

This document provides an overview of gas characterisation and assessment. The Standard is intended to be used by designers of gas protection measures and regulators involved in the assessment of design solutions. The Standard provides a framework in line with CLR11 allowing designers to judge the adequacy of ground gas and related site investigation data. The document provides an approach to determine appropriate ground gas parameters that can be used to identify a range of possible construction solutions mitigating against the presence of ground gas on a development site.

Each of these documents continues to highlight the importance of, and give further guidance towards, carrying out a tiered risk-based decision-making process in accord with government policy on dealing with contamination from historic or natural sources and highlight the importance of the Conceptual Model in site characterisation. These documents also stress the importance that the assessor should be confident that the ground gas monitoring results are representative of the likely worse case ground gas regime on a site and that the data collected from the site is sufficient. With this in mind, CIRIA C665 sets out ideal monitoring periods as below.

Idealised Frequency and Period of Monitoring (after Table 5.5a and 5.5b, CIRIA C665)						
		Generation Potential of Source				
		Very Low	Low	Moderate	High	Very High
Sensitivity of Development	Low (Commercial)	4/1	6/2	6/3	12/6	12/12
	Moderate (Flats)	6/2	6/3	9/6	12/12	24/24
	High (Residential with Gardens)	6/3	9/6	12/6	24/12	24/24

**Notes**

1. First number is the number of readings and the second is the minimum period in months (e.g., 6/2 – six sets of readings over two months).
2. At least two sets of readings must be at low (preferably under 1,000 mb) and falling pressure.
3. High sensitivity end use on high or very high hazard site will not normally be acceptable unless the source is treated to reduce gassing potential.

Before the latest guidance, good practice for site characterisation had been based upon the method proposed by Wilson and Card (1999). CIRIA C665 (2007) effectively supersedes Wilson and Card (1999) and includes a modified version of the Wilson and Card method (Tables 8.5, 8.6 and Box 8.1). Gas concentrations and flow rates for either methane and/or carbon dioxide measured at a site to ‘Characteristic Situations.’ Appropriate protection measures are selected from Table 8.6 (if using modified Wilson & Card method) and from Box 8.4 from CIRIA C665 (if using the NHBC traffic lights method). Throughout the risk assessment process, strong regard must be given to the nature of the gassing source, the flow rates and the estimated surface emissions. Note that certain protection measures are stated in CIRIA Report 149 that are now considered wholly inappropriate to certain developments and consequently should not be used without modification. Throughout the process, it is important to remember that these tables are not

intended to be used as a definitive design tool and have been prepared to show the typical scope of measures for gas control.

Both the NHBC (2007) and CIRIA (2007) guidance documents and BS 8485+A1 (2019) propose that both ground gas concentrations and flow rates are used to calculate the limiting gas well gas volume flow rates for methane and carbon dioxide, based on the ground gas conditions monitored for during the worse-case temporal conditions. This limiting gas well volume flow rate is termed the Gas Screening Value (GSV, note that this was termed borehole gas volume flow), and is calculated as follows:

$$\text{GSV (l/hr)} = \frac{[\text{gas well gas concentration (\%v/v)}] \times [\text{gas well flow rate (l/hr)}]}{100}$$

These GSVs are then compared to generic 'Traffic Lights' contained within the NHBC guidance, which present typical maximum gas concentrations and limiting GSV's, for 'Situation B Development' (Low rise housing with gardens).

**Table 8.7 NHBC Traffic light system for 150 mm void**

Traffic Light	Methane <sup>1</sup>		Carbon Dioxide <sup>2</sup>	
	Typical max concentration <sup>3</sup> (% by volume)	Gas Screening Value <sup>2,4</sup> (litres/hour)	Typical max concentration <sup>3</sup> (% by volume)	Gas Screening Value <sup>2,4</sup> (litres/hour)
Green	1	0.13	5	0.78
Amber 1	5	0.63	10	1.6
Amber 2	20	1.60	30	3.10
Red				

**Notes:**

1. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst-case temporal conditions that the site may be expected to encounter will be the decider as to what Traffic Light is allocated;
2. Borehole Gas Volume Flow Rate, in litres per hour as defined in Wilson and Card (1999), is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;
3. The Typical Maximum Concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;
4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

**Box 8.4 of CIRIA C665 Gas protection measures for low-rise housing development based upon allocated NHBC Traffic light (Boyle and Witherington, 2007)**

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

For a ‘Situation A Development’ (All development except low rise housing with gardens), the GSV value is used to derive the appropriate Characteristic Situation from Table 8.5 of CIRIA C665 (below):

**Table 8.5 from CIRIA C665 Modified Wilson and Card Classification**

Characteristic Situation (CIRIA R149)	Comparable Partners in Technology gas Regime (see Box 8.2)	Risk Classification	Gas Screening Value (CH <sub>4</sub> or CO <sub>2</sub> ) (l/hr) <sup>1</sup>	Additional Factors	Typical Source of Generation
1	A	Very low risk	<0.07	Typically, methane ≤ 1% and/or carbon dioxide ≤ 5%. Otherwise consider increase to Situation 2	Natural soils with low organic content “Typical” made ground
2	B	Low risk	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to characteristic Situation 3	Natural soil, high peat/organic content. “Typical” made ground
3	C	Moderate risk	<3.5		Old landfill, inert waste, mine working flooded
4	D	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures.	Mine working susceptible to flooding, completed landfill (WMP 26B criteria)
5	E	High risk	<70		Mine working unflooded inactive with shallow workings near surface
6	F	Very high risk	>70		Recent landfill site

It was intended in CIRIA C665 that the characteristic situation allocated to the development from the table above would then be used in Table 8.6 of CIRIA C665 in order to determine the level of gas protection the development requires. However, BS8485:2015 superseded this document and a different set of mitigation standards were put forward.

The recommended minimum gas protection score (points) be selected based on the building type (Table 3 which defines four building types) and the ground gas Characteristic Situation as detailed in Table 4 of BS8485:2015+A1:2019 (see below).

The first step in the decision-making process is to obtain the level of gas protection necessary in the range 0 to 7.5 from Table 4. Then a combination of structural barriers (Table 5) ventilation protection measures (Table 6) and/or gas resistant membranes (Table 8) should be chosen to meet that requirement. The level of gas protection necessary should take into account the characteristic gas situation and a number of other factors. The whole decision-making process should be made transparent, where all parties can see the approach being taken, can understand the various steps and decisions made and be confident that a risk-assessed solution has been designed and installed commensurate with the construction and site constraints.

Where the gas Characteristic Situation is 4 or more (and for NHBC Red situations according to CIRIA C665), the site requires a comprehensive risk assessment to confirm the scope of protection measures. These are higher risk sites and reliance on Table 4 alone is not sufficient.

<b>BS8485:2015+A1:2019 Table 3 Building Types</b>				
	<b>Type A</b>	<b>Type B</b>	<b>Type C</b>	<b>Type D</b>
Ownership	Private	Private or commercial/ public, possible multiple	Commercial / public	Commercial / industrial
Control (change of use, structural alterations, ventilation)	None	Some but not all	Full	Full
Room sizes	Small	Small / medium	Small to large	Large industrial / retail park style

BS8485:2015+A1:2019 Table 4 Gas Protection Score by CS and Type of Building				
CS	Required Gas Protection			
	High risk	Medium risk	Low risk	
	Type A	Type B	Type C	Type D
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4	3	2.5
4	6.5 <sup>(A)</sup>	5.5 <sup>(A)</sup>	4.5	3.5
5	<sup>(B)</sup>	6 <sup>(A)</sup>	5.5	4.5
6	<sup>(B)</sup>	<sup>(B)</sup>	<sup>(B)</sup>	6
a)	Residential building should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g., high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g., in institutional and/or fully serviced contractual situations.			
b)	The gas hazard is too high for this empirical method to be used to define the gas protection measures			
<p><small>NOTE 3</small> The NHBC has published guidance for use on residential developments, which utilise an alternative classification (“traffic light”) system. This guidance typically applies to Type A buildings utilising beam and block floor constructions with clear void ventilation. The design choice variables are limited to decisions relating to the membrane specification and verification recommendations (see Table 7). Designers utilising this system would therefore need to refer to NHBC to assess compliance for specific recommendations [see 8485:2015 for further on this note]</p> <p><small>NOTE 4</small> The method of selecting the combination of these types of protection is given in section 7.2 of BS8485:2015. Once type of measures has been decided, the detailed design and specification of the measures should be undertaken (section 7.3)</p>				

Section 7.2 defines the order of selecting protective measures. The first choice is provided by structural barriers as defined in Table 5.

BS8485+A1:2019 Table 5 Gas protection scores for structural barriers		
PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
<b>Floor and substructure design</b>		
<b>Floor slabs</b>		
Block and beam floor slab	0	<i>General – score conditional that breaches of slab are sealed</i>
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)	0.5	
Cast in situ monolithic reinforced ground-bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations (with only nominal mesh reinforcement)	1 or 1.5	<i>To achieve 1.5, raft or suspended slab to be well reinforced to prevent cracking and minimal penetrations</i>
Basement floor and walls to BS 8102:2009, Grade 2 waterproofing – See notes in BS8485:2015+A1:2019	2	
Basement floor and walls to BS 8102:2009, Grade 3 waterproofing - See notes in BS8485:2015+A1:2019	2.5	<i>Conditional that waterproofing is not based on geosynthetic clay liner</i>

Ventilation methods are detailed in Table 6, and points can only be gained from using one of the five types:

**BS8485:2015+A1:2019 Table 6 Gas Protection Scores for Ventilation Protection Measures**

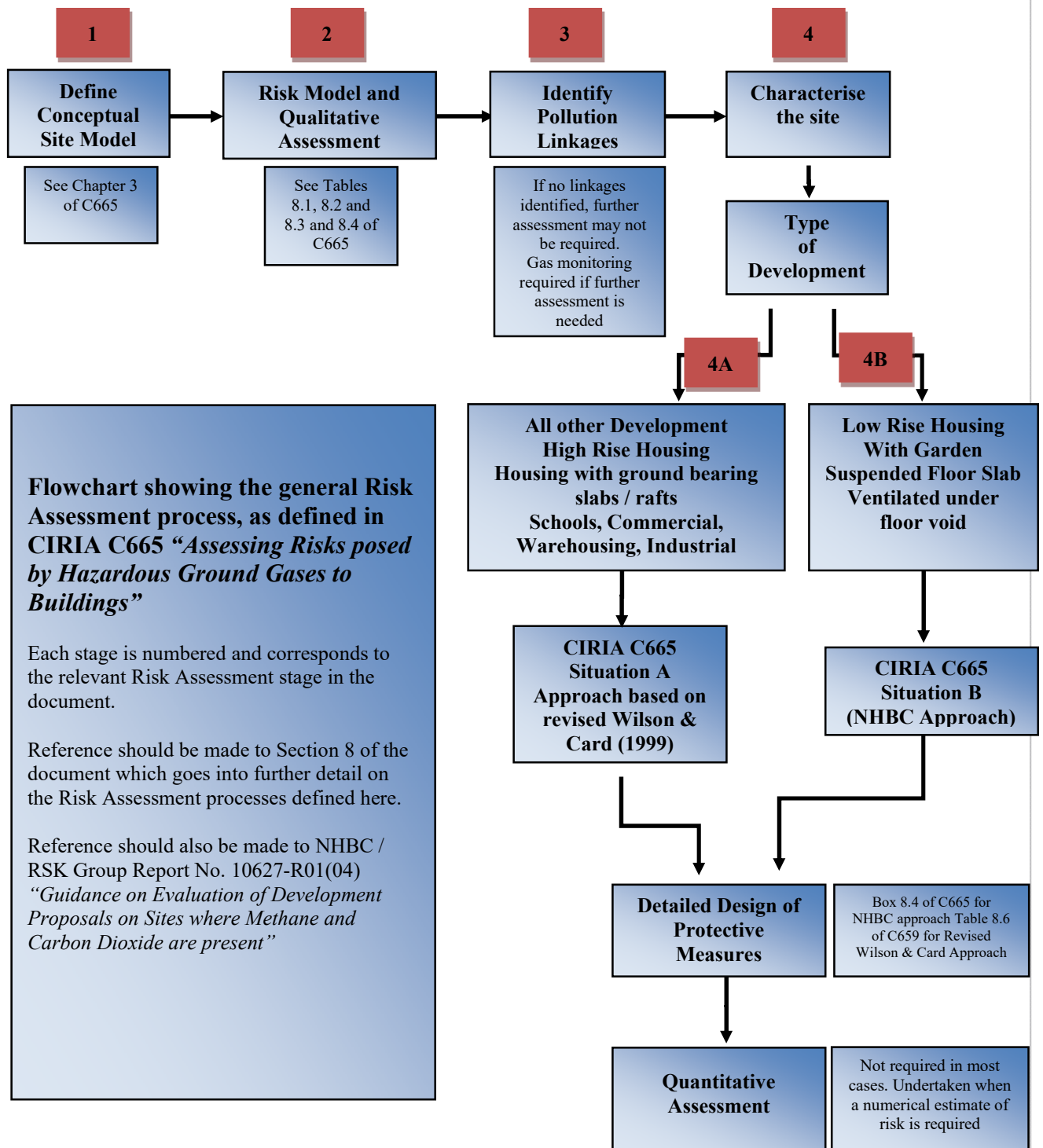
PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
a) Pressure relief pathway (usually formed by low fines gravel or with a thin geocomposite blanket with strips terminating in a gravel trench external to the building)	0.5	<i>Whenever possible, a pressure pathway relief pathway (as a minimum) should be installed in all gas protection measures systems. If a layer has a low permeability and/or is not terminating in a venting trench (or similar), then the score is zero.</i>
b) Passive sub floor dispersal layer Very good performance Good performance Media used to provide the dispersal layer are:	2.5 1.5	<i>Performance criteria shown in Fig B.6 and B.7 of BS 8484:2015.[See Annex B]</i>
<ul style="list-style-type: none"> <li>• Clear void</li> <li>• Polystyrene void forming blanket</li> <li>• Geocomposite void former blanket</li> <li>• No-fines gravel layer with gas drains</li> <li>• No-fines gravel layer</li> </ul>		
c) Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers	1.5 to 2.5	<i>This system relies on continued serviceability of the pumps; therefore, alarm and response systems should be in place. [See Annex B].</i>
d) Active positive pressurisation by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket	1.5 to 2.5	<i>This system relies on continued operation of the pumps; therefore, alarm and response systems should be in place. [See Annex B].</i>
e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft)	4	<i>Assumes car park is vented, designed to Building Regulations 2000, Approved Document F.</i>

Membrane methods are detailed in Table 7.

BS8485:2015+A1:2019 Table 7 Gas protection score for gas resistant membrane		
PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
<p>Gas resistant membrane meeting all of the following criteria:</p> <ul style="list-style-type: none"> <li>• Sufficiently impervious to gases with a methane gas transmission rate &lt;40.0 ml/day/m<sup>2</sup>/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method)</li> <li>• Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;</li> <li>• Sufficiently strong to withstand in-service stresses (e.g., settlement if placed below a floor slab);</li> <li>• Sufficiently strong to withstand the installation process and following trades until covered (e.g., penetration from steel fibres in fibre reinforced concrete, dropping tools etc); and to withstand in-service stresses (e.g., settlement if placed below a floor slab)</li> <li>• capable, after installation, of providing a complete barrier to the entry of the relevant gas; and</li> <li>• verified in accordance with CIRIA C735</li> </ul>	2	<p><i>The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation, and the integrity of joints.</i></p> <p><i>If a membrane is installed that does not meet the criteria, then the score is zero.</i></p>
See notes in BS8485:2015+A1:2019 regarding membrane requirements		

For a site which is impacted by migratory gases from an off source, the development may be protected by imposing pathway intervention methods, which if successfully validated, could also remove the need for further analysis. It is essential that the gas regime in these circumstances has been fully characterised and that the only source impacting the site is located off site and that the pathway is clearly defined and its interception equally proven before construction commences. Pathway intervention methods may include vertical membrane installations, venting trenches, rows of stone columns, activated trenches and various proprietary systems. These systems are particularly relevant to domestic housing where there is limited scope for foundation type solutions.

Following the choice of protection measures, detailed design should be entered into [Section 8 of BS 8485:2015+A1:2019].



Appendix N – Summary of Guidance for Classification of Soils as a  
Waste Material

## **Guidance for Classification of Soil for Off Site Disposal at a Landfill Site**

Many site developments create a portion of excess soils and Made Ground which if not re-usable, are required to be disposed off-site at a suitably licensed landfill site. The regulations and associated guidance published by the Environment Agency is relatively complex and lengthy. This guidance provides a summary of the following documents which should be referred to when assessing soil (and common constituents found within Made Ground on remediation sites) for off-site disposal:

- Guidance for Waste destined for disposal in landfills: Interpretation of the Waste Acceptance Requirements of the Landfill (England and Wales) Regulations 2002 (as amended) (EA, 2004);
- Guidance on Sampling and Testing of Wastes to Meet Landfill Waste Acceptance Procedures (EA, April 2005);
- WM3 - Hazardous Waste: Interpretation of the Definition and Classification of Hazardous Wastes (EA, May 2015);
- European Regulation No 1272/2008 on Classification, Labelling and Packaging of substances 2015 (CLP 2015);
- Guidance on Waste Destined for Disposal in Landfill (EA, June 2006);
- Treatment of Non-hazardous wastes for Landfill (EA, February 2007).

It is important to distinguish between the waste classification system and the designation of materials as “suitable for use” on site. A material may be retained on site for an appropriate end use if that end-use is clearly designated and that a site-specific risk assessment ensures that it does not pose a risk to human health or controlled waters. However, if this material is excavated and sent for disposal, the material is then subject to waste management regulations and the two systems cannot be directly correlated. It is therefore important to note that classifying a material as hazardous (should it be excavated and become a waste) does not necessarily indicate that it might not be suitable to be kept on site for re-use. Separate guidance in the form of a Code of Practice (CL:AIRE Version 2, 2011) has been developed jointly between the development industry and the Environment Agency to provide best practice when assessing whether materials are wastes or not, and for determining when waste can cease to be waste for a particular use.

In accordance with the current waste regulations (or Landfill Directive, as they are more commonly known), from 30<sup>th</sup> October 2007 all waste materials produced from construction sites have to be pre-treated prior to disposal. Pre-treatment includes waste minimisation, recovery (e.g., separation of demolition waste to be used as hardcore) and separation of materials into different waste categories (e.g., separate inert waste from hazardous waste etc). Mixing of different waste types shall be avoided and intentional mixing of inert materials with hazardous waste to ‘dilute it’ and hence change its waste classification, is illegal.

The current waste regulations (based on the EU landfill directive) introduced a two-tier classification system for waste materials, defining them as either being hazardous or non-

hazardous. Landfills are licensed to take wastes based on a three-tier classification system with the non- hazardous waste divided into two sub-categories:

- Non-Hazardous - inert;
- Non-Hazardous - non-hazardous;
- Hazardous.

Waste materials are categorised with a six-figure numeric code in the European Waste Catalogue. Commonly found construction and demolition wastes including excavated soil from contaminated sites and Made Ground with their waste codes are summarised below (this is not a comprehensive list):

Waste Code	What is it?	Likely Waste Category-		
		Inert Waste	Non-Hazardous	Hazardous Waste
<b>17 01 01</b> Concrete	Concrete, possibly with reinforcement (from Construction & Demolition)	✓		
<b>17 01 02</b> Bricks		✓		
<b>17 01 06*</b> Mixtures of concrete, bricks, tiles & ceramics containing dangerous substances	These are not normally considered hazardous but if they are contaminated (e.g., by asbestos) then could be hazardous – see comment above			✓
<b>17 01 07</b> Mixtures of concrete, bricks, tiles & ceramics other than those in 17 01 06	This is mixed inerts c.f. 17 09 04	✓		
<b>17 05 03*</b> soils and stones containing dangerous substances				✓
<b>17 05 04</b> soils and stones other than those mentioned in 17 05 03	Soil and stones only (excluding top soil, peat, soil and stones from contaminated sites)	✓		
<b>17 06 05*</b> Construction materials containing asbestos	e.g., corrugated asbestos sheeting			✓
<b>17 08 02</b> Gypsum-based construction materials other than those mentioned in 17 08 01	Plaster & plasterboard (although specific disposal requirements are required for high sulphate waste – see EA guidance ‘Understanding the Landfill Directive’ version 1.0 March 2010.		✓	

<b>17 09 01*</b> Construction & demolition wastes containing mercury				✓
<b>17 09 02*</b> Construction & demolition wastes containing PCBs	Waste with more than 50 mg/kg of PCB's are hazardous			✓
<b>17 09 03*</b> Other mixed construction & demolition wastes containing dangerous substances	Broad range of potentially (see notes below – if asterix the waste is hazardous) hazardous wastes			✓
<b>17 09 04</b> Mixed construction & demolition wastes other than those mentioned in 17 09 01, 17 09 02 & 17 09 03	Mixed inerts with soil, tarmac, cables, vegetation, plaster, etc. (this waste can only be considered inert if it passes the waste acceptance criteria identified in the regulations).	✓	✓	

**Note:** all wastes with an asterix code are hazardous regardless of whether they are mirror or absolute entries in the EWC list the decision to with regard to composition must come before applying the code for mirror entries.

Some materials are classified as Inert Waste based in its origin (e.g., 17 01 01 Concrete, or glass) without any requirement for laboratory chemical analysis.

However, most soils will require laboratory testing to confirm whether they are classified as Hazardous Waste. The protocol for assessing these materials and the appropriate threshold values is complicated and are set out in the Environment Agency's "Technical Guidance WM3 Hazardous Waste – Interpretation of the Definition and Classification of Hazardous Waste" (2015). If the test results for the waste indicates that it is not hazardous then further analysis of the waste is required to determine whether it is Inert Waste. If the waste does not meet the criteria for either Hazardous or Inert, then it is by default classified as Non-hazardous Waste.

As an alternative location to landfills for off-site disposal of inert and non-hazardous waste, there are a number of sites which have Waste Permit Exemptions that can accept certain categories of inert and non-hazardous wastes. Additionally, some quarries can accept certain types of wastes to be used for quarry restoration material. For both alternatives to disposal at landfill sites the material still requires chemical testing as these sites have site specific acceptance criteria for wastes. It should also be noted that these types of sites do not incur landfill tax which in the 2018/19 tax year is £2.80 for inactive waste (inert and some types of non-hazardous waste) and £88.95/Tonne for active waste (some types of non-hazardous waste and hazardous waste. Note that the Inland Revenue uses a different classification scheme for waste for tax purposes to the European Waste Classification scheme.

### Waste Categorisation

The process of determining the category of wastes is a three-stage process:

- Stage 1 – is the waste either Hazardous or Inert by definition without the requirement for chemical analysis (if it is then Stages 2 and 3 are not required);

- Stage 2 - Waste characterisation;
- Stage 3 - WAC classification.

Waste characterisation determines if a waste is hazardous or not. Excavated soil is characterised using a system based on the contaminants present and their hazardous properties. The system uses total concentrations of the contaminants. Thresholds (as a percentage of the waste) have been set for the various hazardous properties.

Fourteen hazardous properties together with other scenarios where material could cause a hazard have been defined:

- Hazardous properties: explosive, oxidising, highly flammable/flammable, irritant, harmful, toxic, carcinogenic, corrosive, infectious, toxic for reproduction, mutagenic and ecotoxic;
- Substances which can release toxic/very toxic gases in contact with water, acid or air;
- Substances which, after disposal, can yield another substance, e.g., a leachate, which possesses any of the above hazardous properties.

Some of the hazardous properties are sub-divided e.g., there are three categories of carcinogenic, mutagenic and toxic for reproduction substances. The hazardous properties were originally defined in the European Hazardous Waste Directive 91/689/EC. Should a waste contain a contaminant with one or more of the listed hazardous properties at a concentration equal to or above the threshold value for the particular property, then the waste is hazardous. The hazardous properties of a wide range of chemicals are sourced from CLP 2015.

There are many reasons why waste soil is classified as being hazardous, but the majority of reasons can be divided into the following four groups:

- Hydrocarbons – this is probably the most common reason for the hazardous classification of soils. For most soils hydrocarbon analysis will be required for both Polycyclic Aromatic Hydrocarbons (PAH) and speciated Petroleum Hydrocarbons (PHCs) but depending on the site's history other groups of organic contaminants may also be included in any analysis suite for soil samples;
- Metals – Particularly sites from former metal processing or mining sites and also some types of ash have metal concentrations that are sufficiently high to characterise materials requiring disposal as hazardous waste.
- Asbestos;
- Anions – e.g., sulphate in plasterboard (there are special disposal requirements for high sulphate waste and specific WAC requirements); it is possible that sulphate salts of metals and semi-metals could make the waste hazardous – the sulphate concentration could possibly be significant under H12, H13 and H14.

The characterisation of wastes with significant metal concentrations involves some processing of the analysis data. The chemical analysis results for inorganic substances are generally reported as total concentrations e.g., total lead, total arsenic, total sulphate etc. However, CLP 2015 deals with the hazardous properties of actual compounds e.g., lead sulphate, arsenic pentoxide, nickel carbonate. Therefore, the total metal results have to be converted into assessed chemical analysis results for the compound most likely to be present in the soil samples. For example, if the sample contains high total lead concentrations and high sulphate concentrations, then the lead is likely to be present in the soil as lead sulphate. The most likely compounds can often be determined from a desk study or previous site uses. If the site has been derelict for a number of years, consideration should be given as to whether water soluble compounds should or should not be chosen, as rainfall could have removed them from the soil (this does not apply if the soil has been taken from below under a concrete slab etc). Chemical knowledge and common sense needs to be used in choosing a suitable compound.

If no data is available, then a worst-case scenario has to be assumed and the most hazardous compound likely to be present has to be chosen. For example, metal chromates (lead chromate, nickel chromate) are often the most hazardous compounds formed by many metals, but if the chromium concentrations in the soil are low, chromates are unlikely to be present. It should also be noted that for many of the hazard categories, the cumulative hazard from different compounds is added (e.g., add the concentrations of the copper, lead and zinc compounds together to assess the Hazard Category H14 Ecotoxicity).

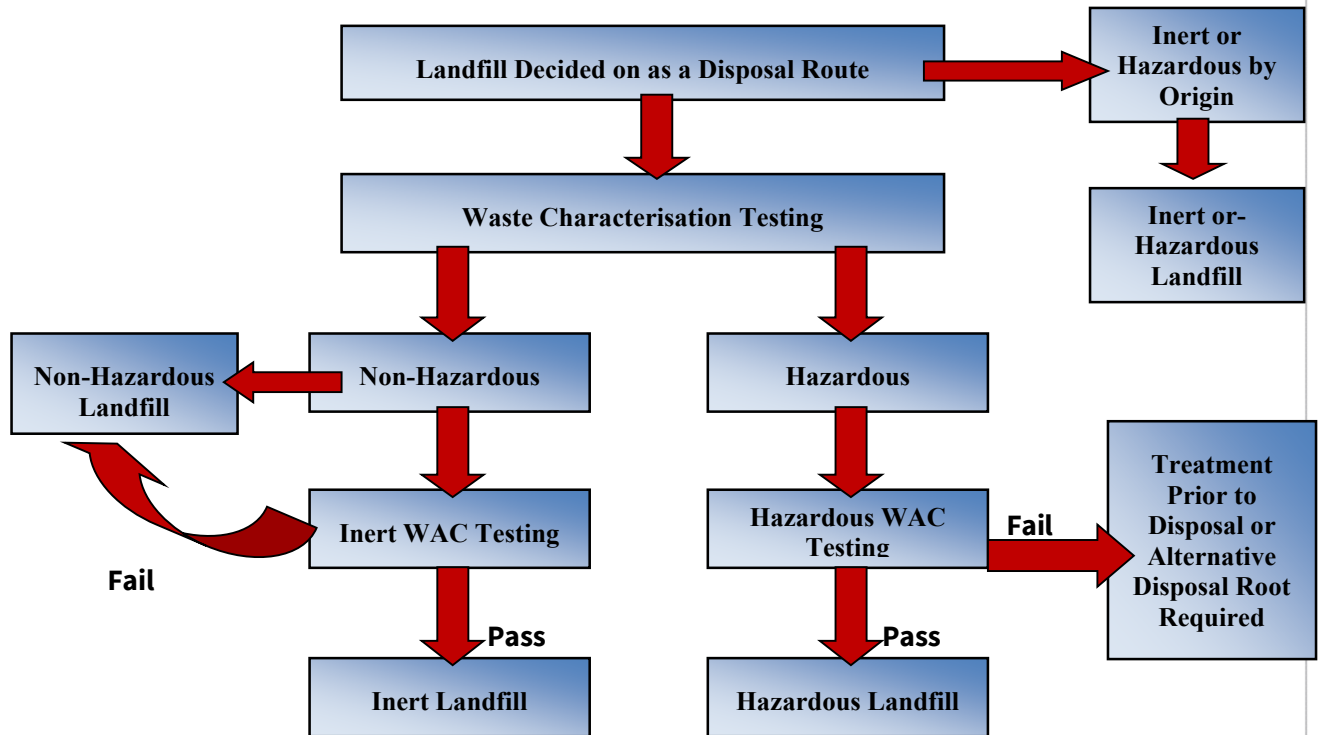
If the results of the above assessment determine that the waste is hazardous, it must then be analysed for the Waste Acceptance Criteria (WAC) analysis contained within appropriate Environmental Permitting Regulations (this comprises mainly leachate but also analysis for TOC and Loss on ignition). WAC limit values have been set for the listed determinands. If any of the determinands exceed their limit value, the waste must be pre-treated to reduce concentrations to below the limit values before the waste may be disposed of at a landfill site licensed to take hazardous waste.

For waste classified as not being hazardous, then there are two options available. Currently, waste correctly characterised as not being hazardous may be disposed of without WAC testing to a non-hazardous landfill. Alternatively, WAC testing for Inert Waste can be carried out (this is similar to the list for hazardous waste with the addition of PAH's, BTEX and Mineral Oil). If the results pass the Inert WAC criteria it can be disposed of at an Inert Waste Landfill. If any of the WAC test results exceed the Inert WAC criteria the waste has to be disposed at a non-hazardous landfill. There are WAC limits for non-hazardous waste set for pH and TOC. If these two criteria are not met then the waste must be pre-treated to so that it meets the criteria before it can be disposed.

If materials fail the WAC criteria it may be possible to pre-treat the waste on-site or be taken to a soil treatment centre for pre-treatment to reduce the soil's hazardous properties (e.g., by bioremediation of hydrocarbons).

It should be noted that in order to dispose of Hazardous Waste, the site must register as a producer of Hazardous Waste with the Environment Agency. When disposing of waste materials to landfill sites the appropriate Duty of Care Waste Transfer procedures must be followed.

**Landfilled Waste Decision Tree**



**Inert By Origin**

EA paper "Waste Acceptance at Landfills - Guidance on waste acceptance procedures and criteria" indicates that 'Inert' wastes listed as acceptable at a landfill for inert waste without testing, if: "they are single stream waste of a single waste type (although different waste types from the list may be accepted together if they are from a single source); and there is no suspicion of contamination and they do not contain other material or substances such as metals, asbestos, plastics, chemicals, etc to an extent which increases the risk associated with the waste sufficiently to justify their disposal in other classes of landfill." Therefore, based on the findings of a suitable desk study natural soils and other materials can be classified as inert without testing based on knowledge of the origin of the waste and confirmatory visual inspection without testing, It must be free of anthropogenic materials (unless it is from a suitably certified waste stream).

**Landfill Tax**

It should be noted that HM Revenue and Customs (HMRC) classify wastes for tax purposes using a different scheme to the threefold landfill EU Landfill Directive scheme (i.e., the hazardous, non-hazardous and inert). HMRC have a two-fold system for landfill tax. The Standard Landfill Tax is currently £88.95/T and applies to all wastes unless they qualify for the reduced rate of landfill tax of £2.80/T. The wastes that qualify for the reduced rate of Landfill Tax are set out in The Landfill Tax (Qualifying Material) Order 2011 with supplementary information on the interpretation of these regulations in HMRS "Notice LFT1 – A General Guide to Landfill Tax" (May 2012) and HMRC Briefing Notes 15/12 and 18/12.

## Appendix O – Revised Groundsure Report

WHALEY ROAD, BARUGH, BARNSELEY, S75 1HT

## Order Details

**Date:** 07/03/2022  
**Your ref:** 14-K0030-000-PO141121  
**Our Ref:** GS-8570600  
**Client:** Rebecca Richardson

## Site Details

**Location:** 432218 408318  
**Area:** 1.71 ha  
**Authority:** [Barnsley Metropolitan Borough Council](#)



**Summary of findings**

p. 2

**Aerial image**

p. 8

**OS MasterMap site plan**

p.12

[groundsure.com/insightuserguide](https://groundsure.com/insightuserguide)

Contact us with any questions at:

[info@groundsure.com](mailto:info@groundsure.com)

08444 159 000

## Summary of findings

Page	Section	Past land use	On site	0-50m	50-250m	250-500m	500-2000m
<a href="#">13</a>	<a href="#">1.1</a>	<b><u>Historical industrial land uses</u></b>	6	12	75	45	-
<a href="#">19</a>	<a href="#">1.2</a>	<b><u>Historical tanks</u></b>	0	0	4	8	-
<a href="#">19</a>	<a href="#">1.3</a>	<b><u>Historical energy features</u></b>	0	0	3	6	-
20	1.4	Historical petrol stations	0	0	0	0	-
<a href="#">20</a>	<a href="#">1.5</a>	<b><u>Historical garages</u></b>	0	0	7	5	-
21	1.6	Historical military land	0	0	0	0	-
Page	Section	Past land use - un-grouped	On site	0-50m	50-250m	250-500m	500-2000m
<a href="#">22</a>	<a href="#">2.1</a>	<b><u>Historical industrial land uses</u></b>	8	16	90	54	-
<a href="#">29</a>	<a href="#">2.2</a>	<b><u>Historical tanks</u></b>	0	0	9	32	-
<a href="#">30</a>	<a href="#">2.3</a>	<b><u>Historical energy features</u></b>	0	0	9	12	-
31	2.4	Historical petrol stations	0	0	0	0	-
<a href="#">32</a>	<a href="#">2.5</a>	<b><u>Historical garages</u></b>	0	0	14	8	-
Page	Section	Waste and landfill	On site	0-50m	50-250m	250-500m	500-2000m
33	3.1	Active or recent landfill	0	0	0	0	-
33	3.2	Historical landfill (BGS records)	0	0	0	0	-
<a href="#">34</a>	<a href="#">3.3</a>	<b><u>Historical landfill (LA/mapping records)</u></b>	0	0	2	0	-
<a href="#">34</a>	<a href="#">3.4</a>	<b><u>Historical landfill (EA/NRW records)</u></b>	1	1	3	3	-
<a href="#">36</a>	<a href="#">3.5</a>	<b><u>Historical waste sites</u></b>	1	1	0	0	-
<a href="#">36</a>	<a href="#">3.6</a>	<b><u>Licensed waste sites</u></b>	2	0	0	0	-
<a href="#">37</a>	<a href="#">3.7</a>	<b><u>Waste exemptions</u></b>	0	5	10	2	-
Page	Section	Current industrial land use	On site	0-50m	50-250m	250-500m	500-2000m
<a href="#">39</a>	<a href="#">4.1</a>	<b><u>Recent industrial land uses</u></b>	1	2	15	-	-
<a href="#">41</a>	<a href="#">4.2</a>	<b><u>Current or recent petrol stations</u></b>	0	0	0	1	-
41	4.3	Electricity cables	0	0	0	0	-
41	4.4	Gas pipelines	0	0	0	0	-
41	4.5	Sites determined as Contaminated Land	0	0	0	0	-



41	4.6	Control of Major Accident Hazards (COMAH)	0	0	0	0	-
42	4.7	Regulated explosive sites	0	0	0	0	-
<b>42</b>	<b>4.8</b>	<b><u>Hazardous substance storage/usage</u></b>	0	1	0	0	-
42	4.9	Historical licensed industrial activities (IPC)	0	0	0	0	-
42	4.10	Licensed industrial activities (Part A(1))	0	0	0	0	-
<b>43</b>	<b>4.11</b>	<b><u>Licensed pollutant release (Part A(2)/B)</u></b>	0	0	4	4	-
<b>44</b>	<b>4.12</b>	<b><u>Radioactive Substance Authorisations</u></b>	0	0	0	1	-
<b>44</b>	<b>4.13</b>	<b><u>Licensed Discharges to controlled waters</u></b>	0	0	0	2	-
45	4.14	Pollutant release to surface waters (Red List)	0	0	0	0	-
45	4.15	Pollutant release to public sewer	0	0	0	0	-
45	4.16	List 1 Dangerous Substances	0	0	0	0	-
45	4.17	List 2 Dangerous Substances	0	0	0	0	-
<b>45</b>	<b>4.18</b>	<b><u>Pollution Incidents (EA/NRW)</u></b>	0	0	0	1	-
46	4.19	Pollution inventory substances	0	0	0	0	-
46	4.20	Pollution inventory waste transfers	0	0	0	0	-
46	4.21	Pollution inventory radioactive waste	0	0	0	0	-
Page	Section	Hydrogeology	On site	0-50m	50-250m	250-500m	500-2000m
<b>47</b>	<b>5.1</b>	<b><u>Superficial aquifer</u></b>	Identified (within 500m)				
<b>48</b>	<b>5.2</b>	<b><u>Bedrock aquifer</u></b>	Identified (within 500m)				
<b>49</b>	<b>5.3</b>	<b><u>Groundwater vulnerability</u></b>	Identified (within 50m)				
50	5.4	Groundwater vulnerability- soluble rock risk	None (within 0m)				
50	5.5	Groundwater vulnerability- local information	None (within 0m)				
51	5.6	Groundwater abstractions	0	0	0	0	0
51	5.7	Surface water abstractions	0	0	0	0	0
51	5.8	Potable abstractions	0	0	0	0	0
51	5.9	Source Protection Zones	0	0	0	0	-
52	5.10	Source Protection Zones (confined aquifer)	0	0	0	0	-
Page	Section	Hydrology	On site	0-50m	50-250m	250-500m	500-2000m
<b>53</b>	<b>6.1</b>	<b><u>Water Network (OS MasterMap)</u></b>	3	0	13	-	-



<b>55</b>	<b>6.2</b>	<b><u>Surface water features</u></b>	1	0	5	-	-
<b>55</b>	<b>6.3</b>	<b><u>WFD Surface water body catchments</u></b>	1	-	-	-	-
<b>56</b>	<b>6.4</b>	<b><u>WFD Surface water bodies</u></b>	0	0	0	-	-
<b>56</b>	<b>6.5</b>	<b><u>WFD Groundwater bodies</u></b>	1	-	-	-	-
Page	Section	River and coastal flooding	On site	0-50m	50-250m	250-500m	500-2000m
57	7.1	Risk of flooding from rivers and the sea	None (within 50m)				
<b>58</b>	<b>7.2</b>	<b><u>Historical Flood Events</u></b>	0	0	2	-	-
58	7.3	Flood Defences	0	0	0	-	-
58	7.4	Areas Benefiting from Flood Defences	0	0	0	-	-
<b>59</b>	<b>7.5</b>	<b><u>Flood Storage Areas</u></b>	0	0	1	-	-
60	7.6	Flood Zone 2	None (within 50m)				
60	7.7	Flood Zone 3	None (within 50m)				
Page	Section	Surface water flooding					
<b>61</b>	<b>8.1</b>	<b><u>Surface water flooding</u></b>	1 in 30 year, 0.3m - 1.0m (within 50m)				
Page	Section	Groundwater flooding					
<b>63</b>	<b>9.1</b>	<b><u>Groundwater flooding</u></b>	Negligible (within 50m)				
Page	Section	Environmental designations	On site	0-50m	50-250m	250-500m	500-2000m
64	10.1	Sites of Special Scientific Interest (SSSI)	0	0	0	0	0
65	10.2	Conserved wetland sites (Ramsar sites)	0	0	0	0	0
65	10.3	Special Areas of Conservation (SAC)	0	0	0	0	0
65	10.4	Special Protection Areas (SPA)	0	0	0	0	0
65	10.5	National Nature Reserves (NNR)	0	0	0	0	0
66	10.6	Local Nature Reserves (LNR)	0	0	0	0	0
<b>66</b>	<b>10.7</b>	<b><u>Designated Ancient Woodland</u></b>	0	0	0	0	5
66	10.8	Biosphere Reserves	0	0	0	0	0
67	10.9	Forest Parks	0	0	0	0	0
67	10.10	Marine Conservation Zones	0	0	0	0	0
<b>67</b>	<b>10.11</b>	<b><u>Green Belt</u></b>	0	1	0	0	1
67	10.12	Proposed Ramsar sites	0	0	0	0	0



68	10.13	Possible Special Areas of Conservation (pSAC)	0	0	0	0	0
68	10.14	Potential Special Protection Areas (pSPA)	0	0	0	0	0
68	10.15	Nitrate Sensitive Areas	0	0	0	0	0
<b>68</b>	<b>10.16</b>	<b><u>Nitrate Vulnerable Zones</u></b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>
<b>70</b>	<b>10.17</b>	<b><u>SSSI Impact Risk Zones</u></b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
71	10.18	SSSI Units	0	0	0	0	0
Page	Section	Visual and cultural designations	On site	0-50m	50-250m	250-500m	500-2000m
72	11.1	World Heritage Sites	0	0	0	-	-
72	11.2	Area of Outstanding Natural Beauty	0	0	0	-	-
72	11.3	National Parks	0	0	0	-	-
72	11.4	Listed Buildings	0	0	0	-	-
73	11.5	Conservation Areas	0	0	0	-	-
73	11.6	Scheduled Ancient Monuments	0	0	0	-	-
73	11.7	Registered Parks and Gardens	0	0	0	-	-
Page	Section	Agricultural designations	On site	0-50m	50-250m	250-500m	500-2000m
<b>74</b>	<b>12.1</b>	<b><u>Agricultural Land Classification</u></b>	Urban (within 250m)				
75	12.2	Open Access Land	0	0	0	-	-
75	12.3	Tree Felling Licences	0	0	0	-	-
75	12.4	Environmental Stewardship Schemes	0	0	0	-	-
75	12.5	Countryside Stewardship Schemes	0	0	0	-	-
Page	Section	Habitat designations	On site	0-50m	50-250m	250-500m	500-2000m
<b>76</b>	<b>13.1</b>	<b><u>Priority Habitat Inventory</u></b>	0	1	2	-	-
77	13.2	Habitat Networks	0	0	0	-	-
77	13.3	Open Mosaic Habitat	0	0	0	-	-
77	13.4	Limestone Pavement Orders	0	0	0	-	-
Page	Section	Geology 1:10,000 scale	On site	0-50m	50-250m	250-500m	500-2000m
<b>78</b>	<b>14.1</b>	<b><u>10k Availability</u></b>	Identified (within 500m)				
<b>79</b>	<b>14.2</b>	<b><u>Artificial and made ground (10k)</u></b>	1	1	1	3	-
<b>81</b>	<b>14.3</b>	<b><u>Superficial geology (10k)</u></b>	0	0	1	0	-



82	14.4	Landslip (10k)	0	0	0	0	-
<b>83</b>	<b>14.5</b>	<b><u>Bedrock geology (10k)</u></b>	2	0	3	6	-
<b>84</b>	<b>14.6</b>	<b><u>Bedrock faults and other linear features (10k)</u></b>	1	0	14	19	-
Page	Section	Geology 1:50,000 scale	On site	0-50m	50-250m	250-500m	500-2000m
<b>86</b>	<b>15.1</b>	<b><u>50k Availability</u></b>	Identified (within 500m)				
<b>87</b>	<b>15.2</b>	<b><u>Artificial and made ground (50k)</u></b>	1	0	1	4	-
<b>88</b>	<b>15.3</b>	<b><u>Artificial ground permeability (50k)</u></b>	1	0	-	-	-
<b>89</b>	<b>15.4</b>	<b><u>Superficial geology (50k)</u></b>	0	0	1	0	-
90	15.5	Superficial permeability (50k)	None (within 50m)				
90	15.6	Landslip (50k)	0	0	0	0	-
90	15.7	Landslip permeability (50k)	None (within 50m)				
<b>91</b>	<b>15.8</b>	<b><u>Bedrock geology (50k)</u></b>	2	0	3	4	-
<b>92</b>	<b>15.9</b>	<b><u>Bedrock permeability (50k)</u></b>	Identified (within 50m)				
<b>92</b>	<b>15.10</b>	<b><u>Bedrock faults and other linear features (50k)</u></b>	1	1	8	21	-
Page	Section	Boreholes	On site	0-50m	50-250m	250-500m	500-2000m
<b>95</b>	<b>16.1</b>	<b><u>BGS Boreholes</u></b>	8	10	47	-	-
Page	Section	Natural ground subsidence					
<b>99</b>	<b>17.1</b>	<b><u>Shrink swell clays</u></b>	Very low (within 50m)				
<b>100</b>	<b>17.2</b>	<b><u>Running sands</u></b>	Very low (within 50m)				
<b>102</b>	<b>17.3</b>	<b><u>Compressible deposits</u></b>	Very low (within 50m)				
<b>104</b>	<b>17.4</b>	<b><u>Collapsible deposits</u></b>	Very low (within 50m)				
<b>105</b>	<b>17.5</b>	<b><u>Landslides</u></b>	Very low (within 50m)				
<b>106</b>	<b>17.6</b>	<b><u>Ground dissolution of soluble rocks</u></b>	Negligible (within 50m)				
Page	Section	Mining, ground workings and natural cavities	On site	0-50m	50-250m	250-500m	500-2000m
108	18.1	Natural cavities	0	0	0	0	-
<b>109</b>	<b>18.2</b>	<b><u>BritPits</u></b>	0	0	0	2	-
<b>109</b>	<b>18.3</b>	<b><u>Surface ground workings</u></b>	5	8	58	-	-
<b>112</b>	<b>18.4</b>	<b><u>Underground workings</u></b>	0	0	0	0	13
113	18.5	Historical Mineral Planning Areas	0	0	0	0	-



<b>113</b>	<b>18.6</b>	<b><u>Non-coal mining</u></b>	1	0	0	0	0
113	18.7	Mining cavities	0	0	0	0	0
114	18.8	JPB mining areas	None (within 0m)				
<b>114</b>	<b>18.9</b>	<b><u>Coal mining</u></b>	Identified (within 0m)				
114	18.10	Brine areas	None (within 0m)				
114	18.11	Gypsum areas	None (within 0m)				
114	18.12	Tin mining	None (within 0m)				
115	18.13	Clay mining	None (within 0m)				
<b>Page</b>	<b>Section</b>	<b>Radon</b>					
<b>116</b>	<b>19.1</b>	<b><u>Radon</u></b>	Between 1% and 3% (within 0m)				
<b>Page</b>	<b>Section</b>	<b>Soil chemistry</b>	<b>On site</b>	<b>0-50m</b>	<b>50-250m</b>	<b>250-500m</b>	<b>500-2000m</b>
<b>117</b>	<b>20.1</b>	<b><u>BGS Estimated Background Soil Chemistry</u></b>	1	0	-	-	-
117	20.2	BGS Estimated Urban Soil Chemistry	0	0	-	-	-
117	20.3	BGS Measured Urban Soil Chemistry	0	0	-	-	-
<b>Page</b>	<b>Section</b>	<b>Railway infrastructure and projects</b>	<b>On site</b>	<b>0-50m</b>	<b>50-250m</b>	<b>250-500m</b>	<b>500-2000m</b>
118	21.1	Underground railways (London)	0	0	0	-	-
118	21.2	Underground railways (Non-London)	0	0	0	-	-
119	21.3	Railway tunnels	0	0	0	-	-
<b>119</b>	<b>21.4</b>	<b><u>Historical railway and tunnel features</u></b>	1	6	10	-	-
120	21.5	Royal Mail tunnels	0	0	0	-	-
120	21.6	Historical railways	0	0	0	-	-
<b>120</b>	<b>21.7</b>	<b><u>Railways</u></b>	0	3	4	-	-
121	21.8	Crossrail 1	0	0	0	0	-
121	21.9	Crossrail 2	0	0	0	0	-
121	21.10	HS2	0	0	0	0	-