Medworth EfW CHP Facility Order:
SI 2024 No.230

Kanadevia INOVA

Contamination and Groundwater: Work No.1, 1A, 2A, 2B and 5 (EfW CHP Facility Site and TCC)

(Requirement 9: part discharge)

June 2025

Revision 1.0
Document ref. CP3_R09

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Contents

1. Introduction

1.1 Background

1.1.1 Medworth CHP Limited (the Developer) has secured a Development Consent Order (the Order)[1] to construct, operate and maintain an Energy from Waste (EfW) Combined Heat and Power (CHP) Facility on the industrial estate, Algores Way, Wisbech, Cambridgeshire. Together with associated Grid Connection, CHP Connection, Access Improvements, Water Connections, Temporary Construction Compound (TCC), and an acoustic fence, these works are the Authorised Development.

1.1.2 The Authorised Development will recover useful energy in the form of electricity and steam from over half a million tonnes of non-recyclable (residual), non-hazardous municipal, commercial and industrial waste each year. The Authorised Development has a generating capacity of over 50 megawatts and the electricity will be exported to the grid. The Authorised Development also has the capability to export steam and electricity to users on the surrounding industrial estate.

1.2 The Developer

1.2.1 The Developer is a wholly owned subsidiary of MVV Environment Limited (MVV). MVV is part of the MVV Energie AG group of companies. MVV Energie AG is one of Germany's leading energy companies, employing approximately 6,500 people with assets of around €5 billion and annual sales of around €4.1 billion. The Authorised Development represents an investment of approximately £450m.

1.2.2 The company has over 50-years' experience in constructing, operating, and maintaining EfW CHP facilities in Germany and the UK. MVV Energie's portfolio includes a 700,000 tonnes per annum residual EfW CHP facility in Mannheim, Germany.

1.2.3 MVV's largest operational project in the UK is the Devonport EfW CHP Facility in Plymouth. Since 2015, this modern and efficient facility has been using up to 275,000 tonnes of municipal, commercial and industrial residual waste per year to generate electricity and heat, notably for His Majesty's Naval Base Devonport in Plymouth, and exporting electricity to the grid.

1.2.4 In Dundee, MVV has taken over the existing Baldovie EfW Facility and has developed a new, modern facility alongside the existing facility. Operating from 2021, it uses up to 220,000 tonnes of municipal, commercial and industrial waste each year as fuel for the generation of usable energy.

1.2.5 Biomass is another key focus of MVV's activities in the UK market. The biomass power plant at Ridham Dock, Kent, uses up to 195,000 tonnes of waste and non-recyclable wood per year to generate green electricity and is capable of exporting heat.

[1] Statutory Instrument 2024 No. 230 https://www.legislation.gov.uk/uksi/2024/230/schedule/1/made

1.3 The EPC Contractor – Kanadevia Inova

1.3.1 The Developer has appointed Kanadevia Inova (KVI) as their EPC Contractor. KVI has appointed a series of specialist contractors to prepare detailed schemes to discharge the Order Requirements to enable the construction of the EfW CHP Facility.

1.4 The Authorised Development

1.4.1 The Authorised Development comprises the following key elements:

- The EfW CHP Facility and Site (Work Nos.1/1A/1B/2A/2B);
- CHP Connection (Work Nos.3/3A/3B);
- Temporary Construction Compound (TCC) (Work No.5);
- Access Improvements (Work Nos.4A/4B);
- Water Connections (Work Nos.6A/6B);
- Grid Connection (Work Nos.7/8/9) and
- Acoustic fence (Work No.10).

1.4.2 A summary description of each Authorised Development element is provided below.

- EfW CHP Facility and Site: A site of approximately 5.3ha located south-west of Wisbech, located within the administrative areas of Fenland District Council and Cambridgeshire County Council. The main buildings of the EfW CHP Facility would be located in the area to the north of the Hundred of Wisbech Internal Drainage Board drain bisecting the site and would house many development elements including the tipping hall, waste bunkers, boiler house, turbine hall, air cooled condenser, air pollution control building and chimneys. The gatehouse, weighbridges, and laydown maintenance area would be located in the southern section of the EfW CHP Facility Site.
- CHP Connection: The EfW CHP Facility would be designed to allow the export of steam and electricity from the facility to surrounding business users via dedicated pipelines and private wire cables located along the disused March to Wisbech railway. The pipeline and cables would be located on a raised, steel structure.
- TCC: Located adjacent to the EfW CHP Facility Site, the compound would be used to support the construction of the Authorised Development. The compound would be in place for the duration of construction.
- Access Improvements: includes access improvements on New Bridge Lane (road widening and site access) and Algores Way (relocation of site access 20m to the south).
- Water Connections: A new water main connecting the EfW CHP Facility into the local network will run underground from the EfW CHP Facility Site along New Bridge Lane before crossing underneath the A47 to join an existing Anglian Water main. An additional foul sewer connection is required to an existing

pumping station operated by Anglian Water located to the northeast of the Algores Way site entrance and into the EfW CHP Facility Site.

- Grid Connection: This comprises a 132kV electrical connection using underground cables. The Grid Connection route begins at the EfW CHP Facility Site and runs underneath New Bridge Lane, before heading north within the verge of the A47 to the Walsoken Substation on Broadend Road. From this point the cable would be connected underground to the Walsoken DNO Substation.
- Acoustic fence: This comprises of a 3m high acoustic fence fronting a residential property at 10 New Bridge Lane, Wisbech.

1.5 Purpose of this document

1.5.1 Schedule 2 of the Order requires the Developer to comply with and/or submit detailed information to implement the Authorised Development.

1.5.2 Requirement 9 (contamination and groundwater) of Schedule 2 states:

> *"(1) No part of the authorised development may commence until a scheme (which may be included in the construction environmental management plan to be submitted under requirement 10) to deal with the contamination of any land (including groundwater)* ***for that part*** [emphasis added] *which is likely to cause significant harm to persons or significant pollution of controlled waters or the environment has been submitted to and approved in writing by the relevant planning authority.*
>
> *(2) The scheme must include an investigation and assessment report, prepared by a specialist consultant, to identify the extent of any contamination and any remedial measures to be taken to render the land fit for its intended purpose, together with a management plan which sets out long-term measures with respect to any contaminants remaining on the site.*
>
> *(3) The relevant planning authority must consult with the Environment Agency before approving a scheme under sub-paragraph (1).*
>
> *(4) Any remedial measures must be carried out in accordance with the approved scheme."*

1.5.3 This document part discharges Requirement 9 for the following Work Nos. of the Authorised Development:

- Work Nos.1, 1A, 2A and 2B – The EfW CHP Facility Site; and
- Work No.5 – the TCC.

1.5.4 Specific groundwater and contamination reports will be prepared for the other Works No(s). and be submitted prior to the commencement of development of that Work No(s).

1.6 Documents schedule

1.6.1 The document submitted to part discharge Order Requirement 9 for the EfW CHP Facility Site and TCC is listed in **Table 1.1** and presented in **Section 2**.

Table 1.1: Order Requirement 9 – EfW CHP Facility Site and TCC documents schedule

Document/ drawing no.	Revision no.	Title	Date
C57/2086-ENV-RS-R001	1.0	Remediation Strategy	20 May 2025
-			

2. Remediation Strategy

Remediation Strategy

Medworth EFW CHP Facility

Report No. C57/2086-ENV-RS-R001

20 May 2025

Revision 1.0

Doran Consulting

Document Control

Project

Medworth EFW CHP Facility

Client

Doran Consulting

Document

Remediation Strategy

Report Number:

C57/2086-ENV-RS-R001

Document Checking:

Date	Rev	Details of Issue	Prepared by	Checked by	Approved by
09 April 2025	00	For Comment	Megan Banks	Dan Mason	Dan Mason
10 April 2025	0.1	Comments Addressed	Therese McDaid	Basil Fagg	Basil Fagg
16 April 2025	0.2	End User Comments Addressed	Therese McDaid	Dan Mason	Dan Mason
30 April 2025	0.3	End User Comments Addressed	Therese McDaid	Dan Mason	Dan Mason
12 May 2025	0.4	Comments Addressed	Dan Mason	Dan Mason	Dan Mason
20 May 2025	1.0	Final Issue	Dan Mason	Dan Mason	Dan Mason

Disclaimer: Please note that this report is based on specific information, instructions, and information from our Client and should not be relied upon by third parties.

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Contents

[1] Introduction

[1.1] Background Information

Ayesa was commissioned by Doran Consulting to provide a Remediation Strategy for the Energy from Waste (EfW) Combined Heat and Power (CHP) Facility Site (the 'EfW CHP Facility Site') and the Temporary Construction Compound (the 'TCC'); Work Nos.1, 1A, 2A, 2B and 5 of the Medworth EfW CHP Facility Order (the 'Order'). This Remediation Strategy is based on the information within Wood's combined Phase 1 and Phase 2 Investigation (September 2020).

This document has been based on:

- *Wood – Wisbech Phases 1 and 2 Geoenvironmental Desk Study and Interpretive Report Ref: 41310-WOOD-XX-XX-RP-OC-001_S3_2, dated September 2020.*
- *Ayesa – Ground Gas Assessment Report, Ref: C57/2086-ENV-GGA-R001, dated March 2025. (See also Appendix D)*

This report has been devised to generally comply with the relevant principles and requirements of a range of guidance including:

- *Part IIA of the Environment Protection Act, 1990;*
- *Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, April 2012);*
- *National Planning Policy Framework (HCA, February 2019);*
- *BS5930:2015: "Code of practice for site investigations";*
- *BS10175: 2011 +A2:2017 "Investigation of Potentially Contaminated Sites - Code of Practice";*
- *The Building Regulations 2010. Part C (HM Government 2013)*
- *EA online guidance: Land Contamination: Risk Management (LCRM) (which replaced Report CLR11 (2004) Model Procedures for the Management of Land Contamination);*
- *Environment Agency (2011) Report GPLC1 "Guiding Principles for Land Contamination";*
- *Environment Agency (2017) "The Environment Agency's Approach to Groundwater Protection" November 2017 Version 1.1*

Ayesa's service constraints and report limitations are presented in *Appendix A* and a description of environmental risk assessment methodology and terminology is presented in *Appendix B*.

[1.2] Development Proposals

The proposed development of the site is understood to comprise:

- *Construction of a development platform.*

- *Construction of a large multi-storey building and chimneys with associated plant, offices and utilities.*
- *A temporary construction compound (the TCC).*

The findings and conclusions of the risk assessments have been set out and recommendations given for the proposed commercial end use. If there is a subsequent change in the proposed land use the risk assessments and conclusions should be reviewed to determine whether they are still applicable for the revised end use.

[1.3] Planning Status and Requirements

This report is designed to comply with the requirements of the National Planning Policy Framework (NPPF, 2023). It has been prepared to aid in the discharge of Requirement 9 of the Medworth EfW CHP Facility Order (the 'Order') for Work Nos. 1, 1A, 2A, 2B and 5 (the EfW CHP Facility and TCC).

[2] Previous Assessment

[2.1] Site Investigation Works

As mentioned previously this Remediation Strategy is based on the findings of the following reports:

- *Wood – Wisbech Phases 1 and 2 Geoenvironmental Desk Study and Interpretive Report Interpretive Report Ref: 41310-WOOD-XX-XX-RP-OC-001_S3_2, dated September 2020.*
- *Ayesa – Ground Gas Assessment Report, Ref: C57/2086-ENV-GGA-R001, dated March 2025. (included as Appendix D)*

Initial investigation works by Wood included the following:

- 12 cable percussive boreholes to depths between 10.0 and 40.0m bgl with rotary follow-on coring in four boreholes to depths between 40.0m and 45.0m bgl.
- 17 mechanically excavated trial pits to depths of between 1.2m and 4.5m bgl.
- One hand excavated trial pit to a depth of 0.75m bgl to replace a machine excavated trial pit in an area constrained by services.
- Associated geotechnical (in-situ and laboratory) testing and chemical testing.
- Installation of gas and groundwater monitoring wells with post site work monitoring.

The investigation by Wood focused on Work Nos. 1, 1A, 2A and 2B areas only, site investigation has not been conducted for Work No.5, the TCC area, adjacent to the rest of the site. It is understood that the TCC is previously undeveloped “greenfield” land however, and while no specific information is available for the area, the likelihood of encountering contamination is very low particularly considering the limited extent of any construction activities that will be carried out on the TCC. Should any unexpected contamination be discovered this will be dealt with in accordance with Appendix C of this report.

A summary of the drilling works is as follows:

Table 2.1 – Borehole Drilling Summary

Borehole No	Method	Borehole Elevation (m AOD)	Depth to Borehole base (m)	Base Level of Borehole (m AOD)
BH01	Cable	2.06	10	-7.94
BH02	Cable / Rotary	2.17	40	-37.83
BH03	Cable	2.31	25	-22.69
BH04	Cable / Rotary	2.56	40	-37.44
BH05	Cable / Rotary	2.04	40	-37.96
BH06	Cable	2.35	10	-7.65
BH07	Cable	2.61	25	-22.39
BH09	Cable	2.25	25.5	-23.25
BH10	Cable	2.42	40	-37.58

BH11	Cable / Rotary	1.99	45	-43.01
BH12	Cable	1.68	25	-23.32
BH13	Cable	1.77	25	-18.23

Chemical testing was undertaken as follows:

Table 2.2 – Chemical Soil Sampling Schedule

Material Type	Total Number of Samples	Standard testing suite*	Asbestos	Redox and Conductivity	Petroleum Hydrocarbon Suite	SVOC and VOCs	WAC
Topsoil	6	5			4	1	5
Made Ground	15	14	1	8	7	4	6
Reworked Tidal Flat Deposits	3	3		1	2	1	
Tidal Flat Deposits	11	8**		1	4	2	2

* The standard testing suite comprises asbestos screen and ID, pH, metals and metalloids (arsenic, cadmium, chromium (III), chromium (hexavalent), copper, lead, mercury, nickel, selenium and zinc), water-soluble boron, ammoniacal nitrogen, monohydric phenols, total organic carbon, and speciated polyaromatic hydrocarbons (PAHs).

** The standard suite did not include asbestos screen or ID for samples obtained from the Tidal Flat Deposits.

Gas monitoring was undertaken on six occasions at the four targeted gas wells (BH01, BH07, BH09, BH11), using a calibrated gas analyser. Measurements of gas flow, carbon dioxide (CO2), methane (CH4), oxygen (O2), lower explosive level (LEL), carbon monoxide (CO) and hydrogen sulphide (H2S) are recorded. Concentrations of total volatile organic compounds (VOCs) were also recorded during each visit using a photo-ionisation detector (PID).

Groundwater levels were recorded on six occasions, over a period of six months. This was undertaken using an oil/water interface probe, with any presence and thickness of non-aqueous phase liquid (NAPL) being recorded.

Groundwater samples were obtained on three occasions, bimonthly over the 6-month monitoring period. Samples were obtained using dedicated tubing per borehole and a submersible WASP5 pump or peristaltic pump. In-situ parameters were also monitored during purging through a flow cell connected to the end of the tubing.

Surface water samples were collected from three locations from the drainage channels surrounding the site. These were obtained at the same time as the groundwater samples, on three occasions.

[2.2] Ground Conditions

Made Ground

Made Ground was encountered in all exploratory hole to depths varying between 0.2m and 2.1m bgl.

A 0.1 to 0.3m thick surface course of crushed macadam or flint or limestone / sandstone or concrete or a combination of all, was encountered in TP02, TP06, TP07, TP08, TP11, TP12, BH01, BH03 and BH10.

The underlying layer primarily comprised a red-brown or grey-brown very sandy cobbly gravel comprising macadam, concrete, brick, flint, sandstone, limestone, quartzite, glazed tile, clay tile and occasional clinker. Layers of predominantly soft to firm brown sandy gravelly CLAY (possibly reworked tidal flat deposits) were encountered locally in BH3 between 0.7 and 2.7m bgl, BH7 between 1.9 and 2.1m bgl, and BH10 between 1.2 and 2.3m bgl.

A geotextile separator was encountered at the base of the Made Ground in most of the exploratory holes.

HP01, TP4A, TP10A, TP12A and TP13A did not penetrate the base of the Made Ground.

Tidal Flat Deposits (TFD)

The Tidal Flat Deposits comprise two stratigraphic groups encountered consistently beneath the site.

A clay / silt group was encountered at between 0.2 to 2.1m and consisted of very soft grey-brown mottled orange sandy silty clay with plant fragments. A desiccated surface was encountered in some exploratory locations. A thin Peat band or peat traces were encountered within the clay in most of the exploratory holes. This was noted as a distinct layer more consistently within the trial pits, and therefore it is likely that this was not distinct in the boreholes due to its thin nature and the drilling technique and UT100 sampling.

A very fine sand group was encountered at between 1.7 to 5.0m and consisted of dense grey locally very silty very fine sand with occasional plant debris and shells. Due to the silt content, the boundary between the clay/silt and very fine sand is uncertain.

The base of the tidal flat deposits was not proved in BH01, BH06, BH13 (terminated at depths of 10-20m bgl), and in the trial pits where Tidal Flat Deposits were encountered.

Glaciofluvial Deposits

Glaciofluvial Deposits comprising dense to very dense brown and grey silty sandy GRAVEL / gravelly SAND were encountered beneath the Tidal Flat Deposits, at depths between 19.2 and 24.0m bgl. The layer varied in thickness between 2.3 and 5.3m. The base of the deposit was not proved in BH03 and BH07, both of which were terminated at 25.0m bgl.

Glacial Deposits

Very stiff becoming hard glacial till was encountered in exploratory holes BH02, BH04, BH05, BH09 BH12 at depths between 24.3 and 25.7m bgl (23.7m and 22.0m AOD). The deposits comprised dark grey silty sandy gravelly clay.

Glaciolacustrine varved deposits, comprising stiff red brown to grey thinly laminated CLAY, were encountered as a band within the glacial deposits in BH05, BH10 and BH11, varying in thickness between 1.1m and 2.7m. The thickness of the glacial deposits ranged from 5.1m to 8.4m. The base of the glacial deposits was not proven in BH09 and BH12, which terminated at depths of 25.5 and 25.0m bgl. The base of the deposit was proven by rotary coring in BH02 and BH05.

Bedrock (Ampthill Clay)

A hard clay to very weathered mudstone was encountered beneath the Glacial Deposits in BH04, BH10 and BH11, and in the rotary coring in BH2 and BH5 at depths between 30.8m and 33.0m bgl (31.0 and 28.2 m AOD). The bedrock comprises a very stiff to hard smooth dark grey-brown laminated silty clay becoming very weak, friable weathered mudstone with frequent fossils of shells and fossil casts. Bands of clay are noted within the mudstone in the rotary cored boreholes. The clay stratum is consistent with the BGS maps indicating the presence of Ampthill Clay Formation. The base of the stratum was not proved.

Earth Bunds

Topsoil was encountered within the earth bunds bordering the site at TP02A, TP04A, TP10A, TP12A and TP13A, and in soft landscaping areas in HP01, BH06 and TP05, to depths between 0.2 and 0.6m bgl.

The topsoil comprised dark brown very loamy slightly gravelly very sandy silty clay with rootlets. The gravel is angular to rounded fine to medium and comprises sandstone, flint, quartzite and occasional brick and concrete. Significant concentrations of anthropogenic fragments such as brick, concrete, macadam, clinker, glazed tile and clay tile, along with cobbles of concrete and brick were encountered in TP04 and TP12A.

[2.3] Soil Assessment

Soil assessment undertaken by Wood suggests that detectable concentrations of inorganic and organic compounds have been recorded in all material types on the site, however no recorded concentrations exceed the relevant GAC for a commercial / industrial end use assuming a conservative 1% SOM content.

Loose fibres of chrysotile and amosite were identified in BH10 at 0.3m bgl, however quantification analysis indicates the concentration is below the laboratory limit of detection.

As such the presence of asbestos on the site is not considered to represent a significant risk to human health.

Wood have highlighted a potential risk from organic contaminants in soil associated with onsite current activities presenting a risk to services including potable water supply pipes through permeation. No specific UKWIR risk assessment appears to have been undertaken but due to the presence of TPH above UKWIR (Anglian Waters) thresholds PE and PVC pipe will not be suitable.

Geotechnical assessment of soils has not been undertaken as it was outside the remit of this Remediation Strategy. It is presented within Wood's Interpretive Report.

[2.4] Water Assessment

Wood summarises the water conditions as follows:

Groundwater flow within the shallow Tidal Flat Deposits is influenced by the adjacent drainage channels. Deeper groundwater in the Tidal Flat Deposits flows in a north-westerly direction, in the direction of the River Nene. This indicates that the adjacent drainage channels are unlikely to be in connectivity with this deeper groundwater unit. The monitoring results indicate that the deeper groundwater is under sub-artesian pressure.

No exceedances of the freshwater EQS have been identified in site groundwater for inorganic contaminants, including metals except for ammoniacal nitrogen which exceeds the freshwater EQS in all samples. In the absence of EQS, the UK DWS were used for comparison against recorded concentrations, with exceedances identified for boron and sulphate in site groundwater.

A marginal exceedance of the EQS for total phenols was identified at BH13.

Heavy end aliphatic hydrocarbons (>C16-35) were identified above the laboratory limit of detection in one location, BH12. This borehole is located away from the fuel tanks on site. All other concentrations of TPH were recorded below the laboratory limit of detection.

The majority of PAHs recorded concentrations below the laboratory limit of detection. Measurable concentrations of PAHs recorded in site groundwater were below the EQS. No other SVOCs were identified above the laboratory limit of detection.

No VOCs were present above the limit of detection in any of the groundwater samples.

Surface water results are broadly comparable to groundwater for inorganic contaminants. Exceedances for lead and zinc were recorded against coastal EQS but not for freshwater EQS. The surface drains ultimately connect to a tidally influenced river ~500m down-gradient of the site. As in groundwater, exceedances were identified for sulphate and ammoniacal nitrogen.

Surface water concentrations of total phenols ranged between 3.4 to 7.5 µg/l. No further organics were recorded above the laboratory limits of detection in surface water, with the exception of other phenolic compounds (of 4- methylphenol and 2,4-dimethylphenol) identified at SW1 and SW2 on one occasion.

One additional laboratory result was provided to Ayesa for the site (Ref: MW02) on 7th April 2025. Analysis was undertaken by Socotec on behalf of Stuart Wells Limited (Project 25033344). It is assumed that this water sample was retrieved from groundwater within a monitoring well installed at 'BH02'. Screening of the lab results for this sample show one exceedance of the freshwater EQS, for Benzo[ghi]perylene. In the absence of EQS, exceedances of the UK DWS were highlighted when results were compared for Manganese, Calcium and Sodium, in addition to PAH total 4 DWS (Sum of Benzo(a)pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, and Chrysene).

[2.5] Ground Gas Assessment

Wood have highlighted a number of potential sources of soil gas on site including, below ground diesel tank and septic tank, Made Ground, natural silt and peat deposits.

The gas monitoring program comprised of six rounds of monitoring over a six-month period in order to support the Environmental Impact Assessment and planning application for the site.

Ground gas has been measured from four boreholes on the site designed specifically to target the potential gas sources on site.

The installation details and the description of the target strata are summarised in the table below:

Table 3.3 – Summary of Gas Monitoring Installations

Monitoring Point	Standpipe Diameter (mm)	Response Zone Top (m bgl)	Response Zone Base (m bgl)	Strata monitored
BH01	0.055	1.0	2.5	Clay and Silt with plant fragments
BH07	0.055	0.5	2.0	Made Ground
BH09	0.055	0.5	2.0	Clay and silt with plant fragments
BH11	0.055	1.0	1.5	Clay, silt and peat

The preliminary results indicate that ground gas generation is negligible within the Made Ground deposits and impermeable clay indicating the site may be classified as Characteristic Situation 1 (CS1). These wells are also above silt/peat deposits, indicating that upward migration of ground gas from these deposits is potentially limited. This is supported by the low gas flows recorded at the site. However, mitigation may be required if a pathway for upward migration, or migration into basements/services is introduced.

The observations of carbon dioxide above 5% v/v in BH09 within the silt/peat layer, along with the depleted oxygen levels, is suggestive of the presence of ground gas at concentrations which could require mitigation if a pathway for upward migration, or migration into basements/services is introduced. The concentrations recorded are representative of CS1, but this is raised to CS2 due to concentrations of carbon dioxide typically being recorded above 5% v/v (in 4 of 6 monitoring rounds).

This is further reviewed in Ayesa's Ground Gas Assessment Report, included within Appendix D, which confirms the findings of the Wood report and suggests that 1.5 points of gas protection will be required for the new development in line with the recommendations from BS8485:2015+A1:2019.

[3] Remediation Strategy

Preparation of the Remediation Strategy falls within Stage 3 of the LCRM (remediation and verification). Stage 3 covers the remediation strategy, remediation, verification and long-term monitoring / maintenance if required.

The remainder of this report addresses Step 1 of this process which is the development of a Remediation Strategy which is effectively a record of how the remediation objectives will be met and carried out.

The Verification Plan is also part of the Remediation Strategy and sets out data requirements and compliance criteria to verify that the remediation has worked or is working.

[3.1] Remediation Objectives

The broad remediation objectives are as follows:

- Provide protection to end users from potential ground gas risk.
- Mitigate the risk to site workers and end users from soil and water contaminants.
- Mitigate the risk to potable water supply pipes from soil and water contaminants.

The remediation approach is detailed below. The remedial measures proposed should be agreed with the Local Authority prior to commencement.

[3.2] Remediation Strategy Objectives

This document does not provide the detailed design elements of the proposed remediation activities but provides a basis from which the detailed design / work plans will be developed by the appointed contractors.

The objective of the Remediation Strategy is to provide guidance and protocols for the contractors to undertake the required remediation and to manage and mitigate key risks to on-site and off-site receptors associated with the remediation works. Management and mitigation of risks to human health and the environment can be achieved through compliance with the framework and guidance presented in this document.

This Remediation Strategy provides the selected contractors and other stakeholders with:

- A summary of the location and nature of impacted soils at the site, based upon intrusive investigation works
- Instructions regarding the excavation and handling of impacted soil
- Instructions on managing general environmental obligations, specifically with respect to known impacted soils and generally with other environmental aspects of the works
- Instructions to ensure the final site condition is remediated to the extent practical with any residual risk quantified

[3.3] Roles and Responsibilities

Table 3.1 presents the roles and responsibilities of the various stakeholders in relation to the Remediation Strategy. Note that there may be some overlap between the roles and responsibilities listed below.

Table 3.1 – Roles and Responsibilities

Position	Responsibilities
Kanadevia Inova (KVI) / Doran Consulting	Oversight of the earthworks contract Assist in communication between stakeholders Engaging appropriate contractors and consultants to implement the works
Groundworks Contractor (earthworks) **TBC**	Understand and work within the requirements of the Remediation Strategy Implementation of the Remediation Strategy Work with the Builder/Construction Contractor to ensure that sequencing of works allows for the installation of gas protection measures to site buildings Ensure site works adhere to the guidance summarised and referenced in the Remediation Strategy Avoid work practices that are damaging to the environment Ensure site activities involving contaminated soils are undertaken in a controlled manner addressing necessary WHS and environmental requirements Do not transport soils, asbestos containing material or wastewater off-site unless approval is confirmed in writing by the Environmental Consultant and the waste depot
Construction Contractor **TBC**	Understand and work within the requirements of the Remediation Strategy Provide specification for gas protection measures including site-specific drawings Work with the earthworks / groundworks contractor to ensure that sequencing of works allows for the installation of gas protection measures to site buildings and that follow-on works do not damage installed membranes. Install gas protection measures and communicate effectively with the Environmental Consultant to allow for sufficient validation inspections Provide capping to gardens and areas of soft landscaping
Environmental Consultant **Ayesa**	Supervise implementation of this Remediation Strategy onsite Validation of soils, as required in this Remediation Strategy Collect evidence to demonstrate compliance with this Remediation Strategy, including photographs, site notes and confirmatory samples (where necessary) Prepare revisions to this Remediation Strategy, as required Preparation of a Remediation Validation Report to document the final condition of the site.
Waste Transporter	Licenced transportation of waste

Position	Responsibilities
TBC – must hold appropriate EA license	
Waste Depot **TBC – must hold appropriate EA license**	Licenced disposal of waste

[3.4] Remediation Steps

[3.4.1] Material Re-use

Due to the low level of contamination present on site with respect to commercial thresholds, it is envisaged that both Made Ground and natural strata will be retained and reused on site.

For the site redevelopment there may be a necessity to excavate, process and reuse this material to enable construction of the intended development platform.

All material excavation and re-use should be undertaken in compliance with the CL:AIRE Definition of Waste Code of Practice (DoWCoP) to ensure waste management regulations are not breached.

[3.4.2] Imported Materials

Although there is no requirement to provide a clean capping system for areas of soft landscaping there may be a requirement to import material to alter site levels or create a growing medium in landscaped areas.

Imported material for use within landscaped areas should meet the screening thresholds as set out in the table below:

Table 3.2 – Screening Criteria for Imported Soils

Determinand	Screening Values for Imported Soils (mg/kg) S4ULs (LQM/CIEH 2014)		
	1% som	2.5% som	6% som
PAHs			
Acenaphthene	210 (57)	500* (141)	500* (366)
Acenaphthylene	170 (86.1)	420 (212)	500* (506)
Anthracene	500*	500*	500*
Benzo[a]anthracene	7.2	11	13
Benzo[a]pyrene	2.2	2.7	3.0
Benzo[b]fluoranthene	2.6	3.3	3.7
Benzo[ghi]perylene	320	340	350
Benzo[k]fluoranthene	77	93	100
Chrysene	15	22	27
Dibenzo[ah]anthracene	0.24	0.28	0.3
Fluoranthene	280	500*	500*
Fluorene	170 (30.9)	400 (76.5)	500* (183)
Indeno[123-cd]pyrene	27	36	41
Naphthalene	2.3	5.6	13
Phenanthrene	95 (36)	220	440
Pyrene	500*	500*	500*
Petroleum Hydrocarbons			
Aliphatic			
>C5-C6	42 (304)	78 (558)	160 (1,150)
>C6-C8	100 (144)	230 (322)	500* (736)
>C8-C10	27 (78)	65 (190)	150 (451)
>C10-C12	130 (48)	330 (118)	500* (451)
>C12-C16	500* (24)	500* (59)	500* (142)
>C16-C35	500* (8.5)	500* (21)	500*
Aromatic			
>C5-C7 (benzene)	70 (1220)	140 (2260)	300 (4710)
>C7-C8 (toluene)	130 (869)	290 (1920)	500* (4360)
>C8-C10	34 (613)	83 (1,500)	190 (3,580)
>C10-C12	74 (364)	180 (899)	380 (2,150)
>C12-C16	140 (169)	330 (419)	500*
>C16-C21	260	500*	500*
>C21-C35	500*	500*	500*
BTEX and MTBE			
Benzene	0.087	0.17	0.37
Toluene	130 (869)	290 (1,920)	500* (4,360)

Determinand	Screening Values for Imported Soils (mg/kg)		
	S4ULs (LQM/CIEH 2014)		
	1% som	2.5% som	6% som
Ethylbenzene	47 (518)	110 (1,220)	260 (2,620)
o-xylene	60 (478)	140 (1,120)	330 (2,620)
m-xylene	59 (625)	140 (1,470)	320 (3,460)
p-xylene	56 (576)	130 (1,350)	310 (3,170)
Asbestos	Below detection limit of <0.001		
Metals			
Arsenic	37		
Cadmium	11		
Chromium (III)	910		
Chromium (VI)	6		
Copper	2400		
Lead	200		
Mercury	40		
Nickel	180		
Selenium	250		
Zinc	3700		

*Note: * = reduced concentration thresholds to more appropriate values for imported materials*

In addition to the above requirements any topsoil imported must meet the requirements of BS3882:2015.

Imported materials shall be validated at a frequency of at least 1 sample per 100m^3 for soils that are from a natural source. For recycled or manufactured topsoil (or where the source of the soil is unknown) a sampling frequency of 1 sample per 50m^3 is required – in any case a minimum of 3 samples are required from each source.

Material not imported as a ‘product’ should be imported under the CL:AIRE Definition of Waste Code of Practice (DoWCoP) and managed accordingly.

[3.4.3] Service Protection

Assessment of risk to services has been undertaken in the Wood report and it is considered likely that barrier pipe will be required. No specific UKWIR risk assessment appears to have been undertaken but due to the presence of TPH above UKWIR (Anglian Waters) thresholds PE and PVC pipe will not be suitable.

This will be confirmed with the utility supplier (Anglian Water) prior to any works being undertaken.

[3.4.4] Gas Protection Measures

Ground gas monitoring undertaken by Wood classes the site under the CIRIA C665 and BS8485 Gas Screening Value as a Characteristic Situation 2 based on Carbon Dioxide readings above 5%v/v. Ayesa's Gas Risk Assessment agrees with this especially considering the lack of gas monitoring data below 1000mb atmospheric pressure which is generally considered to the worst-case scenario for gas generation.

Based on the guidance provided in BS8485 the site is classed as a Type D building and will require 1.5 points of gas protection to meet the CS2 requirements.

These points of gas protection are likely to consist of a combination of a structural slab, vented void and gas proof membrane dependent on the building design.

Any gas protection measures required shall be installed by competent and appropriately trained personnel with a verification report produced to document that the correct protection measures have been installed in relation to the foundation and floor slab solution chosen by the designer.

The Construction Contractor must ensure that the gas membrane is suitably protected from damage by follow on trades.

[3.4.5] Asbestos Impacted Soils

Low levels of asbestos were encountered during the investigation. As such the risk is generally assumed to be low. However, it would be considered prudent to keep a watching brief by suitably trained operatives during earthworks to ensure that significant asbestos contamination, if encountered, is appropriately dealt with.

Should significant asbestos contamination be encountered then work must cease and the Environmental Consultant must be informed to enable a sufficiently robust risk assessment to be undertaken prior to any further works continuing.

[3.5] Additional Comments

[3.5.1] Stockpiling of Material Prior to Re-use or Disposal

Excavated soil shall be stored in a manner as to prevent contamination of the underlying soil or contamination of surrounding areas from water run-off or dust production. This requires placing a suitable plastic membrane below and above the stockpiled material. Different soil types are to be stored in separate stockpiles prior to possible future re-use or disposal. The stockpiling of soils is to be recorded; and include the location and date of excavation; the material type; and quantity. Site won material will not be suitable for reuse in capping layers.

[3.5.2] Watching Brief

Throughout the earthworks programme, it is proposed to adopt a programme of visual screening during groundworks to assess soil conditions as a precautionary approach. This is to be achieved through site inspection visits by a suitably qualified geo-environmental engineer.

During the ground-works phase of construction, if unexpected ground conditions are encountered, work in the suspect area must cease and the procedure stated in Appendix C (Unforeseen Ground Contamination) will be applied.

[3.5.3] Waste Arisings

The Groundworks Contractor will be responsible for the appropriate management of waste generated, to include appropriate waste characterisation and where necessary WAC testing prior to disposal.

The available soil chemical analysis data been assessed in order to determine a preliminary waste characterisation for the site soils. The majority of soil samples across the site area were deemed to classify as "Non-Hazardous" Waste for offsite disposal.

An appropriate waste characterisation can only be undertaken on the material due to be disposed of via chemical testing which should be completed prior to making disposal arrangements. All laboratory testing should be undertaken to a method detection limit appropriate to the screening criteria, by a reputable laboratory with MCERTS accreditation for the analyses required. Where this is not available, an alternative form of accreditation may be considered acceptable.

In all cases where excess soils require off-site disposal, the materials need to be managed under the appropriate legislation and consideration given to any remedial techniques that could be used to improve the soil.

Records will be kept onsite of the destinations of all waste material being exported from site.

[3.5.4] Remediation Strategy Review and Update

The Remediation Strategy will be reviewed as necessary to ensure relevancy and suitability of the measures. A review may be undertaken as a result of the following triggers:

- Issue of stop-work orders
- Non-compliance raised during a site audit
- Availability of new soil data
- Unexpected finds
- Representations by on-site staff
- Complaints from the public or other stakeholders.

[3.6] Health and Safety

As outlined within the HSE publication "Successful Health and Safety Management – HSG65" this report should inform the contractors' development of safe systems of work and the information used as an input to the safety management system. The contents of this report may be used to supplement the contents of the Health and Safety File as required under the Construction Design and Management (CDM) Regulations 2015, and can also be read alongside Kanadevia Inova (KVI)'s CEMP documentation as appropriate.

[4] Environmental Management

Environmental management of the works will be carried out in compliance with the Construction Environmental Management Plan (CEMP) for Work Nos. 1, 1A, 2A, 2B and 5 compiled in accordance with Requirement 10 of the Medworth EfW CHP Facility Order 2024.

[5] Verification Reporting

Evidence of compliance with this Remediation Strategy shall be documented and reported by Ayesa in a Remediation Verification Report (RVR).

The RVR will provide a complete record of any remediation activities on the site and the data collected to support compliance with the remediation objectives and criteria.

The RVR will:

- Document how any remediation works were implemented in accordance with the Remediation Strategy and discuss where works deviated from the plan (if any)
- Document the final condition of the land including presenting validation information, site photographs and surveys
- Include volume reconciliation calculations comparing initial volumes with actual excavated volumes and actual onsite reuse / disposal volumes and details of waste tracking records
- Conclude on whether any contamination has been remediated such that no unacceptable risks to human or ecological receptors remain for the site, in the context of the proposed land use.

Any deviations from the Remediation Strategy due to unforeseen conditions will be clearly documented in the RVR and linked to a review of the conceptual site model and remediation objectives.

Any interim remediation validation updates will be produced by Ayesa as the work progresses. Following completion, all interim validation information will be incorporated into the overarching RVR.

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Appendix A – Service Constraints and Report Limitations

Service Constraints and Report Limitations

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 named at the front of the report (the "client") 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 has been prepared at the date shown on the front page and 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.

Appendix B – Environmental Risk Assessment and Methodology

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 satisfactory 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

Very High Risk (VH)	**There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.**
High Risk (H)	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer-term.
Moderate Risk (M)	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.
Low Risk (L)	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very Low Risk (VL)	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.

Generic Qiantitative 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

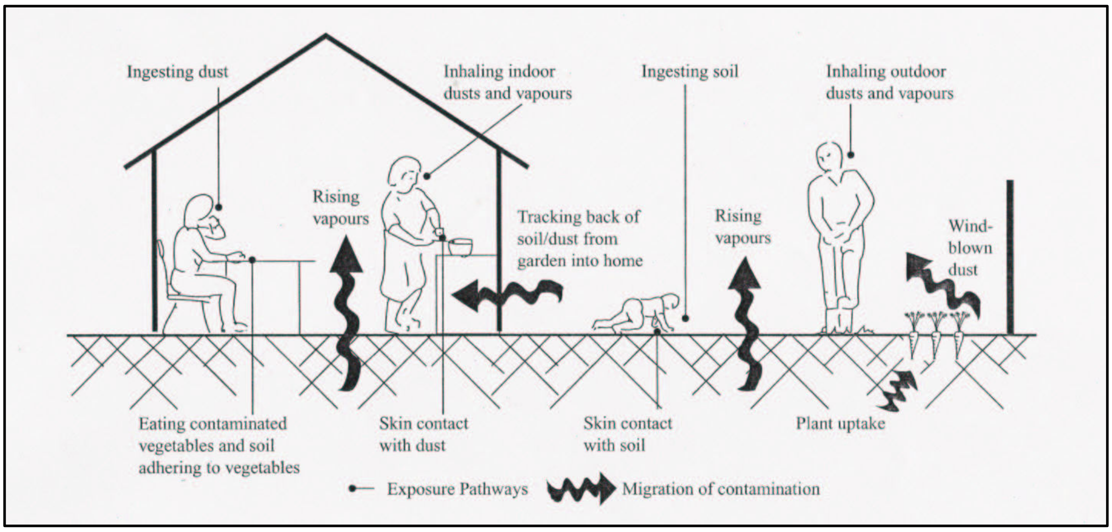
A program for the derivation of SGVs based on the above guidance is provided by the Environment Agency and is entitled "CLEA Software Version 1.06". These reports, together with supporting toxicology reviews ("Tox" or Supplementary Information Reports) for individual substances (which will be gradually 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 (2nd 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.

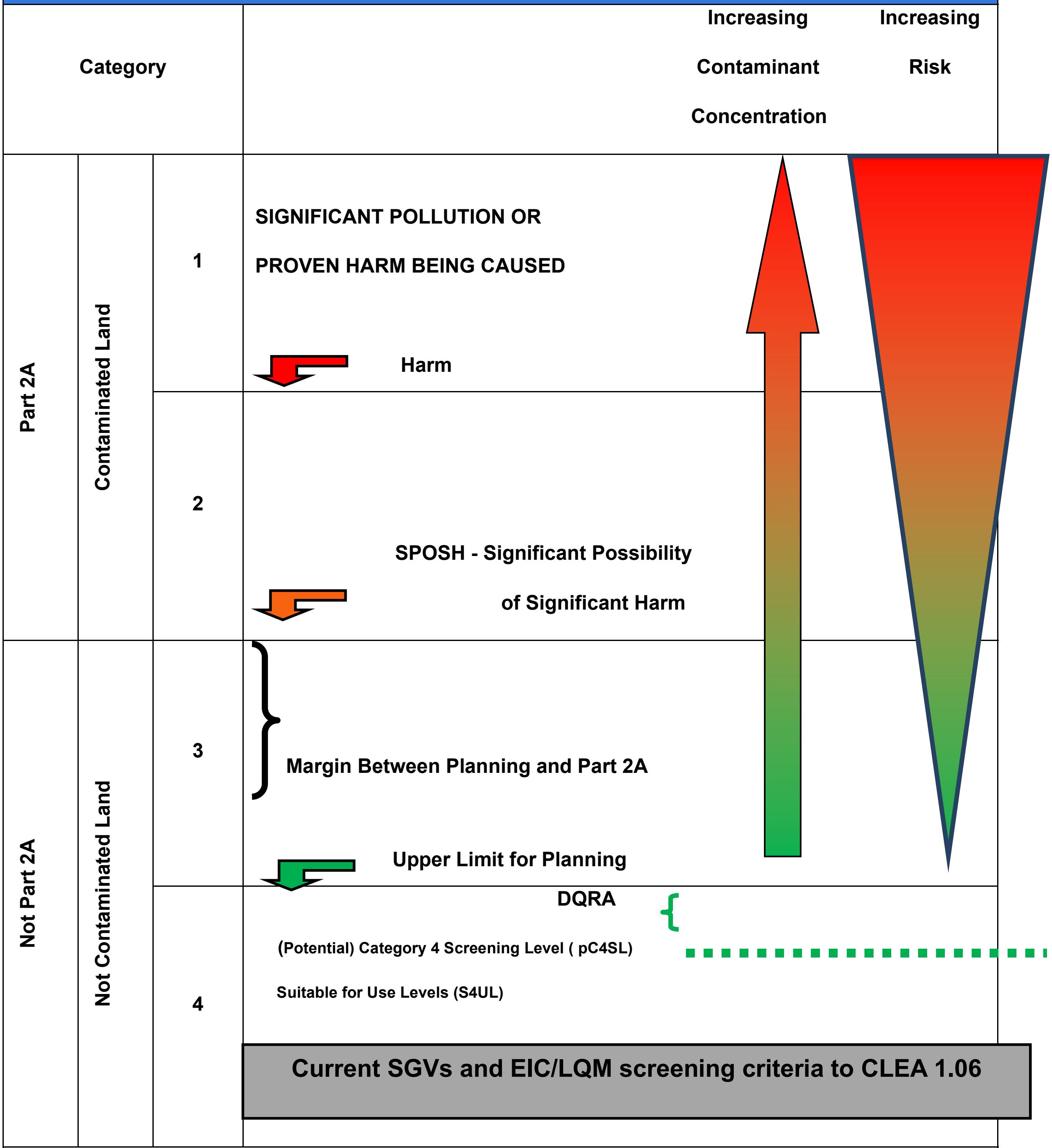
In December 2013 Defra issued the findings of a research project undertaken by CL:AIRE to set out the framework by which potential Category 4 Screening Levels (pC4SL) may be derived. The report was not designed to produce ‘final’ C4SL as the steering group producing the report believes that final C4SL 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 3rd 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.

Relationship Between Contaminant Concentration, Risk and Screening Values



Note:

The vertical scale should not be considered as being linear and will be site and contaminant specific.

- SPOSH concentrations could be 10 to 100 times the SGV/EIC/LQM screening concentration.
- C4SL were issued as ‘potential’ 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 3rd September 2014).

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_{resi}); and,
- Public Open Space – Public Park (POS_{park}).

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_{resi}); and
- Park-type scenario where distance is considered sufficient to discount tracking back of soil (POS_{park}).

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 ICRCL 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 ICRCL 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 ICRCL 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) 135 (pH 6-7) 100 (pH 5.5-6.0)	110 (pH >7) 75 (pH 6-7) 60 (pH 5.5-6.0)	300 (pH >7) 200 (pH 6-7) 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	-	-
Note: * 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 [4] (EPA 1990) provides the regulatory regime, which was introduced by Section 57 of the Environment Act 1995 [5], 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).

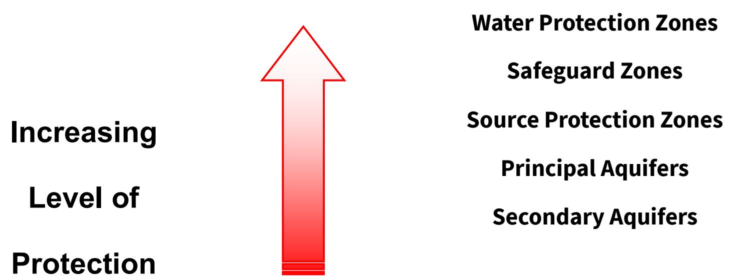
Part IIA places contaminated land responsibility as a part of the planning and redevelopment process rather than Local Authority or Environment Agency taking direct action except in situations of very high pollution risk or where harm is occurring. In the planning process guidance is provided by National 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.

<u>Environment Agency Guidance</u>

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):

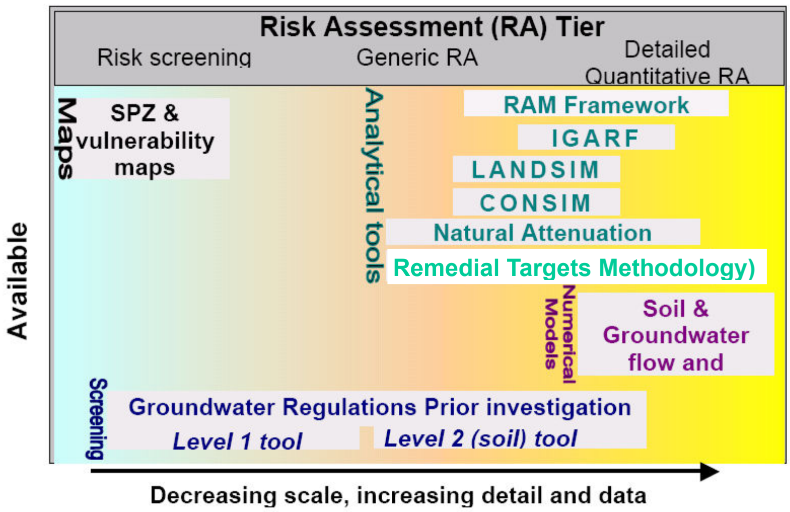


Figure 1-1 Environment Agency groundwater assessment tools, mapped against the different levels of risk assessment.

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.

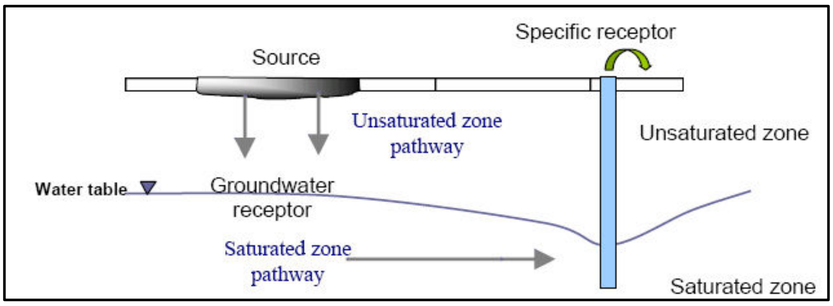
A more advanced code, ConSim 2, developed on behalf of the Environment Agency to support the Remedial Targets Methodology, allows for the introduction of additional geological horizons and is used mainly to determine the concentrations reaching a receptor and the timescales over which this may happen.

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^2)
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^3	Milligram per metre cubed
GAC	General Assessment Criteria	Mg/m^3	Megagram per metre cubed
GL	Ground Level	µg/m^3	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^2	Kilo Newtons per metre squared
LMRL	Lower Method Reporting Limit	kPa	Kilo Pascal – same as kN/m^2
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 – Unforeseen Ground Contamination

Unforeseen Ground Contamination

There is the potential for areas of previously unexpected contamination to be present on the previously developed areas of the EfW CHP Facility Site, as is the case with any "brownfield" site, but this is significantly less likely on the previously undeveloped "greenfield" TCC site. Any significant quantities of asbestos, significant ashy soils, unusual, brightly coloured or significantly oily or odorous material should be considered in this category. If unexpected contamination is found the following procedures will be adhered to:

1. All site works at the position of the suspected contamination will cease.
2. A suitably trained geo-environmental specialist should assess the visual and olfactory observations of the condition of the ground and the extent of contamination, and Kanadevia Inova (KVI) / Doran Consulting and the Relevant Planning Authority should be informed of the discovery. Should the contamination be likely to affect controlled waters the Environment Agency shall also be informed.
3. The suspected contaminated material will be investigated and tested appropriately in accordance with the assessed risks. The investigation works will be carried out in the presence of a suitably qualified geo-environmental engineer. The investigation works shall commence to recover samples for testing and, using visual and olfactory observations of the condition of the ground, delineate the area over which contaminated materials are present.
4. The unexpected, contaminated material will either be left in situ or be stockpiled whilst testing is carried out and suitable assessments completed to determine whether the material can be re-used on site or requires to be disposed as appropriate.
5. Where the material is left in situ awaiting results it will be reburied or covered with plastic sheeting.
6. Where the potentially contaminated material is to be temporarily stockpiled it will either be placed either on a prepared surface of clayey Alluvium, or on 2000-gauge Visqueen sheeting (or other impermeable surface) and covered to prevent dust and odour emissions.
7. Any areas where unexpected visual or olfactory ground contamination will be surveyed, a photographic record kept, and testing results incorporated into the Verification Report.
8. A photographic recorded will be made of relevant observations.
9. The testing suite will be determined by the independent geo-environmental specialist on the basis of visual and olfactory observations.
10. Test results will be compared against current assessment criteria suitable for the future use of the area of the site affected.
11. The results of the investigation and testing of any suspect unexpected contamination will be used to determine the relevant actions. After consultation

with Kanadevia Inova (KVI) / Doran Consulting, the Relevant Planning Authority and if necessary, the Environment Agency, materials should either be:

- re-used in areas where test results indicate that it meets compliance targets so it can be reused without treatment; or
- treatment of material on site to meet compliance targets so it can be reused; or
- removal from site to a treatment centre or to a suitably licensed landfill or permitted treatment facility.

12. Verification Report will be produced for the work.

Asbestos

Asbestos cement products and asbestos fibres have not been encountered in the soils at the site but based on the age of the Made Ground material containing asbestos could be expected to be encountered. If non-notifiable asbestos (e.g., chrysotile asbestos cement board) is encountered in excavations then it will be dealt with in accordance with the Control of Asbestos Regulations 2012 (CAR 2012) and the HSE's ACoP for asbestos (2013). Finding non-notifiable asbestos is a very common occurrence on brownfield sites and is a relatively low risk activity and can be dealt with as a matter of routine. Therefore, it is not proposed that the Relevant Planning Authority will be notified but an appropriate record will be kept of confirmatory testing and disposal. This will be included in remediation verification reports.

If suspect notifiable asbestos is encountered then the Relevant Planning Authority and the HSE will be notified. An appropriate action plan will be agreed with the Relevant Planning Authority and the HSE in accordance with CAR 2012. The action plan will include the preparation of the Risk Assessment and Plan of Work in accordance with CAR and other statutory requirements including:

- Site mobilisation;
- Excavation methodology;
- Handling, movement and storage on-site of excavation arisings;
- Any processing of excavation arisings containing ACMs;
- Movement and placement of arisings to final destination;
- Placing of cover system over soils with and ACMs remaining on-site;
- Off-site disposal of ACMs;
- Licences;
- PPE & RPE; and,
- Dust and fibre monitoring.

Potential mitigation measures that would be required include:

- Ensuring works are carried out by suitably trained and experienced personnel in working with asbestos;
- Site investigation and risk assessment;
- Removal or treatment of asbestos hotspots;
- Use of PPE and RPE by construction workers; and,
- Compliance monitoring.

Unexpected Tanks

Buried underground fuel storage tanks are known to be present on-site; however, there remains a low risk that unknown tanks are present on-site. Should an unexpected underground tank be encountered, operations should cease in the area. Additionally, there may be pipework associated with these tanks which could have oily residues. The following procedures are to be adhered to if these are identified:

1. All site works at the position of the tanks/pipework should stop.
2. A description of the tank should be made by the geo-environmental engineer including; condition and surround, along with visual and olfactory observations should any contents in the tank be apparent. A photographic recorded will also be made of relevant observations.
3. The tank's position and depth should be determined and marked on a plan of the site.
4. The independent geo-environmental engineer will inform Kanadevia Inova (KVI) / Doran Consulting and the Relevant Planning Authority.
5. During the presence of the independent geo-environmental engineer, investigation works should be undertaken to obtain samples of any liquid or sludge contents and to establish dimensions of the tank.
6. Testing will be determined on the basis of visual and olfactory observations by independent geo-environmental engineer.
7. Test results will be compared against current assessment criteria and proposals for disposal of any contents determined in agreement with the appropriate Regulatory Parties.
8. Emptying the tank and disposal of contents to a suitable licenced disposal facility.
9. Degassing and removal of the tank by a suitably qualified contractor will be required, and a Naked Flame Certificate should be provided.
10. Once the tank has been emptied in accordance with the above proposals, it is to be removed for disposal to a licensed waste management facility. Copies of the relevant waste consignment notes are to be kept and included in the Verification Report.

11. Excavation and remediation of any contaminated soils around the tank will be carried out.
12. Samples of the base and sides of the resultant hole will be sampled and supervised by the independent geo-environmental engineer to confirm whether there are risks to human health or controlled waters.

Appendix D – Ground Gas Assessment Report

Ground Gas Assessment

Medworth EfW CHP Facility

Report No. [C57/2086-ENV-GGA-R001]

12 May 2025

Issue 03

Doran Consulting

Document Control

Project

Medworth EfW CHP Facility

Client

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Ground Gas Assessment

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Contents

[1] Introduction

Ayesa have been commissioned by Doran Consulting to undertake a Ground Gas Assessment using historic data issued in the Phase 1 and Phase 2 combined report completed by Wood Environmental and Infrastructure Solutions (Ref: 4130-WOOD-XX-XX-RP-OC-0001_S3_2), for the proposed Energy from Waste (EfW) Combined Heat and Power (CHP) Facility Site (the 'EfW CHP Facility Site') and the Temporary Construction Compound (the 'TCC'); Work Nos.1, 1A, 2A, 2B and 5 of the Medworth EfW CHP Facility Order (the 'Order') (subsequently referred to as 'the Site' throughout this report).

[1.1] Report Objectives

The objectives of this report are as follows:

- Characterise and assess the risk posed to the proposed development from ground-gas contamination.
- Identify likely ground-gas sources, pathways and receptors within a detailed diagrammatic conceptual model.
- Utilise ground-gas monitoring data and the conceptual model to identify gas protection measures which may need to be incorporated into the works.

[1.2] Development Proposals

Ayesa understand the current development proposal consists of construction of a large multi-storey building and chimneys with associated plant, offices and utilities. This also includes construction of a development platform, and a temporary construction compound.

This report has been prepared with consideration of the above outline development proposals. Should the development proposals change significantly, the assessment should be reviewed and appropriately amended where necessary.

[1.3] Scope of Works

Ayesa's scope of work included the following:

- A comprehensive review of historic ground gas data recorded at the site as presented in the Phase 1 and Phase 2 combined report completed by Wood Environmental and Infrastructure Solutions (4130-WOOD-XX-XX-RP-OC-0001_S3_2)
- Ground Gas Risk Assessment (GGRA) (in line with CIRIA C665 and BS:8485:2015).

[2] Site Characteristics

[2.1] Site Description

Figure 2.1 provides an image of the site boundary, and Table 2.1 below details a site description.

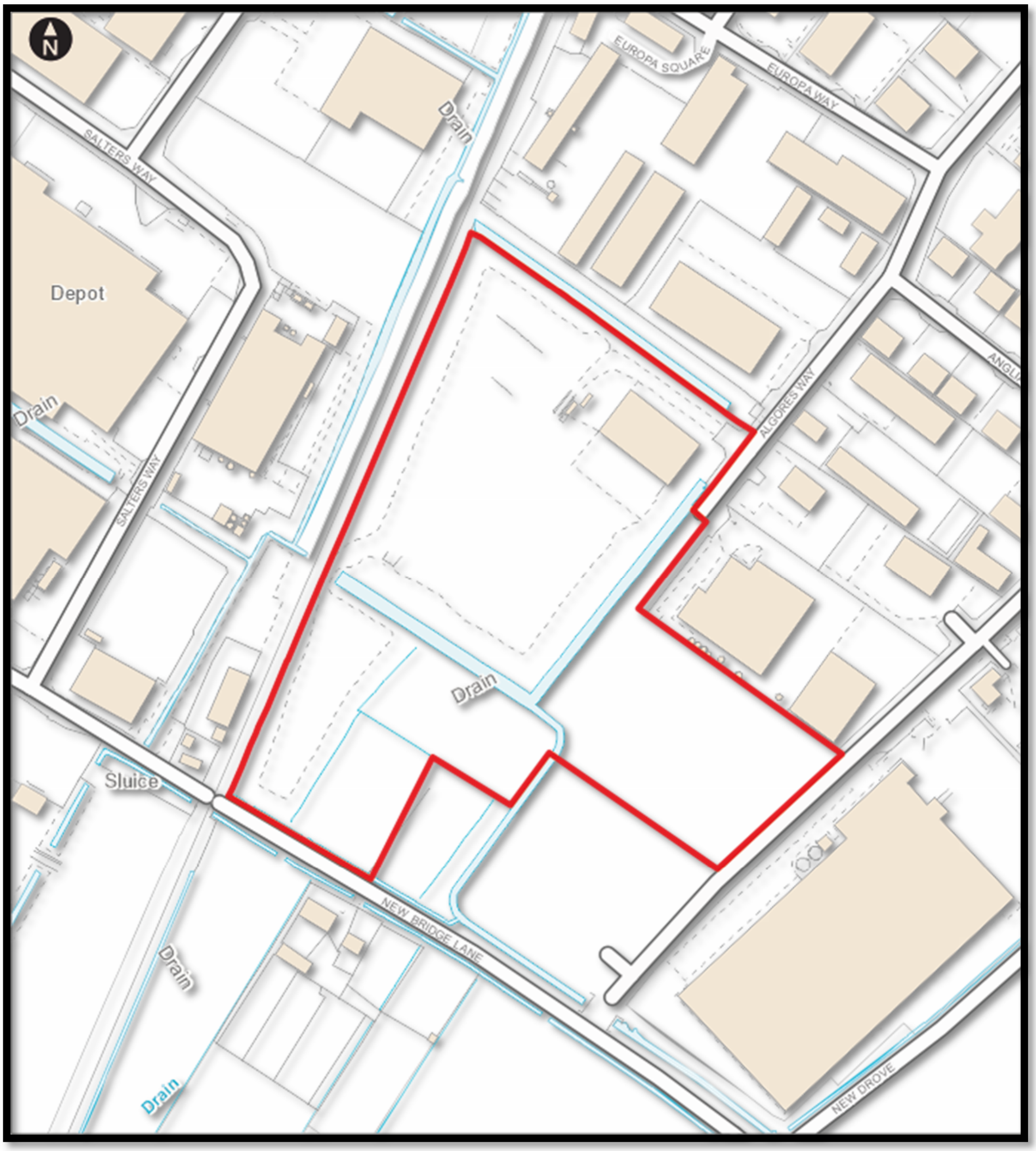


Figure 2.1 Approximate Site Boundary

Table 2.1 Site Details

Description	Details
Address	Mick George Ltd, Algores Way, Wisbech

Postcode		PE13 2TQ
National Grid Reference (approximate centre of site)		545530, 307920
Overview		The site is accessed via Algores Way and comprises 4.5 hectares of brownfield land surfaced with compacted gravel hardstanding (the EfW CHP Facility and Site), and an adjacent area to the east comprising of rough grass (the TCC), understood to be undeveloped, 'greenfield' land. It's understood that the EfW CHP Facility and Site was previously occupied by an aggregate and waste management facility which stockpiles and processes natural aggregates, concrete, brick and household waste. A steel-framed concrete-floored warehouse, weighbridge and site cabins are present in the north-east corner. The site is approx. rectangular in shape with a rectangular extension (the TCC) to the east from the approximate centre. The topography slopes gently to the south-west, from 2.1m above Ordnance Datum (AOD) to the northern boundary, to 1.65m AOD close to the southern boundary. The EfW CHP Facility Site is bound by a ~2m high earth bund on all sides, although the bunds do not continue the full length of the north-west and south-east boundaries.
Boundaries (land uses and relevant features)	North-east	Drainage ditch. Industrial area with various manufacturing businesses.
	North-west	Heavily vegetated disused railway line and possible drainage ditch.
	South-east	Drainage ditch. Industrial area with various manufacturing businesses.
	South-west	Drainage ditch. Disused thickly vegetated land.
Current site activities		It is understood that the site currently remains in use as an aggregate and waste management facility.

[2.2] Site History

A summary of the historical development of the EfW CHP Facility Site and TCC since 1887 based on historical OS maps is presented in Table 2.2 below, which has been replicated from pages 20-21 of the Wood Environment and Infrastructure Solutions UK Ltd Phase 1 and Phase 2 report, with the exception of mapping from 2019 – present.

Only features which are located within 500m of the EfW CHP Facility Site and TCC or have the potential to provide a ground-gas contaminative source or migration pathway are considered.

Table 2.2 EfW CHP Facility and Site History

Map	Description
1887 to 1953 1:10,560 1881 to 1900 1:2,500	**On-Site:** Agricultural land. Drainage channels run along the NE, SE & SW site boundaries, and two through the centre of the site SW-NE and NW-SE. The central SW-NE drainage channel is no longer depicted by 1927 - assumed infilled. TCC area is undeveloped and appears to remain so until present day. **Off-site:** The site is surrounded by agricultural land, orchards, nurseries and allotment gardens. Parcels of land are divided with drainage channels. A branch railway line is depicted adjacent to the NW site boundary, orientated SW-NE. A road is adjacent to the site's SW boundary. The River Nene is depicted 500 m NW of the site flowing SWNE. The works are no longer depicted and partially infilled by 1953. Fishing ponds are depicted 300 to 500m SW of the site and are partially infilled by 1953 and again by 1982.
1982 to 2000 1:10,000 1980 to 2000 1:2,500	**On Site:** No significant change. The western portion of the drainage channel crossing the site NW-SE, is no longer depicted- potentially culverted. **Off-Site:** Large industrial 'factory and works' buildings are depicted 325m to 1000m N to NE of the site, over the former brick works and fishpond sites. Two depots, works buildings and a sports stadium (running track) are depicted 30 to 500m NW of the site. Wisbech rail line running along the NW site boundary is no longer depicted / disused by 2000. An electricity substation is depicted 180m NE and W of the site by 1992. A tank is depicted 50m W of the site by 1992.
1881 to 1900 1:2,500 2006 to 2019 1:10,000	**On Site:** A rectangular building with exterior hardstanding depicted in the eastern quadrant of the EfW CHP Facility Site. Unknown structures, understood to be material segregation dividers, are depicted in the northern quadrant of the site. **Off-Site:** Significant development of an industrial estate with units adjacent to the NW, NE and SE of the site. A vehicle salvage yard is depicted 100m SW of the site. A recycling site is depicted 400m E of the site.
2019 to present (aerial imagery)	On site and off site uses remain the same.

[2.3] Site Geology and Environmental Setting

The environmental setting has been collated from previous reporting and borehole logs and has been summarised below in Table 2.3.

Table 2.3 Site Geology and Environmental Setting

Feature	Description
Made Ground	Observed as gravel aggregate surface across the EfW CHP Facility Site and in the south-east earth bunds comprising topsoil, brick, concrete, macadam and concrete slabs are present. Thickness is unknown.

Superficial Geology	Tidal Flat Deposits – Clay and silt. Sedimentary deposit formed between 11.8 thousand years ago, present during the Quaternary period. Encountered in the 2020 ground investigation as normally consolidated or unconsolidated soft silty clay with layers of sand, gravel and peat, with a maximum thickness of 22.5m. Glacial Till deposits have also been intercepted in nearby boreholes at 22.8m bgl, comprising a mixture of rock fragments, gravels, sand, silt and clays.
Bedrock Geology	Ampthill Clay Formation – Mudstone. Sedimentary bedrock formed between 163.5 and 157.3 million years ago during the Jurassic period. Encountered in the 2020 ground investigation as a pale to medium grey mudstone with argillaceous limestone nodules and some rhythmic alternations of dark grey mudstone, with a maximum thickness of 48m. Kellaways and Oxford Clay Formations underlies the Ampthill Clay Formation at approx. 57m bgl and comprises a marine silty mudstone.
Hydrogeology	The superficial and bedrock deposits beneath the site are classified as an unproductive aquifer. The BGS Borehole records listed above suggest that groundwater held within the superficial deposits are present as perched discontinuous groundwater bodies. The site does not lie within a Source Protection Zone. The nearest groundwater abstraction well is located 480m east of the site for use in horticultural irrigation. Based on the impermeable nature of the underlying geology, Wood does not consider the abstraction location to be within influencing distance of the site.
Hydrology	The nearest named water course is the River Nene, located 550m north-west of the site, flowing towards the north-east. The site is situated within an area served by an extensive network of artificial drainage channels under the control and management of the Internal Drainage Board (IDB). Drainage ditches flow adjacent to the north-east, south-east and south-west boundaries and within the central area of the site, conveying water by gravity to the south-west. Drainage is passed to the River Nene at the Middle Level IDB's South Brink pumping station. The ditches are culverted in the north-east corner of the site adjacent to Algores Way.
Mining / faults	The site is not located within a coal mining area. There are no active quarries nor surface mineral resources within influencing distance.
Radon	The Site is located in a Lower Probability Radon Area, as less than 1% of properties are above the Action Level. The Envirocheck Report provided in the Wood Report states that "no radon protective measures are necessary".
Landfill sites / Infilled sites	There are no registered landfill sites on the site or within 2km of the site.

Areas of historical infilled land (pond, marsh, river, stream or dock) are anticipated between 310m and 955m from the site.

[2.4] Summary of Previous Reporting

Wisbech Phases 1 and 2 Geoenvironmental Desk Study and Interpretative Report, ref 41310-WOOD-XX-XX-RP-OC-0001_S3_3. Wood Environment & Infrastructure Solutions UK Ltd. September 2020.

Wood completed a ground investigation and report in conjunction with Allied Exploration & Geotechnics Ltd in order to inform the Environmental Impact Assessment (EIA), Site Condition Report (SCR) and provide contamination and geotechnical information for foundations, groundworks design and construction.

The field work upon which the Phase 2 Report is based was undertaken between 4th February and 4th March 2020. Intrusive investigations as part of these works included 12no. gas/groundwater boreholes (specifically 4no. gas targeted monitoring wells), 18no. mechanically excavated trial pits, 1no. hand excavated trial pits and geo-environmental soil sampling. Exploratory hole installation and instrumentation summary for the 4no. targeted gas wells is detailed in Table 2.4 below.

Table 2.4 Gas Targeted Wells Installation and Instrumentation Details

Exploratory Hole Number	Instrumentation	Installation Depth (m BGL)	Response Zone (m BGL)	Response Zone Stratum	Flooded
BH01	1no. 50mm diameter slotted standpipe	2.50	1.00 – 2.70	Cohesive Tidal Flat Deposits	Partially
BH07	1no. 50mm diameter slotted standpipe	2.00	0.50 – 2.00	Made Ground	Partially
BH09	1no. 50mm diameter slotted standpipe	2.00	0.50 – 2.00	Made Ground and Cohesive Tidal Flat Deposits	Partially
BH11	1no. 50mm diameter slotted standpipe	1.50	1.00 – 1.50	Cohesive Tidal Flat Deposits / Peat	Partially

Made Ground was encountered in all exploratory holes to depths varying between 0.2m and 2.1m bgl. The surface comprised a thick surface of crushed macadam or flint, limestone / sandstone concrete or a combination of all. The underlying layer primarily comprised a red-brown or grey-brown very sandy cobbly gravel comprising macadam, concrete, brick, flint, sandstone, limestone, quartzite, glazed tile, clay tile and occasional clinker. Layers of clay (possibly reworked tidal flat deposits) were encountered in several locations. A geotextile separator was encountered at the base of the made ground in most exploratory holes.

Tidal Flat Deposits were found to underly the Made Ground consistently, as a clay / silt with plant fragments between 0.2 – 2.1m bgl, progressing as a very fine sand with occasional plant debris and shells between 1.7 – 5.0m bgl.

Glaciofluvial Deposits comprising dense to very dense brown and grey silty sandy GRAVEL / gravelly SAND were encountered beneath the Tidal Flat Deposits, at depths between 19.2 and 24.0m bgl.

Very stiff becoming hard Glacial Till was encountered in exploratory holes BH02, BH04, BH05, BH09-BH12 at depths between 24.3 and 25.7m bgl. The deposits comprised dark grey silty sandy gravelly clay.

Ampthill Clay was encountered as the bedrock formation beneath the Glacial Deposits between 30.8 – 33.0m bgl. The bedrock comprises a very stiff to hard smooth dark grey-brown silty clay, becoming very weak, friable weathered mudstone with frequent fossils of shells and fossil casts.

Wood undertook gas monitoring on six occasions between March and August 2020 at four targeted gas wells (BH01, BH07, BH09, BH11) using a calibrated gas analyser. Measurements of flow, Carbon Dioxide, Methane, Oxygen, Lower Explosive Level, Carbon Monoxide, and Hydrogen Sulphide were recorded. Concentrations of total volatile organic compounds were also recorded using a photo-ionisation detector.

Wood considered the potential for upward migration of ground gas through the clay strata to be negligible, however where basement or deep excavated structures are proposed, these may intercept gas-generating strata and provide a direct pathway into buildings.

Wood also commented that the surface water drainage channels (approx. 2m deep) bordering the EfW CHP Facility Site to the north-east and south-east are anticipated to limit off-site migration of gas / vapours.

[3] Existing Ground Gas Risk Assessment

This section is written using existing ground gas information provided in the Wisbech Phases 1 and 2 Geoenvironmental Desk Study and Interpretative Report, ref 41310-WOOD-XX-XX-RP-OC-0001_S3_3. Wood Environment & Infrastructure Solutions UK Ltd. September 2020.

[3.1] Conceptual Site Model

The conceptual site model is a representation of the relationship between contaminant sources, pathways and receptors developed on the basis of hazard identification. This is discussed below with respect to ground gas risk.

[3.1.1] Potential Contaminant Sources

The presence of Made Ground containing anthropogenic materials on site can contribute to the generation of methane (CH_4) and carbon dioxide (CO_2) through the decomposition of organic matter. Additionally, certain geological formation such as the organic-rich clay and peat observed in the ground investigation may naturally produce ground gases due to biodegradation processes.

Also identified in the conceptual site model were a septic tank and below ground fuel tanks.

[3.1.2] Identified Pathways and Receptors

With respect to ground gas risk the potential pathways include inhalation of vapours / gas, asphyxiation due to concentrations of gas and accumulation of potential explosive gases. The receptors of concern are future site users and building structures.

[3.1.3] Risk Assessment

The main risks identified with respect to ground gases are:

1) Potential Made-Ground which is considered to be a medium severity with a low likelihood giving a risk score of Moderate / Low.
2) Natural Peat Deposits which is considered to be a medium severity with a likely likelihood giving a risk score of Moderate.

[3.2] Ground Gas Monitoring Methodology and Results

Six ground gas monitoring visits were undertaken by Wood over a period of six months between March and August 2020. The monitoring was undertaken using an infrared gas monitor.

The atmospheric pressure at the time of the first, second and fourth monitoring round was falling from 1029 to 1026 mb,1022 to 1020 mb and 1014 to 1013, respectively.

Steady flow rates were low (<0.1 to 0.4 l/hr). High peak positive and negative flow readings recorded in BH01 (-7.5 l/hr during round 1) and BH09 (7.3 l/hr during round 1) fell steadily over 5 minutes and 150 seconds, respectively. Both locations recorded flow rates of <0.1 l/hr during rounds 2, 3 and 4. High peak negative flows were recorded at BH01, BH07 and BH09 during round 6, quickly stabilising to <0.1 l/hr. These negative peak flows are assumed to be due to variations in groundwater levels in between monitoring rounds.

Methane and carbon dioxide have been recorded in monitoring wells BH01 and BH09 which target plant-rich silts and peat strata. Negligible concentrations of ground gases have been recorded in BH07 targeting the made ground and BH11. It is worth noting that the peat and plant-rich silt strata within BH11 were fully saturated at the time of monitoring, therefore, the results reflect the gas generating potential of the overlying impermeable clay stratum and potential upward migration of gas present within the underlying peat. Concentrations of carbon monoxide ranged between <0.1 to 2 ppm, with no measurable concentrations of hydrogen sulphide (<0.1 ppm) being recorded.

Measurable concentrations of total VOCs have been recorded in all four monitoring wells, with the highest concentrations recorded in wells targeting plant-rich strata. The concentrations were generally less than 2ppm which is not considered significant. Depleted oxygen levels have been recorded at BH09. An LEL reading of 17.8%, 7% and 56% were recorded at this location during rounds 2, 3 and 6, which were significantly higher than that recorded at either of the remaining three locations. This is suggestive of the presence of ground gas within the silt/peat deposits. However, the absence of a positive steady flow rate and similar observations within the other boreholes suggests that the ground gas is trapped within the silt/peat layer.

[3.3] Conclusions and Risk Assessment Outcomes

Wood state that the preliminary results indicate that ground gas generation is negligible within the made ground deposits and impermeable clay indicating the site may be classified as Characteristic Situation 1 (CS1). These wells are also above silt/peat deposits, indicating that upward migration of ground gas from these deposits is potentially limited. This is supported by the low gas flows recorded at the site. However, mitigation may be required if a pathway for upward migration, or migration into basements/services is introduced.

The observations of carbon dioxide above 5% v/v in BH09 within the silt/peat layer, along with the depleted oxygen levels, is suggestive of the presence of ground gas at concentrations which could require mitigation if a pathway for upward migration, or migration into basements/services is introduced. The concentrations recorded are representative of CS1, but this is raised to CS2 due to concentrations of carbon dioxide typically being recorded above 5% v/v (in 4 of 6 monitoring rounds).

Ayesa agrees with the conclusions above that the majority of ground gas risk is associated with the peat / silt layer as would be expected. It should be noted that no ground gas monitoring was undertaken during a period of low atmospheric pressure which would generally see increased ground gas production and as such we believe that a CS2 characterisation is a prudent approach.

[4] Risk Mitigation

The protection measures required to mitigate the risk from ground gas is described in British Standard BS8485:2015+A1:2019 “Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings”

The mitigation is based on assigning a points score required for gas protection based on the characteristic situation of the site and the building type of development to be employed.

The building types are described within Table 3 of BS8485 but repeated below for ease.

Table 4.1 Building Types

	Type A	Type B	Type C	Type D
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

These are described as the following:

- **Type A Building:** private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.
- **Type B Building:** private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals and leisure centres) and parts of hotels.
- **Type C Building:** commercial building with central building management control of any alterations to the building or its uses and central building management control of the building’s maintenance, including gas protection measures. Single occupancy of ground floor and basement areas. Small to large size rooms with active ventilation and good passive ventilation of all the rooms and other internal spaces throughout the ground floor and basement area. Probably civil engineering construction. Examples include offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).

- **Type D Building:** industrial style building having large volume internal spaces that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement areas of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floor areas and warehouses (small rooms within these buildings should be separately categorized as Type B or C).

Based on the above description this development should be classified as **Type D.**

The building type and site characteristic situation can then be cross referenced in Table 4 of BS8485 (repeated below) to determine gas protection score required.

Table 4.2 Gas Protection Score

CS	Type A	Type B	Type C	Type D
CS1	0	0	0	0
CS2	3.5	3.5	2.5	1.5
CS3	4.5	4	3	2.5
CS4	6.5*	5.5*	4.5	3.5
CS5	**	6*	5.5	4.5
CS6	**	**	**	6

* Residential buildings 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, eg high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system.

** The gas hazard is too high for this empirical method to be used to define the gas protection measures.

Based on this site being classified as Characteristic Situation CS2 and Building Type D, 1.5pts of gas protection will be required. This can be accomplished by a number of different means including structural barrier (floor and substructure), ventilation and membrane as described in Tables 5, 6 and 7 in BS8485.

In this case it is considered that provision of a ground slab and gas protection membrane would provide sufficient protection to mitigate the risk.

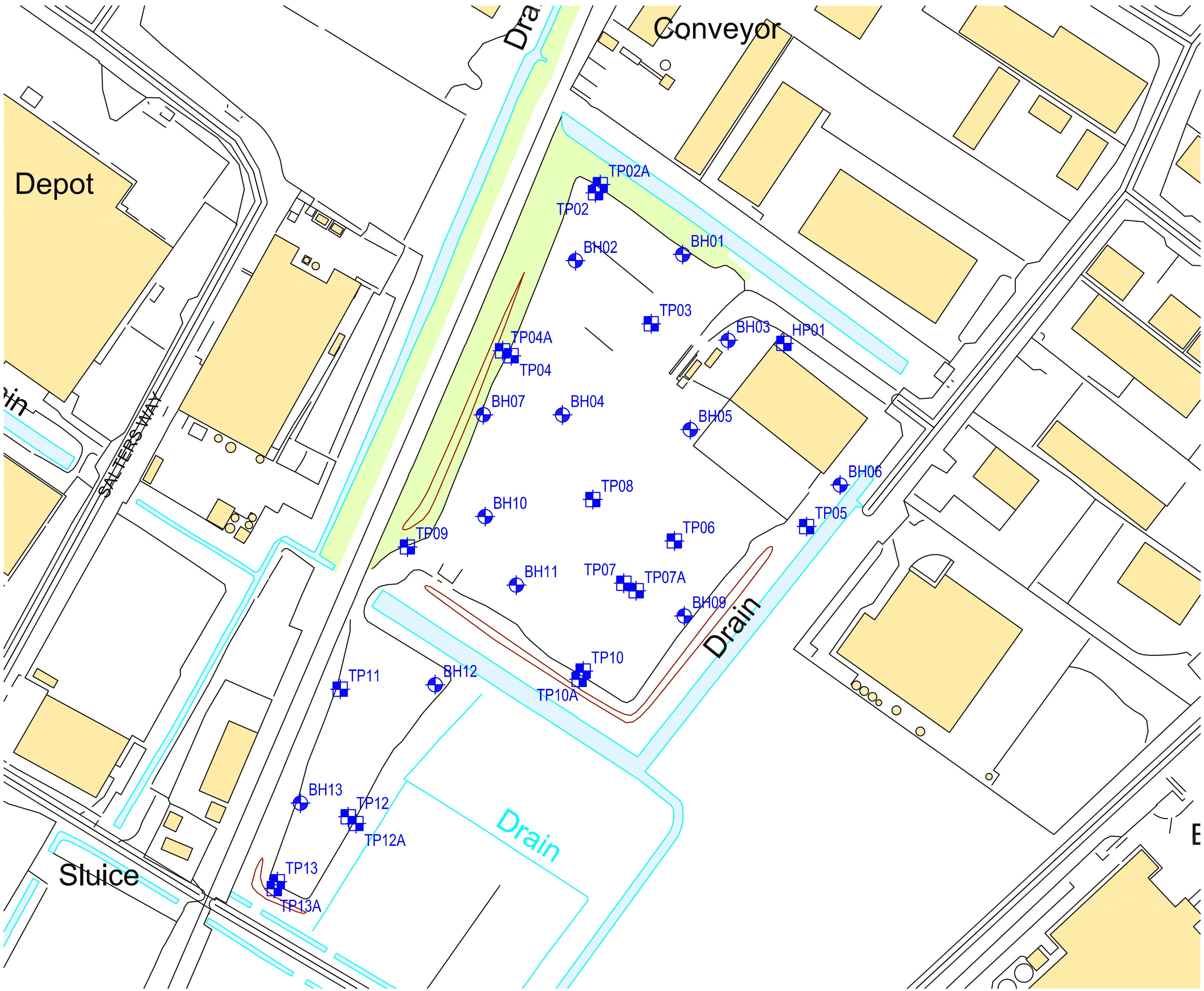
[5] Conclusion

The findings indicate that the primary ground gas risk is associated with the presence of organic-rich peat and silty strata underlying the site, with recorded carbon dioxide concentrations exceeding 5% v/v in multiple monitoring rounds and depleted oxygen levels, suggestive of gas generation within these layers. However, the overall gas flow rates were consistently low and no significant concentrations of methane or other hazardous gases were observed. The impermeable nature of the overlying clay strata is considered to reduce the potential for upward gas migration to the surface.

Although the majority of the site has been assessed as Characteristic Situation 1 (CS1), the repeated detection of elevated carbon dioxide in BH09 warrants a precautionary upgrade to Characteristic Situation 2 (CS2) in accordance with CIRIA C665 and BS8485:2015+A1 2019. This classification reflects the potential for gas accumulation as future construction activities such as deep excavations, service trenches, or basement structures may introduce preferential pathways.

Based on the assessment, gas protection measures should be incorporated into the design of the proposed development in line with BS8485 guidance for CS2 sites. Any significant changes to the development design may prompt a reassessment of ground gas risk.

Appendix A – Borehole Locations



Allied Exporation and Geotechnics Limited
Unit 25 Stella Gill Industrial Estate
Pelton Fell
Chester - Le - Street
Co Durham
DH2 2RG
(Tel): 0191 387 4700
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KEY:

(borehole symbol)	BOREHOLE
(pit symbol)	TRIAL/HAND DUG PIT

N W E S

Base Plan Supplied by Consulting Engineer

Drawing Title: ENC 01 : Exploratory Hole Location Plan

Drawing No.: AEG/4269/01

Contract Title: Wisbech Waste Transfer Station, on Land off Algores Way, Wisbech

Client: MVV Environment Ltd, Ground Floor North Quay House, Sutton Harbour, Plymouth, PL4 0RA

Consultant: Wood Environment & Infrastructure Solutions UK Ltd, Cannon Court, Abbey Lawn, Abbey Foregate, Shrewsbury, Shropshire, SY2 5DE

Contract No.: 4269

Scale: 1:1000 @ A3

Date: 13/03/2020

Appendix B – Gas Monitoring Data

CIRIA C665 Gas Screening Value Calculator

Project Number:	41310	Site:	Wisbech	Zone:	N/A

Ground conditions (including vegetation stress, visual contamination):	e.g. Gravel hardstanding covers the majority of the site, with some soft landscaping

Monitoring Point	Standpipe Diameter (m)	Response Zone Top (m bgl)	Response Zone Base (m bgl)	Strata Monitored	Evidence of potential gas generation sources?
BH01	0.055	1	2.5	CLAY and SILT with plant fragments	Decomposing plant fragments within SILT.
BH07	0.055	0.5	2	Made Ground	Made Ground & migration of gas through underlying clay
BH09	0.055	1	2.5	CLAY & SILT with plant fragments	Decomposing plant fragments within SILT.
BH11	0.055	1	1.5	CLAY, SILT & PEAT	Peat strata
End					

BS8485:2015 / CIRIA C665 Characteristic situation: Situation A - All development types except those in Situation B

Project Number:	41310	**Site:**	Wisbech	**Zone:**	N/A

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10	Round 11	Round 12	Round 13	Round 14	Round 15	Round 16	Round 17	Round 18	Round 19
Monitoring Dates	17/03/2020	15/04/2020	27/05/2020	15/06/2020	09/07/2020	13/08/2020													
l atmospheric pressure	1029	1022	1033	1014	1010	1011													
l atmospheric pressure	1026	1020	1033	1013	1010	1011													
Low Pressure (<1000mbar)	N	N	N	N	N	N													
Falling Pressure?	Y	Y	N	Y	N	N													

Monitoring Point	**Number of rounds**	**Flow Rate (Peak positive or negative)**	**Flow Rate (Steady)**	**Methane (Peak)**	**Methane (Steady)**	**Carbon Dioxide (Peak)**	**Carbon Dioxide (Steady)**	**Oxygen (lowest value)**	**Oxygen (lowest steady)**	**Carbon Monoxide**	**Hydrogen Sulphide**	**Groundwater level**	**Methane GSV**	**Carbon Dioxide GSV**	**Characteristic situation based on Steady readings**				**VOC**
		(l/hr)	**(l/hr)**	**(%v/v)**	**(%v/v)**	**(%v/v)**	**(%v/v)**	**(%v/v)**	**(%v/v)**	**(ppm)**	**(ppm)**	**(m bgl)**	**(l/hr CH4)**	**(l/hr CO2)**	**Methane CS**	**Carbon dioxide CS**	**Comments on methane CS**	**Comments on carbon dioxide CS**	**Direct measurement - steady (ppm)**
BH01	6	<0.1 to 0.2	<0.1 to 0.2	<0.1	<0.1	0.8 to 2.2	0.8 to 2.2	16.9 to 21.6	16.9 to 21.7	<0.1 to 2	<0.1	1.03 to 1.6	0.0002	0.0044	**CS-1**	**CS-1**			<0.1 to 8.1
BH07	6	<0.1 to 0.4	<0.1 to 0.4	<0.1	<0.1	0.1 to 1.2	0.1 to 1.2	18.8 to 19.9	18.8 to 19.9	<0.1	<0.1	0.76 to 1.21	0.0004	0.0048	**CS-1**	**CS-1**			<0.1 to 2
BH09	6	<0.1 to 7.3	<0.1 to 0.2	<0.1 to 2.4	<0.1 to 2.4	1.9 to 20.8	1.9 to 20.6	0.2 to 12.4	0.2 to 12.5	<0.1 to 2	<0.1	1.4 to 1.73	0.0048	0.0412	**CS-2***	**CS-2***	*Typical maximum concentration exceeded - assumed CS-2	*Typical maximum concentration exceeded - assumed CS-2	<0.1 to 1.9
BH11	5	<0.1 to 0.4	<0.1 to 0.4	<0.1	<0.1	0.2 to 1.9	0.1 to 1.9	20.5 to 21.9	20.5 to 22.2	<0.1	<0.1	0.5 to 1.38	0.0004	0.0076	**CS-1**	**CS-1**			<0.1 to 1.7
End																			

Monitoring Round 1

Project Number:	41310	**Site:**	Wisbech	**Zone:**	N/A
Date:	17/03/2020	**Instrument model(s):**	GA2000	**Atm. Pressure (start) (mb):**	1029
Engineer:	C Jackson & J Mendham	**Instrument S/No.(s):**		**Atm. Pressure (end) (mb):**	1026
Temp (˚C if known):	14	**Recent weather:**	Stable high pressure with slight wind		

Record any other observations which may have an impact on the soil gas monitoring results. These observations may include damage to the gas tap or top of well, damage to the cover or an open gas tap.

Damage to the well cover was noted on BH02 and BH09, however gas tap remained intacked.

Monitoring Point	Time	Flow Rate		Methane		Carbon Dioxide		Oxygen		Steady State Carbon Monoxide	Steady State Hydrogen Sulphide	Steady State VOCs	GW level	Notes (include peak CO, H2S, VOC values if identified)	Borehole Flooded?	Volume Of Gas In Well
		Peak positive or negative (l/hr)	Steady (l/hr)	Peak (%v/v)	Steady (%)	Peak (%v/v)	Steady (%)	Lowest value (%v/v)	Steady (%)	(ppm)	(ppm)	Direct measurement (ppm)	(m bgl)			(m^3)
BH01	12:25	-7.5	<0.1	<0.1	<0.1	2	1.1	21.6	21.7	2	<0.1	0.9	1.03	Peak flow due to changes in GrW level. GrW level measured from top of pipe. No survey level for pipe.	NO	0.002447104
BH07	16:35	0	<0.1	<0.1	<0.1	0.1	0.1	19.5	19.5	<0.1	<0.1	0.1	1.01	GrW level measured from the top of well cover	NO	0.002399588
BH09	10:39	7.3	<0.1	0.3	0.3	1.9	1.9	12.4	12.5	2	<0.1	1.2	1.4	Peak flow due to changes in GrW level. GrW level measured from top of pipe. No survey level for pipe.	NO	0.003326161
BH11	10:06	<0.1	<0.1	<0.1	<0.1	0.2	0.1	21.9	22.2	<0.1	<0.1	<0.1	1.12	GrW level measured from ground level	NO	0.002660929

Monitoring Round 2

Project Number:	41310	**Site:**	Wisbech	**Zone:**	N/A
Date:	15/04/2020	**Instrument model(s):**	GFM436	**Atm. Pressure (start) (mb):**	1022
Engineer:	Ish Konteh	**Instrument S/No.(s):**	13311	**Atm. Pressure (end) (mb):**	1020
Temp (˚C if known):	13 degrees	**Recent weather:**	Dry, Sunny		

Record any other observations which may have an impact on the soil gas monitoring results. These observations may include damage to the gas tap or top of well, damage to the cover or an open gas tap.

Monitoring Point	Time	Flow Rate		Methane		Carbon Dioxide		Oxygen		Steady State Carbon Monoxide	Steady State Hydrogen Sulphide	Steady State VOCs	GW level	Notes (include peak CO, H2S, VOCs if identified)	Borehole Flooded?	Volume Of Gas In Well
		Peak positive or negative (l/hr)	Steady (l/hr)	Peak (%v/v)	Steady (%)	Peak (%v/v)	Steady (%)	Lowest value (%v/v)	Steady (%)	(ppm)	(ppm)	Direct measurement (ppm)	(m bgl)			(m^3)
BH01	11:26	-5.7	<0.1	<0.1	<0.1	0.8	0.8	19.2	19.2	<0.1	<0.1	1.6	1.41	Peak flow -5.7	NO	0.00334992
BH07	12:20	<0.1	<0.1	<0.1	<0.1	0.8	0.8	19.9	19.9	<0.1	<0.1	<0.1	1.2	water bubbling up pipe	NO	0.002850995
BH09	13:10	-7	<0.1	0.7	0.7	8	8	0.8	0.8	<0.1	<0.1	0.1	1.47	Headworks full of clay. Tap standing proud of cover but folded under. Peak flow -7.0. LEL17.8%	NO	0.003492469
BH11	12:40	-13.5	<0.1	<0.1	<0.1	0.2	0.2	20.6	20.6	<0.1	<0.1	1.4	1.38	Peak flow -13.5. Some hissing from around bottom of bung	NO	0.003278645

Monitoring Round 3

Project Number:	41310	**Site:**	Wisbech	**Zone:**	N/A
Date:	27/05/2020	**Instrument model(s):**	GFM436	**Atm. Pressure (start) (mb):**	1033
Engineer:	Ish Konteh	**Instrument S/No.(s):**	13311	**Atm. Pressure (end) (mb):**	1033
Temp (˚C if known):		**Recent weather:**	Dry, sunny		

Record any other observations which may have an impact on the soil gas monitoring results. These observations may include damage to the gas tap or top of well, damage to the cover or an open gas tap.

Monitoring Point	Time	Flow Rate		Methane		Carbon Dioxide		Oxygen		Steady State Carbon Monoxide	Steady State Hydrogen Sulphide	Steady State VOCs	GW level	Notes (include peak CO, H2S, VOCs if identified)	Borehole Flooded?	Volume Of Gas In Well
		Peak positive or negative (l/hr)	Steady (l/hr)	Peak (%v/v)	Steady (%)	Peak (%v/v)	Steady (%)	Lowest value (%v/v)	Steady (%)	(ppm)	(ppm)	Direct measurement (ppm)	(m bgl)			(m^3)
BH01	13:41	< 0.1	< 0.1	< 0.1	< 0.1	1	1	19.3	19.3	< 0.1	< 0.1	< 0.1	1.53	voc 0.4PPM PEAK	NO	0.003635019
BH07	16:27	< 0.1	< 0.1	< 0.1	< 0.1	0.9	0.8	19.1	19.1	< 0.1	< 0.1	0.2	1.14		NO	0.002708446
BH11	16:37	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.3	20.6	20.6	< 0.1	< 0.1	< 0.1	1.16	vocs down from 0.5 in 10 seconds	NO	0.002755962
BH09	13:35	< 0.1	< 0.1	< 0.1	< 0.1	15.8	15.8	0.3	0.3	< 0.1	< 0.1	0.3	1.58	LEL 7.0	NO	0.003753811

Monitoring Round 4

Project Number:	41310	**Site:**	Wisbech	**Zone:**	N/A
Date:	15/06/2020	**Instrument model(s):**	GFM 435	**Atm. Pressure (start) (mb):**	1014
Engineer:	IK	**Instrument S/No.(s):**		**Atm. Pressure (end) (mb):**	1013
Temp (˚C if known):	23	**Recent weather:**	Sunny		

Record any other observations which may have an impact on the soil gas monitoring results. These observations may include damage to the gas tap or top of well, damage to the cover or an open gas tap.

Business as usual. Deodouriser fan was turned on at site entrance.

Monitoring Point	Time	Flow Rate		Methane		Carbon Dioxide		Oxygen		Steady State Carbon Monoxide	Steady State Hydrogen Sulphide	Steady State VOCs	GW level	Notes (include peak CO, H2S, VOCs if identified)	Borehole Flooded?	Volume Of Gas In Well
		Peak positive or negative (l/hr)	Steady (l/hr)	Peak (%v/v)	Steady (%)	Peak (%v/v)	Steady (%)	Lowest value (%v/v)	Steady (%)	(ppm)	(ppm)	Direct measurement (ppm)	(m bgl)			(m^3)
BH01	13.45	< 0.1	< 0.1	< 0.1	< 0.1	1.1	1.1	17.3	17.3	< 0.1	< 0.1	< 0.1	1.6	Flow peaked at 6.2 then to 0 after 2 seconds	NO	0.003801327
BH07	13.14	< 0.1	< 0.1	< 0.1	< 0.1	0.7	0.7	19.5	19.5	< 0.1	< 0.1	< 0.1	1.15	Flow peaked at -1.8 then returned to 0 after 2 seconds	NO	0.002732204
BH11	13	< 0.1	< 0.1	< 0.1	< 0.1	0.4	0.4	20.5	20.5	< 0.1	< 0.1	< 0.1	1.14	Missing bolts, barriers broken	NO	0.002708446
BH09	13.56	< 0.1	< 0.1	< 0.1	< 0.1	3.4	3.4	2.9	2.9	< 0.1	< 0.1	< 0.1	1.68	Hissed when GFM detatched after reading gas, but not flow	NO	0.003991393

Monitoring Round 5

Project Number:	41310	**Site:**	Wisbech	**Zone:**	N/A
Date:	09/07/2020	**Instrument model(s):**		**Atm. Pressure (start) (mb):**	1010
Engineer:	IK	**Instrument S/No.(s):**		**Atm. Pressure (end) (mb):**	1010
Temp (˚C if known):	16	**Recent weather:**	Rain		

Record any other observations which may have an impact on the soil gas monitoring results. These observations may include damage to the gas tap or top of well, damage to the cover or an open gas tap.

Monitoring Point	Time	Flow Rate		Methane		Carbon Dioxide		Oxygen		Steady State Carbon Monoxide	Steady State Hydrogen Sulphide	Steady State VOCs	GW level	Notes (include peak CO, H2S, VOCs if identified)	Borehole Flooded?	Volume Of Gas In Well
		Peak positive or negative (l/hr)	Steady (l/hr)	Peak (%v/v)	Steady (%)	Peak (%v/v)	Steady (%)	Lowest value (%v/v)	Steady (%)	(ppm)	(ppm)	Direct measurement (ppm)	(m bgl)			(m^3)
BH01	10:30	0.2	0.2	< 0.1	< 0.1	1.9	1.9	17.5	17.5	<0.01	<0.01	8.1	1.47		NO	0.003492469
BH07	10:55	0.4	0.4	< 0.1	< 0.1	0.3	0.3	19.2	19.2	<0.01	<0.01	2	0.76		NO	0.00180563
BH11	12:05	0.4	0.4	< 0.1	< 0.1	1.9	1.9	20.6	20.6	<0.01	<0.01	1.7	0.5	Lots of standing water around installation	YES	0.001187915
BH09	12:45	0.3	0.2	< 0.1	< 0.1	17.2	17.2	1.1	1.1	<0.01	<0.01	1.9	1.63		NO	0.003872602

Monitoring Round 6

Project Number:	41310		
Site:	Wisbech	**Zone:**	N/A
Date:	13/08/2020		
Instrument model(s):	GFM 435	**Atm. Pressure (start) (mb):**	1011
Engineer:	IK		
Instrument S/No.(s):	13311	**Atm. Pressure (end) (mb):**	1011
Temp (˚C if known):	not known		
Recent weather:	Stormy and sunny		

Record any other observations which may have an impact on the soil gas monitoring results. These observations may include damage to the gas tap or top of well, damage to the cover or an open gas tap.

Business as usual. Deodouriser fan was turned on at site entrance.

Monitoring Point	Time	Flow Rate		Methane		Carbon Dioxide		Oxygen		Steady State Carbon Monoxide	Steady State Hydrogen Sulphide	Steady State VOCs	GW level	Notes (include peak CO, H2S, VOCs if identified)	Borehole Flooded?	Volume Of Gas In Well
		Peak positive or negative (l/hr)	Steady (l/hr)	Peak (%v/v)	Steady (%)	Peak (%v/v)	Steady (%)	Lowest value (%v/v)	Steady (%)	(ppm)	(ppm)	Direct measurement (ppm)	(m bgl)			(m^3)
BH07	09:09	-7	< 0.1	< 0.1	< 0.1	1.2	1.2	18.8	18.8	< 0.1	< 0.1	< 0.1	1.21	Flow peaked at -7 then returned to 0 after 2 seconds.	NO	0.002874754
BH01	09:39	-10	< 0.1	< 0.1	< 0.1	2.2	2.2	16.9	16.9	< 0.1	< 0.1	< 0.1	1.53	Flow peaked at -10 then to 0 after 2 seconds.	NO	0.003635019
BH09	08:23	-57	< 0.1	2.4	2.4	20.8	20.6	0.2	0.2	< 0.1	< 0.1	< 0.1	1.73	peak flow -57 down to 0 after 27 seconds. lel 56. lot of suction when tap opened. bung on tap closed. 0.012 hexane.	NO	0.004110185
BH011	08:57	-	-	-	-	-	-	-	-	-	-	-	-	Missing under sand	#N/A