Phase 3: Remediation Strategy

Worlaby House Farm, Worlaby

Produced for Truelove Properties

July 2022

Humberside Materials Laboratory Ltd
Atherton Way, Brigg
North Lincolnshire DN20 8AR
Tel [redacted]

www.humbersidematerialslab.co.uk

Document control

Title:	Phase 3: Remediation Strategy Worlaby House Farm, Worlaby
Client:	Truelove Properties
Report number:	0154/4621/P/P3

Revision	*Purpose*	*Originated*	*Checked*	*Date*
0.0	Document for issue	M Driver *Director*	M Driver *Director*	July 2022

CONTENTS

1 Introduction

Humberside Materials Laboratory Limited (HML) were commissioned by Truelove Properties (the client) to produce a remediation strategy for a proposed residential development on land north of Low Road, Worlaby, North Lincolnshire formally Worlaby House Farm. The land is hereinafter referred to as *the site*.

This document is produced solely for the above client and should only be copied in full. When transmitted electronically, the definitive copy of the report is held by Humberside Materials Laboratory Ltd.

1.1 Aims

The aim of this remediation strategy is to provide a robust framework of procedures to ensure the site is suitably remediated and is fit for the proposed residential end use.

1.2 Scope

The scope of this remediation strategy includes details of:

1. What remediation is required
2. Who will undertake the remediation works and
3. What remediation methods will be employed

While health and safety risks involved with the proposed remediation measures described herein have been considered, this document does not provide a method statement for works based on health and safety risk assessments. Safe systems of work should be designed and adopted by those implementing the remediation measures detailed herein.

1.3 Background

The site has been the subject of previous site investigation reports by Humberside Material Laboratory (HML) and Nicholls Colton (NC), as follows.

- HML Phase 1 (desk study) report: Worlaby House Farm, Worlaby (dated August 2018, report no. 0154/4621/P/P1, revision 0.0)
- NC Phase 2 (ground investigation) report: Worlaby House Farm, Worlaby (dated January 2022, report no. G21154-IR)
- HML Phase 2 (ground investigation) report: Worlaby House Farm, Worlaby (dated June 2022, report no. 0154/4621/P/P2, revision 0.0)

2 Site Constraints

2.1 Proposed development

The proposed development is to construct residential properties across the site with associated infrastructure. The development will include a shop section and the current plan indicates 37 plots of linked semi-detached and detached housing including barn conversions. This development includes access roads and soft landscaping and private gardens.

2.2 Location, size, description and topography

The site is situated in Worlaby House Farm on the northwest edge of Worlaby, North Lincolnshire. It occupies land to the east of the B1204, Low Road and occupies an irregular shaped tract of land. The total area is about 1.7 hectares. The post code is DN20 0LX

The site is centred around national grid reference (NGR) 501100 413940. The proposed site will be access from the B1204 at two locations with one location for access for the shops. There is a further access from New Road.

The site is a disused farmyard covered extensively with storage barns and tracks. The storage barns include a double shed (northwest part of site), a main old building (in the centre of the site), a small barn (in the northeast part of the site) and various smaller sheds and compounds. There are many other smaller features on site. Between the main building and the double shed is an electric sub-station. Adjacent to the entrance from New Road is a weigh bridge next to offices. Adjacent to the site are cottages. The main entrance is secured by a locked electric steel gate.

The main old building originally surrounded an open courtyard which has been rooved creating an indoor courtyard. Most buildings that were inspected were found to be empty. No chemicals or fuels leaks noted there were some silos on site. Some piles of inert construction material were noted. Tracks around the site were either concrete, or stony/chalk hardcore.

The ground level at the site varies. The site starts about 15m above ordnance datum (AOD) and rises to 20m to the east of site.

2.3 Site history

The site has been a farm prior to 1886. There is a steady growth at the farm as buildings and building extensions have been added since 1886 as the farm's storage has increased. In 1973 the farm added an electrical sub-station and in 1994 the last noted new building was added to the site. The site occupies 1.7 Ha.

The adjacent land has remained relatively rural and undeveloped. There are farm cottages and fields surrounding the site and woodland to the north. The village of Worlaby has grown a little to the southeast

2.4 Geology, hydrogeology and hydrology

Desk-top sources of information indicate the anticipated sub-strata (in descending order) are as follows.

- Made ground:
  Soil, fill and construction waste – probably less than 0.5m depth
- Topsoil:
  Sandy topsoil with organic matter
- Silty Sand:
  Loose to medium dense sand
  Probably reaches a depth of between about 3mbelow ground level (bgl)
- Clay:
  Firm/stiff blue clay
  Probably reaches a depth of between 10m and 20m bgl

2.4.1 Hydrogeology

The site is located on a hill slope with west being down slope. There are records of previous historical boreholes nearby with water strikes at depths of 1.30m bgl suggesting that the groundwater could be reasonably shallow.

In terms of *groundwater vulnerability*, the soils are classified as being of high Leaching Potential. This suggests that they are likely to allow pollutants to readily transmit a wide range of pollutants due to their rapid drainage and low attenuation.

The *bedrock aquifer* designation beneath the site is an unproductive stratum, this being the Kimmeridge clay. The *superficial aquifer* classification is Secondary Aquifer (A).

The site is not within a *source protection zone*. However, a zone III is situated 464m north of the site. There are no nearby reported water abstractions (within 1km of the site).

2.4.2 Hydrology

There are nearby surface water features 3m from site in the form of drainage ditches on the sites north western boundary.

There is potential for groundwater flooding at site and there is a possible risk from surface water flooding. The site is not at risk from coastal or river flooding.

2.5 Radon gas

The site is not in an area significantly affected by radon. No radon protection measures should be required.

3 Ground Conditions & Contamination

3.1 Ground conditions

Twenty-four trial pits (TP1, TP1A, TPs 2 to 15, TP4A to TP4D and TP8A to TP8D) were carried out at the site to maximum depths ranging between 1.25m and 2.50m below existing ground level (begl) during the recent HML Phase 2 site investigation and five boreholes (WS1 to WS5) to a maximum drill depth of 5.0m begl during previous NC phase 2 site investigation.

A summary of the revealed ground conditions is presented below (in Table 1 and 2). The holes revealed made ground down to a depths ranging between about 0.22m and 0.70m below ground level (begl), sands (Breighton sands) down to depths ranging between 0.25m and 4.3m begl and clays (Kimmeridge clays) down to depths ranging between 1.1m and 5.0m begl.

Table 1: Summary of revealed ground conditions with HML phase 2 report																
Strata descriptions		*Exploratory hole*														
		TP1	TP1A	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14	TP15
		Depth to base of stratum (m bgl)															
MADE GROUND	Brown sandy TOPSOIL												0.13				
	Concrete		0.15											0.10	0.14		
	Dark silty fine to medium SAND and gravel of chalk and brick.	0.29	0.75	0.28		0.10	0.13				0.07	0.34				0.20	0.41
	Fine to coarse chalk gravels and occasional brick						0.31				0.22		0.50			0.55	
	Brown Sandy CLAY with gravel of concrete, brick, asphalt and chalk.							0.47	0.10					0.15			
SANDS	Grey to yellow brown silty fine to coarse SAND with occasional gravels and rare cobbles	1.00	0.85	1.15	1.10	0.70			0.22	0.45	0.60						1.25
	Light brown fine to coarse SAND with occasional gravels and rare cobbles					1.50					1.10						
	Yellow light brown fine to medium SAND				1.20		1.00	1.10	1.05	1.50							
KIMMERIDGE CLAY FORMATION	Dark grey brown sandy CLAY with much fine to coarse gravels of chalk and rare cobbles		1.00				0.60								1.12	1.00	
	Firm dark grey brown silty CLAY											1.00	1.10	1.00			

Table 2: Summary of revealed ground conditions within additional HML site investigations works and NC phase 2 site investigation									
Strata descriptions		*Exploratory hole*							
		TP4A	TP4B	TP4C	TP4D	TP8A	TP8B	TP8C	TP8D
		Depth to base of stratum (m bgl)							
MADE GROUND	Brown sandy TOPSOIL				0.3				
	Brown sandy TOPSOIL with brick	0.4		0.2		0.3			
	Dark silty fine to medium SAND and gravel of chalk and brick.	1.1	0.57				0.3		
	Fine to coarse chalk gravels and occasional brick			0.5	0.6			0.1	
	Fine to coarse brick gravels and occasional cobble brick							0.25	
	Brown Sandy CLAY with gravel of concrete, brick, asphalt and chalk.							0.47	0.3
SANDS	Yellow light brown fine to medium SAND				1.0				
	Brown/grey silty fine SAND						0.9		0.5
	Grey to yellow brown silty fine to coarse SAND with occasional gravels and rare cobbles	2.5	1.45	1.5	1.5	0.45			0.22
	Light brown fine to coarse SAND with occasional gravels and rare cobbles					1.1	1.4	1.0	1.1
KIMMERIDGE CLAY FORMATION	Dark grey brown sandy CLAY with much fine to coarse gravels of chalk and rare cobbles								
	Firm dark grey brown silty CLAY						1.45	1.20	1.15

NC summary
Topsoil/Made ground
- Brown, reddish brown and white TOPSOIL
- Pale and dark grey variably clayey, gravelly SAND/sandy GRAVEL with occasional brick and rock fragments.
- Dark brown sandy, gravelly CLAY.

To depths from 0.0m to 0.7m.
Breighton Sand Deposits.
- Pale brown and brown variably clayey gravelly SAND.
- Brown sandy GRAVEL.

To depths from 0.25m to 4.3m.
Kimmeridge Clay Formation
- Grey CLAY

To depths from 0.5m to 5.0m.

Some groundwater was observed in five of the twenty-four trial pits (TPs, 3, 7, 8, 9, and 15) and three of the five boreholes, as detailed below (in Table 3). No water was observed in the additional trial pits (TP4A to 4D and TP8A to 8D), these trial pits were excavated during a prolonged dry spell.

Table 3: Groundwater observations during site works (27th April 2022)			
Trial pit	*Hole total depth (m)*	*Observation 1*	
		Depth (m bgl)	*Comment*
TP1	1.00	Dry	
TP1A	1.00	Dry	
TP2	1.15	Dry	
TP3	1.20	0.80	GWL after 20 mins
TP4	1.50	Dry	
TP5	1.00	Dry	
TP6	1.10	Dry	
TP7	1.05	0.90	GWL after 20 mins
TP8	1.30	1.20	GWL ingress at 1.24m filled to 1.2m
TP9	1.10	0.90	GWL after 20 mins
TP10	1.00	Dry	
TP11	1.10	Dry	
TP12	1.00	Dry	
TP13	1.12	Dry	
TP14	1.00	Dry	
TP15	1.25	1.20	GWL after 20 mins
WS2	4.1	2.1	Seepage noted
WS3	4.0	2.0	Seepage noted
WS4	5.0	2.5	Seepage noted
GWL- Ground water level			

3.1.1 Visual olfactory evidence of contamination

The logged made ground could include contamination (e.g. metals, PAHs and asbestos). The recorded petroleum staining/odours could indicate hydrocarbon contamination. Otherwise, no evidence of potential contamination was identified.

3.2 Initial contamination screening

Near surface samples of made ground (from 0.1m to 0.8m depth) were tested for metals, PAHs and asbestos as well as TPH including BTEX & MTBE. In total 22no metal suites, 22no PAH suites, 22no Asbestos identifications, 17no TPH suites, 5no Semi VOC suites, 2no PCB suites and 7no Organo pesticide suites.

Some concentrations of lead, beryllium and some fractions of the PAH suites were found to be above the generic assessment criteria (GAC). These were identified within TP3, TP6, TP7 and TP15 within the HML site investigation report and TP1, TP3 and TP5 (assumed as WS1, WS3 and WS5) within the NC site investigation report.

Some concentrations of TPH were identified within TP4 and TP8 of the HML report and slight traces were identified within the NC report but not in enough concentrations to

be above assessment criteria. The HML site investigation report recommended that the encountered TPH's required further assessment to assist with possible remediation, these works were carried out on 7th July 2022. Findings along with assessment are included below (section 3.3).

3.3 Further site assessment

HML site investigation report ref (0154/4621/P/P2) recommended further analysis within the areas of TP4 and TP8 (HML report references) to establish the extent of TPH contamination, soil organic matter (SOM) tests were also undertaken to assist with the assessment. The further assessment included four trials evenly spaced around the identified elevated areas (TP4A to TP4D and TP8A to TP8D), encountered geology for these trial pits has been discussed earlier (section 3.1) which shows comparable descriptions with the original trial pits 4 and 8.

Tests for the presence of TPH contaminants of concern were carried out on six samples of near surface made ground and six samples of assumed natural sands (Breighton sands), as follows:

- TP4A-1 (0.10m to 0.40m depth) – TPH & SOM
- TP4B-1 (0.10m to 0.50m depth) – TPH & SOM
- TP4C-1 (0.10m to 0.50m depth) – TPH & SOM
- TP4D-1 (0.10m to 0.50m depth) – TPH & SOM
- TP8A-1 (0.10m to 0.40m depth) – TPH
- TP8A-2 (0.40m to 1.10m depth) – TPH
- TP8A-3 (1.20m to 1.40m depth) – TPH
- TP8B-2 (0.90m to 1.20m depth) – TPH
- TP8C-1 (0.50m to 1.00m depth) – TPH
- TP8D-1 (0.20m to 0.50m depth) – TPH
- TP8D-2 (0.50m to 1.00m depth) – TPH
- TP8D-3 (1.00m to 1.22m depth) – TPH

Several sources have been used to determine suitable generic acceptance criteria (GAC), shown as follows in general order of selected preference.

- *Land Quality Management Ltd/Chartered Institute of Environmental Health suitable for use levels* (LQM/CIEH S4Uls) report (LQM/CIEH, 2015).
- Category 4 Screening Levels (C4SL), e.g. as published for lead by Defra (2014)
- GAC from EIC/AGS/CL:AIRE (2010)

The GAC are based on the context of a residential scenario in which there is potential for the consumption of home grown produce. This is appropriate for most of the site development (except the proposed shop/commercial property).

Where detected concentrations are consistently below the GAC then the hazard from the contaminant is usually considered to be acceptable. If a pollutant is recorded at concentrations higher than the GAC then an unacceptable hazard is not necessarily present, but it does indicate that further consideration is merited.

Table 4 (below) gives the GAC (from LQM/CIEH, 2015) for speciated TPH fractions. These vary with soil organic matter (SOM) content. At this stage, the most onerous SOM of 1% is assumed, which should be reasonably conservative.

Table 4 - Total Petroleum hydrocarbons (TPHs) generic acceptance criteria – residential with plant uptake				
Compound		*1% SOM*	*2.5% SOM*	*6% SOM*
TPH Aliphatic	C5-6	42	78	160
	C6-8	100	230	530
	C8-10	27	65	150
	C10-12	130 (48)	330 (118)	760 (283)
	C12-16	1100 (24)	2400 (59)	4300 (142)
	C16-35	65000 (8.5)	92000 (21)	110000
	C35-44	65000 (8.5)	92000 (21)	110000
TPH Aromatic	C5-7	70	140	300
	C7-8	130	290	660
	C8-10	34	83	190
	C10-12	74	180	380
	C12-16	140	330	660
	C16-21	260	540	930
	C21-35	1100	1500	1700
Note: values in parentheses indicate vapour saturation limit (v) or limit of solubility (s)				

Further assessment from the additional twelve samples has not identified any elevated levels of TPH's. In summary some very slight levels of C10-C12, C12-C16 aromatic ranges and C12-16, C16-C35 aliphatic ranges, the majority of the results are below detection limits.

Soil organic matter results (TP4A – TP4D) from around original TP4 have results ranging from 1.9% to 3.2% with an average of 2.5%.

Individual test reports are included within appendix B.

3.4 Revised risk assessment

The results of the desk study review, site works, lab testing and screening of the results have been used to carry out a revised qualitative risk assessment, as shown below (in Table 5) using a source-pathway-receptor model of potential pollution linkages.

It should be noted that some contamination risks have been dismissed as they should be mitigated through standard building practice. For example, the risks from sulphate attack on concrete should be mitigated by correct appliance of BRE Special Digest 1.

Table 5: Revised conceptual site model and risk assessment

Revised conceptual site model			*Revised risk assessment*			
Potential source	*Potential pathway*	*Potential receptor*	*Probability*	*Severity*	*Risk rating*	*Comments*
1. Made ground beneath the site, e.g. of construction waste 2. Former land use: farm 3. Former land use: electrical substation PAHs, metals, asbestos, petroleum hydrocarbons, semi VOCs	Inhalation, ingestion, absorption	Site users	Low likelihood	Medium	Low/ Moderate	Several detected contaminants such as Beryllium elevated PAH and TPH concentrations (e.g. benzo(a)pyrene) from the made ground samples are above the GAC (for a residential development). Therefore, the contaminants could cause harm through ingestion, inhalation (of dust) and absorption via residential garden areas. Additional testing shows no migration of concern from original elevated levels from soil samples within encountered ground water levels.
		Site workers	Low likelihood	Mild	Low	
	Inhalation of vapours	Site users	Low likelihood	Medium	Low/ Moderate	
		Site workers	Unlikely	Mild	Very low	
	Migration	Aquifer waters	Low likelihood	Medium	Low	
	Migration	Surface waters	Unlikely	Mild	Very low	
	Ingestion, absorption	Local flora and fauna	Unlikely	Mild	Very low	
	Aggressive attack	Building materials	Unlikely	Mild	Very low	
		Site workers	Unlikely	Medium	Low	

3.4.1 Risks to human health (future site users)

There are unacceptable risks identified with respect to the health of (residential) future site users. Site users could be harmed by ingestion and absorption of metal and PAH and TPH contaminants in the existing made ground. Beryllium, asbestos and some TPHs and PAHs have been found to be present at unacceptable levels across site.

On the other hand, there does not appear to be any substantial risk to commercial site users. Detected levels of contaminants are below the relevant generic assessment criteria (GAC) for a commercial shop development within site.

Human health does appear to be at any significant risk in (residential) indoor areas. Possible volatiles originating from TPHs at site may permeate through concrete and into indoor spaces. The area around TP8 and TP4 have elevated TPH concentrations and may create potential pathways from the soils to site user via the inhalation of volatile organic compounds. Further assessment around TP4 and TP8 has not identified any elevated levels of TPH's and has a 2.5% SOM on average around TP4, taking the SOM into account this brings the original sample from TP4 below assessment criteria and does not require any further consideration for remediation. There have been no GAC exceedances of TPH concentrations and detected PAH profiles do not indicate any petrogenic source anywhere else of site.

Human health also does not appear to be at any significant risk from the inhalation of permanent gases (in residential or commercial indoor areas). There is no nearby source for ground gas. No records of nearby landfills or mine workings have been found and no deep (degradable) made ground is present. Accordingly, no viable sources of harmful ground gas have been identified.

3.4.2 Risks to human health (construction workers)

No significant risk has been identified with respect to the health of construction workers. The detected levels of contamination should not generally pose a hazard although there can sometimes be unforeseen contamination within made ground material. However, any risks to health should be acceptable when they are dealt with by a competent contractor.

Nevertheless, it is still expected that site contractors will provide adequate training and supervision to groundworkers to mitigate the risks of dealing with made ground. It is expected that suitable personal protective equipment (PPE) and welfare facilities will be provided to groundworkers, and safe methods of work will be adopted and maintained.

3.4.3 Risks to controlled waters

Originally potentially significant risk has been identified with respect to controlled waters. That is, superficial aquifer receptors are assessed to be at risk from potential pollution at the site.

The Breighton sands that underlay site are permeable and have a high leaching potential and there is relatively shallow ground water at site, as seen by the presence of ground water in TP3, TP7, TP8. TP9 and TP15.

Any pollution within shallow deposits may leach into the groundwater below and may flow downhill into the Ancholme valley and threatening local water courses. The site is not in a source protection zone.

Elevated levels of metals and PAH's are limited to the made ground with no evidence of migration into the underlying sands. Elevated TPH's within TP8 have been proven to have not migrated with additional trial pits circa 5m from the original TP8, this includes sample depths from within the originally encountered ground water level of 1.2m begl. Additional TPH testing shows migration into local water courses not to be a viable risk.

3.5 Contamination assessment

A revised risk assessment only identified two relevant contamination linkages (RCL1 and RCL2) with an unacceptable level of risk, as detailed below (in Table 6). The risks concern potential harm to human health and controlled waters from soil contamination (e.g. metals, PAHs and TPH) in the made ground.

Table 6: Unacceptable contamination risks (from revised risk assessment)

Ref.	*Source*	*Pathway*	*Receptor*	*Risk rating*
RCL1	1. Made ground beneath the site, e.g. construction waste 2. Former land use: farm 3. Former land use: electrical substation PAHs, metals, asbestos, petroleum hydrocarbons	Inhalation, ingestion, absorption	Residential site users	Low / Moderate
RCL2	1. Elevated TPHs within the made ground beneath the site. TPHs	Inhalation of vapours	Residential site users	Low/ Moderate

RCL1 could occur in soft landscaped areas and gardens where future site users (including children) could be exposed to soil contamination.

RCL2 could occur in indoor areas (near TP4 and TP8) where volatile vapours (from lighter fractions of petroleum) might migrate and accumulate within dwellings and in soft landscaped areas and gardens where future site users (including children) could be exposed to soil contamination.

3.6 Hazardous ground gas

No viable source of hazardous ground gas has been identified. The site is not affected by radon. Therefore, no ground gas protection measures (for permanent ground gases) should be required.

On the other hand, vapour protection measures may be selected as a possible remediation measure around TP8.

3.7 Water supply pipework

Some TPH ranges and some PAHs petroleum hydrocarbons have been detected at concentrations that might potentially adversely affect plastic water supply pipework. Therefore, in the absence of more comprehensive testing, it would be prudent to provide barrier piping for water supply, based on guidance within the UKWIR publication: "*Guidance for the selection of water supply pipes to be used in Brownfield sites*". Barrier piping typically involves polyethylene pipework with an aluminium core and is subject to approval by the local water authority (e.g. Anglian Water).

4 Remediation options appraisal

The objectives for the remediation works include the following.

- Provide a safe environment for proposed end users (occupants and site workers)
- Minimise contamination risks to construction workers, adjacent residents and other receptors to acceptable levels
- Implement a sustainable approach to the remediation works

Contamination linkages are generally broken by either (a) removing the source, (b) severing the pathway, (c) moving the receptors or (d) a combination of any of the three (a – c).

At the site, the identified pathways for plausible contamination linkages are different for the three different relevant contamination linkages (RCL1 to RCL3). Therefore, it is sensible to consider their remediation options separately, as follows.

4.1 RCL1

Possible remediation options to address RCL1 could include the following.

1. Remove all potentially contaminated sub-surface soils. (remove the source)
2. Clean up the *in situ* soil materials on site. (remove the source)
3. Install a hardstanding layer across the site. (break the pathway)
4. Install a cover system in garden and soft landscaped areas. (remove source & break the pathway)

Option 1, removing all potentially contaminated sub-surface soil, is probably unnecessary onerous. Only the made ground material in garden areas needs removing. A cover system in garden areas is probably a more efficient and equally robust alternative.

Option 2, cleaning up the *in situ* soil materials, would provide a potentially more sustainable remediation solution, eliminating the need to removed waste off-site. However, existing remediation technologies currently available struggle to reduce inorganic contaminants (such as metals) to acceptable levels (for residential end use). Also, the garden areas are of limited size which means that there is insufficient economy of scale available to make it economically or environmentally viable to bring such clean up plant and operations to the site.

Option 3, installing a hardstanding layer across the site, is unrealistic for the development proposed.

Option 4, installing a cover system in garden areas, offers a very robust solution. It can be reasonably sustainable if local disposal sites and sources of clean soils are used. There

may also be potential to re-use any clean site won natural soils within the site to increase the sustainability. The soils for removal from garden areas should not contain gross contamination, so might be readily recycled by a local company and turned into a useable product.

4.2 RCL2

Possible remediation options to address RCL2 could include the following.

1. Remove all potentially petroleum hydrocarbon-impacted soils and groundwater from around TP8. Circa 5m buffer zone should be proposed (remove the source)
2. Clean up *in situ* petroleum-impacted soils on site (remove the source)
3. Install a verified, vapour-resistant barrier (and ventilation) within the floors of proposed buildings (break the pathway)
4. Avoid building any dwellings in the area of TP8 (move the receptors)

Option 1, removing impacted soils, could be very feasible since the anticipated petroleum-impacted soils are of limited extent (the vicinity TP8). It should be relatively simple to identify potentially impacted soils from their appearance and smell.

Option 2, cleaning up the *in situ* soil materials, is unlikely to be feasible for such limited anticipated contamination. Many clean-up techniques can be effective with petroleum hydrocarbons, but they are costly to implement and require large volumes to be economically viable, or environmentally sustainable.

Option 3, installing a vapour-resistant barrier (and ventilation) beneath buildings is a less robust remediation measure. Even verified barriers can be subject to leakages. This option is likely to only form one part of the remediation strategy, for instance, as a back-up for other remediation options.

Option 4, moving receptors, is a matter for the developer, and is not considered as a valid option herein. It may be considered if other, chosen options are not effective (for instance, if unforeseen extensive, gross contamination is revealed).

4.4 Chosen remediation measures

Accordingly, the chosen remediation solution is multi-faceted, as follows.

I. Provide a suitable clean barrier system (i.e. cover system) within residential garden areas and soft landscaped areas across the site

II. Chase out and remove any petroleum-impacted soils from the area around TP8, circa 5m buffer zone around TP8

Should any unforeseen visual or olfactory evidence of contamination be detected, then this must be investigated to the satisfaction of the local planning authority and any other relevant regulatory bodies.

If unforeseen contamination is revealed, remediation measures would be subject to review. For instance, a vapour-resistant barrier within floors might be specified if extensive TPH contamination is revealed.

No soil cover system should be required beneath buildings / roads / permanent hardstanding where there will be no viable (ingestion or absorption) pathway between site occupants and the identified contamination sources. The general, widespread made ground contaminants (i.e. metals and PAHs) are low in volatility and not present in concentrations to make inhalation of vapours (within buildings) a plausible contamination linkage.

Permanent hardstanding is where the asphalt, concrete, paving or compacted granular stone fill means there is an insignificant likelihood that the area could be converted into soft landscaping in future. However, if, say, a 50mm-thick layer of sand is used below patio paving, then the area should be classed as temporary hardstanding only and will require a 0.60m-thick cover system (as it could potentially be converted to soft garden area in the future).

5 Remediation strategy

5.1 Contractors and personnel

The following parties are named key stakeholders in the remediation works.

- *Client and project manager for the site:* Truelove Properties
- *Main contractor:* to be confirmed
- *Appointed independent Environmental Engineer:* HML (or other chosen engineer)
- *The licenced landfill site for material removed from site:* to be confirmed
- *Local Authority:* North Lincolnshire Council
- *Source of imported topsoil:* to be confirmed
- *Source of imported granular materials:* to be confirmed

The success of the remediation is dependent on good operational procedures and communication links between the different parties. There is a strict obligation to keep the local authority informed of any problems or requests for variations to this remediation strategy.

5.2 Outline remediation strategy

The remediation works shall include the following steps (possibly in the order shown).

1. Carry out site preparation works (e.g. vegetation clearance and utilities surveys)
2. Chase out any petroleum-impacted soils near TP8 and remove off site
3. Commence and complete construction works on the site
4. Remove *in situ* soils in ALL soft garden areas (and soft landscaped areas) to 0.60m below final ground level (bfgl) – and take photos
5. Inspect, sample and test any site won soils identified for potential reuse within the cover system
6. Import clean soils (following inspections and testing) from off-site
7. Install general cover / barrier system in soft gardens and soft landscaped areas using clean soils
8. Carry out validation works on installed cover system
9. Prepare and submit (Phase 4) validation / verification report for the remediation works

All remediation works are subject to validation and verification at the completion of works. All evidence and documentation related to the remediation works must be retained and included in the verification report. Further details are presented later.

Remediation works shall not begin until the strategy has been approved by the local planning authority (LPA).

5.3 Chasing out petroleum-impacted soils

Further assessment discussed above (section 3) has identified that only the area around TP8 requires removal from site. An environmental engineer shall supervise the removal of the identified hotspot around TP8 and inspect the revealed sides of the excavations for olfactory or visual signs of potential petroleum-impacted soils. Excavations containing identified impacted soils shall be chased out (i.e. extended laterally and vertically, as appropriate) until clean, non-impacted soils are revealed, the further assessment has identified a buffer zone of 5m from original TP8 with a depth of 0.47m (base of made ground) should be adequate to remove the source. An indicative area has been noted on the site plan within appendix A.

The excavated impacted soils shall be placed in bunded areas underlain by geomembrane to prevent migration of any contamination or loaded directly into lorries. The excavated soils shall be removed from site by suitably licensed waste contractors.

If the environmental engineer is not satisfied that the TPH impacted soils have all been removed by the 5m buffer zone samples from the sides and bases of completed excavations (around the impacted soils) may be recommended for petroleum testing (e.g. TPH by CWG). The results shall be compared against suitable GAC, as detailed later (in Section 5.4.5), to confirm the remaining soils are suitably free of petroleum contamination.

If the results indicate concentrations of petroleum hydrocarbons above the GAC (residential with the potential for home grown produce) then further remediation action will be required. This could comprise further soil excavation and disposal works.

Waste transfer notes of removed, impacted soils must be retained for inclusion within the Phase 4 (verification report).

5.4 Installation of a cover / barrier system in soft landscaped areas

5.4.1 Removal of in situ soils

In situ below ground material shall be removed down to a depth at least 600mm below final ground level (bfgl) in gardens and soft landscaped areas to accommodate a 600mm deep cover system. Should final ground levels be raised, the depth required for removal will be reduced commensurately.

Some adjustments may be needed for existing or proposed trees. Close to existing trees, the cover system shall be reduced to a depth of 300mm (and carefully hand dug). For proposed trees, the cover system depth shall be locally increased for tree planting to accommodate any new tree root balls.

The *in situ* potentially contaminated made ground soils from garden areas will be removed off-site to a licensed waste operator. It is roughly estimated that the total area for remediation is about 5866m^2 based on available drawings, as shown later (in Appendix A). Therefore, the total volume of soils for removal could be as much as about 3520m^3, which could be up to about 6335 tonnes (about 317 full wagon loads).

The volume of soils for removal (and importation) could be significantly reduced if clean, site won, *in situ* natural soils (from below the made ground) are re-used within the cover system. However, clean *in situ* natural soils are generally at least 0.60m below existing ground levels (begl). Therefore, only limited amounts of site won clean natural soils are expected.

Raising ground levels would also reduce the volume of soils needed for removal.

Contaminated material at this stage and advanced stages will be either removed directly from site by loading into vehicles or, alternatively, stockpiled in such a manner (i.e. underlain with plastic sheeting) as to contain it and stop the spread of contamination, prior to loading for transport and disposal.

The receiving landfill / recycling site (or soil treatment facility, STF) for waste material shall be supplied with available existing test data from the site (i.e. from the HML and NC Phase 2 site investigation) for their classification and acceptance that the material is suitable for their (landfill / treatment) site. The receiving landfill or STF may also need Waste Acceptance Criteria (WAC) tests or other compliance tests on material for removal.

Documentary evidence must be retained to demonstrate the suitable removal of waste soils. The volumes and timings of exported material shall be recorded in site notes. Copies of all consignment, transfer and delivery notes and tickets shall be retained for inclusion within the (Phase 4) validation / verification report.

5.4.2 Re-use of site won, clean soils

If clean, natural soils are excavated during site works, they could be suitable for use within the soil cover system. This could include clean, natural soils excavated from foundation and service trenches from around the site. This is likely to be revealed as light brown glaciofluvial sands and gravels below the made ground. They shall be set aside (away from potentially contaminated spoil) for potential re-use within cover systems.

Site notes shall be maintained of where site won, clean, natural soils have come from.

Any site won, clean soil to be re-used within cover systems will need to be inspected by an environmental engineer to check its suitability. This can be confirmed with sampling and testing.

5.4.3 Importation of suitable soils

Sampling and testing of proposed imported material for the cover system should be undertaken as early as possible and prior to importation. Otherwise, there is a risk of unnecessary costs to remove or treat any unsuitable imported soils.

To help ensure that suitable topsoil material is procured, guidance (e.g. YALPAG, 2021) recommends the client should ask the supplier the following questions.

- *What proof is there of the material source? Is it greenfield, brownfield, etc.?*
- *Will all the material be coming from the same source?*
- *Is the material a suitable growing medium?*
- *Has the supplier evidence of sampling and testing the imported material including tests for the suitable contaminants, as detailed below (in Section 5.4.4)?*
- *Were the contamination tests performed by a laboratory with UKAS and MCERTS accreditation for the tests?*
- *Is a copy of the whole laboratory report available and does it include an interpretive section?*
- *Will the provided certificate be dated within the last 2 months?*

An Environmental Engineer should perform an initial inspection of the material prior to importation. During this inspection and all subsequent inspections, the Environmental Engineer should check the imported topsoil material is:

- A suitable growing medium
- Free from obvious contamination and signs of asbestos containing materials
- Not from a location suspected to be inhabited with invasive or injurious plants
- Free from strong or unsuitable odours
- Free from unsuitable material e.g. bricks, timber and glass

Imported topsoil shall be deposited within the site in such a manner that it cannot be cross-contaminated by any other materials (e.g. by placing on a clean plastic sheet). It shall, when required, be loaded into small dumpers or barrows and transported for deposition and levelling in the garden area to the required finished level.

5.4.4 Minimum sampling and testing requirements for imported soils

At this stage, it is provisionally estimated that the area for remediation in gardens is about 5866m^2, although this depends on how much permanent hardstanding is installed in rear gardens. Therefore, the required total volume of imported soil material for rear

gardens could be as much as about 3520m³ (5866m² x 0.60m) – although this could be reduced if site won clean soils are also used.

The scope of testing on imported soils shall depend on the source origin (greenfield / manufactured or brownfield / screened) which must be verified with documentation. The testing provided by suppliers must be performed on the identified material destined for site. If insufficient documentation is provided from the supplier, additional sampling and testing will be needed and the minimum rates of sampling and testing are given below (in Table 7), based on current YALPAG guidance (available online from LPA websites).

Table 7: Imported soil sampling and testing requirements

*Contaminant**	*Greenfield / Manufactured source*	*Brownfield / Screened source*	*Virgin quarried material*	*Crushed hardcore, stone, brick (excluding asphalt)*
Metals	**ü**	**ü**	**ü**	**ü**
PAHs	**ü**	**ü**		**ü**
Asbestos	**ü**	**ü**		**ü**
TPHs		**ü**		**ü**
Soil organic matter	**ü**	**ü**		
pH	**ü**	**ü**		
Minimum rate of testing:	3 samples or 1 per 250m³ +	6 samples or 1 per 100m³ +	1 or 2 samples	1 per 500m³

* other contaminants (e.g. phenols, cyanide, BTEX, MTBE) may require testing for brownfield/screened/recycled sources subject to assessment

+ whichever is more and dependent on source and receptor (could be up to 1 sample per 50m³)

Any shortfall in test data shall be satisfied with testing from sampling by an Environmental Engineer of the imported material. The sample(s) will be taken either from the stockpile or from the placed soil. Often, samples are taken from the placed soil when the cover system thickness can also be verified.

Brownfield, screened or recycled imported soils may require testing for additional contaminants depending on the source. This will be subject to an assessment by an Environmental Engineer which will consider former land use of the source site and potential contaminants of concern and will require local planning authority agreement.

5.4.5 Acceptability criteria for imported soils

The acceptance criteria (or screening values) for the imported topsoil are mostly taken from the LQM/CIEH S4ULs for human risk assessment based on a residential context (with potential for home grown produce), as reproduced below (in Tables 8 to 10). These are also detailed in the HML Phase 2 site investigation report. The testing must be undertaken by a UKAS / MCERTS laboratory, accredited for the type of tests involved.

Table 8 – Metals (and metalloids) acceptance criteria	
Element	*mg/kg*
Arsenic	37
Beryllium	1.7
Boron	290
Cadmium	11
Chromium III	910
Chromium VI	6
Lead	200
Mercury Element	1.2
Mercury Inorganic	40
Mercury Methyl	11
Selenium	250
Copper	2400
Nickel	130
Zinc	3700

Table 9 - Total Petroleum hydrocarbons (TPHs) acceptance criteria							
TPH aliphatic				*TPH aromatic*			
Equivalent carbon fraction	*Residential with plant uptake mg/kg*			*Equivalent carbon fraction*	*Residential with plant uptake mg/kg*		
	1% SOM	*2.5% SOM*	*6% SOM*		*1% SOM*	*2.5% SOM*	*6% SOM*
C5-6	42	78	160	C5-7	70	140	300
C6-8	100	230	530	C7-8	130	290	660
C8-10	27	65	150	C8-10	34	83	190
C10-12	130 (48)	330 (118)	760 (283)	C10-12	74	180	380
C12-16	1100 (24)	2400 (59)	4300 (142)	C12-16	140	330	660
C16-35	65000 (8.5)	92000 (21)	110000	C16-21	260	540	930
C35-44	65000 (8.5)	78	160	C21-35	1100	1500	1700
-	-			C35-44	1100	140	300
Figure in parentheses is the vapour or soluble saturation limit							

Table 10 – Polycyclic aromatic hydrocarbons (PAHs) acceptance criteria							
Compound	*Residential with plant uptake mg/kg*			*Compound*	*Residential with plant uptake mg/kg*		
	1% SOM	2.5% SOM	6% SOM		1% SOM	2.5% SOM	6% SOM
Acenaphthene	210	510	1100	Chrysene	15	22	27
Acenaphthylene	170	420	920	Dibenzo anthracene	0.24	0.28	0.3
Anthracene	2400	5400	11000	Fluoranthene	280	560	890
Benzo a anthracene	7.2	11	13	Fluorene	170	400	860
Benzo pyrene	2.2	2.7	3	Indenopyrene	27	36	41
Benzo b fluoranthene	2.6	3.3	3.7	Naphthalene	2.3	5.6	13
Benzo k fluoranthene	77	93	100	Phenanthrene	95	220	440
Benzo perylene	320	340	350	Pyrene	620	1200	2000

PAH and TPH assessment criteria are based on a 1% soil organic matter content, which can be conservative. However, organic matter testing will be undertaken per batch of samples and the assessment criteria can be adjusted if appropriate.

No imported material found to contain contamination above the assessment criteria limits shall be allowed to remain on site.

5.4.6 Installation of general cover / barrier system in gardens and soft landscaping

Following successful completion (or before, if necessary) of the structural works, the cover system can be installed in garden and soft landscaped areas (e.g. below lawns or plant beds). This shall be placed to a thickness of 0.60m below final ground levels which is based on current best practice and is recommended by BRE Report 465 (Tedd *et al.*, 2004).

The cover system should include at least 200mm of clean topsoil. The imported material should be compliant with BS 3882:2015, Specification for topsoil.

A section of the proposed general cover system is shown later (in Appendix A) along with a plan of the anticipated remediation area.

A geotextile (e.g. Fastrack™ 1800) shall be placed over the garden areas prior to the laying of imported granular fill and soils. This will fulfil the role of separation and marker layer between the cover system and underlying remaining made ground.

A minimum 100mm thickness of granular gravel material, or at least three times the nominal size of the aggregate, whichever is the lesser, shall be placed on the geotextile as a capillary break. This will consist of proven clean inert material, e.g. sampled and tested to the above requirements (in Tables 8 to 10). It is recommended that a virgin material be used from a reputable local quarry.

Extensive photographs shall be taken during installation of the cover system to show the following.

- Location of the geotextile
- Close-up photos to show the quality and thickness of the capillary break layer
- Close-up photos to show the quality and thickness of imported / placed soils
- Background features to prove the location of the close-up photos
- Site stockpile or quarantine areas

Tape measures or measuring staffs will need to be included in the close-ups to demonstrate the thickness of the cover system elements. Site identification boards or other media should also be included to detail the dates, photo locations and site name.

5.4.7 Cover system around proposed and existing trees

Allowance shall be made to increase the cover system thickness at the location of proposed trees to accommodate the root balls.

Care will be needed to effect a suitable cover system around existing trees and the cover system works will need to comply with any tree protection requirements for the site. Soil around trees will need to be hand dug to a depth of 300mm and any accidental cuts to roots must be trimmed with a sharp blade. Work must only be carried out in small sections and the exposed roots must be kept moist with wet sacking. The roots will need to be backfilled with sharp sand and then covered with (uncompacted) clean topsoil.

The extent of hand dug cover system around tree roots shall roughly equal (i.e. +/- 20%) the calculated root protection area of the trees based on current best practice. A tree specialist can confirm these areas for specific trees on the site.

Photos should be taken of the cover system around any existing trees showing partly exposed roots. The photos will be needed for inclusion within the verification report.

5.4.8 Cover system inspection and depth check

An environmental engineer shall carry out hand dug inspection pits to verify the thickness of installed cover systems. This shall be carried out at a frequency no less than once per four plots with gardens. About six or seven inspection pits are anticipated.

The environmental engineer shall record the thickness of the cover system and log the revealed materials (soil, stone and geotextile). This information shall be retained for inclusion in the Phase 4 (validation/verification) report.

The environmental engineer shall carry out tests on excavated samples from the inspected cover system, as required. This shall include tests on any samples which are suspected to contain elevated levels of contamination (e.g. due to the presence of man-

made materials). Tests may also be carried out to meet the minimum sampling and testing requirements for imported material, as discussed earlier.

6 Site Management Procedures

The proposed remediation measures, discussed previously, consider the long-term risk at the site to human health and other environmental receptors. However, in the short-term, there are potential health, safety and environmental risks during the construction works.

The main / principal contractor at site is fully responsible for devising their own suitable safe working practices to address all existing health, safety and environmental risks during the construction phase. The following guidance is provided to highlight some of these hazards and risks which should be dealt with by the contractor's method statements and risk assessments.

6.1 Health and safety

The HML site investigation report identified some contamination in the near surface soils at the site. Some elevated levels of metals, PAHs and TPHs were detected in shallow made ground soils. These contaminants can be potentially toxic.

No asbestos was identified within enough quantity to be hazardous. Nevertheless, there is always the potential for asbestos within made ground. The risk from asbestos in made ground should never be entirely discounted.

Some basic minimum measures to protect site workers from the hazards of contaminated soil could include the following.

- Inform site staff about anticipated soil contaminants and related hazards and safety measures, e.g. through site inductions, toolbox talks, etc.
- Provide personnel protective equipment (PPE), e.g. boots, helmets and gloves, for the use of ground workers
- Provide and enforce designated safe areas for smoking, eating and drinking
- Provide suitable hygiene facilities for washing, drying and changing
- Display contact details for emergency services
- Ensure there are no naked flames or other ignition sources where hazardous ground gas is a potential risk (e.g. in confined spaces)
- Implement suitable procedures to prevent the generation and spread of dust

The site is near some existing residential dwellings. Appropriate safety precautions should be employed for working near to domestic properties.

6.1.1 Site security and working hours

The site is to be secure when work is not being undertaken once construction has started. Entry and egress shall be controlled when the site is active.

Site working hours shall be Monday to Friday 07:30am to 17:30pm and 08:00am to 14:00pm on Saturday, unless written consent for extended hours is given by the local authority.

6.2 Dust, odours and fumes

The contractor should minimise emissions to air and take all necessary precautions to prevent the accumulation and spread of smoke emissions, fumes, dust or odours from site plant, stored fuel or other substances and prevent them from drifting around the site or into the nearby properties and public space. A record of any complaints received should be kept for comparison against daily work logs.

6.2.1 Dust

During excavations, soil stockpiling and other earth movements, measures will need to be implemented to prevent migration of dust.

The contractor should introduce suitable working methods and dust suppression techniques to mitigate the generation and spread of dust. Suitable health and safety protocols should be determined through appropriate consultations with qualified asbestos specialists. The following measures are options that should help minimise and control dust.

- Soil dampening (e.g. on bare earth and stockpiles) especially during dry weather
- Dust curtains
- Wheel washing and street sweeping
- Sheets/hoarding around site, plant or other locations
- Sheeting for lorries entering/leaving the site
- Liaison with neighbours
- Designated areas for parking and loading/unloading
- Low drop heights during movement of soils
- Cessation of potential dust-spreading activities during high winds

6.2.2 Odours

No strong odours are anticipated during the remediation works, i.e. during the excavation and movement of soil materials. If unexpected odours are detected, such works must halt and the local planning authority must be informed. Works shall only continue after further investigation by an environmental specialist with appropriate local authority approval.

6.2.3 Fumes

All work plant should be maintained in good repair and should meet legal emission standards. Plant should not be left running for long periods when not directly in use. Consideration should be given to the use of electrically powered plant instead of diesel.

6.3 Noise and Vibration

Some noise is unavoidable during construction works. Nevertheless, the following measures should help minimise the generation of noise and vibration:

- Maintenance of plant
- The use of silencers on plant, if required
- Switching off plant when not in use
- Unloading and loading of material within designated areas
- Coordinating plant and lorry movements to reduce site traffic
- Liaison with neighbours

The site is adjacent to a residential area. Therefore, any activities likely to generate unusually large amounts of noise and ground vibration (e.g. sheet pile driving) might be potentially unsuitable. Any such works should be approved in advance by the local authority.

Procedures to reduce noise and vibration are detailed in BS 5228-1:2009+A1:2014 (Code of practice for noise and vibration control on construction and open sites).

6.4 Fuel, oils and chemicals

Measures and procedures should be put in place to prevent leaks and spills of oil, fuel or chemicals. Further information on this is provided in Guidance for Pollution Prevention, GPP2, produced by the EA and other organisations, available free online. The measures and procedures include:

- Suitable bunding or overflow storage (110% capacity of liquid storage volume)
- Locks on valves and covers to prevent vandalism
- Drip trays for diesel-fired engines, pumps and generators
- Suitably maintained diesel-engined plant
- Spill kits with staff suitably trained in their application
- An oil, chemical and product inventory for the site
- Site drainage plans
- Emergency procedures (included in the site induction)

Regular inspections should be made of on-site discharge points, bunding, drainage systems, oil separators (and drip-trays) to check that these are in good condition.

The storage, itinerary, and use of hazardous materials on-site should be conducted in accordance with the Control of Substances Hazardous to Health (COSHH) regulations (2002). Records should be maintained of all hazardous materials on-site.

6.5 Unforeseen Contamination

Protocols shall be in place to deal with unforeseen potentially contaminated materials identified by visual or olfactory evidence (i.e. the presence of staining, odours or harmful substances, etc.). The protocols shall include the following.

- Cessation of work in the area followed by immediately informing an Environmental Engineer and the local authority to agree how to deal with the material
- Testing of potentially contaminated material, as required
- Removal of contaminated soils for segregation, storage or stockpiling within a bunded and covered area, as appropriate
- Extraction of contaminated groundwater to be placed in suitable containers
- Transfer off-site of contaminated soil, if necessary
- Testing of samples from the base/ sides of excavations
- Recording of the locations, quantities and nature of any removed materials, results of tests and the subsequent actions taken

6.6 Other pollution control measures

Any discharges to local watercourses or surface water drainage should only be made with the appropriate discharge consents. These can be obtained from the Environment Agency and or local drainage authority. For example, appropriate consents should be obtained where wastewater, e.g. from a wheel wash, needs to be poured into drains.

Procedures will be required to reduce the migration of suspended solids (e.g. silts and fine sands). All soil should be stockpiled away from surface water features and drains and where the gradient is at a minimum. Rain protection covers and/or water collection gutters should be used where surface run-off of silty water could occur. These measures can also mitigate any risks of migration of potentially contaminated leachate from stockpiled or surface soils.

6.7 Utilities

Service locations should be investigated at an early stage in the development to minimise project costs and potential disruptions. Services should be turned off / disconnected as appropriate to make safe during development and minimise any health, safety or environmental risks.

7 Validation and Verification

7.1 Verification requirements

Validation of the remediation works comprises four elements:

1 Verification of the exploration for and removal of possible petroleum hydrocarbon-impacted soils
2 Verification of the depth of the cover system and the suitability of the constituent material
3 Verification of the removal of potentially contaminated made ground

Validation shall be carried out by suitably qualified and experienced environmental specialists (e.g. from HML). Validation will be achieved with the aid of appropriate inspections, sampling, testing, photographing and collection of relevant documentation.

Validation and verification shall meet the requirements of suitable guidance, e.g. as outlined in the latest version of YALPAG's *Verification Requirements for Cover Systems: Technical Guidance for Developers, Landowners and Consultants*.

The purpose of the validation / verification phase (Phase 4) is to ensure that all the remediation works have been carried out as specified. Therefore, the following items shall be directly checked and verified to be satisfactory (or otherwise) compared with the requirements specified within this document.

- Records and photos from the chasing out of petroleum hydrocarbon-impacted soils
- Imported (or *in situ*) soil sampling and testing
- Visual / olfactory inspection records of imported materials
- Photos to show placement and thicknesses of suitable layers in the cover system
- Inspection records of cover system inspection pits
- Documentary evidence of import/export of soil to or from the site

7.2 Phase 4 (validation / verification) report

A verification / validation report shall be produced by the appointed independent engineer at the end of all remediation works. The report shall include the following (e.g. as per the latest YALPAG requirements).

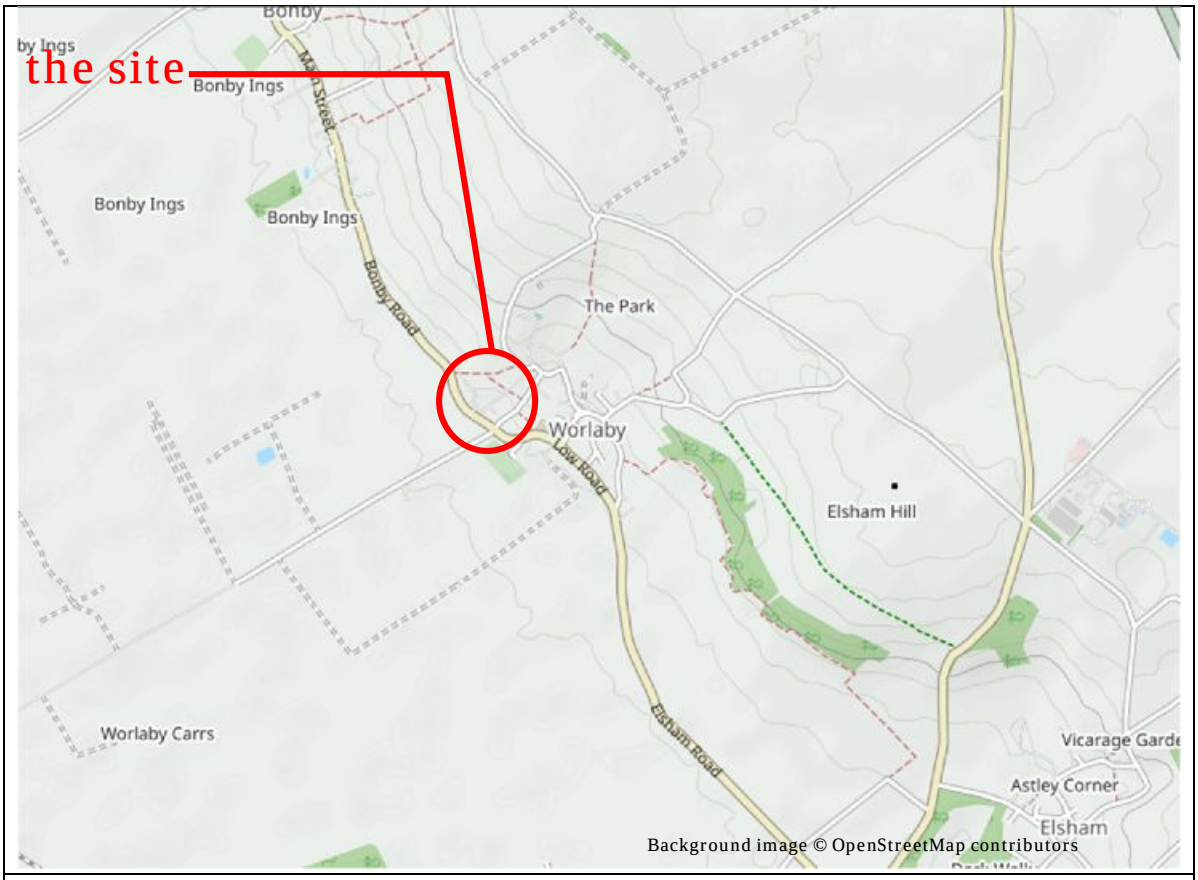
- Site details including planning application reference
- Summary of areas and remediation works undertaken
- Diary of events
- Details of quantity, location for disposal, conveyance notes for contamination materials removed from site
- Details of source, test data and quantity for capillary break layer material

- Details of geotextile used in the cover system
- Details of imported topsoil including the location, quantity and test data at the specified rate
- Photographic record of the works and depths of soil cover
- Results of chemical analyses
- Details of any non-conformances and rectifications

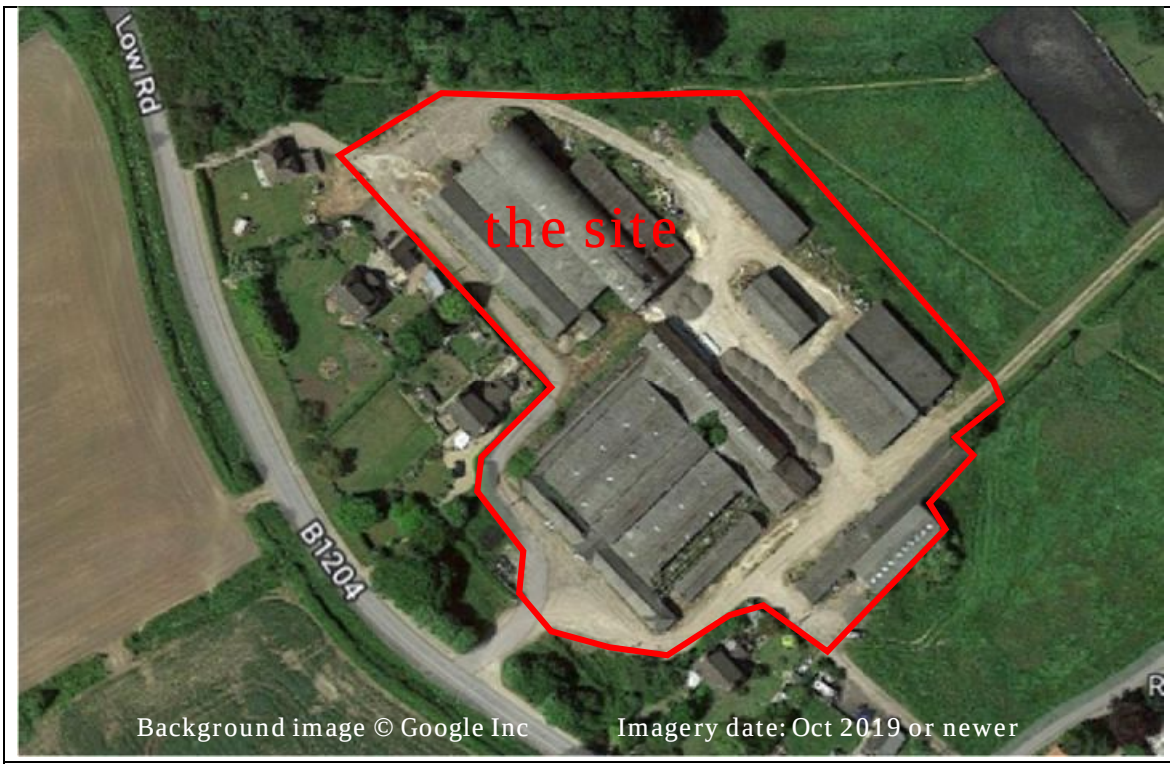
An example of a barrier system verification report proforma is provided by YALPAG guidance. A full copy of the final verification report shall be forwarded to the local authority for their review.

Appendix A

Plans & Photographs



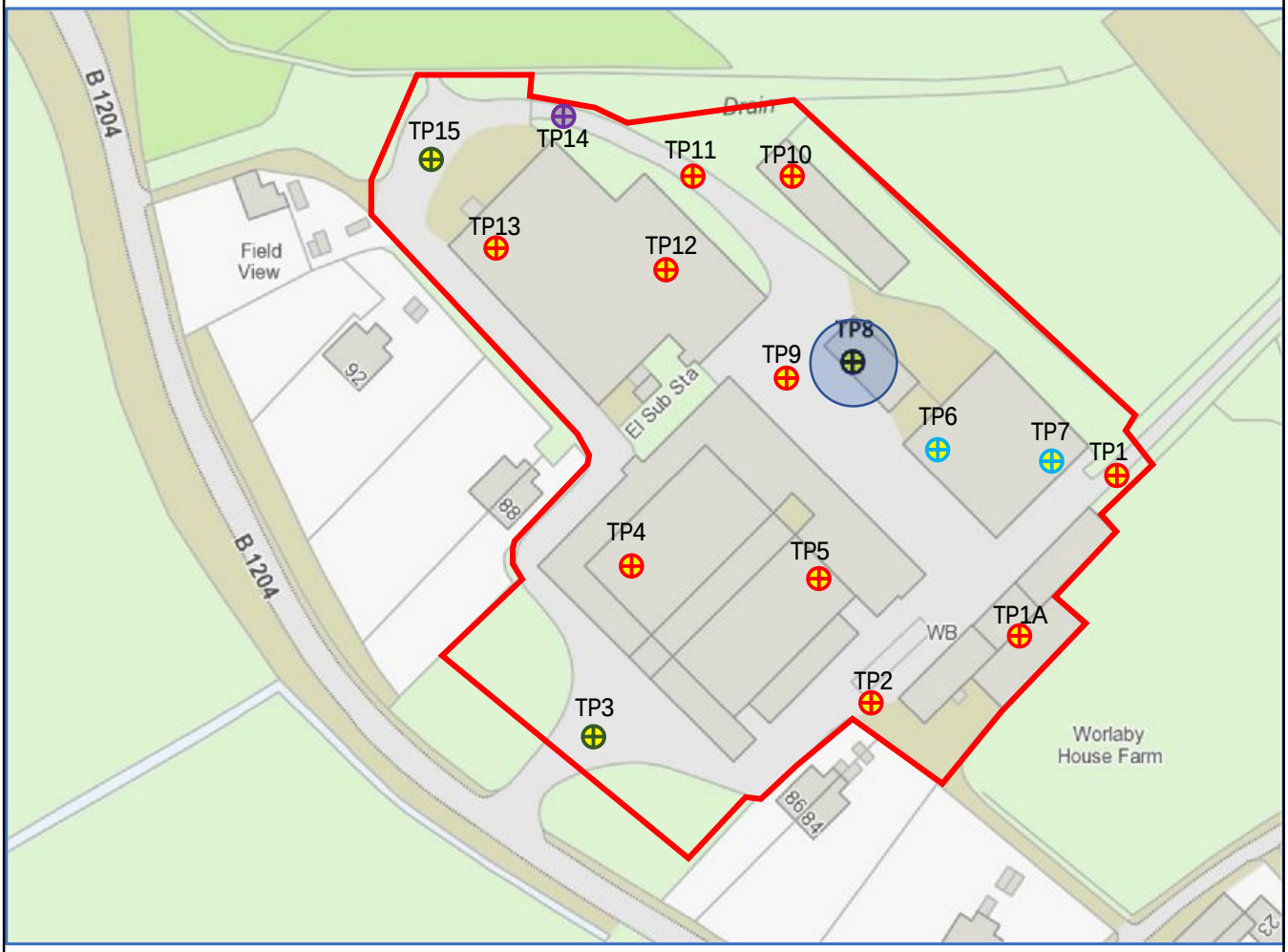
Site location plan *Date copied:* 10 Jun 2022 *Source:* openstreetmap.org



Aerial photograph: 1 *Date copied:* 10 Jun 2022 *Source:* Google Earth

Notes:

1. Do not scale
2. Locations of all features are approximate only
3. Background image from Proposed site plan (drawing No. 059-SP-01) dated January 2018
4. Site works were carried out on 27th April 2022 & 7th June 2022



Key

- Trial pit
- Site border
- Trial pit with elevated metals
- Trial pit with elevated PAHs
- Trial pit with elevated TPH
- Trial pit with Asbestos detected
- Remediation buffer zone around TP8

HUMBERSIDE MATERIALS LABORATORY LIMITED
Atherton Way
Brigg
North Lincolnshire
DN20 8AR
Telephone & [redacted]
www.humbersidematerialslab.co.uk

Drawing Title: Proposed site plan
Drawing No.: 0154/4621/P/P2-01 Revision: - 1.0
Site: Worlaby House Farm
Client: Truelove properties
Project No.: 0154/4621/P/P2
Date: 15/07/2022

Notes:

1. Do not scale
2. Locations of all features are approximate only
3. Background images from Truelove Property drawing number 059-SP-01 Revision e, dated January 2018
4. This drawing should be read in conjunction with the HML Phase 3 Remediation strategy (HML ref.: 0154/4621/P/P3)
5. Soft lanscaped areas will require 600mm-thick, clean cover systems

N

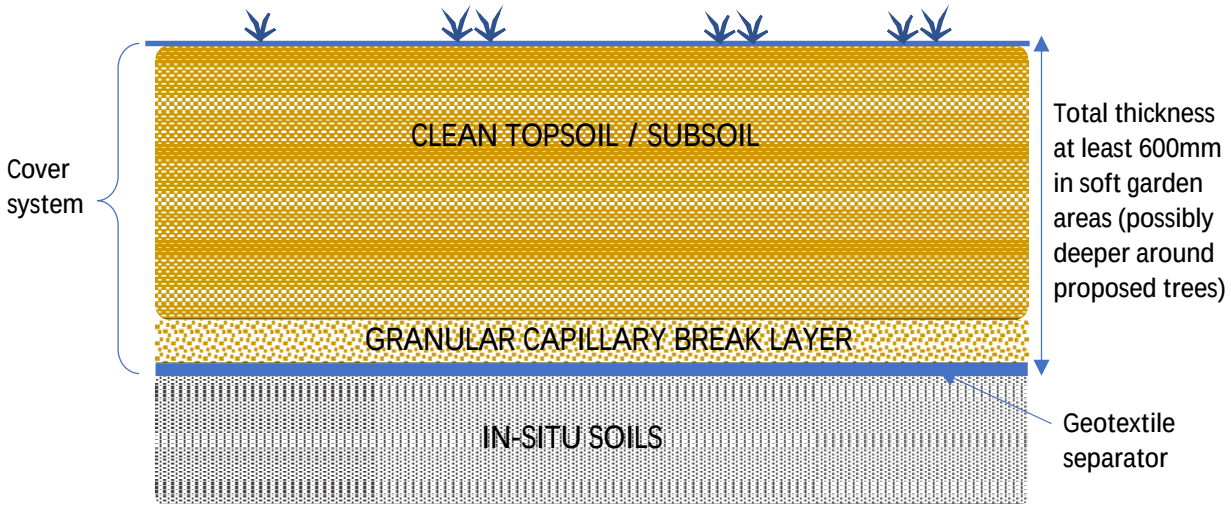
Proposed soft landscaped areas

HUMBERSIDE MATERIALS LABORATORY LIMITED
Atherton Way
Brigg
North Lincolnshire
DN20 8AR
Telephone & Fax [redacted]
www.humbersidematerialslab.co.uk

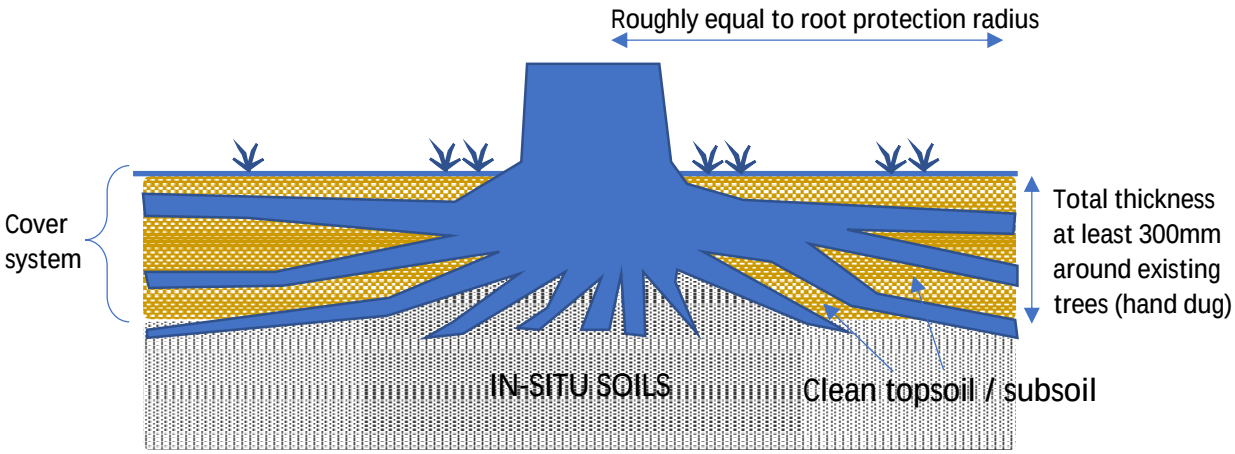
Drawing Title: Remediation plan
Drawing No.: 0154-4621-P3-01 Revision: - 0.0
Site: Worlaby House Farm, Worlab
Client: Truelove Propert
Project No.: 0154/4
Da

Notes:

1. Do not scale from this drawing
2. This drawing should be read in conjunction with the HML Phase 3 Remediation strategy (HML ref.: 0154/4621/P/P3)
3. Imported topsoil shall meet British Standards BS 3882:2015 topsoil specification for at least uppermost 200mm
4. Topsoil and subsoil shall be a suitable growing medium
5. Cover system soils shall be free from obvious contamination and signs of asbestos containing materials
6. Cover system soils shall not be from a location suspected to be inhabited with invasive or injurious plants
7. Cover system soils shall be free from strong or unsuitable odours
8. Cover system soils shall be free from unsuitable material e.g. bricks, timber and glass
9. Cover system shall meet latest requirements of Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG) guidance for cover systems including proposed sampling and testing regime
10. Geotextile shall be a suitable separator layer (e.g. Fastrack 1800 or similar)
11. Granular capillary break layer shall be 100mm thick or 3 times nominal diameter of particles
12. Allowance shall be made for increasing the cover system thickness below new trees to accommodate the root ball



GENERAL COVER SYSTEM



COVER SYSTEM BENEATH EXISTING TREES

HUMBERSIDE MATERIALS LABORATORY LIMITED
Atherton Way
Brigg
North Lincolnshire
DN20 8AR
Telephone & Fax [redacted]
www.humbersidematerialslab.co.uk

Drawing Title: Cross-section through cover system
Drawing No.: 0154-4621-P3-02 Revision: - 0.0
Site: Worlaby House Farm, Worlaby
Client: Truelove Properties
Project No.: 0154/4621/P
Date: 15/07/2022

Appendix B

Test results

ANALYTICAL TEST REPORT

Contract no: 111327

Contract name: Worlaby House Farm, Worlaby

Client reference: 0154/4621

Clients name: Humberside Materials Laboratory

Clients address: Atherton Way
Brigg
North Lincolnshire
DN20 8AR

Samples received: 11 July 2022

Analysis started: 11 July 2022

Analysis completed: 15 July 2022

Report issued: 15 July 2022

Key

U	UKAS accredited test
M	MCERTS & UKAS accredited test
$	Test carried out by an approved subcontractor
I/S	Insufficient sample to carry out test
N/S	Sample not suitable for testing

Approved by: [redacted]

Reporting Manager

Chemtech Environmental Limited

SOILS

Lab number			111327-1	111327-2	111327-3	111327-4	111327-5	111327-6
Sample id			S/63897-TP8A-1	S/63898-TP8A-2	S/63899-TP8A-3	S/63900-TP8B-2	S/63901-TP8C-1	S/63902-TP8D-1
Depth (m)			0.10-0.74	0.40-1.10	1.20-1.40	0.90-1.20	0.50-1.00	0.20-0.50
Date sampled			07/07/2022	07/07/2022	07/07/2022	07/07/2022	07/07/2022	07/07/2022
Test	**Method**	**Units**						
Total Organic Carbon (TOC)	CE197	% w/w C	-	-	-	-	-	-
Estimate of OMC (calculated from TOC)	CE197	% w/w	-	-	-	-	-	-
TPH								
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	0.02	0.02	<0.01	<0.01	<0.01	<0.01
EPH Aromatic (>EC10-EC12)	CE250	mg/kg	2	3	3	3	3	2
EPH Aromatic (>EC12-EC16)	CE250	mg/kg	5	16	6	5	17	5
EPH Aromatic (>EC16-EC21)	CE250	mg/kg	<1	18	<1	<1	19	<1
EPH Aromatic (>EC21-EC35)	CE250	mg/kg	1	2	<1	<1	<1	<1
EPH Aromatic (>EC35-EC44)	CE250	mg/kg	<1	<1	<1	<1	<1	1
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	0.78	<0.1	<0.1	<0.1	<0.1
EPH Aliphatic (>C10-C12)	CE250	mg/kg	<6	10	<6	<6	<6	<6
EPH Aliphatic (>C12-C16)	CE250	mg/kg	<6	58	<6	<6	62	<6
EPH Aliphatic (>C16-C35)	CE250	mg/kg	<15	72	<15	<15	76	<15
EPH Aliphatic (>C35-C44)	CE250	mg/kg	<10	<10	<10	<10	<10	<10

Chemtech Environmental Limited

SOILS

Lab number			111327-7	111327-8	111327-9	111327-10	111327-11
Sample id			S/63903-TP8D-2	S/63904-TP8D-3	S/63905-4A-1	S/63906-4B-1	S/63908-4D-1
Depth (m)			0.50-1.00	1.00-1.20	0.10-0.40	0.10-0.50	0.10-0.50
Date sampled			07/07/2022	07/07/2022	07/07/2022	07/07/2022	07/07/2022
Test	**Method**	**Units**					
Total Organic Carbon (TOC)	CE197	% w/w C	-	-	1.5	1.2	1.1
Estimate of OMC (calculated from TOC)	CE197	% w/w	-	-	2.7	2.1	1.9
TPH							
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	<0.01	0.03	0.03	0.03	0.03
EPH Aromatic (>EC10-EC12)	CE250	mg/kg	2	4	<1	<1	<1
EPH Aromatic (>EC12-EC16)	CE250	mg/kg	4	7	<1	2	<1
EPH Aromatic (>EC16-EC21)	CE250	mg/kg	<1	<1	<1	<1	<1
EPH Aromatic (>EC21-EC35)	CE250	mg/kg	<1	<1	<1	3	2
EPH Aromatic (>EC35-EC44)	CE250	mg/kg	<1	2	<1	<1	<1
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	0.68	<0.1	<0.1	<0.1
EPH Aliphatic (>C10-C12)	CE250	mg/kg	<6	<6	<6	<6	<6
EPH Aliphatic (>C12-C16)	CE250	mg/kg	<6	<6	<6	<6	<6
EPH Aliphatic (>C16-C35)	CE250	mg/kg	<15	<15	<15	<15	<15
EPH Aliphatic (>C35-C44)	CE250	mg/kg	<10	<10	<10	<10	<10

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE197	Total Organic Carbon (TOC)	Carbon Analyser	Dry		0.1	% w/w C
CE197	Estimate of OMC (calculated from TOC)	Calculation from Total Organic Carbon	Dry		0.1	% w/w
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC7-EC8)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC8-EC10)	Headspace GC-FID	As received		0.01	mg/kg
CE250	EPH Aromatic (>EC10-EC12)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC12-EC16)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC16-EC21)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC21-EC35)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC35-EC44)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE067	VPH Aliphatic (>C5-C6)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C6-C8)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C8-C10)	Headspace GC-FID	As received		0.1	mg/kg
CE250	EPH Aliphatic (>C10-C12)	Solvent extraction, GCxGC-FID	As received		6	mg/kg
CE250	EPH Aliphatic (>C12-C16)	Solvent extraction, GCxGC-FID	As received		6	mg/kg
CE250	EPH Aliphatic (>C16-C35)	Solvent extraction, GCxGC-FID	As received		15	mg/kg
CE250	EPH Aliphatic (>C35-C44)	Solvent extraction, GCxGC-FID	As received		10	mg/kg

Chemtech Environmental Limited

ADDITIONAL INFORMATION

Notes

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

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

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

Methods, procedures and performance data are available on request.

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

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

Samples will be disposed of 4 weeks from initial receipt unless otherwise instructed.

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

For soils and solids, analytical results are inclusive of stones, where applicable.

ANALYTICAL TEST REPORT

Contract no: 111437

Contract name: Worlaby House Farm, Worlaby

Client reference: 0154/4621

Clients name: Humberside Materials Laboratory

Clients address: Atherton Way
Brigg
North Lincolnshire
DN20 8AR

Samples received: 13 July 2022

Analysis started: 13 July 2022

Analysis completed: 15 July 2022

Report issued: 15 July 2022

Key

U	UKAS accredited test
M	MCERTS & UKAS accredited test
$	Test carried out by an approved subcontractor
I/S	Insufficient sample to carry out test
N/S	Sample not suitable for testing

Approved by: [redacted]

Reporting Manager

Chemtech Environmental Limited

SOILS

Lab number			111437-1
Sample id			S/63907
Location			4C-1
Depth (m)			0.10-0.50
Date sampled			07/07/2022
Test	**Method**	**Units**	
Total Organic Carbon (TOC)	CE197	% w/w C	1.9
Estimate of OMC (calculated from TOC)	CE197	% w/w	3.2
TPH			
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	<0.01
EPH Aromatic (>EC10-EC12)	CE250	mg/kg	<1
EPH Aromatic (>EC12-EC16)	CE250	mg/kg	<1
EPH Aromatic (>EC16-EC21)	CE250	mg/kg	<1
EPH Aromatic (>EC21-EC35)	CE250	mg/kg	<1
EPH Aromatic (>EC35-EC44)	CE250	mg/kg	<1
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1
EPH Aliphatic (>C10-C12)	CE250	mg/kg	<6
EPH Aliphatic (>C12-C16)	CE250	mg/kg	<6
EPH Aliphatic (>C16-C35)	CE250	mg/kg	<15
EPH Aliphatic (>C35-C44)	CE250	mg/kg	<10

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE197	Total Organic Carbon (TOC)	Carbon Analyser	Dry		0.1	% w/w C
CE197	Estimate of OMC (calculated from TOC)	Calculation from Total Organic Carbon	Dry		0.1	% w/w
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC7-EC8)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC8-EC10)	Headspace GC-FID	As received		0.01	mg/kg
CE250	EPH Aromatic (>EC10-EC12)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC12-EC16)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC16-EC21)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC21-EC35)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE250	EPH Aromatic (>EC35-EC44)	Solvent extraction, GCxGC-FID	As received		1	mg/kg
CE067	VPH Aliphatic (>C5-C6)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C6-C8)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C8-C10)	Headspace GC-FID	As received		0.1	mg/kg
CE250	EPH Aliphatic (>C10-C12)	Solvent extraction, GCxGC-FID	As received		6	mg/kg
CE250	EPH Aliphatic (>C12-C16)	Solvent extraction, GCxGC-FID	As received		6	mg/kg
CE250	EPH Aliphatic (>C16-C35)	Solvent extraction, GCxGC-FID	As received		15	mg/kg
CE250	EPH Aliphatic (>C35-C44)	Solvent extraction, GCxGC-FID	As received		10	mg/kg

Chemtech Environmental Limited

ADDITIONAL INFORMATION

Notes

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

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

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

Methods, procedures and performance data are available on request.

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

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

Samples will be disposed of 4 weeks from initial receipt unless otherwise instructed.

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

For soils and solids, analytical results are inclusive of stones, where applicable.