PHASE 1 & 2 ENGINEERING & ENVIRONMENTAL ASSESSMENT

FOR A MIXED-USE DEVELOPMENT SITE ADJACENT THE A59 AND CLITHEROE ROAD, WHALLEY

VOLUME 1

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APPENDICES

1.0 INTRODUCTION

1.01 Following instructions from Applethwaite Ltd during August 2018, CoDA Structures have undertaken an appraisal of a potential mixed-use development site adjacent the A59 and Clitheroe Road, Whalley. The appraisal assesses both engineering and environmental issues.

1.02 The site is grassland.

1.03 It is proposed to develop the site for housing, a care home, a pub, a hotel, a gym and two showrooms.

1.04 Sections 2.0 – 7.0 of this report undertake a desk based assessment to determine the environmental quality of the land at the site and to identify the potential for any environmental risks as follows:-

- to establish the likely extent of any potential contamination at the site as a result of its current and previous use;
- to establish the sensitivity of the site in relation to the site's geology, hydrogeology and hydrology;
- to assess the significance of any potential contamination at the site with respect to possible harm to the surrounding environment and site end users;
- to provide recommendations for further works as appropriate.

1.05 The interpretation provided in this report is based upon information gathered from public data sources for the recent small bungalow development adjacent the north eastern corner of the site.

1.06 A trial pit ground investigation was undertaken on the site on 04 and 05 December 2018.

1.07 The local authority is Ribble Valley Borough Council (RVBC).

2.0 LOCATION, TOPOGRAPHY & CURRENT CONDITION

2.01 The site is located to the west of the A59 and lies approximately 4.0 miles to the south of Clitheroe Town Centre. A site location plan is attached in Volume 2, Appendix B.

2.02 The Ordnance Survey co-ordinates for the centre of the site are 373725mE, 437400mN.

2.03 The site is approximately 6.35 hectares in area.

2.04 The boundaries of the site are defined as follows:-

- Northern boundaries : Post and wire or close board timber fencing to adjacent residential development and post and wire fence to adjacent field;
- Southern boundaries : Post and wire fence to adjacent verge of the A59;
- Eastern boundary: Post and wire fence to adjacent verge of the A59;
- Western boundaries: Post and wire fence and hedgerow to the back of verge to Clitheroe Road and post and wire fence to adjacent residential properties.

2.05 The site can be accessed from Clitheroe Road.

2.06 A site walk-over was undertaken in June 2028 and the following noted:-

- the site is grassland.
- there are hedgerows to the northern and western boundaries.
- there is a hedgerow across in the central sector of the site.
- there are isolated trees on the site.
- There is a small stockpile of material adjacent the northern boundary
- there are no obvious signs of contamination on the site.

2.07 The general fall of the site is to the southwest. Site levels vary as follows:-

Location	**Level m (AOD)**
Northern boundaries	67.48 – 68.72; 70.46 – 80.79
Southern boundaries	63.91 – 64.99; 70.41 – 75.72
Eastern boundary	75.72 – 80.79
Western boundaries	63.91 – 67.48; 64.99 – 70.41; 68.72 – 70.46

2.08 The site is grassland.

2.09 A site topographical survey (Fig. 2) is attached in Volume 2, Appendix C.

2.10 Site aerial photograph is attached in Volume 2, Appendix D.

3.0 HISTORIC SITE USAGE

3.01 Extracts from Ordnance Survey Sheets dating back to 1848 have been examined and the following constitutes a brief history of the entire site and the surrounding land:-

Map date & Scale	On-site Features	Features within 250m of site	Features within 1000m of site
1848 1:10,000	- the site is undeveloped.	- the surrounding area is predominantly undeveloped.	- the surrounding area is predominantly undeveloped; - print works to the north; - village of Wiswell to the East; - railway line to the west.
1893 1:2,500	- no significant change noted.	- small residential development to the north.	- Not Applicable (N/A).
1895 1:10,000	- no significant change noted.	- no significant change noted.	- village of Barrow to the north; - expansion of print works to the north; - brickworks to the southwest; - residential development to the south.
1912 1:2,500	- no significant change noted.	- no significant change noted.	- N/A
1913/14 sheets 1:10,000	- no significant change noted.	- no significant change noted.	- sewage works to the north; - old clay pit to the southwest; - further railway line to the west; - gasometer to the north.
1932 1:2,500	- no significant change noted.	- no significant change noted.	- N/A
1932/33 sheets 1:10,000	- no significant change noted.	- small building just to the north of the site.	- further residential development to the south; - residential development to the west.
1955 1:10,000	- no significant change noted.	- no significant change noted.	- further residential development to the south.
1968 1:2,500	- no significant change noted.	- garage to the north; - corn mill to the north.	- N/A
1970 1:10,000	- no significant change noted.	- no significant change noted.	- depot to the west; - printing works to the north indicated as an engraving works; - further residential development to the south; - depot to the south.
1973 1:2,500	- no significant change noted.	- bypass constructed to the southeast.	- N/A
1975 1:10,000	- no significant change noted.	- no significant change noted.	- transport depot to the west.
1978 1:2,500	- no significant change noted.	- no significant change noted.	- N/A
1989 1:2,500	- no significant change noted.	- no significant change noted.	- N/A
1992 1:2,500	- no significant change noted.	- no significant change noted.	- N/A

1996 1:2,500	- no significant change noted.	- mill to the north indicated as Whalley Industrial Estate; - glasshouse adjacent the northern boundary.	- N/A
2006 1:10,000	- no significant change noted.	- no significant change noted.	- residential development to the north; - warehouse and engineering works to the north re-developed with housing; - commercial development to the north.
2014 1:10,000	- no significant change noted.	- no significant change noted.	- further residential development to the north; - further commercial development to the north.

3.02 Historic Ordnance Survey plans are attached in Volume 2, Appendix E.

4.0 GEOLOGY AND HYDROGEOLOGY

4.01 Geology:

1:50,000 British Geological Survey (BGS) geological sheet 68 Clitheroe indicates the following:-

- The site is underlain by Limestone of the Dinantian Age.
- No faults lie within approximately 900m of the site.
- Glacial deposits of boulder clay are likely to be present at the surface.

4.02 Mining & Minerals:

A mining report has been obtained from D. Bellis Consulting Surveyors and is summarised as follows:-

- There are no recorded mine workings below the site.
- There are no recorded mine entries on or within 20m of the site.
- The site is not within the boundary of former opencast coal mining site and is not within 800m of a current or planned opencast coal mining site.
- There is no evidence of coal mining related subsidence in relation to the site.

The mining search is attached in Volume 2, Appendix F.

There is 1 no. recorded BGS mineral site within 1000m of the site. However, it is not within 500m of the site.

4.03 **Hydrogeology:**

The site is not believed to be prone to flooding and the Environment Agency flood map indicates the site is in Flood Zone 1.

A piped watercourse flows through the site.

From the inspection of OS Maps and the Environmental Agency River Network Map there are open watercourses in the surrounding area (within 500m) of the site as follows:-

- unnamed watercourse approximately 125m to the southeast
- unnamed watercourse approximately 150m to the northwest
- unnamed watercourse approximately 150m to the south
- unnamed watercourse approximately 450m to the northwest
- unnamed watercourse approximately 400m to the southeast

There is a spring approximately 250m to the northeast,300m to the southeast and 400m to the east of the site.

The site is underlain by a bedrock aquifer designated as a Secondary Aquifer – A which is strata which contains 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.

The superficial aquifer is designated as unproductive strata.

The overlying soils are classified as having a high leaching potential, unless proved otherwise.

There are 14 no. discharge consents within 1000m of the site of these 1 no. is within 500m of the site and details are summarised as follows:-

- Surface water 132m to the west

There have been 16 no. pollution incidents within 1000m of the site of these 5 no. have been within 500m of the site and details are summarised as follows:-

1 no. Category 2 Significant Incident involving:

- filter backwash water 260m to the northwest

4 no. Category 3 Minor Incident involving:

- unknown pollutant 171m to the northwest
- oils 174m to the northwest
- unknown pollutant 260m to the southwest
- unknown pollutant 275m to the southwest.

There are 4 no. water abstraction licenses held within 1000m of the site and details are summarised as follows:-

- unrecorded abstraction 428m to the west
- surface abstraction for industrial use 800m to the north
- surface abstraction for a fish farm (2 No.) 950m to the northeast.

The site is not within a Source Protection Zone.

There are no prosecutions relating to controlled waters within 1000m of the site.

5.0 POLLUTION CONTROLS & WASTE

5.01 Pollution Controls:

There are no Integrated Pollution Control Permits held within 1000m of the site.

There are no Integrated Pollution Prevention and Control Permits held within 1000m of the site.

There are no Local Authority Pollution Prevention and Control Permits held within 1000m of the site.

There are no Local Authority Integrated Pollution Prevention and control Permits held within 1000m of the site.

There are no registered radio active substance licences held within 1000m of the site.

There are no COMAH (Control of Major Accident Hazard Sites) within 1000m of the site.

There have been no prosecution relating to authorised processes within 1000m of the site.

5.02 Waste:

There are no registered landfill sites within 1000m of the site.

There are no British Geological Survey recorded landfill sites within 1000m of the site.

There are no Local Authority recorded landfill sites within 1000m of the site.

There is 1 no. historic landfill site within 1000m of the site but it is not within 500m of the site.

There are no waste treatment/disposal sites within 1000m of the site.

There are no waste management facilities within 1000m of the site.

There are no waste transfer sites within 1000m of the site.

6.0 IDENTIFIED POSSIBLE SOURCES OF CONTAMINATION

The past history of the site would indicate no obvious sources of contamination.

6.01 Soil Contamination:

There is no evidence the site has been filled or artificially raised in level. However, there may be some fill materials in the area of the embankment to the A59. There is also a small stockpile of material adjacent the northern boundary. Any fill that has been imported onto the site may have elevated levels of contamination, depending upon the source and nature of the material used.

The site has not been previously developed.

Potentially contaminative activities in the near vicinity (within 250m) of the site have included the following:-

- petrol filling station
- industrial estate

Potentially contaminative activities in the surrounding area (250 – 1000m) of the site have included the following:-

- print works
- railway lines
- depot
- brickworks
- sewage works
- transport depot
- gasometer
- engraving works

However, it does not appear that the site has been at risk from the uncontrolled tipping of waste products, residues or chemicals from surrounding past industries.

Contemporary Trade Directory entries in the vicinity of the site (within 250m) are summarised as follows:-

Furniture Manufacturers – Home & Office	(Active)	64m to the north
Horse Boxes & Transporting	(Inactive)	64m to the north
Clothing & Fabrics – Manufacturers	(Inactive)	64m to the north
Carpets & Rugs – Manufacturers	(Inactive)	64m to the north
Car Dealers	(Inactive)	64m to the north
Electrical Engineers	(Inactive)	64m to the north
Furniture Manufacturers – Home & Office	(Active)	64m to the north
Janitorial Equipment – Servicing & Repairs	(Inactive)	64m to the north
Tyre Dealers	(Inactive)	64m to the north
Machinery – Industrial & Commercial	(Inactive)	64m to the north
Precision Engineers	(Inactive)	64m to the north
Air Purification Equipment	(Inactive)	64m to the north
Window Tinting	(Inactive)	64m to the north
Laundry Equipment – Sales & Services	(Inactive)	64m to the north

Printers	(Active)	64m to the north
Window Frame Manufacturers	(Active)	64m to the north
Car Body Repairs	(Active)	73m to the north
Laundry Equipment – Sales & Services	(Inactive)	81m to the north
MOT Testing Centres	(Active)	81m to the north
Precision Engineers	(Active)	81m to the north
Catering Equipment	(Active)	97m to the north
Lawnmowers & Garden Machinery – Sales & Services	(Active)	153m to the north
Road Haulage Services	(Inactive)	155m to the southwest

Fuel station entries in the vicinity of the site (within 500m) are summarised as follows:-

Location:	Clitheroe Road, Barrow	75m to the northwest
Status:	Closed	

It should be noted that the filling station has been recently re-developed for housing and the fuel tanks have been removed.

The adjacent nursery has also been recently re-developed for bungalows.

It is recommended that a ground investigation is undertaken on the site with soil sampling and contamination testing if made ground or suspected contamination is encountered.

6.02 **Pollution of Controlled Waters:**

The possibility of leachate contamination, particularly if any uncontrolled filling has taken place on the site, may need to be investigated to assess the potential for pollution to controlled waters.

6.03 **Gas Contamination:**

The development does not appear to be at risk from the migration of landfill gas onto the site as there are no known landfill sites in the surrounding area.

Database information indicates that the site is in an area where Radon protection measures are not required in the construction of new dwellings or extensions.

Therefore, gas monitoring is not required on the site.

7.0 RISK ASSESSMENT

70.1 The following contaminated land risk assessment methodology is based on CIRIA C552 (2001) Contaminated Land Risk Assessment – 'A Guide to Good Practice', in order to quantify potential risk via risk estimation and risk evaluation, which can be adopted at the Phase 1 stage. This will then determine an overall risk category which can be used to identify likely actions. This methodology uses qualitative descriptors and is therefore a qualitative approach.

The methodology requires the classification of:

- the magnitude of the consequence (severity of risk occurring), and
- the magnitude of the probability (likelihood) of a risk occurring.

7.02 The potential consequences of contamination risks occurring at this site are classified in accordance with table 7.1, which is adapted from the CIRIA guidance.

Table 7.1 - Classification of Consequences:

Classification:	Definition of Consequence:
Severe	Short term (acute risks to human health). Short term risk of pollution of sensitive water resource or ecosystem. Catastrophic damage crops/buildings/property/infrastructure, including off-site soils.
Medium	Medium/long term (chronic) risks to human health. Medium/long term risk of pollution of sensitive water resource or ecosystem. Significant damage to crops/buildings/property/infrastructure (on or off-site). Contamination of off-site soils.
Mild	Easily preventable, permanent health effects on humans. Pollution of non-sensitive water resources. Localised damage to crops/buildings/property/infrastructure (on or off site).
Minor	Easily preventable non-permanent health effects on humans, or no effects. Minor, low level and localised contamination of on-site soils. Easily repairable damage to crops, buildings/property/infrastructure.

7.03 The probability of contamination risks occurring at this site will be classified in accordance with Table 7.2, which is also adapted from the CIRIA guidance. Note that for each category it is assumed that a pollution linkage exists. Where a pollution linkage does not exist the likelihood is zero, as is the risk.

Table 7.2 – Classification of Probability:

Classification:	Definition of Probability:
High Likelihood	Circumstances are such that an event appears very likely in the short term, or almost inevitable in the longterm; or there is already evidence that such an event has occurred.
Likely	Circumstances are such that an event is not inevitable, but is possible in the short term, and is likely over the longterm.
Low Likelihood	Circumstances are such that it is by no means certain that an event will occur even over along period, and it is less likely in the short term.

Unlikely	Circumstances are such that it is improbable that an event would occur even in the longterm.

7.04 For each possible pollution linkage (source-pathway-receptor) identified the potential risk can be evaluated. Based upon this CIRIA C552 presents definitions of the risk categories, together with the investigatory and remedial actions that are likely to be necessary in each case, as indicated in Table 7.3. These risk categories apply to each pollutant linkage, not simply to each hazard or receptor.

Table 7.3 – Definition of Risk Categories and Likely Actions required:

Risk Category:	Definition of Likely Actions Required:
Very high	Severe harm to a defined receptor is very likely, or has already occurred. The risk is likely to result in a substantial liability. Urgent investigation (if not already undertaken) is likely to be required. Urgent remediation is likely to be required.
High	Harm to a defined receptor is likely. The risk, if realised, may result in a substantial liability. Urgent investigation (if not already undertaken) is likely to be required. Remediation is likely to be required in the long term, possibly sooner.
Moderate	Harm to a defined receptor is possible, but severe harm is unlikely. Investigation is likely to be required to clarify the level of potential liability and risk. Some remediation may be required in the long term.
Low	Harm to a defined receptor is possible, but is likely to be mild at worst. Liabilities could theoretically arise, but are unlikely. Further investigation is not required at this stage. Remediation is unlikely to be required.
Very low	Harm to a defined receptor is unlikely and would be minor at worst. No liabilities are likely to arise. Further investigation is not required at this stage. Remediation is unlikely to be required.

7.05 This relationship can also be represented as a matrix, as indicated in Table 7.4.

Table 7.4 – Probability / Consequence Matrix:

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

7.06 The following potential contamination pathways have been identified on the site:-

Horizontal and vertical migration pathways of leachate through the potentially permeable soils and geological formations.

Human Uptake Pathways (derived from CLEA model and LQA for residential use with plant uptake):

- Ingestion of soil
- Ingestion of indoor dust
- Dermal contact with soil
- Contact with indoor dust
- Inhalation of vapours outside
- Inhalation of vapours inside
- Vertical and lateral migration of volatile vapours and ground gas
- Indirect ingestion
- Airborne hazardous fibres
- Plant root uptake.

7.07 The following environmental receptors have been identified on site:-

- Groundwater residing in the underlying secondary aquifer – A
- Piped watercourse
- Buildings / structures
- Flora / Fauna
- Underground services
- Third party land.

7.08 The following human receptors have been identified on the site:-

- Construction.
- Maintenance Workers.
- End users.

7.09 Summary – Earthworks and Construction Phase:

A Risk Assessment of the site is summarised in the table below:-

Source	Receptor	Pathway	Consequence	Probability	Risk Category	Comments
S1: Contamination in made ground if present on the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities. S3: Hydrocarbon contamination from former nearby PFS.	R1: Groundwater (secondary aquifer – A). R2: Piped watercourse.	P1: Horizontal and Vertical migration of leachate through potentially permeable soils and service trenches.	Medium	Unlikely	Low	Low permeability soils are likely to be present below the site, which will prevent the migration of contaminants. Some types of contamination is likely to be localised. Site remediation works and measures can reduce risk. Fuel tanks have been removed from the adjacent site.
S1: Contamination in made ground if present on the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities.	R3: Buildings and structures.	P1: Horizontal and Vertical migration of leachate through potentially permeable soils and service trenches.	Medium	Unlikely	Low	Made ground if present on the site may contain elevated sulphate levels which could result in corrosion of buried concrete structures. However, sulphate resisting cement can be used in concrete.
S3: Hydrocarbon contamination from former nearby PFS.	R3: Buildings and structures.	P1: Horizontal and Vertical migration of leachate through potentially permeable soils and service trenches.	Minor	Unlikely	Very Low	Fuel tanks have been removed from the adjacent site.
S1: Contamination in made ground used to fill the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities. S3: Hydrocarbon contamination from former nearby PFS.	R4: Construction workers.	P1: Horizontal and Vertical migration of leachate through potentially permeable soils and service trenches. P2: Human uptake pathways (see 7.06).	Severe	Unlikely	Low	The risk to workers who do not use the appropriate PPE is likely to be significant. Low permeability soils are likely to be present below the site, which will prevent the migration of contaminants. Fuel tanks have been removed from the adjacent site.

S4 Gas Generation in landfill sites within 250m of the site.	R4: Construction workers.	P3: Vertical migration of volatile vapours and ground gas.	Severe	Unlikely	Low	
S1: Contamination in made ground if present on the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities.	R5: Neighbouring Sites.	P1: Horizontal and Vertical migration of leachate through potentially permeable soils and service trenches.	Medium	Unlikely	Low	

7.10 Site Risk Assessment Summary Post Development:

Source	Receptor	Pathway	Consequence	Probability	Risk Category	Comments
S1: Contamination in made ground if present on the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities. S3: Hydrocarbon contamination from former nearby PFS.	R6: Maintenance Workers.	P2: Human uptake pathways. P3: Vertical migration of volatile vapours and ground gas.	Severe	Unlikely	Low	Low permeability soils are likely to be present below the site, which will prevent the migration of contaminations. Site remediation works such as hot spot removal, if required, will reduce risk to low. The risk to maintenance workers who do not use the appropriate PPE is likely to be significant. Fuel tanks have been removed from the adjacent site.
S4: Gas generation in landfill sites within 250m.	R6: Maintenance Workers.	P3: Vertical migration of volatile vapours and ground gas.	Severe	Unlikely	Low	
S1: Contamination in made ground if present on the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities. S3: Hydrocarbon contamination from former	R7: Site end users.	P2: Human uptake pathways. P3: Vertical migration of volatile vapours and ground gas.	Severe	Unlikely	Low	Low permeability soils are likely to be present below the site, which will prevent the migration of contaminations. Hardcover areas will act as a barrier between contamination, if present, and end users. Remediation works such as contamination hot spot removal and provision of an inert capping layer, ir

nearby PFS.						required, to garden areas will reduce risk to Low. Fuel tanks have been removed from the adjacent site.
S4: Gas generation in landfill sites within 250m. S7: Radon generation in underlying geology.	R7: Site end users.	P3: Vertical migration of volatile vapours and ground gas.	Severe	Unlikely	Low	
S1: Contamination in made ground if present on the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities. S3: Hydrocarbon contamination from former nearby PFS.	R7: Flora and Fauna.	P4: Plant root uptake.	Medium	Unlikely	Low	Low permeability soils are likely to be present below the site, which will prevent the migration of contaminations. Remediation works such as contamination hot spot removal and provision of an inert capping layer, if required, will reduce risk to Low. However, such works are not envisaged. Fuel tanks have been removed from the adjacent site.
S1: Contamination in made ground if present on the site. S2: Uncontrolled tipping of waste products and residues from adjacent industries/activities. S3: Hydrocarbon contamination from former nearby PFS.	R8: Services	P1: Horizontal and Vertical migration of leachate through potentially permeable soils and service trenches.	Severe	Unlikely	Low	Low permeability soils are likely to be present below the site, which will prevent the migration of contaminations. Site remediation works such as hot spot removal, if required will reduce risk to Low. Service trenches to be back filled with inert material. 'Protector line' water pipes can be used if necessary. Fuel tanks have been removed from the adjacent site.

A site conceptual section has not been prepared for the site as there are no obvious environmental risks.

8.0 GROUND INVESTIGATION

8.01 Fieldwork:

16 No. trial pits were excavated to depths of between 1.40 – 2.70m using a JCB 3CX excavator on 04 and 05 December 2018. It should be noted trial pit TP03,TP10, TP13 and TP16 were not excavated due to time constraints and extremely poor weather conditions. TP11 was excavated into he stockpile of material adjacent the northern boundary. The purpose of the trial pits was to allow an insitu visual inspection of the superficial soils, recover samples for laboratory testing and to undertake insitu testing.

The location of the trial pits are indicated on Fig. 2 attached in Volume 2, Appendix F.

8.02 Laboratory Testing:

To provide an assessment of soil contamination with respect to the proposed residential development soil samples were screened for a range of potential general contaminants. The screening included the following:-

Arsenic	Mercury	Zinc	PAH (16EPA)
Cadmium	Selenium	Boron (ws)	
Chromium	Copper	Sulphate (ws)	
Lead	Nickel	pH	

In view of the ground conditions encountered the following geotechnical testing was undertaken:-

- Atterberg Limits 7 No.

8.03 Ground Conditions:

The following typical ground conditions were encountered in the trial pit investigation:-

Strata	Location					
	TP01	**TP02**	**TP04**	**TP05**	**TP06**	**TP07**
Approx. Ground Level (m AOD)	67.25	65.50	65.00	69.00	66.25	67.75
Topsoil	-	0.00 – 0.30m	0.00 – 0.20m	-	0.00 – 0.40m	0.00 – 0.20m
Made Ground	0.00 – 0.90m	-	-	0.00 – 0.65m	-	-
Clay	0.90 – 2.50m (soft becoming firm, high strength)	0.30 – 2.70m (firm, medium to high strength)	0.20 – 1.20m (firm, high strength)	0.65 – 1.40m (stiff, high strength)	0.40 – 2.50m (firm, becoming soft, medium strength)	0.20 – 0.80m (firm, high strength)
			1.20 – 2.70m (firm, medium strength)	1.40 – 2.50m (firm, becoming soft, medium strength)		0.80 – 2.50m (soft, medium strength)
Stability	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open

Strata	Location					
	TP08	TP09	TP11	TP12	TP14	TP15
Approx. Ground Level (m AOD)	70.50	68.50	stockpile	71.00	70.50	70.50
Topsoil	0.00 – 0.30m	0.00 – 0.45m	-	0.00 – 0.30m	0.00 – 0.20m	0.00 – 0.30m
Made Ground	-	-	0.00 – 1.40m (mound)	-	-	-
Clay	0.30 – 0.50m (stiff)	0.45 – 1.50m (firm, medium strength)	-	0.30 – 1.00m (firm, medium strength)	0.20 – 0.40m (firm)	0.30 -1.20m (firm, medium strength)
	0.50 – 1.30m (firm, high strength)	1.50 – 2.40m (soft)		1.00 – 2.00m (soft to firm, medium strength)	0.40 – 1.60m (firm, high strength)	1.20 – 2.50m (soft to firm)
	1.30 – 2.60m (firm, medium strength)			2.00 – 2.50m (soft)	1.60 – 2.50m (firm, medium strength)	
Stability	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open

Strata	Location			
	TP17	TP18	TP19	TP20
Approx. Ground Level (m AOD)	73.50	72.00	74.25	74.00
Topsoil	0.00 – 0.20m	0.00 – 0.40m	0.00 – 0.30m	0.00 – 0.20m
Made Ground	-	-	-	-
Clay	0.20 – 2.50m (firm, high becoming medium strength)	0.40 – 1.10m (firm, medium strength)	0.30 – 1.80m (firm)	0.20 – 2.50m (firm, locally stiff, medium strength)
		1.10 – 2.50m (firm)		
Stability	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open

For the detailed description of the strata encountered see the trial pit logs attached in Volume 2, Appendix F.

8.04 Groundwater:

Groundwater was encountered during the trial pit investigation as follows:-

Strata	Location					
	TP01	TP02	TP04	TP05	TP06	TP07
Approx. Ground Level (m AOD)	67.25	65.50	65.00	69.00	66.25	67.75
Groundwater	Not encountered	Seepage at 1.20m	Seepage at 1.20m	Not encountered	Not encountered	Seepage at 1.40m

Strata	Location					
	TP08	TP09	TP11	TP12	TP14	TP15
Approx. Ground Level (m AOD)	70.50	68.50	stockpile	71.00	70.50	70.50
Groundwater	Seepage at 1.30m	Not encountered	Not encountered	Not encountered	Not encountered	Not encountered

Strata	Location			
	TP17	TP18	TP19	TP20
Approx. Ground Level (m AOD)	73.50	72.00	74.25	74.00
Groundwater	Seepage at 1.30m	Not encountered	Not encountered	Not encountered

8.05 **Excavations:**

The sides of the trial pits were stable whilst open.

8.06 **Laboratory Testing:**

Soils:

The results of the chemical analyses on the soil samples are summarised below.

Chemical Test result certificates are attached in Volume 2, Appendix G.

Samples taken from the topsoil (TP02, TP08, TP12, TP18 and TP19):-

Contaminant	Concentration in soils mg/kg*	No. of samples tested
Arsenic	10.0 – 38.0	5
Cadmium	0.87 – 1.80	5
Chromium	22.0 – 47.0	5
Lead	48.0 – 190	5
Mercury	<0.1 – 0.66	5
Selenium	1.3 – 1.6	5
Copper	180 – 140	5
Nickel	25.0 – 63.0	5
Zinc	80.0 – 230	5
Boron (Water Soluble)	<0.4 – 0.79	5
Sulphate (Water Soluble)	<0.01 g/l	5
pH	6.3 – 8.0	5
PAH	<2.0 – 24.0	5

* unless stated otherwise

The results of sulphate and pH determinants indicate sulphate content expressed as 2:1 aqueous extract of <0.01 g/l SO_4 with pH values between 6.3 – 8.0.

Samples taken from the made ground (TP01, TP05 and TP11):-

Contaminant	Concentration in soils mg/kg*	No. of samples tested
Arsenic	16.0 – 25.0	4
Cadmium	0.7 – 1.6	4
Chromium	26.0 – 30.0	4
Lead	41.0 – 120	4
Mercury	<0.1 – 0.3	4
Selenium	0.8 – 1.7	4
Copper	25.0 – 36.0	4
Nickel	31.0 – 57.0	4
Zinc	87.0 – 120	4
Boron (Water Soluble)	0.6 – 0.7	4
Sulphate (Water Soluble)	<0.01 – 0.13 g/l	4
pH	7.0 – 8.2	4
PAH	14.0 – 94.0	4

* unless stated otherwise

The result of sulphate and pH determinations indicate sulphate content expressed as 2:1 aqueous extract of between <0.01 g/l SO_4 with pH values between 7.0 – 8.2.

Samples taken from the natural ground (TP01):-

Contaminant	Concentration in soils mg/kg*	Number of samples tested
Arsenic	11.0 – 30.0	2
Cadmium	0.5 – 0.8	2
Chromium	17.0 – 32.0	2
Lead	21.0 – 28.0	2
Mercury	<0.1	2
Selenium	0.5 – 1.1	2
Copper	18.0 – 25.0	2
Nickel	40.0 – 55.0	2
Zinc	69.0 – 85.0	2
Boron (Water Soluble)	<0.4	2
Sulphate (Water Soluble)	<0.01 g/l	6
pH	7.6 – 8.4	6
PAH	<2.0	2

* unless stated otherwise

The results of a sulphate and pH determinations indicate a sulphate content expressed as 2:1 aqueous extract of <0.01g/1 SO_4 with pH values between 7.6 – 8.4.

The results of Atterberg Limits tests are summarised in the following table:-

Trial Pit	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Plasticity
TP02	1.30	67	31	36	Intermediate
TP02	2.40	27	14	13	Low
TP08	1.10	33	18	15	Low
TP15	1.30	43	23	20	Intermediate
TP15	2.20	22	13	9	Low
TP19	0.40	32	16	16	Low
TP19	1.50	32	15	17	Low

The geotechnical test result certificates are attached in Volume 2, Appendix H.

8.07 Insitu Testing:

The results of hand shear vane testing are summarised in the following table:-

Strata	Cohesion (kPa)
Medium strength clay	76, 70, 45, 59, 52, 74, 50, 44, 44, 46, 66, 56, 41, 63, 64, 72, 59, 69, 63, 58, 56, 61
High strength clay	92, 102, 119, 130, 80, 79, 124,

The results of re-compaction tests (4.5kg rammer) are summarised in the following table:-

Trial Pit	Natural Moisture Content (%)	Optimum Moisture Content (%)	Maximum Dry Density (Mg/m^3)
TP12	32	13.4	1.79
TP15	42	10.7	1.59
TP17	17	9.4	1.57
TP19	18	10.3	1.69

The geotechnical test result certificates are attached in Volume 2, Appendix H.

9.0 CONTAMINATION - DESIGN OBJECTIVES & PHILOSOPHY

9.01 Identification of Potential Hazards:

In January 2015 Land Quality Management Ltd (LQM) published Safe for Use Levels (S4UL's) for Human Health Risk Assessment introducing updated guidance for the assessment of risk to human health from land contamination. The S4UL's are based on assumptions on soil conditions, the existence of exposure pathways behaviour and type of contaminants. The apparent exceedence of the quoted S4UL's is taken as indicating that further detailed assessment is required or that remedial actions should be taken.

9.02 Sensitivity of Development:

The presence of elevated concentrations of particular analytes may present hazards in terms of personal health, damage to plant life and other environmental issues. The S4UL's are classified particular end uses as follows:-

Residential with home grown produce
Residential without home grown produce
Residential public open space
Allotments
Commercial/Industrial

9.03 **Design Life:**

It is important to recognise when considering a particular problem that the solution has finite life, a concept with which those in the construction industry are familiar. The design life is influenced by the materials used in construction, the environment and the degree of maintenance carried out to extend the design life.

Monitoring is required to determine whether a design is functioning correctly, commensurate with the prevailing environmental conditions. It is essential that future users are aware of today's solutions since historically most buildings and infrastructure works continue in service. The effect of an increased design life should not be allowed to prejudice the original design principles.

9.04 **Legislation:**

The principle legislation relating to a potential pollution and contamination problems addressed in the Environmental Protection Act 1990 and Environmental Act 1995.

For 'contaminated' land to exist a significant 'pollution linkage' must be present, that is, there should be a source of contamination, a pathway by which the contamination can migrate, to an identified 'receptor' where it could cause 'significant harm'.

Should any link within this chain be severed then the land may not strictly be regarded as 'contaminated land' under the Environmental Protection Act 1990.

Based on the historic site usage and activities on and in the vicinity of the site it was anticipated that there may be contamination present on site use.

A ground investigation was commissioned to investigate soils and the chemical constituents of these soils, especially any made ground. The site was not expected to be severally contaminated and therefore a comprehensive testing regime based on the current industry standard BS 10175 : 2001 was not considered necessary. However, a contamination survey was undertaken with a provision that return visits would have to be made if contamination was exposed at a sufficient concentration to justify more extensive investigations.

9.05 **Design Objectives:**

i) The objective of reclamation works is to improve any marginal land into ground suitable for its use for residential use with home grown produce and commercial use. The standards would be in accordance with the LQM/ CIEH S4UL's for Human Health Risk Assessment and SP1010: Development of Category 4 Screening Levels (C4SL's) for Assessment of Land Affected by Contamination as attached in Volume 2, Appendix I. The Assessment Criteria values are based upon an SOM of 1.0%. If considered appropriate a further quantitative risk assessment will be undertaken using calculated site specific target values or S4UL's for SOM values obtained for the site by laboratory testing.

ii) Risk Assessment
A qualitative risk assessment of any contaminants identified on the site will be undertaken. This will consider the significance of the contaminants identified in terms of source, pathway, receptor (ie. pollution linkage).

10.0 DISCUSSION

10.01 Soils:

The investigation has generally revealed the presence of topsoil on the site, except for isolated areas of made ground in TP01, TP05 and TP11 (stockpile of material adjacent the northern boundary). The results have been assessed using the proposed Assessment Criteria for residential use with home grown produce attached in Volume 2, Appendix I.

The test results from samples taken from the topsoil on the site are compared in the following tables:-

Contaminant	Concentration in soils mg/kg*	No. of samples tested	Assessment Criteria mg/kg	No. of samples exceeding Assessment Criteria
Arsenic	10.0 – 38.0	5	37	1
Cadmium	0.87 – 1.80	5	26	0
Chromium	22.0 – 47.0	5	910	0
Lead	48.0 – 190	5	200	0
Mercury	<0.1 – 0.66	5	40	0
Selenium	1.3 – 1.6	5	250	0
Copper	180 – 140	5	2400	0
Nickel	25.0 – 63.0	5	180	0
Zinc	80.0 – 230	5	3700	0
Boron (Water Soluble)	<0.4 – 0.79	5	290	0
Sulphate (Water Soluble)	<0.01 g/l	5	-	-
PH	6.3 – 8.0	5	<5	0
PAH	<2.0 – 24.0	5	#	#

* unless stated otherwise
# see following table

Speciated PAH analysis of samples from the topsoil on the site are summarised in the following table:-

PAH 16 EPA	Concentrations in soils mg/kg	No. of Samples tested	Assessment Criteria mg/kg	No. of Samples exceeding Assessment Criteria
Acenaphthene	<0.1	5	210	0
Acenapthylene	<0.1	5	170	0
Anthracene	<0.1 – 0.5	5	2400	0
Benzo (a) Anthracene	<0.1 – 1.8	5	7.2	
Benzo (a) Pyrene	<0.1 – 1.4	5	5.0	0
Benzo (b) Fluoranthene	<0.1 – 1.8	5	2.6	0
Benzo (k) Fluoranthene	<0.1 – 0.9	5	77.0	0
Benzo (g,h,i) Perylene	<0.1 – 2.1	5	320	0
Chrysene	<0.1 – 27	5	15.0	0

Di-benzo (a,h) Anthracene	<0.1 – 1.4	5	0.24	2
Indeno (1, 2, 3-cd) Pyrene	<0.1 – 0.9	5	27.0	0
Fluoranthene	0.3 – 3.6	5	280	0
Fluorene	<0.1	5	170	0
Napthalene	<0.1	5	2.3	0
Phenanthrene	<0.1 – 2.9	5	95.0	0
Pyrene	0.5 – 3.5	5	620	0
Total	<2.0 – 24.0	5	-	-

When compared with the proposed Assessment Criteria in relation to residential use with home grown produce, the following determinants with levels in excess of Assessment Criteria were encountered in the topsoil on the site:-

Arsenic	1 No.	TP08	0.10 - 0.30m	38.0 mg/kg
Di-benzo (a,h) Anthracene	2 No.	TP01	0.10 - 0.30m	0.54 mg/kg
		TP11	0.10 - 0.30m	1.40 mg/kg

The Upper Bound Values (US95) for the determinants with concentrations in excess of Assessment Criteria in the topsoil have been calculated as follows:-

Arsenic 29.4 mg/kg < AC of 37.0 mg/kg
Di-benzo (a,h) Anthracene 0.98 mg/kg > AC of 0.24 mg/kg

In view of the above there is a significant pollution linkage present on the site in relation to Di-benzo (a,h) Anthracene in the topsoil on the site. However, it should be noted the US95 value for Di-benzo (a,h) Anthracene is significantly below the Assessment Criteria for commercial use (3.5 mg/kg) but above the Assessment Criteria for residential open space (0.57 mg/kg).

Samples taken from the made ground on the site are assessed in the following table:-

Contaminant	**Concentration in soils mg/kg***	**No. of samples tested**	**Assessment Criteria mg/kg**	**No. of samples exceeding Assessment Criteria**
Arsenic	16.0 – 25.0	4	37	0
Cadmium	0.7 – 1.6	4	26	0
Chromium	26.0 – 30.0	4	910	0
Lead	41.0 – 120	4	200	0
Mercury	<0.1 – 0.3	4	40	0
Selenium	0.8 – 1.7	4	250	0
Copper	25.0 – 36.0	4	2400	0
Nickel	31.0 – 57.0	4	180	0
Zinc	87.0 – 120	4	3700	0
Boron (Water Soluble)	0.6 – 0.7	4	290	0
Sulphate (Water Soluble)	<0.01 – 0.13 g/l	4	-	-
PH	7.0 – 8.2	4	<5	0
PAH	14.0 – 94.0	4	#	#

* unless stated otherwise
# see following table

Speciated PAH analysis of samples from the made ground site are summarised in the

following table:-

PAH 16 EPA	Concentrations in soils mg/kg	No. of Samples tested	Assessment Criteria mg/kg	No. of Samples exceeding Assessment Criteria
Acenaphthene	<0.1 – 1.8	4	210	0
Acenapthylene	<0.1 – 0.9	4	170	0
Anthracene	<0.1 – 1.7	4	2400	0
Benzo (a) Anthracene	1.3 – 7.9	4	7.2	1
Benzo (a) Pyrene	1.1 – 7.9	4	5.0	0
Benzo (b) Fluoranthene	1.6 – 12.0	4	2.6	2
Benzo (k) Fluoranthene	0.8 – 4.5	4	77.0	0
Benzo (g,h,i) Perylene	1.0 – 5.9	4	320	0
Chrysene	2.6 – 9.3	4	15.0	0
Di-benzo (a,h) Anthracene	0.7 – 2.2	4	0.24	4
Indeno (1, 2, 3-cd) Pyrene	0.7 – 5.4	4	27.0	0
Fluoranthene	2.2 – 14.0	4	280	0
Fluorene	<0.1 – 1.3	4	170	0
Napthalene	<0.1 – 0.6	4	2.3	0
Phenanthrene	<0.1 – 8.5	4	95.0	0
Pyrene	2.2 – 15.0	4	620	0
Total	14.0 – 94.0	4	-	-

When compared with the proposed Assessment Criteria in relation to residential use with home grown produce the following determinants with levels in excess of Assessment Criteria were encountered in the made ground on the site:-

Benzo (a) Anthracene	1 No.	TP01	0.50m	7.9 mg/kg
Benzo (b) Fluoranthene	2 No.	TP01	0.50m	12.0 mg/kg
		TP11	1.20m	3.0 mg/kg
Di-benzo (a,h) Anthracene	4 No.	TP01	0.50m	2.2 mg/kg
		TP05	0.20m	1.1 mg/kg
		TP11	0.10m	0.65 mg/kg
		TP11	1.20m	1.1 mg/kg

The Upper Bound Values (US95) for the determinants with concentrations in excess of Assessment Criteria in the made ground have been calculated as follows:-

Benzo (a) Anthracene	7.1 mg/kg	<	AC of 7.2 mg/kg
Benzo (b) Fluoranthene	10.5 mg/kg	<	AC of 2.6 mg/kg
Di-benzo (a,h) Anthracene	2.0 mg/kg	>	AC of 0.24 mg/kg

In view of the above there is a significant pollution linkage present on the site in relation to Benzo (b) Fluoranthene and Di-benzo (a,h) Anthracene in the made ground on the site. However, it should be noted the US95 value for Benzo (b) Fluoranthene and Di-benzo (a,h) Anthracene are significantly below their respective Assessment Criteria for commercial use (44.0 and 3.5 mg/kg) but above their respective Assessment Criteria for residential open space (7.1 and 0.57 mg/kg).

Samples taken from the natural ground on the site are compared in the following table:-

Contaminant	Concentration in soils mg/kg*	No. of samples tested	Assessment Criteria mg/kg	No. of samples exceeding Assessment Criteria
Arsenic	11.0 – 30.0	2	37	0
Cadmium	0.5 – 0.8	2	26	0
Chromium	17.0 – 32.0	2	910	0
Lead	21.0 – 28.0	2	200	0
Mercury	<0.1	2	40	0
Selenium	0.5 – 1.1	2	250	0
Copper	18.0 – 25.0	2	2400	0
Nickel	40.0 – 55.0	2	180	0
Zinc	69.0 – 85.0	2	3700	0
Boron (Water Soluble)	<0.4	2	290	0
Sulphate (Water Soluble)	<0.01 g/l	6	-	-
pH	7.6 – 8.4	6	<5	0
PAH	<2.0	2	#	#

* unless stated otherwise
# see following table

Speciated PAH analysis of samples from the natural ground on the site are summarised in the following table:-

PAH 16 EPA	Concentrations in soils mg/kg	No. of Samples tested	Assessment Criteria mg/kg	No. of Samples exceeding Assessment Criteria
Acenaphthene	<0.1	3	210	0
Acenapthylene	<0.1	3	170	0
Anthracene	<0.1	3	2400	0
Benzo (a) Anthracene	<0.1	3	7.2	0
Benzo (a) Pyrene	<0.1	3	5.0	0
Benzo (b) Fluoranthene	<0.1	3	2.6	0
Benzo (k) Fluoranthene	<0.1	3	77.0	0
Benzo (g,h,i) Perylene	<0.1	3	320	0
Chrysene	<0.1	3	15.0	0
Di-benzo (a,h) Anthracene	<0.1	3	0.24	0
Indeno (1, 2, 3-cd) Pyrene	<0.1	3	27.0	0
Fluoranthene	<0.1	3	280	0
Fluorene	<0.1	3	170	0
Napthalene	<0.1	3	2.3	0
Phenanthrene	<0.1	3	95.0	0
Pyrene	<0.1	3	620	0
Total	<0.2	3	-	-

When compared with the proposed Assessment Criteria in relation to residential use with home grown produce no determinants with levels in excess of Assessment Criteria were encountered in the natural ground on the site.

Based on the assessment of the test results the following remediation measures are recommended on the site:-

- The topsoil local to TP02 and TP19 should be stockpiled for re-use in the commercial area of the site.

- Other topsoil stockpiled for re-use in the residential gardens should be tested to ensure levels of Di-benzo (a,h) Anthracene are below the Assessment Criteria for residential use with home grow produce.

- The made ground on the site should be excavated and placed in the commercial areas. If the made ground is retained in garden or landscape areas it should be capped with 0.60m of inert capping (including 0.15m of topsoil) laid on Terram 1000.

- Excavated natural ground on the site can be used as fill material in all areas of the site.

10.02 **Controlled Waters:**

The levels of contamination encountered on the site are not considered to pose a significant risk to controlled waters.

It should be noted that:-

- the developed site will be between 60 and 90% positively drained hardcover which will limit the amount of rainwater percolating through the soils.

- the site is underlain by relatively impermeable clays which will prevent the migration of contamination.

- there are no groundwater abstractions within 428m of the site.

- the site is not in a Source Protection Zone.

10.03 **Mining:**

The site is not affected by shallow coal seams or mine entries.

10.04 **Gas:**

The development does not appear to be at risk from the migration of landfill gas onto the site as there are no known landfill sites in the surrounding area.

Database information indicates that the site is in an area where Radon protection measures are not required in the construction of new dwellings or extensions.

Therefore, gas protection measures are not required on the site.

10.05 **Foundations:**

The made ground and soft clays on the site are not considered to be a suitable foundation strata as potentially damaging settlements could occur.

Strip footings and pad can be utilised on the development founded on the medium and high strength clays below the site. The underside of foundations should be a minimum of 0.90m below finished ground level. Trench fill will be required where made ground and/or soft clays are present or where foundations are in the influence zone of trees.

Due to the variable nature of the clays it is recommended that strip footings are mesh reinforced to resist potential small differential settlements.

A safe working bearing pressure of 100 KN/m^2 can be adopted in the medium strength clays. A safe working bearing pressure of 150 KN/m^2 can be adopted in the high strength clays.

10.06 **Ground Floor Construction:**

Where made ground and/or soft clays and where cohesive soils are present in the influence of trees it is recommended a suspended ground floor with a 300 mm minimum under floor void is utilised.

Where medium and high strength clays are present, provided the sub base thickness does not exceed 600mm, ground bearing slabs on well compacted hardcore can be utilised.

10.07 **Sulphate attack on Buried Concrete**:

The results of the sulphate analysis compared to BRE Special Digest 1, 'Concrete in Aggressive Ground' indicate Class DS-1 conditions and ACEC site classification AC-1s.

10.08 **Excavations:**

Excavations in the made ground on the site are likely to be unstable in the short term, whereas excavations in the natural clay strata are stable in the short term. Notwithstanding this trench support should be provided in accordance with current Health & Safety Guidance.

Generally groundwater is unlikely to be encountered in foundation or drainage excavations but seepages were recorded in TP02, 04, 07, 08 and 17 between 1.2 and 1.4m below existing ground level. However, it should also be noted that the groundwater table is likely to be subject to seasonal variations.

10.09 **Pavements:**

CBR values in the made ground are likely to be low (<2%) and variable. If made

ground is present under the adopted highways the made ground should be excavated and replaced by well compacted 6F2 material.

CBR values in the medium and high strength clays are likely to be reasonable (circa 3-5%). However, soft spots may be present in cohesive strata which would need to be excavated and replaced with well compacted granular material.

CBR values in the soft clays are likely to be low (< 2%). Therefore, a well compacted 6F2 capping layer may be required to the adopted highway construction. Under drives and car parks oversized granular material should be rolled into the soft clays to stiffen the formation. However, localised very soft areas may be present that would require excavated and replacement with compacted granular material.

10.10 **Drainage:**

As relatively impermeable clays are present on the site, the use of soakaways on the development will not be feasible.

A conventional granular bed and surround can be adopted to drainage.

10.11 **Recompacted Fill:**

The results of re-compaction tests on clay soils indicate that the nature moisture content of the soil is in excess of the optimum moisture content to achieve 95% of maximum dry density when the material is recompacted.

Therefore, in order to use excavated clay soils as engineered bulk fill material the soils will need to be 'dried back'. Lime stabilisation could be utilised to achieve this but advice should be sought from specialist contractors.

11.0 CONTAMINATION RISK ASSESSMENT

11.01 **General:**

In order to evaluate the environmental risks identified during the investigation, a simple source-pathway-target model has been developed and is summarised at the end of this section in table form. The model has been used to determine significant pollutant linkages and identify suitable risk management proposals on which the remediation design is based.

11.02 **Sources:**

Chemical analyses of samples have indicated elevated levels of Di-benzo (a,h) Anthracene in the topsoil on the site and elevated levels of Benzo (b) Fluoranthene and Di-benzo (a,h) Anthracene in the made ground on the site.

11.03 **Pathways:**

The following potential contamination pathways have been identified on the site:-

Vertical migration pathways.

Human Uptake Pathways (derived from CLEA model and LQA for residential use):

- Ingestion of soil
- Ingestion of indoor dust
- Dermal contact with soil
- Contact with indoor dust
- Inhalation of vapours outside
- Inhalation of vapours inside
- Vertical and lateral migration of volatile vapours and ground gas
- Indirect ingestion
- Airborne hazardous fibres
- Plant root uptake.

11.04 **Targets:**

The following environmental receptors have been identified on site:-

- Groundwater residing in the underlying geology
- Waterourse
- Buildings / structures
- Flora / Fauna
- Underground services
- Third party land.

The following human receptors have been identified on the site:-

- Construction workers
- Maintenance workers
- End users.

11.05 Assessed Risk – Topsoil – Di-benzo (a,h) Anthracene

SOURCES	PATHWAYS	TARGETS	LIKELIHOOD OF OCCURRENCE	SEVERITY OF CONSEQUENCE	RISK RATING	RISK MANAGEMENT ACTION TAKEN
Topsoil	Direct Ingestion/ Inhalation or Contact	End Users	Likely	Severe	High	The topsoil local to TP02 and TP19 should be stockpiled for re-use in the commercial area of the site. Other topsoil stockpiled for re-use in the residential gardens should be tested to ensure levels of Di-benzo (a,h) Anthracene are below the Assessment Criteria for residential use with home grow produce.
	Direct Ingestion/ Inhalation or Contact	Construction workers	Likely	Severe	High	Induction, PPR, high standard of personal hygiene.
	Indirect Ingestion	End Users	Unlikely	Severe	Moderate	The topsoil local to TP02 and TP19 should be stockpiled for re-use in the commercial area of the site. Other topsoil stockpiled for re-use in the residential gardens should be tested to ensure levels of Di-benzo (a,h) Anthracene are below the Assessment Criteria for residential use with home grow produce.
	Indirect Ingestion	Construction workers	Likely	Severe	High	Induction, PPE, high standard of personal hygiene.
	Root Uptake	Plants	Likely	Medium	Moderate	The topsoil local to TP02 and TP19 should be stockpiled for re-use in the commercial area of the site. Other topsoil stockpiled for re-use in the residential gardens should be tested to ensure levels of Di-benzo (a,h) Anthracene are below the Assessment Criteria for residential use with home grow produce.
	Vertical/ lateral migration to controlled waters	Aquifer Watercourse	Unlikely	Minor	Low	The developed site will be between 60 and 90% positively drained hardcover which will Limit the amount of rainwater percolating through the soils. The site is underlain by relatively impermeable clays which will prevent the migration of contamination. There are no groundwater abstractions within 428m of the site. The site is not in a Source Protection Zone.

11.06 Assessed Risk – Made Ground - Benzo (b) Fluoranthene and Di-benzo (a,h) Anthracene

SOURCES	PATHWAYS	TARGETS	LIKELIHOOD OF OCCURRENCE	SEVERITY OF CONSEQUENCE	RISK RATING	RISK MANAGEMENT ACTION TAKEN
Made Ground	Direct Ingestion/ Inhalation or Contact	End Users	Likely	Severe	High	The made ground on the site should be excavated and placed in the commercial areas. If the made ground is retained in garden or landscape areas it should be capped with 0.60m of inert capping (including 0.15m of topsoil) laid on Terram 1000.
	Direct Ingestion/ Inhalation or Contact	Construction workers	Likely	Severe	High	Induction, PPR, high standard of personal hygiene.
	Indirect Ingestion	End Users	Unlikely	Severe	Moderate	The made ground on the site should be excavated and placed in the commercial areas. If the made ground is retained in garden or landscape areas it should be capped with 0.60m of inert capping (including 0.15m of topsoil) laid on Terram 1000.
	Indirect Ingestion	Construction workers	Unlikely	Severe	Moderate	Induction, PPE, high standard of personal hygiene.
	Root Uptake	Plants	Unlikely	Medium	Low	The made ground on the site should be excavated and placed in the commercial areas. If the made ground is retained in garden or landscape areas it should be capped with 0.60m of inert capping (including 0.15m of topsoil) laid on Terram 1000.
	Vertical/ lateral migration to controlled waters	Aquifer Watercourse	Unlikely	Medium	Low	The developed site will be between 60 and 90% positively drained hardcover which will Limit the amount of rainwater percolating through the soils. The site is underlain by relatively impermeable clays which will prevent the migration of contamination. There are no groundwater abstractions within 428m of the site. The site is not in a Source Protection Zone.

12.0 RECLAMATION PROPOSALS

The proposed works shall include the following, although this does not necessarily indicate the order or full extent of the works.

- Disconnect and/or divert any live services on the site.

- Grub out all vegetation and remove from site. Any vegetation to be retained, should be adequately protected from the works.

- Inspect the site for hazardous materials visible on the surface, remove from site together with any fly tipping and rubbish to a suitably licensed tip, using approved methods and a suitably licensed contractor.

- After the initial site strip the formation is to be inspected. Any areas of deleterious material or contamination not identified in the ground investigation identified by visual or olfactory evidence and subsequent chemical testing is to be remediated if necessary, in accordance with a risk assessment.

- The topsoil local to TP9 should be excavated and either removed from site to a suitably licensed tip or buried on the site below a 1.0m inert capping layer.

- The topsoil local to TP02 and TP19 should be stockpiled for re-use in the commercial area of the site.

- Other topsoil stockpiled for re-use in the residential gardens should be tested to ensure levels of Di-benzo (a,h) Anthracene are below the Assessment Criteria for residential use with plenty uptake.

- The made ground on the site should be excavated and placed in the commercial areas. If the made ground is retained in garden areas it should be capped with 0.60m of inert capping (including 0.15m of topsoil) laid on Terram 1000.

- Excavated natural ground on the site can be used as fill material in all areas of the site.

- Any imported engineering fill material should be compacted in accordance with the Dpt. Highways Specification.

- Arisings from the made ground on the site are likely to be classified as inert but guidance should be sought from the local Waste Management Regulation Office regarding the disposal of soils from the site.

13.0 SUMMARY

Site Name & Location	A59 and Clitheroe Road, Whalley
Proposal	Housing and Commercial Use
Local Authority	Ribble Valley Borough Council.
Site History	The site has not been previously developed. Other potentially contaminative activities within 250m of the site have included an industrial estate and a petrol filling station. Potentially contaminative activities in the surrounding area (250 – 1000m) to the site have included a print works, a brick works, a gasometer, railway lines, a sewage works, an engraving works, a depot and a transport depot.
Geology	1:50,000 British Geological Survey (BGS) geological sheet 68 Clitheroe indicates the following:- The site is underlain by Limestone of the Dinantian Age. No faults lie within approximately 900m of the site. Glacial deposits of boulder clay are likely to be present at the surface.
Hydrogeology	The site is in a relatively high sensitivity hydrogeological area as a watercourse flows through the site. However, there are no groundwater abstractions within 1000m of the site and the site is not in a Source Protection Zone.
Flooding	The site does not appear to be prone to flooding and is in Flood Zone 1.
Mining Issues	The site is not affected by coal workings or mine entries.
Gas Precautions	The development does not appear to be at risk from the migration of landfill gas onto the site as there are no known landfill sites in the surrounding area.
Ground Conditions	The following typical ground conditions were encountered in the trial pit investigation:-

Strata	Location					
	TP01	**TP02**	**TP04**	**TP05**	**TP06**	**TP07**
Approx. Ground Level (m AOD)	67.25	65.50	65.00	69.00	66.25	67.75
Topsoil	-	0.00 – 0.30m	0.00 – 0.20m	-	0.00 – 0.40m	0.00 – 0.20m
Made Ground	0.00 – 0.90m	-	-	0.00 – 0.65m	-	-
Clay	0.90 – 2.50m (soft becoming firm, high strength)	0.30 – 2.70m (firm, medium to high strength)	0.20 – 1.20m (firm, high strength)	0.65 – 1.40m (stiff, high strength)	0.40 – 2.50m (firm, becoming soft, medium strength)	0.20 – 0.80m (firm, high strength)
			1.20 – 2.70m (firm, medium strength)	1.40 – 2.50m (firm, becoming soft, medium strength)		0.80 – 2.50m (soft, medium strength)
Stability	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open

Strata	Location					
	TP08	**TP09**	**TP11**	**TP12**	**TP14**	**TP15**
Approx. Ground Level (m AOD)	70.50	68.50	stockpile	71.00	70.50	70.50
Topsoil	0.00 – 0.30m	0.00 – 0.45m	-	0.00 – 0.30m	0.00 – 0.20m	0.00 – 0.30m
Made Ground	-	-	0.00 – 1.40m (mound)	-	-	-
Clay	0.30 – 0.50m (stiff)	0.45 – 1.50m (firm, medium strength)	-	0.30 – 1.00m (firm, medium strength)	0.20 – 0.40m (firm)	0.30 -1.20m (firm, medium strength)
	0.50 – 1.30m (firm, high strength)	1.50 – 2.40m (soft)		1.00 – 2.00m (soft to firm, medium strength)	0.40 – 1.60m (firm, high strength)	1.20 – 2.50m (soft to firm)
	1.30 – 2.60m (firm, medium strength)			2.00 – 2.50m (soft)	1.60 – 2.50m (firm, medium strength)	
Stability	Pit walls stable whilst	Pit walls stable whilst	Pit walls stable whilst	Pit walls stable whilst	Pit walls stable whilst	Pit walls stable whilst

	open	open	open	open	open	open

Strata	Location			
	TP17	TP18	TP19	TP20
Approx. Ground Level (m AOD)	73.50	72.00	74.25	74.00
Topsoil	0.00 – 0.20m	0.00 – 0.40m	0.00 – 0.30m	0.00 – 0.20m
Made Ground	-	-	-	-
Clay	0.20 – 2.50m (firm, high becoming medium strength)	0.40 – 1.10m (firm, medium strength) 1.10 – 2.50m (firm)	0.30 – 1.80m (firm)	0.20 – 2.50m (firm, locally stiff, medium strength)
Stability	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open	Pit walls stable whilst open

Groundwater:

Groundwater was encountered during the trial pit investigation as follows:-

Strata	Location					
	TP01	TP02	TP04	TP05	TP06	TP07
Approx. Ground Level (m AOD)	67.25	65.50	65.00	69.00	66.25	67.75
Groundwater	Not encountered	Seepage at 1.20m	Seepage at 1.20m	Not encountered	Not encountered	Seepage at 1.40m

Strata	Location					
	TP08	TP09	TP11	TP12	TP14	TP15
Approx. Ground Level (m AOD)	70.50	68.50	stockpile	71.00	70.50	70.50
Groundwater	Seepage at 1.30m	Not encountered	Not encountered	Not encountered	Not encountered	Not encountered

Strata	Location			
	TP17	TP18	TP19	TP20
Approx. Ground Level (m AOD)	73.50	72.00	74.25	74.00
Groundwater	Seepage at 1.30m	Not encountered	Not encountered	Not encountered

Foundations	The made ground and soft clays on the site are not considered to be a suitable foundation strata as potentially damaging settlements could occur. Strip footings and pad can be utilised on the development founded on the medium and high strength clays below the site. The underside of foundations should be a minimum of 0.90m below finished ground level. Trench fill will be required where made ground and/or soft clays are present or where foundations are in the influence zone of trees. Due to the variable nature of the clays it is recommended that strip footings are mesh reinforced to resist potential small differential settlement. A safe working bearing pressure of 100 KN/m^2 can be adopted in the medium strength clays. A safe working bearing pressure of 150 KN/m^2 can be adopted in the high strength clays.
Ground Floor Construction	Where made ground and/or soft clays and where cohesive soils are present in the influence of trees it is recommended a suspended ground floor with a 300 mm minimum under floor void is utilised. Where medium and high strength clays are present, provided the sub base thickness does not exceed 600mm, ground bearing slabs on well compacted hardcore can be utilised.
Building Near Trees	Applicable as cohesive soils are present.
Pavements	CBR values in the made ground are likely to be low (<2%) and variable. If made ground is present under the adopted highways the made ground should be excavated and replaced by well compacted 6F2 material. CBR values in the medium and high strength clays are likely to be reasonable (circa 3-5%). However, soft spots may be present in cohesive strata which would need to be excavated and replaced with well compacted granular material. CBR values in the soft clays are likely to be low (< 2%). Therefore, a well compacted 6F2 capping layer

<table>
<tr><td></td><td>may be required to the adopted highway construction. Under drives and car parks oversized granular material should be rolled into the soft clays to stiffen the formation. However, localised very soft areas may be present that would require excavated and replacement with compacted granular material.</td></tr>
<tr><td>Dewatering</td><td>Generally groundwater is unlikely to be encountered in foundation or drainage excavations but seepages were recorded in TP02, 04, 07, 08 and 17 between 1.2 and 1.4m below existing ground level. However, it should also be noted that the groundwater table is likely to be subject to seasonal variations.
However, it should also be noted that the groundwater table is likely to be subject to seasonal variations.</td></tr>
<tr><td>Excavations</td><td>Excavations in the made ground on the site are likely to be unstable in the short term, whereas excavations in natural strata are stable in the short term. Notwithstanding this trench support should be provided in accordance with current Health & Safety Guidance.</td></tr>
<tr><td>Sulphate Classification</td><td>The results of the sulphate analysis compared to BRE Special Digest 1, 'Concrete in Aggressive Ground' indicate Class DS-1 conditions and ACEC site classification AC-1s.</td></tr>
<tr><td>Drainage</td><td>As relatively impermeable clays are present on the site, the use of soakaways on the development will not be feasible.
A conventional granular bed and surround can be adopted to drainage.</td></tr>
<tr><td>Contamination Assessment</td><td>When compared with the proposed Assessment Criteria in relation to residential use with home grown produce, the following determinants with levels in excess of Assessment Criteria were encountered in the topsoil on the site:-
When compared with the proposed Assessment Criteria in relation to residential use with home grown produce, the following determinants with levels in excess of Assessment Criteria were encountered in the topsoil on the site:-
<table>
<tr><td>Arsenic</td><td>1 No.</td><td>TP08</td><td>0.10 - 0.30m</td><td>38.0 mg/kg</td></tr>
<tr><td>Di-benzo (a,h) Anthracene</td><td>2 No.</td><td>TP01
TP11</td><td>0.10 - 0.30m
0.10 - 0.30m</td><td>0.54 mg/kg
1.40 mg/kg</td></tr>
</table>
The Upper Bound Values (US95) for the determinants with concentrations in excess of Assessment Criteria in the topsoil have been calculated as follows:-
Arsenic 29.4 mg/kg < AC of 37.0 mg/kg
Di-benzo (a,h) Anthracene 0.98 mg/kg > AC of 0.24 mg/kg
In view of the above there is a significant pollution linkage present on the site in relation to Di-benzo (a,h) Anthracene in the topsoil on the site. However, it should be noted the US95 value for Di-benzo (a,h) Anthracene is significantly below the Assessment Criteria for commercial use (3.5 mg/kg) but above the Assessment Criteria for residential open space (0.57 mg/kg).
When compared with the proposed Assessment Criteria in relation to residential use with home grown produce the following determinants with levels in excess of Assessment Criteria were encountered in the made ground on the site:-
<table>
<tr><td>Benzo (a) Anthracene</td><td>1 No.</td><td>TP01</td><td>0.50m</td><td>7.9 mg/kg</td></tr>
<tr><td>Benzo (b) Fluoranthene</td><td>2 No.</td><td>TP01
TP11</td><td>0.50m
1.20m</td><td>12.0 mg/kg
3.0 mg/kg</td></tr>
<tr><td>Di-benzo (a,h) Anthracene</td><td>4 No.</td><td>TP01
TP05
TP11
TP11</td><td>0.50m
0.20m
0.10m
1.20m</td><td>2.2 mg/kg
1.1 mg/kg
0.65 mg/kg
1.1 mg/kg</td></tr>
</table>
The Upper Bound Values (US95) for the determinants with concentrations in excess of Assessment Criteria in the made ground have been calculated as follows:-
Benzo (a) Anthracene 7.1 mg/kg < AC of 7.2 mg/kg
Benzo (b) Fluoranthene 10.5 mg/kg > AC of 2.6 mg/kg
Di-benzo (a,h) Anthracene 2.0 mg/kg > AC of 0.24 mg/kg
In view of the above there is a significant pollution linkage present on the site in relation to Benzo (b) Fluoranthene and Di-benzo (a,h) Anthracene in the made ground on the site. However, it should be noted the US95 value for Benzo (b) Fluoranthene and Di-benzo (a,h) Anthracene are significantly below their respective Assessment Criteria for commercial use (44.0 and 3.5 mg/kg) but above their respective Assessment Criteria for residential open space (7.1 and 0.57 mg/kg).
When compared with the proposed Assessment Criteria in relation to residential use with home grown produce no determinants with levels in excess of Assessment Criteria were encountered in the natural ground on the site.</td></tr>
<tr><td>Controlled</td><td>The levels of contamination encountered on the site are not considered to pose a significant risk to</td></tr>
</table>

Waters	controlled waters. It should be noted that:- - the developed site will be between 60 and 90% positively drained hardcover which will limit the amount of rainwater percolating through the soils. - the site is underlain by relatively impermeable clays which will prevent the migration of contamination. - there are no groundwater abstractions within 428m of the site. - the site is not in a source protection zone.
Remediation Proposals	The topsoil local to TP02 and TP19 should be stockpiled for re-use in the commercial area of the site. Other topsoil stockpiled for re-use in the residential gardens should be tested to ensure levels of Di-benzo (a,h) Anthracene are below the Assessment Criteria for residential use with plenty uptake. The made ground on the site should be excavated and placed in the commercial areas. If the made ground is retained in garden areas it should be capped with 0.60m of inert capping (including 0.15m of topsoil) laid on Terram 1000. Excavated natural ground on the site can be used as fill material in all areas of the site.
Remediation Statement	Required.
Gas Protection	The development does not appear to be at risk from the migration of landfill gas onto the site as there are no known landfill sites in the surrounding area. Therefore, gas monitoring is not required on the site.
Radon	No protection measures are required on the development.
Unforeseen Circumstances	Should any areas of previously unidentified potentially contaminated soil be encountered during site construction works we would recommend consultation with CoDA Structures to ensure that the recommendations continue to apply.
Construction Works	It is recommended that construction personnel with direct contact with the soils at the site use appropriate PPE equipment (i.e. gloves and overalls) together with welfare facilities in accordance with general health and safety guidelines.
Utilities	We would recommend that a copy of the ground investigation report when available, is supplied to Utility Companies, and that their recommendations relating to appropriate supply pipes are adhered to.
Statutory Consultation	We would recommend that a copy of the ground investigation report once prepared is issued to the Local Authority for comment and approval prior to the development of the site.

14.0 CAVEATS

14.01 The comments given in this report and recommendations made are based on the information that could be obtained from reasonably accessible sources. Discussions have not yet been held with statutory bodies and the local authority.

14.02 The comments and recommendations made in this report are based on the ground conditions encountered during the site work, and on the results of laboratory testing on a selected number of samples taken in the field. There may be conditions prevailing at the site with respect to ground conditions and contamination that have not been encountered during the investigations, and which have therefore not been taken into account in this report.

14.03 This report has been prepared for the sole use of Applethwaite Ltd and their development funders, unless agreed otherwise in writing by CoDA Structures.

Signed: .....

J Lawrence B Eng C Eng M I Struct E