LITHOS

Detailed Site-Specific Risk Assessment

Land at Westgate, Cleckheaton

For Strata Homes Ltd

Report no: 3043/3

Date: December 2020

Tel: 01937 545330 • info@lithos.co.uk • www.lithos.co.uk

EXECUTIVE SUMMARY (RISK ASSESSMENT)

Job No.	3043	**Site area/ha**	6.5
Client:	Strata Homes Ltd	**NGR:**	SE 184 250
Site:	Westgate, Cleckheaton	**Nearest postcode:**	BD19 3NW

The site is located off Westgate, approximately 1km east of Cleckheaton town centre and has had a mixed industrial use including Chemical Works, Iron Rolling Mill, Textile Mill, Scrap Yard and Malt House. Numerous backfilled quarries are also present on site.

It is understood that the site is to be redeveloped with residential dwelling; a proposed layout has been provided.

Lithos were commissioned by Strata Homes Ltd to undertake a site-specific risk assessment to determine the significance of known ground contamination with respect to both human health (future site residents) and controlled waters (Blacup Beck).

Plausible contaminant linkages included potential risks to:

- Future on-site residents through volatilisation of vapours in unsaturated soils
- Migration of shallow groundwater to Blacup Beck

Remedial target concentrations for soils have been derived. These concentrations should be used as a "clean-up" criteria during the required remedial works. Remedial target concentrations assume a minimum 1,000mm clean cover in all garden and landscaped areas.

Site-specific remedial target concentrations for health should be applied to all Areas (A to D) but only to the uppermost 2m of material placed below development formation levels.

Remedial targets levels for protection of controlled waters only apply to Area A & B and only to material placed at or below 97mAOD.

Remedial target concentrations for soils

Determinand	Human health soil (mg/kg)	Human health vapour (mg/m³)	Controlled waters soil leachate (µg/L)
Naphthalene	5	9	130
Benzene	4	681	50
Methylphenol (cresol)	65,800	4,456	100
Phenol	2,870	30	46
TPH aliphatic C5-6	420	1,521,105	-
TPH aliphatic C6-8	420	702,399	-
TPH aliphatic C8-10	23	9,649	-
TPH aliphatic C10-12	23	2,024	-
TPH aromatic C5-7	156	24,804	-
TPH aromatic C7-8	9	3,581	-
TPH aromatic C8-10	5	239	-
TPH aromatic C10-12	243	2,306	-
PAH (with BaP as indictor)	-	-	0.27
Lead	-	-	14
Arsenic	-	-	50

This assessment assumes remediation will include the removal\treatment of soils that contain significant free product.

CONTENTS

APPENDICES

FOREWORD (human health and environmental risk assessment report)

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

This report has been reviewed by a Competent Person, as defined in the National Planning Policy Framework. We ensure that all projects are managed by individuals with necessary experience, relevant qualifications, and current membership of a relevant professional organisation. Records of engineers, project managers and reviewers involved in this project are maintained by us. Lithos QA/QC procedures for all our work forms an integral part of our ISO9001 accreditation and as such is regularly audited.

The report provides an assessment of human health and environmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from Lithos prior to significant revision of the development proposals.

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

The report should be read in its entirety, including all associated drawings and appendices. Lithos cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context. However, it should be noted that in order to keep the number of sheets of paper in the hard copy to a minimum, some information (e.g. laboratory test certificates) is only included within the "electronic", PDF Report on the accompanying CD.

The report represents the findings and opinions of experienced geo-environmental consultants. Lithos does not provide legal advice and the advice of lawyers may also be required.

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

Lithos reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

QUANTATIVE RISK ASSESSMENT FOR LAND AT WESTGATE, CLECKHEATON

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited (Lithos) were commissioned by Strata Homes Ltd to undertake a site-specific risk assessment (QRA) to determine the significance of known ground contamination with respect to both human health (future site residents) and controlled waters (rivers, aquifers etc).

1.1.2 Where risks are identified, Site Specific Remedial Target Concentrations will be derived; clean-up to these concentrations will mitigate potential risks.

1.1.3 Lithos have already issued the following reports:

- Preliminary Geoenvironmental Appraisal of land at Westgate, Cleckheaton. Report 3043/1, dated December 2018.
- Geoenvironmental Appraisal of land at Westgate, Cleckheaton. Report 3043/2B, dated November 2020.

1.1.4 This QRA is based on UK assumptions and uses site-specific data presented in the reports listed above. The findings of this QRA may be used to refine and\or develop an appropriate Remedial Strategy.

1.2 The proposed development

1.2.1 It is understood that consideration is being given to redevelopment of the site with a total of 200 'traditional' two/three storey domestic dwellings with associated gardens and adoptable roads and sewers.

1.2.2 A site layout has been provided 'Westgate, Cleckheaton, sketch layout', ref. 18-CL2-SEGB-WE-01 rev L, dated November 2020 which is reproduced in Drawing 3043/2 in Appendix B to this report.

1.3 Report format and limitations

1.3.1 All analytical results, exploratory hole etc logs referred to in this QRA are contained within Report 3043/2B, dated November 2020.

1.3.2 All model assumptions, procedures and any applicable guidance used in this QRA are contained within Appendix A.

1.3.3 Limitations relevant to Lithos risk assessments are described in the Foreword, which should be read in conjunction with this report. The text of the report draws specific attention to any modification to these procedures and to any other special techniques employed.

2 BACKGROUND

2.1 Site description and history

2.1.1 Site details are summarised below.

Detail	Remarks
Location	1km west of Cleckheaton town centre.
NGR	SE 184 250
Area	6.5 ha (16 acres).
Known services	Underground electric, water, BT, sewer and gas.

2.1.2 A location plan and current salient features are shown on Drawings 3043/1 and 3043/3 in Appendix B.

2.1.3 The site can be considered as **four** distinct areas; each area is shown on Drawing 3043/3. Areas are based on former land uses (described further in Site History; see Section 3 below) which still dominate the current site features.

- Area A (1.1 ha) - former chemical works in the north-west.
- Area B (1.7 ha) - former rolling mill & Wharfe Works in the south & south-west.
- Area C (2.0 ha) - former Scrap Yard, Malthouse, Brickworks and Quarry in the east.
- Area D (1.6 ha) - industrial area in the centre-north

2.1.4 Westgate Chemical Works in **Area A** (also referred to as Cleckheaton Chemical Company) was established prior to 1894 and remained on site until its closure in the 1970s. Internet searches link Westgate Chemicals with Henry Ellison Limited, predominantly involved in manufacturing dyestuffs by distillation of timber products and coal tar.

2.1.5 Anecdotal evidence also suggests that Westgate Chemical Works also made sulphuric acid, most likely via the lead chamber process which involved sulphur dioxide and nitrogen dioxide introduced as steam into large chambers lined with lead. It was also common for spent oxide, from gas works, to be used in the process.

2.1.6 Old Rolling Mill (Iron works) in **Area B** is likely to have included one or more blast furnaces to produce pig iron (or cast iron) and may have also included a number of pudding furnaces or a foundry where pig iron was further processed to form wrought iron. Furnaces were most commonly fuelled by coal.

2.1.7 Wharfe Works (textile engineering) was one of several textile mills in the area. Theses mills predominantly produced serviceable yarn from raw materials. This may have included shrinking of the yarn and dyeing.

2.1.8 An earth bund separates **Area C** from the rest of the site. Levels across Area C vary by up to 6m, with steep embankments in the south-east where land is 3m to 6m lower than adjacent land to the north & west.

2.1.9 Part of a retaining wall of the former Malthouse is still evident. Little evidence of historic activities remain, with much of the site covered with dense vegetation and small trees.

2.1.10 A former Quarry lies within of Area C but is no longer evident; the area is now covered by rough tarmac chippings.

2.1.11 The majority of central and western parts of the site were occupied by Celette (Industrial Housing) Ltd during the late 1990s, with a metal scrap yard to the east. Celette (Industrial Housings) Ltd imported drums of resins, dyes and acetone, and rolls of glass fibre, required for the manufacture of glass reinforced buildings.

2.1.12 Later, post 2000, **Area D** is recorded as Celette Industrial Estate. Multiple businesses are recorded to operate from the industrial park. These are listed below:

- Ward Fabrication- auto parts store
- Garnett Wire
- Williams Automotive Engineering- vehicle repair shop
- Lonsdale- precision engineer
- Stables Garage- vehicle repair shop, authorised for respraying of vehicles
- Wilkinson & Sons- scooter repair shop
- Angels tyres- tyre shop
- Shingleton J T & Sons- waste collection service
- IPM Workshop services- educational supply shop

2.1.13 The location of those recent industries, listed above, still operating on site are shown on Drawing 3043/3. Former building and quarry footprints are shown on Drawing 3043/4.

2.1.14 An assessment of potential contaminants associated with the former uses has been undertaken, anticipated potential contaminants, within soil and/or groundwater include:

- Areas A & B – volatile and semi volatile organics, chlorinated solvents, acids, coal tar constituents, cyanide, metals (particularly lead), asbestos and petroleum products
- Area C – metals, PAH, petroleum products (predominantly lubricating oils), asbestos, combustible Ash & Clinker
- Area D – metals, PAH, petroleum products, asbestos

2.2 Environmental setting

2.2.1 Search responses received from the Coal Authority, Landmark, the BGS and the Environment Agency have been referred to in order to assess the site's environmental setting, which is summarised below.

Issue	Summary
Geology	Drift – None recorded. Solid – Clifton Rock (Sandstone). Shallowest coal seam – 32 Yard coal at about 20m depth. Faults – none shown.
Mining	This site is located within a Coal Mining Development Low Risk Area. Past and present workings – present 100m south of site. Opencast – none recorded. Mine entries – nearest is 25m southeast of site,
Quarrying	Numerous disused quarries on site, predominantly to the south east associated with the former Brickworks. Smaller quarries recorded in the centre and north west.
Hydrogeology	Source Protection Zone? none. Secondary A Aquifer (Solid). Groundwater abstractions? None within 250m.
Hydrology	Nearest watercourse(s) – Blacup Beck along southern boundary. Joins Water Framework Directive operational catchment Spen Beck from source to River Calder approx. 1km to the east. Water quality - moderate. Pollution incidents? Nearest is category 1 incident 18m southwest, industrial effluent into surface water. Abstractions? None within 1km. Discharge consents? Nearest is 266m east, Yorkshire Water storm tank into Syke Beck.

2.3 Ground conditions

2.3.1 Ground conditions, particularly issues relevant to contamination are summarised below.

Made ground

2.3.2 Made Ground has been encountered across the entirety of **Area A** to depths of between 1.3m (TP436) and 10.7m (BH501). The made ground generally comprises granular and cohesive made ground, with some burnt shale, brickfill and filter sands.

2.3.3 Made Ground has been encountered across **Area B** to between 0.4m (TT428) and greater than 3.5m (TP524). The made ground generally comprises granular and cohesive made ground, with some ash & clinker and brickfill.

2.3.4 Made Ground has been encountered in **Area C** to between 0.8m (TP404) and 12.0m (BH504) and generally comprises granular made ground with ash & clinker.

2.3.5 Made Ground has been encountered across **Area D** to between 0.6m (TP517) and 9.0m (BH506). The made ground generally comprises granular and cohesive made ground, with some ash & clinker and brickfill.

Reservoir

2.3.6 According to historical OS plans, a former reservoir occupied an area of c. 1,000m^2, in the north-west of **Area B**. Anecdotal evidence suggests that the reservoir was associated with the chemical works rather than the former mills.

2.3.7 A total of 7 trial pits and one trial trench were advanced within and adjacent to the backfilled reservoir.

2.3.8 Major inflows of groundwater prevented deep trenching in the reservoir. Similarly, inflows of groundwater prevented the base and all extents of the reservoir being identified. However, 3rd party holes by AIG suggest the reservoir extends to depths of up to around 4m in its centre.

Natural ground

2.3.9 Natural ground was encountered in most exploratory locations across the site and generally comprised Cohesive and Granular Residual Soils (weathered bedrock).

2.3.10 Competent Coal Measures bedrock was recorded below residual soils in all areas comprising Sandstone and Mudstone.

2.3.11 Whilst not mapped, evidence of Alluvium drift deposits was recorded in the south adjacent to Blacup Beck.

Groundwater

2.3.12 Groundwater was encountered within the majority of exploratory holes excavated across Areas D and B as seepages and inflows from around 2.0m; most notably in the south (Area B).

2.3.13 Excavations in Areas A & C generally remained drier, with groundwater ingress comprising relatively minor seepages where encountered.

3 GROUND CONTAMINATION & CONCEPTUAL MODEL

3.1.1 The site has been formerly used as:

- Chemical works
- Rolling iron mill
- Textile mill
- Scrap yard
- Malthouse
- Brickworks
- Quarry
- Industrial estate with various units

3.1.2 The exact raw materials stored and used across site are unknown, although potential contaminants have been suggested based on knowledge of industrial processes and detailed in Section 2.1.14 above.

3.1.3 Targeted sampling of made ground and groundwater has confirmed the presence of metals (predominantly arsenic, lead and zinc), localised areas of petroleum products, possible tars and associated indictor compounds, as well as benzene, naphthalene and phenol.

3.1.4 Concentrations of volatile and semi-volatile organic compounds were also recorded, predominantly in Area A, although in most cases these may be attributed to leaching from coal tar. These included low levels of trimethylbenzene, tert-butylbenzene, methylnaphthalene, dibenzofuran & carbazole.

3.1.5 Extensive ground investigation has been undertaken both to assess the potential for contamination and to consider geotechnical constraints. Whilst areas of gross contamination have not been identified and concentrations of contaminants do not consistently exceed generic screening values, the ground conditions are highly variable and complicated by the degree of historic earthworks.

3.1.6 The identification of volatile organic compounds in groundwater, particularly in Area A, supports the likelihood of the presence of source material that has not yet fully been identified.

3.1.7 It is considered highly likely that these source areas will be encountered during earthworks. Therefore, this risk assessment has been developed to manage the identified risks and to be pre-emptive of anticipated source material based on previous site activities.

3.1.8 Furthermore, significant cut and fill is likely to be required to provide a suitable development platform. The depth to contamination will influence the risk to future site residents and groundwater / surface water. This risk assessment considers the effect of depth but also the potential need to move material between Areas to achieve sustainable earthworks balance.

3.1.9 The determinants considered within this assessment can be used as indictors for key sources of contamination, these include:

- **Naphthalene** is generally the most abundant single chemical in coal tar, although composition does vary depending on the type of coal. Naphthalene is also a key indicator for diesel and is used in its own right in various chemical processes. Naphthalene has been identified in Area A, but could also be a useful indicator in Area C (former scrap yard).
- **Benzene** is a natural constituent of crude oil, a key component of coal tar and an indicator for petrol. Benzene is also used in pure form in many chemical processes. In soil, benzene tends to degrade and volatilise rapidly, but once in groundwater it can be more persistent and highly mobile. Low concentrations of benzene have been identified in groundwater Area A.
- **Methylphenol** (cresol) is derived from creosote and can be used in the chemical treatment of timber. Evidence indicated that Westgate Chemicals were predominantly involved in manufacturing dyestuffs by distillation of timber products, before moving to the manufacture of sulphuric acid.
- **Phenol** (total) can be an indicator of coal tar but is also used in the chemical industry. Phenol has been identified in Area A in low concentrations.
- **Total Petroleum Hydrocarbons** (TPH) is not a single compound and can reflect numerous sources including naturally occurring hydrocarbons, coal, ash & clinker, combustion wastes. However, where speciated testing is undertaken (adopting the approach advocated by the THPCWG), TPH can identify petrol, diesel, lubricating / hydraulic oils. Speciated TPH would be a useful indicator in Area C (former scrap yard).
- **Polycyclic Aromatic Hydrocarbons** (PAH) can be a useful indicator when considering the significance of TPH in controlled waters and can support the positive identification of coal tar. Benzo(a)pyrene has been used as a marker for total PAH.
- **Leachable metals** (lead, arsenic) are a by-product of the production of sulfuric acid using lead lined chambers, thought to have been undertaken in Area A. However, lead is also an indicator of leakage from car batteries in Area C. Elevated concentrations of metals have been identified in all Areas, with highest concentrations in Area A & C.

3.1.10 The above does not represent an exhaustive list of all determinants detected during soil and groundwater sampling. However, these compounds are considered to reflect all potential sources based on plausible pathways (see below).

3.2 Plausible pathways

Health

3.2.1 Made Ground across all 4 Areas yielded elevated concentrations of a number of inorganic determinants, including arsenic, copper, lead, nickel and zinc, as well as sporadic fragments of asbestos containing materials and trace amounts of free asbestos fibres.

3.2.2 Given the volume of made ground, it would not be possible to simply isolate made ground below areas of hardstanding. Therefore, it was recommended in the Geoenvironmental Appraisal (Lithos Report 3043/2B) that a 1,000mm **soil cover**, underlain by a minimum 150mm thick "**hard dig**" layer be placed immediately beneath in all garden and landscaped areas. Alternatively, a high visibility contaminated ground warning / marker barrier, such as Lotrak Alarm18, could be placed beneath the soil cover.

3.2.3 The inclusion of a break layer and clean cover in garden and landscaped areas effectively breaks the **direct contact pathways** (ingestion, dermal contact & inhalation of dust).

3.2.4 Cyanide was also detected in Area A at very low concentrations and may indicate the use of spent oxide within the manufacture of sulphuric acid. Cyanide does not have a generic screening value as it is an acute toxin as well as a presenting long term exposure risks. However, whilst cyanide can present an exposure risk via inhalation, it is not volatile. Precautions are recommended to protect site works during earthworks and construction phase, but once made ground is isolated below the clean cover, cyanide would not present a risk to future site users.

3.2.5 With the exception of PAH and metals, the indicator compounds identified in Section 3.1.9 above are all potentially volatile and only indoor and outdoor **inhalation pathways** have been considered further within this assessment for human health.

Controlled waters

3.2.6 Based on groundwater monitoring to date, levels fluctuate across the entire site from 96mAOD to 101mAOD (see table below).

3.2.7 Historic monitoring of installations sealed in the Clifton Rock Sandstone, indicated a groundwater level of c. 90mAOD.

Groundwater level data (Lithos 2020)

Hole ID	Response zone (depth range & strata)	Groundwater body	Ground level	Rest water levels	
			mAOD	m bgl	m AoD
PH505	3.0m – 6.0m (Ash & Clinker).	No water identified	100	ND	ND
PH506	3.0m – 6.0m (Cohesive Made Ground).		99.4	ND	ND
PH507	3.0m – 6.0m (Ash & Clinker).		96.35	ND	ND
PH510	3.0m – 6.0m (Cohesive made Ground).		97.9	ND	ND
PH514	3.0m – 6.0m (Granular Made Ground).		101.55	ND	ND
PH511	3.0m – 6.0m (Ash & Clinker).	Wells destroyed	-	NR	NR
PH502	2.5m – 5.5m (Cohesive Made Ground).		92.95	NR	NR
BH504	6.0m – 12.0m (Ash & Clinker).		97.55	NR	NR
PH508	3.0m – 6.0m (Ash & Clinker).		96.35	NR	NR
BH507	1.5m – 3.0m (Granular Made Ground).	Drift Aquifer	94.75	0.46	94.29
BH508	2.2m – 2.8m (Cohesive Alluvium).		94.7	1.08	93.62
BH509	1.5m – 3.0m (Cohesive Alluvium).		94.5	1.00	93.5
PH501	6.0m – 9.0m (Sandstone).	Bedrock groundwater. (**GW1**)	100.1	5.21	94.89
PH513	3.0m – 9.0m (Sandstone).		105.25	5.1	100.15
PH515	3.0m – 9.0m (Sandstone & Mudstone).		100.85	4.68	96.17
PH518	4.5m – 7.5m (Sandstone).		100.7	5.7	95
PH520	4.5m – 7.5m (Sandstone).		97.8	2.14	95.66
BH501	4.0m – 10.0m (various made ground).	Suspected Bedrock groundwater resting in made ground (**GW1**)	100.85	4.26	96.59
PH512	1.5m – 4.5m (Granular Made Ground).		99.75	4	95.75
PH516	3.0m – 6.0m (Granular Made Ground).		101.05	4.42	96.63
PH517	1.5m – 4.5m (Granular Made Ground).		100.9	4.25	96.65
PH519	1.2m – 2.7m (Granular Made Ground).		98.35	1.28	97.07
BH502	3.0m – 6.0m (Ash & Clinker).	Suspected Bedrock groundwater (**GW2**)	96	4.41	91.59
BH503	2.8m – 8.8m (Cohesive Made Ground).		100.4	8.48	91.92
BH505	2.8m – 8.6m (Ash & Clinker).		98.9	8.24	90.66
BH506	3.0m – 9.0m (Cohesive Made Ground).		100.5	6.87	93.63
PH509	3.0m – 6.0m (Ash & Clinker).		97.15	5.71	91.44

3.2.8 Following review of current and historic data it is likely that two discrete water tables are present within the Coal Measures (GW1 & GW2).

3.2.9 Whilst the geological map indicates the entire site is directly underlain by the Clifton Rock Sandstone, exploratory logs suggest that relatively thin Sandstone bands are separated by Mudstone. The low permeable Mudstone can lead to groundwater from unconnected Sandstone bands resting at different levels. Where deep backfill lies below the top of the Coal Measures, following quarrying, groundwater is recorded within the made ground.

3.2.10 A third possible groundwater table was recorded in BH507, 508 & 509 adjacent to Blacup Beck. In all cases groundwater appears to be flowing to the south with topography.

3.2.11 Cross sections showing groundwater levels and key features on site are included as Drawing 3043/14. These cross sections indicate that:

- groundwater from **Areas A & B** (GW1) is likely to be flowing through the reservoir and discharging to the Beck, but
- that groundwater in **Areas C & D** (GW2) is unlikely to intercept Blacup Beck.

3.2.12 The Clifton Rock Sandstone is recorded as a Secondary A aquifer. However, the site is located in a densely populated urban area with a long industrial history. It is not considered likely or indeed plausible to abstract the shallow groundwater in this area as a potable supply.

3.2.13 Blacup Beck and groundwater that discharges into the Beck form part of the operational catchment for Spen Beck. Under the Water Framework Directive (WFD) Spen Beck is recorded as being of moderate quality.

3.2.14 A key objective of the WFD is to promote improvement of all water quality, and to ensure that there is no deterioration. Spen Beck catchment is considered the critical controlled waters receptor and discharge from the site to Blacup Beck the most plausible pathway.

Leachable metals

3.2.15 High concentration of metals, predominantly arsenic, lead & zinc were identified in all four areas. However, as discussed in Sections 3.2.1 to 3.2.5 above, direct contact will be mitigated by the inclusion of a clean cover system.

3.2.16 Therefore, the remaining plausible pathway relating to metal contamination is the potential for this to leach from soils and impact Spen Beck, via Blacup Beck.

3.3 Updated conceptual site model

3.3.1 With respect to the proposed end use (see Section 1.2) and the site's environmental setting, potential receptors are:

- Construction workers (when the site is being redeveloped)
- On-site residents post development
- Blacup Beck

3.3.2 Assessment of the site investigation data enabled formulation of a conceptual model, which is presented as Drawing 3043/9A in Appendix B.

3.3.3 In terms of the proposed redevelopment potential contaminant linkages are summarised below:

Receptors	Pathways	Contaminant source	Plausible contaminant linkage?
Human health (future residents) ◊	Consumption of contaminated vegetables	Metals, Hydrocarbons in the made ground	No, existing made ground in garden & landscaped areas will be isolated beneath a min. 1,000mm thickness of "clean" soil cover, plus a 150mm compacted break layer, or high viability marker.
	Ingestion		
	Inhalation (dust)		
	Dermal contact		
	Inhalation (Vapours)	Volatile organic compounds in the made ground	**Yes** – site specific screening values of indicator compounds required
	Migration & accumulation of hazardous ground gas	Methane, Carbon Dioxide in the made ground	TBC – gas monitoring is ongoing, recommendations regarding hazardous ground gas will be provided once this has been completed.
	Infiltration of water supply pipes	BTEX, Halogenated aliphatic & aromatics, Phenol, CN, Sulphate, Sulphide & Chloride in the made ground	**Yes** – Barrier pipe such as Protectaline will be required. Remedial action based on this risk assessment will not be sufficient to remove this requirement.
Blacup Beck	Migration of leachable components	Metals, Hydrocarbons in the made ground	**Yes** - site specific screening values of indicator compounds required *and* SWMP should be adopted during construction work.
	Surface water run-off		

◊ Transient risks to construction workers will be addressed by the adoption of appropriate health and safety measures in accordance with the Health and Safety at Work Act 1974, and regulations made under the Act including for example the COSHH Regulations.

3.3.4 This QRA will only consider those contaminant linkages considered plausible in the above table.

4 HUMAN HEALTH RISK ASSESSMENT

4.1 The model (CLEA)

4.1.1 Lithos have derived remedial target concentrations by using the UK Contaminated Land Exposure Assessment (CLEA) methodology, taking account of UK policy decisions, Health Criteria Values and reviewing the appropriateness of UK exposure defaults.

4.1.2 Given the proposed end use of the site, the most sensitive receptor has been deemed to be a female child resident (0-6 years old) in a ground floor building. The selection of this receptor is consistent with the UK Contaminated Land Exposure Assessment (CLEA) Model 2002 and associated guidance.

4.1.3 Human exposure assumptions and the physical parameters (such as building volume, air exchange rate, average wind speed, air mixing heights etc) have been based upon "defaults" outlined in the EA/DEFRA publication SR3 "*Updated technical background to the CLEA model*" 2009. A summary of the inputs and justifications for their use is included in Appendix A.

4.1.4 The CLEA model assumes that all pathways, other than inhalation of vapours, occur within 0.5m of ground level. Consequently, after placement of a minimum 1,000mm thick soil cover in proposed garden and landscaped areas, the only pathway of significance is vapour migration.

4.1.5 This assessment has assumed that the made ground can be best described as a clay sandy loam, based on descriptions in the exploratory logs. The properties have been assumed to be semi-detached houses based on the site layout (rather than the small, terraced houses used in the CLEA default). The increased footprint of the semi-detached house type could increase the potential vapour risk.

4.1.6 A complete turnover of made ground has been advocated across all Areas, although this may be limited to 3m in the former quarries. This turnover provides the opportunity to remove primary sources of contamination such as tanks or areas of free product. Therefore, this risk assessment has assumed a declining source term in respect to vapour migration for secondary sources (residual contamination) remaining within the soil mass.

4.1.7 With respect to TPH, only volatile fractions are included in the health assessment (C_5 to C_{12}). Further heavier fractions are considered in the controlled waters assessment. This is also the case for PAH, with the exception of naphthalene, which is included in the health assessment. PAHs with 3 or more rings are not generally considered volatile.

4.1.8 The plausibility of inhalation pathways decreases with increased depth. Therefore, only material placed in the **uppermost 2m** below the final development formation should be screened against inhalation target concentrations. Material below this depth is not considered to pose a plausible risk to end users, although consideration should be given to risks to controlled waters (see Section 5 below).

4.1.9 Further model assumptions and justifications are contained in Appendix A to this report.

4.2 Risk assessment results (health)

4.2.1 This section provides a summary of the results of the Human Health risk assessment, which are presented in full in Appendix A.

4.2.2 Under the proposed residential site use, the site-specific remedial targets for the soil volatilisation to indoor and outdoor air for each contaminant of concern are presented below.

Table 1 Site specific remedial targets for soil (volatilisation)

Determinand	Soil remedial target (mg/kg)
Naphthalene	5
Benzene	4
Methylphenol (cresol)	65,800
Phenol	2,870
TPH aliphatic C5-6	420
TPH aliphatic C6-8	420
TPH aliphatic C8-10	23
TPH aliphatic C10-12	23
TPH aromatic C5-7	156
TPH aromatic C7-8	9
TPH aromatic C8-10	5
TPH aromatic C10-12	243
TPH fractions C12 to C40	NR

NB: Values rounded to nearest decimal place

4.2.3 Concentrations of naphthalene, benzene and TPH fractions have been recorded on site in excess of the above screening values. However, this has only been in localised areas in the former Chemical Works (Area A) and the former scrap yard (Area C). Concentrations exceeding these target concentrations are also expected in the backfilled reservoir on the boundary between Area A & B.

4.2.4 During remediation works and validation sampling, careful consideration should be given to the source of any exceedances and whether determinants are likely to be in a form that is volatile, or locked within a matrix, such as coal fragments. Where concentrations exceed screening values, consideration should also be given to vapour monitoring.

4.2.5 It is envisaged that this would typically be a three-step approach:

- on site head space test using a PID, positive results
- laboratory analysis of VOCs using a head space extraction
- in-situ vapour monitoring of soils using targeted tenax absorbent tubes

4.2.6 Vapour results should be compared to the remedial targets presented in the table below

Table 2 Site specific remedial targets for soil (volatilisation)

Determinand	Soil vapour target (mg/m³)
Naphthalene	9
Benzene	681
Methylphenol (cresol)	4,456
Phenol	30
TPH aliphatic C5-6	1,521,105
TPH aliphatic C6-8	702,399
TPH aliphatic C8-10	9,649
TPH aliphatic C10-12	2,024
TPH aromatic C5-7	24,804
TPH aromatic C7-8	3,581
TPH aromatic C8-10	239
TPH aromatic C10-12	2,306
TPH fractions C12 to C40	NR

NB values represent CLEA soil vapour concentration converted from mg/cm^3

4.2.7 It should be noted that in some cases the soil vapour concentration is disproportionately high compared to the soil screening value (Aliphatic C5-6 & 6-8 are good examples). This is because the soil screening value is influenced by the volatility, solubility and the ability for compounds to absorb to soil particles, whereas the vapour target solely considers the volatility of the compound within the soil.

4.2.8 Therefore, the total allowable soil concentration in Table 1 may result in a much lower screening value than would actually present a vapour risk and this is why the option of vapour monitoring is important in the remediation design, rather than conservatively just adopting soil target concentrations.

4.2.9 Further detail on the timings and application of vapour monitoring should be included in the Remediation Strategy.

4.2.10 It is a core assumption of all detailed risk assessments that free product is not present and Lithos recognise that it is unacceptable to leave free product in the ground where redevelopment of a site is proposed.

4.2.11 Consequently, Lithos recommend that any Remediation Strategy advocates the removal\treatment of soils that contain significant free product, even if the QRA indicates the free product contaminants do not pose a significant risk.

4.2.12 In this context, significant free product would be readily identifiable by the naked eye, and pervasive throughout the soil mass, probably with noticeable seepages. Traces of free product in fissures or localised, cobble-sized pockets, would not normally be considered significant.

5 CONTROLLED WATERS ASSESSMENT

5.1 General

5.1.1 Groundwater has been identified across the site and based on current data this appears to comprise two discrete water tables in the Coal Measures (GW1 & GW2) and groundwater in the Alluvium adjacent to Blacup Beck (thought to be in continuity with GW1). Groundwater dip data and site features are shown on cross sections included on Drawing 3043/14 in Appendix B.

5.1.2 Groundwater gradients and conductivity can be highly variable in undisturbed Coal Measures, although groundwater flow tends to be with topography. Establishing site specific groundwater parameters to support a modelling assessment is even more problematic at Westgate due to extensive historic quarrying and variability in the nature of the backfill. Site based values would have a high degree of uncertainty and variability.

5.1.3 Groundwater within the Coal Measures has been discounted as a critical receptor due to Cleckheaton's industrial history and the low likelihood of groundwater being abstracted for any potable use (see Section 3.2).

5.1.4 However, review of plausible pathways, based on the available site data indicates that shallow groundwater in Areas A & B is likely to move through the infilled reservoir and have some degree of connectivity with Blacup Beck. The shallow groundwater (GW1) has been assumed to form part of Blacup Beck catchment, which feeds Spen Beck WFD operational catchment.

5.1.5 The travel distance from Areas A & B to the Beck is minimal and would not reasonably result in any significant dilution or attenuation of contaminants. Consequently, this risk assessment is qualitative.

5.1.6 Therefore, it is proposed that the freshwater maximum allowable concentrations as agreed under Water Framework Directive are applied to the indicator compounds as a leachate concentration for soils placed at or below 97mAOD in **Areas A & B** only. Controlled waters targets are not considered necessary in Areas C & D as there is no plausible pathway to the Beck.

5.1.7 A complete turnover of made ground has been advocated in Area A & B (beyond the very deep quarry backfill in the far north of Area A). This turnover provides the opportunity to remove primary sources of contamination such as tanks or areas of free product which are anticipated in the former Chemical Works and backfilled reservoir. As a minimum the reservoir should be excavated to its full extent and backfilled with material meeting the recommended target concentrations.

5.1.8 Significantly elevated metals (predominately lead and arsenic) were recorded in Area A, and to a lesser extent Area B. These are most likely associated with the production of sulphuric acid using lead lined chambers. Whilst not included in health remedial targets, these are important indicators for controlled waters.

5.2 Site screening values (waters)

5.2.1 The table below summarises **soil** target concentrations to be protective of Blacup Beck.

Determinand	Soil leachate target (µg/L)
Naphthalene	130
Benzene	50
*Methylphenol (cresol)	100
Phenol	46
PAH (with BaP as indictor)	0.27
Lead	14
Arsenic	50

NB values are based on UK maximum allowable concentrations

* value taken from EU registration dossier as no UK agreed value

6 UNCERTAINTIES

6.1 Human Health

6.1.1 The critical exposure pathway to end users via **inhalation** is highly dependent on the fraction of organic carbon, gas flow rate and the permeability of soils. The made ground is highly heterogenous and therefore allocating a single organic carbon content or soil physical property will always increase the uncertainty in the risk assessment.

6.1.2 This has been managed by remaining conservative on other assumptions regarding the nature of the ground, most specifically assuming contamination is present throughout the entirety of the uppermost 2m of made ground.

6.1.3 The depth to contamination has also been assumed to be directly below the building and spread evenly through the uppermost 2m, although a declining source term has also been assumed given the degree of remediation proposed. Remediation should remove areas of gross contamination and these were not identified across all 4 Areas. However, assuming contamination is consistently present also takes account of uncertainty in the final cut and fill design, which is not yet available.

6.1.4 It may be reasonable once cut and fill design is finalised to consider more refined zoning of the site.

6.2 Controlled Waters

6.2.1 Depth to groundwater has been estimated based on available site data. However the groundwater table and fluctuation is likely to be heavily influenced by localised areas of cohesive made ground, particularly in deep former quarries. If during earthworks the groundwater table is considered to be significantly higher, or lower, than that assumed, remedial targets may need revisiting.

6.2.2 Remedial targets for controlled waters are particularly low given the very short travel distance to Blacup Beck. Whilst these targets have not consistently been exceeded in groundwater or surface water samples to date, consideration should be given to the practical application of such low targets and whether these can be achieved through remediation.

6.3 General

6.3.1 Indicator determinants have been selected based on currently available site data. These should remain under review during remediation if areas of unexpected contamination are identified, or where indicators do not adequately represent an area of gross contamination. In such cases further risk assessment should be undertaken to derive suitable remedial values.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1.1 A Quantitative Risk Assessment (QRA) has been undertaken to assess the risks posed by ground contamination to future site residents and a qualitative assessment undertaken for controlled waters.

7.1.2 Plausible contaminant linkages include potential risks to:

- Future on-site residents through volatilisation of vapours in unsaturated soils
- Migration of shallow groundwater to Blacup Beck

7.1.3 Remedial target concentrations for soils have been derived. These concentrations should be used as a "clean-up" criteria during the required remediation works.

7.1.4 Site-specific remedial target concentrations for health should be applied to all Areas (A to D) but only to the uppermost 2m of material placed below development formation levels.

7.1.5 Remedial targets levels for protection of controlled waters only apply to Area A & B (as shown on Drawing 3043/3) and only to material placed at or below 97mAOD.

Remedial target concentrations for soils

Determinand	Human health soil (mg/kg)	Human health vapour (mg/m³)	Controlled waters soil leachate (µg/L)
Naphthalene	5	9	130
Benzene	4	681	50
Methylphenol (cresol)	65,800	4,456	100
Phenol	2,870	30	46
TPH aliphatic C5-6	420	1,521,105	-
TPH aliphatic C6-8	420	702,399	-
TPH aliphatic C8-10	23	9,649	-
TPH aliphatic C10-12	23	2,024	-
TPH aromatic C5-7	156	24,804	-
TPH aromatic C7-8	9	3,581	-
TPH aromatic C8-10	5	239	-
TPH aromatic C10-12	243	2,306	-
PAH (with BaP as indictor)	-	-	0.27
Lead	-	-	14
Arsenic	-	-	50

7.1.6 Lithos recommend that any Remediation Strategy advocates the removal\treatment of soils that contain significant free product. This is because all risk assessment models assume there is no free product so do not accurately consider the risk and free product is considered a primary source of contamination, i.e. it will not degrade rapidly, if at all and allows a continued loading of contamination to soil and groundwater.

7.1.7 In this context, significant free product would be readily identifiable to the naked eye, and pervasive throughout the soil mass, probably with noticeable seepages. Traces of free product in fissures or localised, cobble-sized pockets, would not normally be considered significant.

7.1.8 It is understood that Blacup Beck will be diverted as part of the development. However, the travel distance from Areas A & B to the Beck is minimal and would not reasonably result in any significant dilution or attenuation of contaminants.

7.1.9 Details of the diversion are not known, but it has been assumed that this would not result in large sections of the Beck being placed in culvert as this is usually discouraged to increase the habitat potential of the water course. If it transpires that the Beck is being placed in closed culvert, the potential risk from, and interaction with, groundwater should be revisited.

7.1.10 Surface water sampling, both up and down gradient has been undertaken on three occasions. No elevated concentrations of determinants were recorded during any sampling round, suggesting a low mobility of site contamination.

7.1.11 However, site preparatory earthworks and remediation can result in mobilisation of contamination either via groundwater flow or sediment discharge. It is recommended that a Surface Water Management Plan be developed and fully implemented, having due regard to this risk assessment, before any earthworks start on site.

7.1.12 It is strongly recommended that a cut and fill drawing is developed prior to preparation of a Remediation Strategy to ensure detailed site-specific recommendations are included.

7.1.13 Finally, elevated concentrations of elemental sulphur were recorded in Area A and given the likely production of sulphuric acid, higher concentrations are anticipated. Whilst Sulphur has not been considered as a health or controlled waters risk, it will oxidise rapidly to sulphate and this can influence concrete mixes. The potential for particularly high sulphate concentrations should be considered further in the Remediation Strategy.

Appendix A

General notes, input and output parameters

Q2 - General Note

Contaminated Land Exposure Assessment (CLEA) Model

Created by the EA

The UK Environment Agency in conjunction with DEFRA to consider the risks posed to human health from soil contamination.

How it works and general assumptions

CLEA is a probabilistic computer model. This means that, for certain parameters (eg body weight, total body surface areas, respriation rate and daily vegetable consumption rate), a value is selected from a range, rather than using a single number. CLEA should be used in conjunction with the DEFRA/Environment Agency Science Report SR3 and SR4, published 2009, which provides the technical and scientific basis, and algorithms that underpin CLEA. CLEA can be used to derive Soil Guideline Value's (SGV's) and has been undated to refect the generic conceptual models adopted in the Defra C4SL project, published 2015.

CLEA can be run in generic mode to calculate a screening value (similar to an SGV) using conservative, default assumptions.

CLEA can also be run in site-specific mode to derive target concentrations, against which actual site concentrations can be compared, in order to determine whether or not remedial action is required. Where remediation is required, the site-specific target concentrations can be used as "clean-up" criteria.

When run in site-specific mode, maximum permissible target concentrations can be calculated under site-specific conditions without the need for input of maximum recorded site concentrations.

Intended uses

CLEA is consistent with current UK legislation and guidance for assessing risks to human health from soil contamination.

Limitations

The available site-specific refinements that can be made within the model are limited. The model only considers the impacts on human receptors within a number of land use scenarios, and via a total of nine exposure pathways. However, pathways can be selected as required depending on the Conceptual Site Model, and desired end use.

CLEA only considers the effects on receptors situated above the source zone; it will not consider off-site receptors.

This Report

For the purposes of the risk assessment outlined in the main body of text for this Report, Lithos have run the CLEA model using available site-specific data. Details of the input parameters used, where these deviate from default assumptions, including a contaminant inventory, assumptions and uncertainties, are included in CLEA report below.

CLEA Software Version 1.071

Report generated 16/12/2020

Report title Westgate, Cleakheaton

Created by Liz Hart at Lithos

BASIC SETTINGS

Land Use Residential without produce (C4SL)

Building Semi-detached house
Receptor Female (res C4SL) Start age class 1 End age class 6 Exposure Duration 6 years
Soil Sandy clay loam

Exposure Pathways

Direct soil and dust ingestion	✖	Dermal contact with indoor dust	✖	Inhalation of indoor dust	✖
Consumption of homegrown produce	✖	Dermal contact with soil	✖	Inhalation of soil dust	✖
Soil attached to homegrown produce	✖			Inhalation of indoor vapour	✓
				Inhalation of outdoor vapour	✓

Environment Agency

Land Use Residential without produce (C4SL) **Receptor** Female (res C4SL)

Age Class	Exposure Frequencies (days yr^{-1})						Occupation Periods (hr day^{-1})		Soil to skin adherence factors (mg cm^{2})		Direct soil ingestion rate (g day^{-1})	Body weight (kg)	Body height (m)	Inhalation rate (m^{3} day^{-1})	Max exposed skin factor		Total skin area (m^{2})
	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with indoor dust	Dermal contact with soil	Inhalation of dust and vapour, indoor	Inhalation of dust and vapour, outdoor	Indoors	Outdoors	Indoor	Outdoor					Indoor (m^{2} m^{-2})	Outdoor (m^{2} m^{-2})	
1	180	0	180	170	365	365	23.0	1.0	0.06	0.10	0.10	5.60	0.7	5.4	0.32	0.26	3.43E-01
2	365	0	365	170	365	365	23.0	1.0	0.06	0.10	0.10	9.80	0.8	8.0	0.33	0.26	4.84E-01
3	365	0	365	170	365	365	23.0	1.0	0.06	0.10	0.10	12.70	0.9	8.9	0.32	0.25	5.82E-01
4	365	0	365	170	365	365	23.0	1.0	0.06	0.10	0.10	15.10	0.9	10.1	0.35	0.28	6.36E-01
5	365	0	365	170	365	365	19.0	1.0	0.06	0.10	0.10	16.90	1.0	10.1	0.35	0.28	7.04E-01
6	365	0	365	170	365	365	19.0	1.0	0.06	0.10	0.10	19.70	1.1	10.1	0.33	0.26	7.94E-01
7	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	22.10	1.2	12.0	0.22	0.15	8.73E-01
8	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	25.30	1.2	12.0	0.22	0.15	9.36E-01
9	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	27.50	1.3	12.0	0.22	0.15	1.01E+00
10	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	31.40	1.3	12.0	0.22	0.15	1.08E+00
11	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	35.70	1.4	12.0	0.22	0.14	1.19E+00
12	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	41.30	1.4	15.2	0.22	0.14	1.29E+00
13	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	47.20	1.5	15.2	0.22	0.14	1.42E+00
14	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	51.20	1.6	15.2	0.22	0.14	1.52E+00
15	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	56.70	1.6	15.2	0.21	0.14	1.60E+00
16	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	59.00	1.6	15.2	0.21	0.14	1.63E+00
17	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	70.00	1.6	15.7	0.33	0.27	1.78E+00
18	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	70.90	1.6	13.6	0.33	0.27	1.80E+00

Consumption Rates

Environment Agency

Consumption rates (g FW kg^{-1} bodyweight day^{-1}) by Produce Group

	MEAN RATES						90TH PERCENTILE RATES					
Age Class	Green veg	Root veg	Tuber veg	Herb. Fruit	Shrub fruit	Tree fruit	Green veg	Root veg	Tuber veg	Herb. Fruit	Shrub fruit	Tree fruit
1	3.47E+00	5.22E+00	9.22E+00	8.90E-01	1.07E+00	1.87E+00	7.12E+00	1.07E+01	1.60E+01	1.83E+00	2.23E+00	3.82E+00
2	3.34E+00	1.61E+00	3.14E+00	1.93E+00	2.60E-01	5.84E+00	5.87E+00	2.83E+00	6.60E+00	3.39E+00	4.60E-01	1.03E+01
3	3.34E+00	1.61E+00	3.14E+00	1.93E+00	2.60E-01	5.84E+00	5.87E+00	2.83E+00	6.60E+00	3.39E+00	4.60E-01	1.03E+01
4	3.34E+00	1.61E+00	3.14E+00	1.93E+00	2.60E-01	5.84E+00	5.87E+00	2.83E+00	6.60E+00	3.39E+00	4.60E-01	1.03E+01
5	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
6	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
7	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
8	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
9	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
10	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
11	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
12	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
13	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
14	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
15	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
16	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
17	1.26E+00	6.00E-01	1.18E+00	6.90E-01	9.00E-02	1.27E+00	2.36E+00	1.12E+00	2.35E+00	1.29E+00	1.80E-01	2.38E+00
18	1.35E+00	6.40E-01	1.25E+00	7.40E-01	1.00E-01	1.36E+00	2.34E+00	1.12E+00	2.36E+00	1.28E+00	1.80E-01	2.37E+00

Top 2 applied? Yes

Where top 2 method is applied, two produce categories use 90th percentile rates, while the remainder use the mean. Produce categories vary on a chemical-by-chemical basis. Where top 2 method is not used, all produce categories for all chemicals assume 90th percentile rates.

Building Semi-detached house

Soil Sandy clay loam

Environment Agency

Building footprint (m^2)	4.30E+01
Living space air exchange rate (hr^{-1})	5.00E-01
Living space height (above ground, m)	4.80E+00
Living space height (below ground, m)	0.00E+00
Pressure difference (soil to enclosed space, Pa)	3.10E+00
Foundation thickness (m)	1.50E-01
Floor crack area (cm^2)	5.25E+02
Dust loading factor ($\mu g\ m^{-3}$)	5.00E+01

Porosity, Total ($cm^3\ cm^{-3}$)	5.30E-01
Porosity, Air-Filled ($cm^3\ cm^{-3}$)	1.60E-01
Porosity, Water-Filled ($cm^3\ cm^{-3}$)	3.70E-01
Residual soil water content ($cm^3\ cm^{-3}$)	1.50E-01
Saturated hydraulic conductivity ($cm\ s^{-1}$)	2.37E-03
van Genuchten shape parameter *m* (dimensionless)	3.10E-01
Bulk density ($g\ cm^{-3}$)	1.20E+00
Threshold value of wind speed at 10m ($m\ s^{-1}$)	7.20E+00
Empirical function (F_x) for dust model (dimensionless)	1.22E+00
Ambient soil temperature (K)	2.83E+02
Soil pH	7.00E+00
Soil Organic Matter content (%)	1.00E+00
Fraction of organic carbon ($g\ g^{-1}$)	5.80E-03
Effective total fluid saturation (unitless)	5.79E-01
Intrinsic soil permeability (cm^2)	3.16E-08
Relative soil air permeability (unitless)	5.78E-01
Effective air permeability (cm^2)	1.83E-08

Environment Agency

Soil - Vapour Model

Depth to top of source (no building) (cm)	**100**
Depth to top of source (beneath building) (cm)	65
Default soil gas ingress rate?	**No**
Soil gas ingress rate ($cm^3\ s^{-1}$)	1.06E+01
Building ventilation rate ($cm^3\ s^{-1}$)	2.87E+04
Averaging time surface emissions (yr)	6
Finite vapour source model?	**Yes**
Thickness of contaminated layer (cm)	200

Air Dispersion Model

Mean annual windspeed at 10m ($m\ s^{-1}$)	5.00
Air dispersion factor at height of 0.8m *	2400.00
Air dispersion factor at height of 1.6m *	0.00
Fraction of site cover ($m^2\ m^{-2}$)	0.75

* Air dispersion factor in $g\ m^{-2}\ s^{-1}$ per $kg\ m^{-3}$

Soil - Plant Model

	Dry weight conversion factor	Homegrown fraction Average	Homegrown fraction High	Soil loading factor	Preparation correction factor
	$g\ DW\ g^{-1}\ FW$	dimensionless		$g\ g^{-1}\ DW$	dimensionless
Green vegetables	0.096	0.05	0.33	1.00E-03	2.00E-01
Root vegetables	0.103	0.06	0.40	1.00E-03	1.00E+00
Tuber vegetables	0.210	0.02	0.13	1.00E-03	1.00E+00
Herbaceous fruit	0.058	0.06	0.40	1.00E-03	6.00E-01
Shrub fruit	0.166	0.09	0.60	1.00E-03	6.00E-01
Tree fruit	0.157	0.04	0.27	1.00E-03	6.00E-01

Gardener type None

CLEA Software Version 1.071

Report generated	16-Dec-20
Report title	Westgate, Cleakheaton
Created by	Liz Hart at Lithos

RESULTS

Environment Agency

		Assessment Criterion (mg kg^{-1})			Ratio of ADE to HCV			Saturation Limit (mg kg^{-1})	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
1	Naphthalene	NR	5.35E+00	NR	0.00	1.00	NR	7.70E+01 (sol)	No	No	Yes	No	No	No	No	No	No
2	Benzene (C4SL child)	NR	4.20E+00	4.20E+00	0.00	1.00	1.00	1.27E+03 (sol)	No	No	Yes	No	Yes	No	No	No	Yes
3	m-Cresol	NR	6.58E+04	NR	0.00	1.00	NR	1.99E+04 (sol)	No	No	Yes	No	No	No	No	No	No
4	Phenol	NR	2.87E+03	2.87E+03	0.00	1.00	1.00	4.36E+04 (vap)	No	No	Yes	No	No	No	No	No	No
5	ALIPHATIC C5-C6	NR	4.20E+02	4.20E+02	0.00	1.00	1.00	3.42E+02 (sol)	No	No	Yes	No	No	No	No	No	No
6	ALIPHATIC C6-C8	NR	4.20E+02	4.20E+02	0.00	1.00	1.00	1.63E+02 (sol)	No	No	Yes	No	No	No	No	No	No
7	ALIPHATIC C8-C10	NR	2.29E+01	2.29E+01	0.00	1.00	1.00	8.37E+01 (sol)	No	No	Yes	No	No	No	No	No	No
8	ALIPHATIC C10-C12	NR	2.29E+01	2.29E+01	0.00	1.00	1.00	5.01E+01 (sol)	No	No	Yes	No	No	No	No	No	No
9	AROMATIC C5-C7	NR	1.56E+02	1.56E+02	0.00	1.00	1.00	4.25E+02 (vap)	No	No	Yes	No	No	No	No	No	No
10	AROMATIC C7-C8	NR	9.11E+00	9.11E+00	0.00	1.00	1.00	5.27E+02 (vap)	No	No	Yes	No	No	No	No	No	No
11	AROMATIC C8-C10	NR	4.56E+00	4.56E+00	0.00	1.00	1.00	6.22E+02 (sol)	No	No	Yes	No	No	No	No	No	No
12	AROMATIC C10-C12	NR	2.43E+02	2.43E+02	0.00	1.00	1.00	3.72E+02 (sol)	No	No	Yes	No	No	No	No	No	No
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	

Environment Agency

	Assessment Criterion (mg kg^{-1})			Ratio of ADE to HCV			Saturation Limit (mg kg^{-1})	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
	oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
21																
22																
23																
24																
25																
26																
27																
28																
29																
30																

Environment Agency

		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
		%	%	%	%	mg kg^{-1}	mg m^{-3}	mg kg^{-1}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW
1	Naphthalene	92.4	7.6	0.0	100.0	5.35E+00	8.71E+00	NA	NA	NA	1.06E-03	2.25E-07	0.00E+00	NA	NA	NA	NA	NA	NA
2	Benzene (C4SL child)	54.8	43.1	2.2	100.0	4.20E+00	6.81E+02	NA	NA	NA	5.08E-03	2.00E-05	0.00E+00	NA	NA	NA	NA	NA	NA
3	m-Cresol	68.4	31.6	0.0	100.0	6.58E+04	4.46E+03	NA	NA	NA	1.54E+00	3.14E-03	0.00E+00	NA	NA	NA	NA	NA	NA
4	Phenol	61.0	39.0	0.0	100.0	2.87E+03	3.03E+01	NA	NA	NA	1.17E-02	1.26E-04	0.00E+00	NA	NA	NA	NA	NA	NA
5	ALIPHATIC C5-C6	48.5	3.2	48.3	100.0	4.20E+02	1.52E+06	NA	NA	NA	7.99E+00	2.22E-03	0.00E+00	NA	NA	NA	NA	NA	NA
6	ALIPHATIC C6-C8	76.7	1.0	22.3	100.0	4.20E+02	7.02E+05	NA	NA	NA	7.99E+00	2.22E-03	0.00E+00	NA	NA	NA	NA	NA	NA
7	ALIPHATIC C8-C10	94.2	0.2	5.6	100.0	2.29E+01	9.65E+03	NA	NA	NA	4.35E-01	1.21E-04	0.00E+00	NA	NA	NA	NA	NA	NA
8	ALIPHATIC C10-C12	98.8	0.0	1.2	100.0	2.29E+01	2.02E+03	NA	NA	NA	4.35E-01	1.21E-04	0.00E+00	NA	NA	NA	NA	NA	NA
9	AROMATIC C5-C7	77.7	20.2	2.1	100.0	1.56E+02	2.48E+04	NA	NA	NA	1.73E-01	6.44E-04	0.00E+00	NA	NA	NA	NA	NA	NA
10	AROMATIC C7-C8	53.0	41.7	5.2	100.0	9.11E+00	3.58E+03	NA	NA	NA	1.73E-01	4.81E-05	0.00E+00	NA	NA	NA	NA	NA	NA
11	AROMATIC C8-C10	96.1	3.2	0.7	100.0	4.56E+00	2.39E+02	NA	NA	NA	8.67E-02	2.41E-05	0.00E+00	NA	NA	NA	NA	NA	NA
12	AROMATIC C10-C12	97.8	2.1	0.1	100.0	2.43E+02	2.31E+03	NA	NA	NA	8.67E-02	1.28E-03	0.00E+00	NA	NA	NA	NA	NA	NA
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			

Environment Agency

	Soil Distribution				Media Concentrations													
	Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg^{-1}	mg m^{-3}	mg kg^{-1}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW
21																		
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		

Environment Agency

		Average Daily Exposure (mg kg^{-1} bw day^{-1})							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Naphthalene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-04	3.94E-04	1.70E-04	0.00	0.00	0.00	0.00	80.26	0.00	0.00	19.74
2	Benzene (C4SL child)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.98	0.02	0.00	0.00
3	m-Cresol	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.99	0.01	0.00	0.00
4	Phenol	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.58E-03	1.97E-02	2.42E-03	0.00	0.00	0.00	0.00	75.72	0.04	0.00	24.25
5	ALIPHATIC C5-C6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.19E+00	5.63E-02	6.37E-02	0.00	0.00	0.00	0.00	98.79	0.00	0.00	1.21
6	ALIPHATIC C6-C8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.19E+00	5.63E-02	6.37E-02	0.00	0.00	0.00	0.00	98.79	0.00	0.00	1.21
7	ALIPHATIC C8-C10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.83E-01	1.13E-03	3.46E-03	0.00	0.00	0.00	0.00	98.79	0.00	0.00	1.21
8	ALIPHATIC C10-C12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.83E-01	1.13E-03	3.46E-03	0.00	0.00	0.00	0.00	98.79	0.00	0.00	1.21
9	AROMATIC C5-C7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-01	2.25E-03	1.39E-03	0.00	0.00	0.00	0.00	98.76	0.02	0.00	1.22
10	AROMATIC C7-C8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-01	2.25E-03	1.39E-03	0.00	0.00	0.00	0.00	98.78	0.00	0.00	1.22
11	AROMATIC C8-C10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.63E-02	4.50E-04	6.67E-04	0.00	0.00	0.00	0.00	98.83	0.00	0.00	1.17
12	AROMATIC C10-C12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.63E-02	4.50E-04	6.67E-04	0.00	0.00	0.00	0.00	98.76	0.07	0.00	1.17
13																
14																
15																
16																
17																
18																
19																
20																

Environment Agency

	Average Daily Exposure (mg kg^{-1} bw day^{-1})							Distribution by Pathway (%)							
	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															

Environment Agency

		Oral Health Criteria Value ($\mu g\ kg^{-1}\ BW\ day^{-1}$)		Inhalation Health Criteria Value ($\mu g\ kg^{-1}\ BW\ day^{-1}$)		Oral Mean Daily Intake ($\mu g\ day^{-1}$)	Inhalation Mean Daily Intake ($\mu g\ day^{-1}$)	Air-water partition coefficient ($K_{s,w}$) ($cm^3\ cm^{-3}$)	Coefficient of Diffusion in Air ($m^2\ s^{-1}$)	Coefficient of Diffusion in Water ($m^2\ s^{-1}$)	log K_{oc} ($cm^3\ g^{-1}$)	log K_{ow} (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor ($g\ g^{-1}$ DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
1	Naphthalene	TDI	20	TDI	0.86	7	2.8	6.60E-03	6.50E-06	5.16E-10	2.81	3.34	0.13	0.5	1	1	1
2	Benzene (C4SL child)	ID	0.57	ID	3.3	NR	NR	1.16E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
3	m-Cresol	TDI	500	TDI	1000	0	0	6.60E-05	7.40E-06	8.30E-10	2.06	2.06	0.1	0.5	1	1	1
4	Phenol	TDI	700	TDI	10	350	40	8.35E-06	7.90E-06	6.36E-10	1.92	1.48	0.3	0.5	1	1	1
5	ALIPHATIC C5-C6	TDI	5000	TDI	5257	1000	1051	3.44E+01	1.00E-03	1.00E-06	2.9	3.3	0.1	0.5	10	1	1
6	ALIPHATIC C6-C8	TDI	5000	TDI	5257	1000	1051	5.03E+01	1.00E-03	1.00E-06	3.6	4	0.1	0.5	10	1	1
7	ALIPHATIC C8-C10	TDI	100	TDI	286	20	57	8.22E+01	1.00E-03	1.00E-06	4.5	4.8	0.1	0.5	10	1	1
8	ALIPHATIC C10-C12	TDI	100	TDI	286	20	57	1.31E+02	1.00E-03	1.00E-06	5.4	5.6	0.1	0.5	10	1	1
9	AROMATIC C5-C7	TDI	200	TDI	114	40	23	2.43E-01	7.78E-06	5.88E-10	2.31	2.73	0.1	0.5	10	1	1
10	AROMATIC C7-C8	TDI	200	TDI	114	40	23	2.91E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
11	AROMATIC C8-C10	TDI	40	TDI	57	8	11	5.02E-01	1.00E-03	1.00E-06	3.2	3.1	0.1	0.5	10	1	1
12	AROMATIC C10-C12	TDI	40	TDI	57	8	11	1.41E-01	1.00E-03	1.00E-06	3.4	3.5	0.1	0.5	10	1	1
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	

Environment Agency

	Oral Health Criteria Value (µg kg^{-1} BW day^{-1})		Inhalation Health Criteria Value (µg kg^{-1} BW day^{-1})		Oral Mean Daily Intake (µg day^{-1})	Inhalation Mean Daily Intake (µg day^{-1})	Air-water partition coefficient ($K_{s,w}$) (cm^3 cm^{-3})	Coefficient of Diffusion in Air (m^2 s^{-1})	Coefficient of Diffusion in Water (m^2 s^{-1})	log K_{oc} (cm^3 g^{-1})	log K_{ow} (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor (g g^{-1} DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
21																
22																
23																
24																
25																
26																
27																
28																
29																
30																

Environment Agency

		Soil-to-water partition coefficient ($cm^3\ g^{-1}$)	Vapour pressure (Pa)	Water solubility ($mg\ L^{-1}$)	Soil-to-plant concentration factor for green vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for root vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tree fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)
1	Naphthalene	3.74E+00	2.31E+00	1.90E+01	model	model	model	model	model	model
2	Benzene (C4SL child)	3.92E-01	6.24E+03	1.78E+03	model	model	model	0.00E+00	0.00E+00	model
3	m-Cresol	6.66E-01	4.27E+01	2.04E+04	model	model	model	model	model	model
4	Phenol	4.82E-01	1.15E+01	8.41E+04	model	model	model	0.00E+00	0.00E+00	model
5	ALIPHATIC C5-C6	4.61E+00	3.60E+04	3.60E+01	model	model	model	model	model	model
6	ALIPHATIC C6-C8	2.31E+01	6.40E+03	5.40E+00	model	model	model	model	model	model
7	ALIPHATIC C8-C10	1.83E+02	6.40E+02	4.30E-01	model	model	model	model	model	model
8	ALIPHATIC C10-C12	1.46E+03	6.53E+01	3.40E-02	model	model	model	model	model	model
9	AROMATIC C5-C7	1.18E+00	1.73E+03	5.90E+02	model	model	model	model	model	model
10	AROMATIC C7-C8	3.92E-01	6.24E+03	1.78E+03	model	model	model	model	model	model
11	AROMATIC C8-C10	9.19E+00	6.40E+02	6.50E+01	model	model	model	model	model	model
12	AROMATIC C10-C12	1.46E+01	6.40E+01	2.50E+01	model	model	model	model	model	model
13										
14										
15										
16										
17										
18										
19										
20										

Environment Agency

	Soil-to-water partition coefficient ($cm^3\ g^{-1}$)	Vapour pressure (Pa)	Water solubility ($mg\ L^{-1}$)	Soil-to-plant concentration factor for green vegetables ($mg\ g^{-1}$ plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for root vegetables ($mg\ g^{-1}$ plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tuber vegetables ($mg\ g^{-1}$ plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for herbaceous fruit ($mg\ g^{-1}$ plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for shrub fruit ($mg\ g^{-1}$ plant DW or FW basis over $mg\ g^{-1}$ DW soil)	Soil-to-plant concentration factor for tree fruit ($mg\ g^{-1}$ plant DW or FW basis over mg g^{-1} DW soil)
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

Appendix B

Drawings

LITHOS CONSULTING
info@lithos.co.uk
www.lithos.co.uk
Tel 01937 545330

CLIENT	STRATA
JOB TITLE	WESTGATE, CLECKHEATON
DRAWING TITLE	SITE LOCATION PLAN
DRAWN	GLM
DATE	23/11/2020
CHECKED	ASw
DATE	23/11/2020
STATUS	FOR COMMENT ☐ DRAFT ☐ FOR APPROVAL ☐ FINAL ☑
SCALE	1:25,000
SHEET	A4
DRAWING NO.	3043/1
REVISION	

NOTES

APPROXIMATE SITE BOUNDARY

REPRODUCED FROM STRATA HOMES' DRAWING 'WESTGATE, CLECKHEATON, BD12 5HT, PLANNING LAYOUT' REF. 18-CL2-SEGB-WE-01 rev. L, DATED 16 NOVEMBER 2020

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

STRATA

JOB TITLE

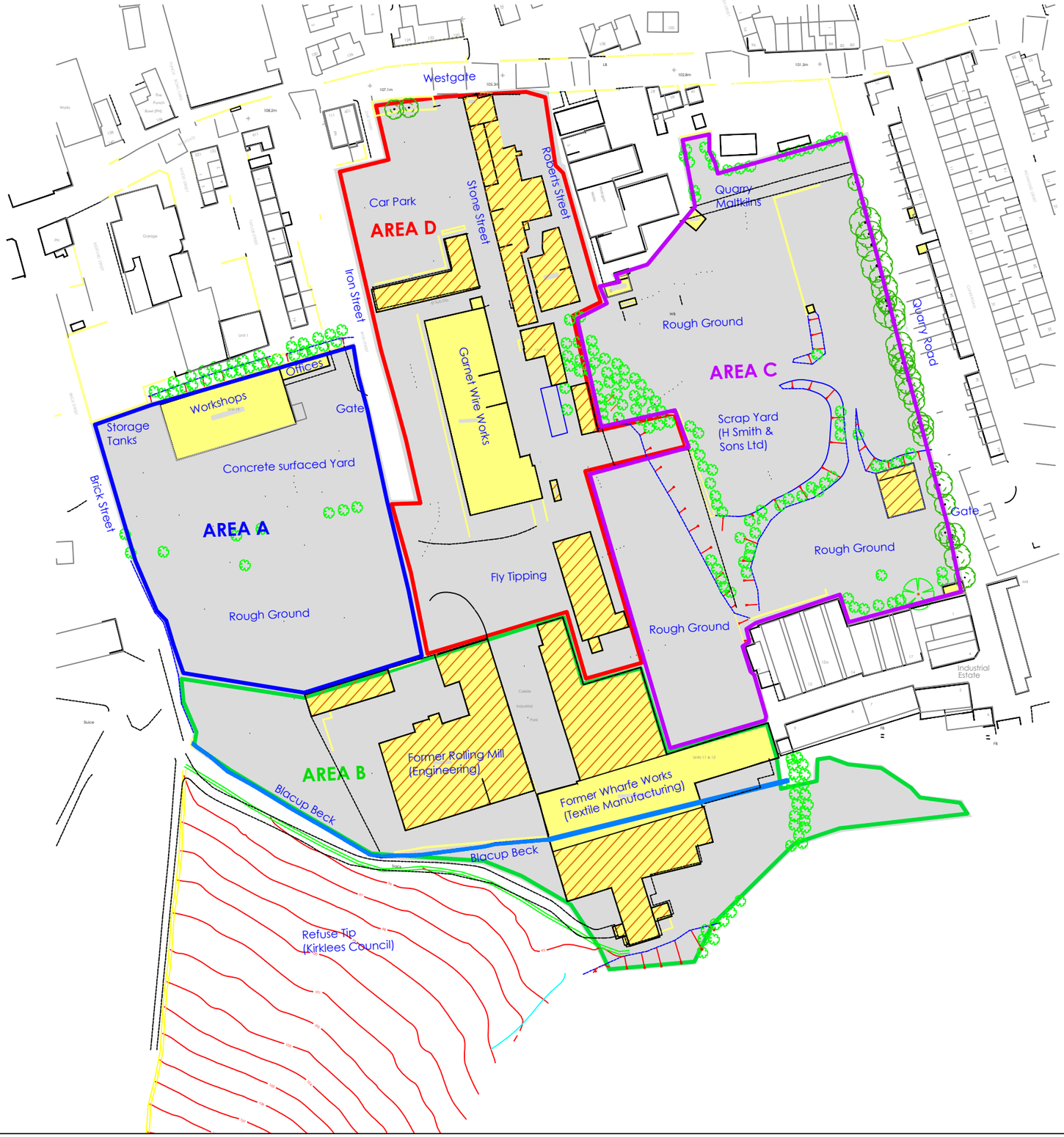
WESTGATE, CLECKHEATON

DRAWING TITLE

PROPOSED SITE LAYOUT

DRAWN	DATE	STATUS
GLM	23/11/2020	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	23/11/2020	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:1,250	A3	3043/2	



NOTES

- EXISTING BUILDING
- CONCRETE HARDSTAND (FORMER BUILDING FOOTPRINT)
- EXTERNAL SURFACING (CONCRETE HARDSTAND/TARMAC/ ROUGH GROUND)

REV.	DESCRIPTION	DATE
A	UPDATE OF SITE FEATURES & CONDITION	23/11/2020

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

STRATA

JOB TITLE

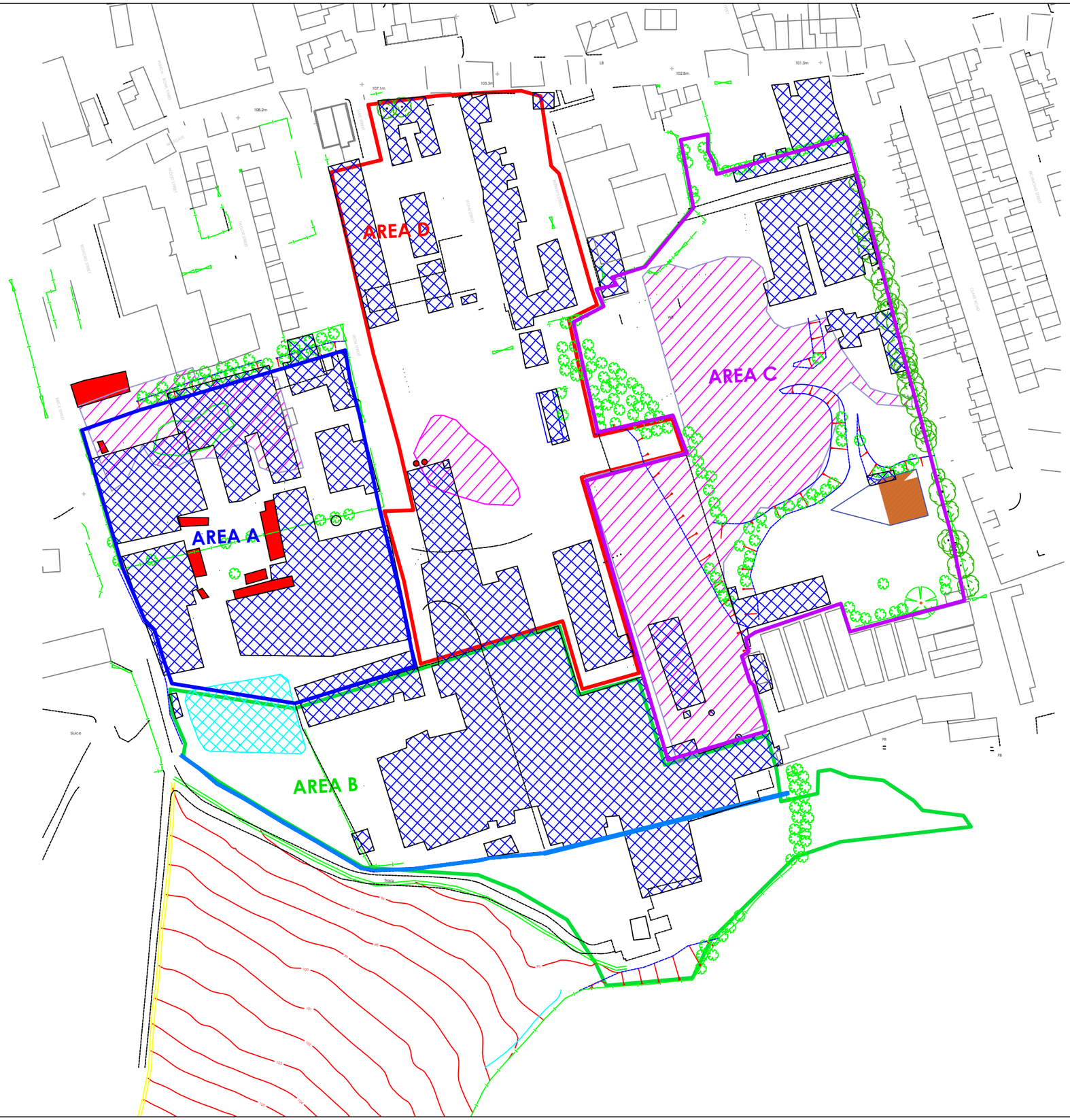
WESTGATE, CLECKHEATON

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
GLM	23/11/2020	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	23/11/2020	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:1500	A3	3043/3	A



NOTES

- FORMER QUARRY FOOTPRINT (1894 - 1938)
- FORMER BUILDING FOOTPRINT (1938)
- FORMER RESERVOIR FOOTPRINT (1938)
- APPROXIMATE LOCATION OF FORMER TANKS (1938)

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

STRATA

JOB TITLE

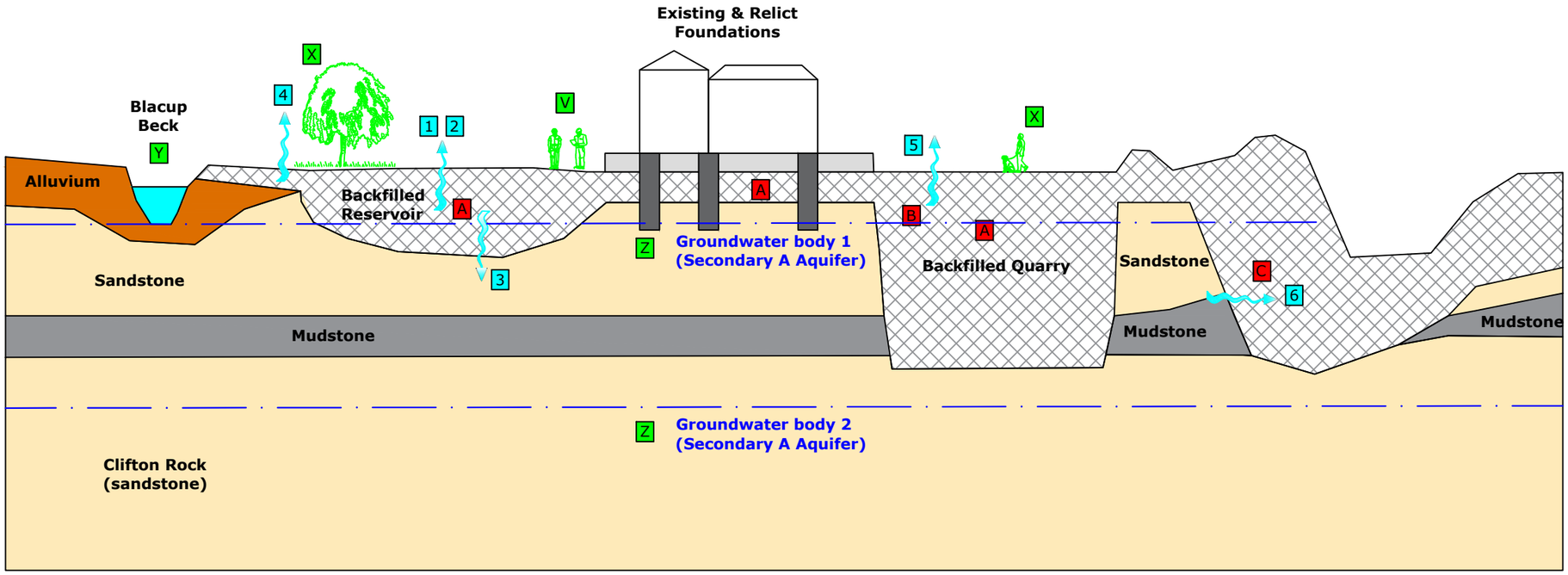
WESTGATE,
CLECKHEATON

DRAWING TITLE

HISTORICAL SITE FEATURES

DRAWN	DATE	STATUS
GLM	17 12 18	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	17 12 18	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:1500	A3	3043/3	



SOURCES	
A	MADE GROUND (ABESTOS & HEAVY METALS)
B	MADE GROUND (HYDROCARBONS)
C	DEEP MADE GROUND (HAZARDOUS GAS)

PATHWAYS	
1	DERMAL CONTACT
2	INGESTION/INHALATION
3	LEACHING OF CONTAMINANTS
4	UPTAKE BY PLANTS
5	VOLATILISATION
6	MIGRATION OF GAS

RECEPTORS	
X	END USERS (RESIDENTS)
Y	SURFACE WATERS
Z	GROUNDWATER
W	WORKERS
V	VEGETATION

NOTES

REV.	DESCRIPTION	DATE
A	REVISION OF SITE GEOLOGY & GROUNDWATER BODIES	17/12/2020

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

STRATA

JOB TITLE

WESTGATE,
CLECKHEATON

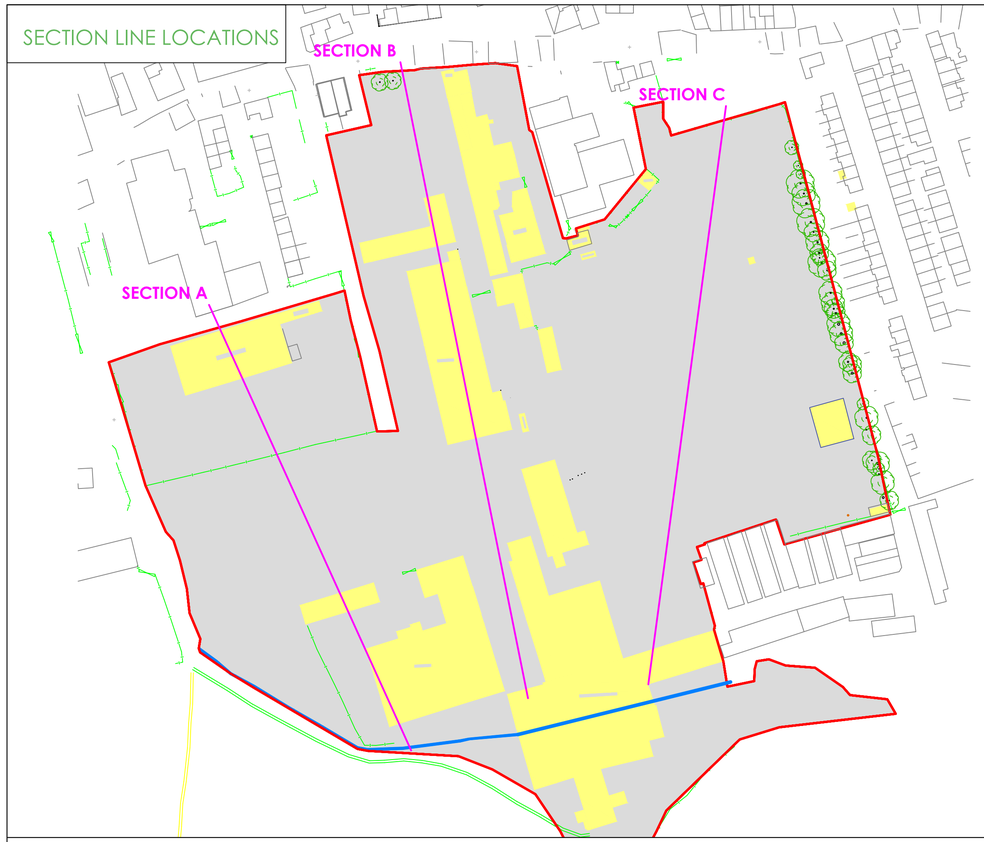
DRAWING TITLE

REVISED CONCEPTUAL SITE MODEL

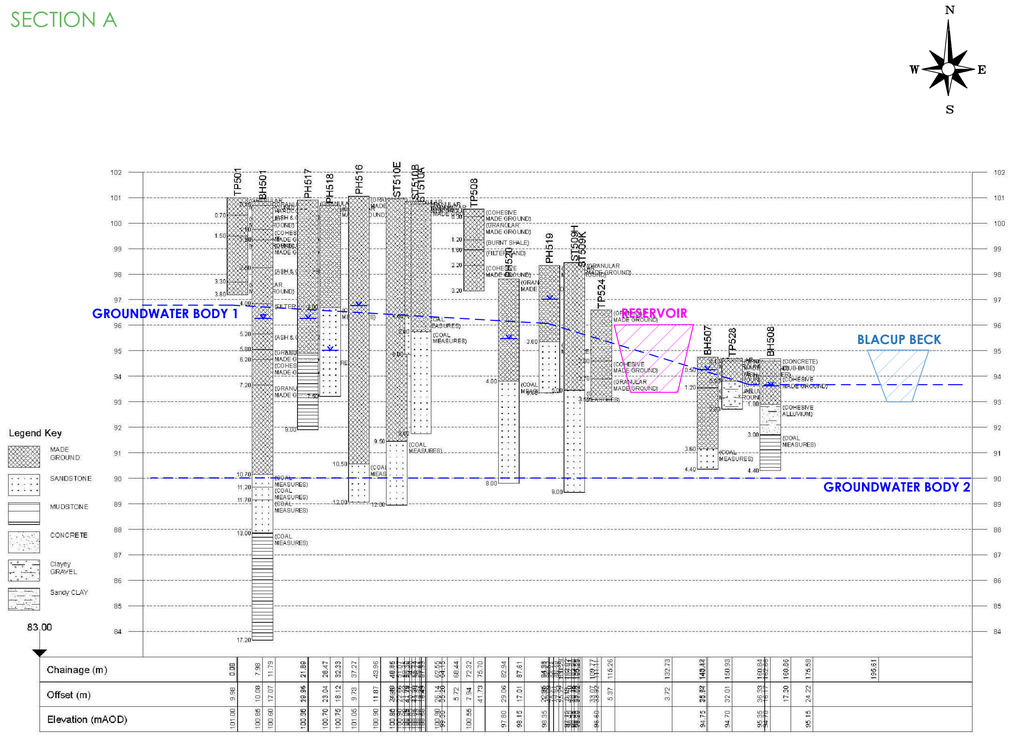
DRAWN	DATE	STATUS
GLM	17/12/2020	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	17/12/2020	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
Not to scale	A3	3043/9	A

SECTION LINE LOCATIONS



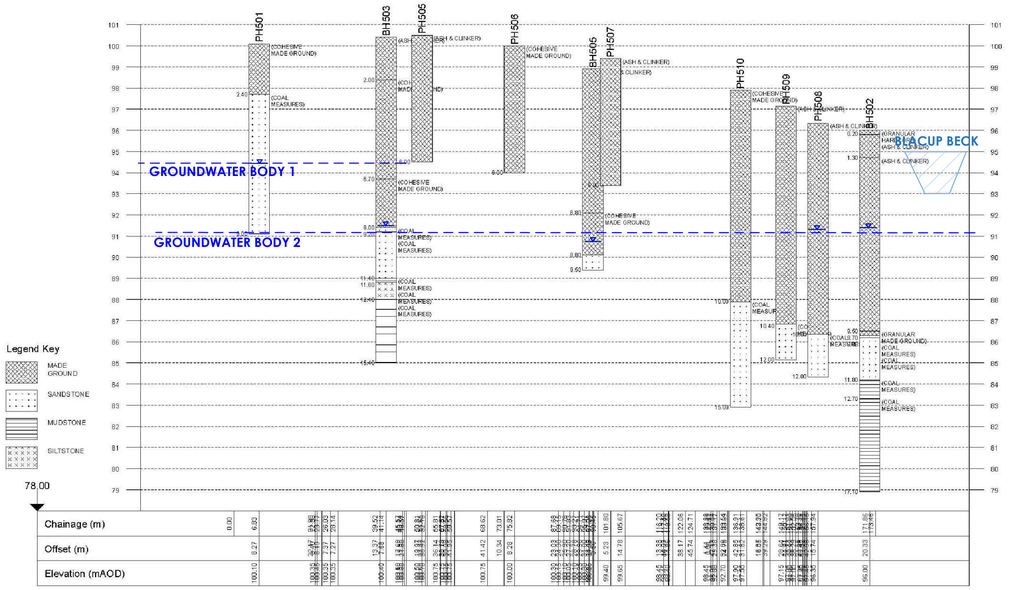
SECTION A



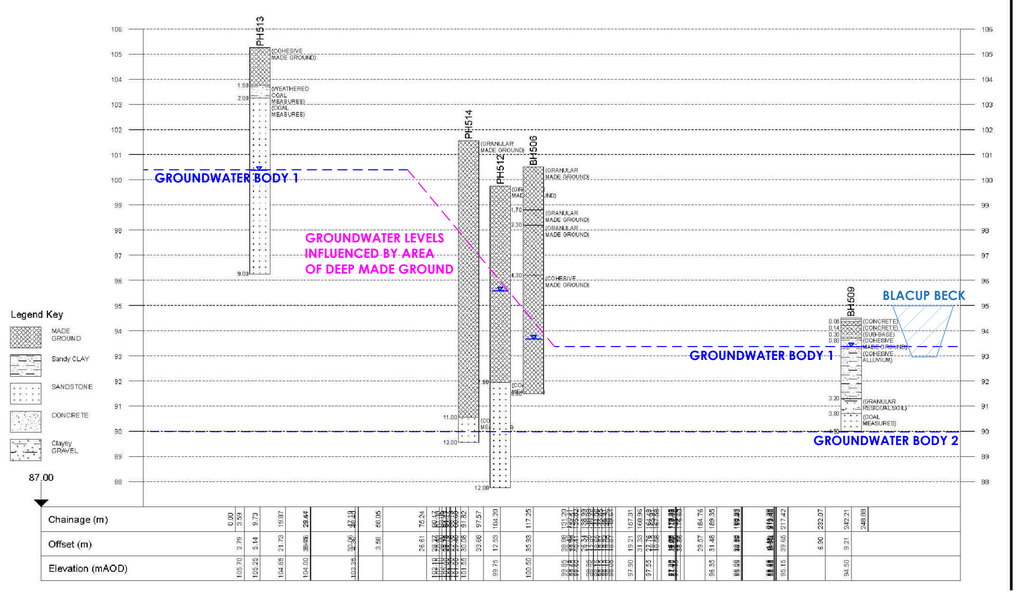
NOTES

- LINE OF CROSS SECTION
- APPROXIMATE SITE BOUNDARY
- GROUNDWATER LEVEL FROM MONITORING WELL DIPS
- GROUNDWATER LEVEL
- BACKFILLED RESERVOIR
- SUFACE WATERCOURSE

SECTION C



SECTION B



REV.	DESCRIPTION	DATE

LITHOS CONSULTING
info@lithos.co.uk
www.lithos.co.uk
Tel 01937 545330

CLIENT: STRATA

JOB TITLE: WESTGATE, CLECKHEATON

DRAWING TITLE: HYDROGEOLOGICAL CROSS SECTIONS

DRAWN	DATE	STATUS
GLM	17/12/2020	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	17/12/2020	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
NOT TO SCALE	A1	3043/14	