LITHOS

Land at Shires Lane, Embsay

For The Devonshire Group

Report no: 3161/1A

Date: November 2018

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SUMMARY OF GEOENVIRONMENTAL ISSUES

Job No.	3161	**Site area/ha**	0.46
Client:	The Devonshire Group	**NGR:**	SE 012 536
Site:	Shires Lane, Embsay	**Nearest postcode:**	BD23 6SB

The site is located off Shires Lane, approximately 3km north-east of Skipton, and currently comprises the northern parcel of a larger open field using for cattle grazing. No development appears to have taken place on site throughout its history.

Lithos were commissioned by the Devonshire Group to provide a geoenvironmental appraisal of the site, as redevelopment with housing is being considered. Lithos' investigation included a review of the site's history and environmental setting, and a ground investigation comprising 9 trial pits.

A summary of salient geoenvironmental issues is provided in the table below.

Issue	Remarks
Made ground	Encountered in one trial pit only (TP06) in the south-east, likely associated with infilling of Green Bottom Beck. Materials comprised Made Ground Topsoil overlying Re-worked Glacial Till to 1.6m depth.
Natural ground	Identified in all locations. Materials comprised topsoil overlying: • Cohesive Glacial Till (firm to stiff gravelly, sandy clay, often with cobbles and boulders of mixed lithologies. • Granular Glacial Till (very clayey/sandy gravel and cobbles, often with boulders, and locally sands). Typically, firm to stiff clay (Cohesive Glacial Till) was encountered at shallow depth, becoming more gravelly/cobbly and softer with depth (likely due to the impact of groundwater), before grading into granular deposits (Granular Glacial Till). In one trial pit (TP01) and all boreholes, weathered siltstone (clayey gravel) was encountered from 2.9m depth.
Contamination	None encountered. Topsoil is chemically suitable for re-use.
Mining & quarrying	This site is located beyond the Coal Authority's defined coalfields. There are no known quarries on, or within 50m of the site.
Hazardous gas	The site is in an area where between 10% and 30% of homes are estimated to be above the radon action level, therefore full radon protection measures are required. No other sources of hazardous gas have been identified.
Preparatory works	Topsoil strip & stockpile.
Foundations	All two or three storey residential properties constructed on this site will be founded on shallow strip or deepened trench fill footings, founding within medium to high strength clays or medium dense granular deposits. Where soft clay is encountered, foundation excavations should be taken through this material and into the competent strata below.
Groundwater & excavations	Excavations may encounter some difficulty beyond around 1.5m due to the presence of boulders but should remain stable in the short term. Groundwater seepages/inflows may be encountered within the vicinity of Green Bottom Beck beyond around 2.0m.
Flooding & drainage	The EA indicate that the site is not located within an indicative floodplain. The south-east of the site (within the vicinity of Green Bottom Beck) lies within a 1 in 30 year flood area relating to surface water. The vast majority of the site lies within an area where there is considered to be potential for groundwater flooding to occur at surface. Soakaways will not provide a suitable drainage solution for surface water run-off at the site. Consequently, it will be necessary to consider alternative sustainable drainage systems (SUDS), and there may be a need for surface water balancing.
Highways	Based on visual inspection of the shallow natural materials and published guidance, the Glacial Till should provide a CBR value of at least 3%. This value should be verified prior to or during construction.
Constraints	Easements/diversions will be required for the Yorkshire Water sewer and main, as well as the culverted Green Bottom Beck.

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.

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APPENDICES

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3161/3	A	Site features
3161/4	-	Site photographs
3161/5	-	Preliminary conceptual site model
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Appendix C - Commission

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Appendix E - Search responses#

From	Date	Content
Landmark	21/8/18	Environmental search data

Appendix F - Trial pit records

Appendix G - Borehole records

Appendix H - Chemical test results

Appendix I - Geotechnical test results

Some of this data is not included within the paper or PDF copies of this report; by request, it can be provided on a CD.

FOREWORD (geoenvironmental appraisal 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.

The report presents observations and factual data obtained during our site investigation and provides an assessment of geoenvironmental 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 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. full copy of the Landmark/Groundsure Report) is not included in the pdf, by request, it can be provided on a CD.

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 represents the findings and opinions of experienced geoenvironmental consultants. Lithos does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Lithos, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy

It should be borne in mind that the timescale over which the investigation was undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

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 cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed remediation options.

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

GEOENVIRONMENTAL APPRAISAL
of land at
SHIRES LANE, EMBSAY

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited were commissioned by The Devonshire Group to carry out a geoenvironmental appraisal of land at Shires Lane, Embsay.

1.1.2 This document is a revision of the Geoenvironmental Appraisal (Report 3161/1) issued by Lithos in September 2018; Report 3161/1A is now superseded. This document now includes the findings of cable percussion drilling undertaken at the site, with the only significant revisions to 3161/1 having been made in Sections 6, 7.5, 11.5, 11.6 and 12.4. Revisions have also been made to Drawing 3161/6A.

1.1.3 Correspondence regarding Lithos' appointment, including the brief for this investigation, is included in Appendix C. The agreed scope of works included:

- A site walkover and inspection
- An assessment of the land use history
- Determination of the site's environmental setting
- An intrusive ground investigation comprising 9 trial pits
- Assessment of the geotechnical properties of the near surface deposits to enable provision of foundation and highway recommendations
- A qualitative assessment of contamination risks
- Recommendations for the necessary site preparatory works

1.1.4 Primary aims of this investigation were to identify salient geoenvironmental issues affecting the site to support the submission of a planning application, and also to enable Devonshire Group to obtain budget costs for: foundations; gas protection measures; and site preparatory works.

1.2 The proposed development

1.2.1 It is understood that consideration is being given to redevelopment of the site with traditional two storey domestic dwellings, associated gardens, POS and adoptable roads and sewers. No site layout has been provided at this stage.

1.3 Report format and limitations

1.3.1 All standard definitions, procedures and guidance are contained within Appendix A, which includes background, generic information on:

- Assessment of the site's environmental setting
- Ground investigation fieldwork
- Geotechnical testing
- Contamination testing

1.3.2 General notes and limitations relevant to all Lithos geoenvironmental investigations are described in the Foreword and 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 SITE DESCRIPTION

2.1 General

2.1.1 The site's location is shown on Drawing 3161/1 presented in Appendix B to this report. Site details are summarised in the table below.

Detail	Remarks
Location	Embsay, 3km north east of Skipton town centre
NGR	SE 012 536
Approximate area	0.46ha (1.02 acres)
Known services	Underground water main and surface water sewer (running from pump house immediately north-west)

2.2 Site features

2.2.1 Lithos completed a walkover survey of the site on 30th August 2018.

2.2.2 Existing salient features, at the time of the walkover are presented on Drawing 3161/3 in Appendix B to this report and summarised in the table below.

Feature	Remarks
Current Access	Off Shires Lane
Topography	Undulating, with a general fall to the south-east of around 1 in 16, but a steep slope in the far east of around 1 in 3 associated with Green Bottom Beck
Nature of boundaries	North, east & west – dry stone walls and post & wire fencing South – partially dry stone walls, with no physical boundary in the south-east
Surrounding land uses	North – Housing (Shires Lane& Moorland Rise) South – Pastoral farmland East – Low Lane with open fields beyond West – Pumping station and Embsay Cricket Club with open fields beyond

2.2.3 A selection of site photographs is included on Drawing 3161/4.

2.2.4 The entire site comprises the northern section of an open grassed field used for grazing cattle.

2.2.5 The majority of site boundaries comprise dry stone walls with post & wire fencing on the inside and intermittent trees/bushes. A line of around 15 no. mature trees, c. 15m tall, is present just beyond the south-west boundary.

2.2.6 The surface gently undulates, but with a general fall to the south-east. In the far east, the land slopes steeply upwards. This appears to be associated with the line of Green Bottom Beck (now mostly culverted) which runs along the bottom of this slope.

2.2.7 Green Bottom Beck is shown on historical plans from 1854 as running north-east to south-west through the east of the site but becomes culverted in the 1930s (see Section 3). Immediately south-east of the site there is a pond which is fed by a ceramic drainage pipe (see Drawings 3164/3 & 3164/4), roughly 50cm in diameter; this indicates the start of the culvert. Here, soil has been exposed (likely associated with former earthworks/maintenance of the culvert) and contains a number of anthropogenic materials such as glass bottles, ceramic and terracotta pipe fragments.

2.2.8 A second pipe (a sewer outlet) also feeds the pond from the west. This is associated with a Yorkshire Water surface water sewer, for which a discharge consent is in place for stormwater overflow (see Section 4.1).

2.2.9 It should be noted that the line of the water main and sewer (taken from Yorkshire Water plans and superimposed onto Drawing 3161/3) do not match with the position of the outlet pipes around the pond (also shown on Drawing 3161/3).

2.2.10 Walking northwards along the base of the slope, there are two locations where 'hollows' can be seen, exposing flowing water (Green Bottom Beck) below. The hollows look to be a result of gaps in concrete/boulders which have been placed over the top of the culverted watercourse, and are of limited depth (<1m). One of the hollows had plastic-coated cables running through; the origin or purpose of these is not clear.

2.2.11 Although marked on service records, there was no evidence of an overhead BT cable (recorded position from service plans shown on Drawing 3131/3).

3 SITE HISTORY

3.1 Site centred extracts from Ordnance Survey (OS) plans dating back to 1854 have been examined. Some of these plans are presented in Appendix D to this report.

3.2 The table below provides a summary of the salient points relating to the history of the site. It is not the intention of this report to describe in detail all the changes that have occurred on or adjacent to the site. Significant former uses/operations are highlighted in **bold** text for ease of reference.

Date	Site	Surrounding land
1854	Fields split into two parcels. **Green Bottom Beck** watercourse running north-east to south-west through east of the site.	Shires Lane and Low Lane adjacent to northern and eastern boundaries respectively. Embsay village centre c. 300m north-west.
1891	No significant changes.	Railway around 240m south. Quarries around 400m south.
1938	Green Bottom Beck still shown to the north & south, but no longer runs through the site.	'Moorlands' property shown c.40m north.
1965	No significant changes.	'Sinks' shown to the north and 'issues' shown to the south associated with Green Bottom Beck. Residential development immediately north; cricket ground with pavilions shown immediately west.
1987		Allotments shown c.85m south-east. Extensive residential development (Embsay village) c.80m north.
2018	No significant changes.	

4 ENVIRONMENTAL SETTING

4.1 General

4.1.1 Notes describing how the site's environmental setting has been assessed are included in Appendix A to this report. Extracts from the response received from Landmark is presented in Appendix E. These responses are summarised below, together with the findings of our own "desk study" investigation.

Issue	Data reviewed	Summary
Geology	1:50,000 BGS map (Sheet 61) BGS Online Geology Viewer (see 4.1.2 below)	Drift – Glacial Till. Solid – Mudstone of the Clitheroe Limestone Formation Strata dip – unknown. Faults – none.
Mining	Coal Authority	This site is located beyond the Coal Authority's defined coalfields.
Quarrying	Historical OS plans	None on site, or within 50m.
Landfills	Envirocheck Report	No known landfills within 250m.
Radon	Public Health England	The site lies in an area where between 10% and 30% of homes are estimated to be above the action level.
Hydrogeology	Envirocheck Report	Groundwater Source Protection Zone? No. Aquifer – Secondary Undifferentiated (Drift); Secondary A (Solid). Groundwater abstractions? Closest 400m south, abstracting from the limestone bedrock. Soil leaching potential - Low. Pollution incidents? None within 500m.
Hydrology	Envirocheck Report Environment Agency	Nearest watercourse(s) - Green Bottom Beck (on site, but likely as culvert/underground flow) flowing north-east to south-west, tributary of Haw Beck. Part of the catchment for Haw Beck from source to Eller Beck. Water quality – catchment rated as ecologically moderate and chemically good between 2013 and 2016. Pollution incidents? Three within 20m in 1994 to 1995, all involving animal slurry. Two category 2 significant incidents, one category 3 minor incident. Additional category 2 significant incident in 1992 involving yard run-off (dirty water) at 30m north-east. All of these will likely be associated with Green Bottom Beck. Abstractions? Various at c.300m south relating to abstractions for Skipton Rock Quarry, most recently issued in October 2015. Discharge consents? One c. 20m south. Yorkshire sewage discharges (storm water overflow) discharging into Green Bottom Beck. Issued on 24th March 2004. No others within 250m.
Flood risk	Environment Agency	The site lies in Flood Zone 1, where the risk of flooding from rivers or the sea is classified as low. The land surrounding Green Bottom Beck in the south-east lies within a 1 in 30 year flood area relating to surface water. The vast majority of the site lies within an area where there is considered to be potential for groundwater flooding to occur at surface.

4.1.2 Geological information for the areas is somewhat scarce, with the 1:50,000 scale BGS plan of poor quality, and no 1:10,000 mapping available. In addition, there are no nearby BGS borehole records available online.

5 GROUND INVESTIGATION DESIGN

5.1 Anticipated ground conditions & potential issues

5.1.1 Based on the data reviewed in Sections 3 (Site History) and 4 (Environmental Setting), anticipated ground conditions are expected to comprise:

Anticipated condition	Remarks
Made ground	Possibly associated with culverting of Green Bottom Beck
Natural soils	Glacial Till (sandy, gravelly clays)
Bedrock	Mudstone, depths to which are unknown
Groundwater	Possible perched groundwater within any granular lenses of Glacial Till

5.1.2 Based on the data above and that in Sections 2 (Site Description) and 3 (History), potential ground-related issues associated with this site are likely to include:

Type of issue	Specific issue	Remarks
Potential on-site contamination sources	1. Made ground (associated with culvert)	1. Inorganics, organics, asbestos
Potential off-site contamination sources	None of significance	
Potential geotechnical hazards	1. Steep slope 2. Soft/loose ground	1. Far east associated with Green Bottom Beck 2. Possible (though unlikely) within Glacial Till
Other potential constraints	1. Green Bottom Beck (culverted) 2. Underground sewer & water mains	1. Will require easement

5.2 Preliminary conceptual site model

5.2.1 A preliminary conceptual site model, presented as Drawing 3161/5 in Appendix B, has been prepared after consideration of all the data presented in Sections 2 to 5.1 inclusive of this report.

5.2.2 Historical plans show that the site has been occupied by arable farmland which is not considered likely to have caused significant ground contamination. Nonetheless, activities such as slurry spreading, the discharge of chemicals to ground, and unregulated burial have all occurred on farmland. Potential pollutants associated with farming activity might include any of the following:

Agricultural activity	Potential contaminant
Carcase burial	Anthrax & other biohazards
Plant & animal protection	Pesticides & herbicides
Waste burial, land levelling, backfilling ponds/quarries	Methane, metals, PAH etc
Naturally occurring contaminants	Arsenic, metals
Sheepfolds	Arsenic

5.2.3 Potential pollutant linkages are shown on the preliminary conceptual site model.

5.3 Ground investigation design & strategy

5.3.1 The preliminary conceptual site model was used as a basis for design of an appropriate ground investigation, the scope of which is summarised below.

Exploratory holes	Purpose
Nine Trial Pits	To determine the general nature of soils underlying the site, including the: • Nature, distribution and thickness of shallow soils, including any made ground • Suitability of the ground for founding structures and highways

5.3.2 Proposed exploratory hole locations were selected to provide a representative view of the strata beneath the site. A nominal 50m grid spacing was proposed. Additional exploratory locations might be scheduled by the site engineer in light of the ground conditions actually encountered.

5.3.3 The number of representative samples taken will be reflective of the geological complexity actually encountered.

6 FIELDWORK

6.1 Objectives

6.1.1 The original investigation strategy is outlined in Section 5.3 above.

6.1.2 The additional exploratory holes listed below were advanced in light of ground conditions actually encountered.

Exploratory holes	Purpose
Three cable percussion boreholes	To retrieve geotechnical data from depth following discovery of suspected soft clays in the trial pits, and to install groundwater monitoring wells across the site.

6.2 Exploratory hole location constraints

6.2.1 The Yorkshire Water sewer and water main were given easements; as well as the estimated line of the culvert (not mapped).

6.3 Scope of works

6.3.1 Fieldwork was supervised by Lithos on the 30th August 2018 (trial pits) and the 23rd October 2018 (boreholes), comprising the exploratory holes listed below.

Technique	Exploratory holes	Final depth(s)	Remarks
Trial pitting (machine dug)	TPs 01 to 09	2.4m to 3.6m	Vane tests in cohesive soils where possible
Cable percussion boreholes	BHs 01 to 03	5.45m to 6.35m	SPT tests every 0.5m for the first 3m, then every 1m after. Water monitoring wells installed in all boreholes.

6.3.2 Notes describing ground investigation techniques, in-situ testing and sampling are included in Appendix A to this report.

6.3.3 Exploratory hole logs are presented in Appendix F and G to this Report. These logs include details of the:

- Samples taken
- Descriptions of the solid strata, and any groundwater encountered
- Monitoring wells installed
- Results of the in-situ testing

6.3.4 Exploratory hole locations are shown on Drawing 3161/6B presented in Appendix B.

7 GROUND CONDITIONS

7.1 General

7.1.1 A complete record of strata encountered beneath the proposed development site is given on the various exploratory hole logs, presented in Appendices F & G.

7.1.2 Typical ground conditions encountered at the site are described below in Sections 7.2 (made ground) and 7.3 (natural ground), with a summary provided in the table on page 9.

7.2 Made ground

7.2.1 Made ground was only encountered in one trial pit (TP06) in the far south-east, likely associated with infilling of Green Bottom Beck.

7.2.2 Materials comprised **Made Ground Topsoil** (topsoil with fragments of brick and lenses of ash) over **Re-worked Glacial Till** (clay with gravel of mixed lithologies including brick, terracotta pipe, sandstone and mudstone) to a depth of 1.6m.

7.3 Natural ground

7.3.1 Natural ground was encountered in all exploratory holes, and typically comprised topsoil (300mm thick) over:

- **Cohesive Glacial Till** (firm to stiff gravelly, sandy clay, often with cobbles and boulders of mixed lithologies.
- **Granular Glacial Till** (very clayey/sandy gravel and cobbles, often with boulders, and locally sands).

7.3.2 Typically, firm to stiff clay (Cohesive Glacial Till) was encountered beneath the topsoil to an average of 2.1m, becoming more gravelly/cobbly and softer with depth (likely due to the impact of groundwater), before grading into granular deposits (Granular Glacial Till).

7.3.3 'Soft' clay was logged in TPs 1, 2, 3 & 5 and BH03 at depths ranging from 1.3m to 2.9m. These 'soft' clays might be a consequence of water flow as the material grades into a granular deposit.

7.3.4 Cohesive deposits were locally absent in TPs 4 & 6, whilst granular deposits were absent from TPs 1 & 9 and BH01.

7.3.5 It was often difficult to distinguish between cohesive and granular soils due to the amount of minor constituents in the soil, therefore a number of bulk bag samples were taken and scheduled for particle size distribution tests (see Section 11.3). The log descriptions and the table below have been updated in light of the laboratory results where necessary.

7.3.6 **Weathered mudstone/siltstone** (clayey gravel) was encountered in all boreholes, from 4m depth in BHs 01 and 03, and from 5m depth in BH02. In one trial pit (TP01), weathered Siltstone (clayey gravel) was encountered from 2.9m depth.

7.3.7 **Mudstone bedrock** was encountered at 5.9m in BH02, and was penetrated down to 6.35m.

7.4 Visual & olfactory evidence of organic contamination

7.4.1 No visual/olfactory evidence of organic contamination was noted in any of the trial pits or boreholes.

7.5 Groundwater

7.5.1 A slight groundwater seepage was encountered in TP06 at 2.7m (close to the beck).

7.5.2 No other seepages/inflows were recorded, but strata often became damp/wet where the granular materials were encountered.

7.5.3 Groundwater levels in the boreholes have been monitored on one occasion to date (1st November 2018); results are summarised below:

Hole ID	Response zone (depth range & strata)	Groundwater body	Standing water level	
			m bgl	m AoD#
BH01	1.0m to 4.0m Cohesive Glacial Till	Secondary Undifferentiated (drift)	Dry	<153.5
BH02	2.0m to 5.0m Granular Glacial Till		Dry	<151.2
BH03	1.0m to 4.0m Granular Glacial Till (clay from 1.45-1.95m)		2.95	156.3

 # estimated from topo survey data to inform foundation design

7.6 Excavations & stability

7.6.1 Stability of excavations was generally good, however some overbreak and spalling was noted in TP1 (natural ground) and TP6 (made ground).

7.6.2 Excavations often became difficult to excavate due to the presence of boulders within the natural soils (between 0.4m and 0.7m diameter).

7.7 Revised conceptual ground model (ground conditions)

7.7.1 The Preliminary Conceptual Site Model has been revised in light of data obtained during the ground investigation, most notably with respect to:

- The nature and distribution of made ground
- The strength, nature and depth of underlying natural strata

7.7.2 The revised Conceptual Site Model is presented in Appendix B, as Drawing 3161/7.

7.7.3 Further refinement of the Conceptual Site Model is presented in Section 9.2 where the results of laboratory testing for contaminants have been considered.

Summary of Ground Conditions

Hole	Final depth (m)	Depth to Base of Made Ground (m)	Depth to Base of (m)						Depth to rockhead (Clitheroe Formation)	Remarks
			Made Ground		Natural Soils					
			Made Ground Topsoil	Re-worked Glacial Till	Topsoil	Cohesive Glacial Till	Granular Glacial Till	Weathered Clitheroe Formation		
TP01	3.6				0.3	2.9		> 3.6		Soft clay 1.7m to 2.9m
TP02	3.4				0.3	2.0	>3.4			Soft clay 1.3m to 2.0m
TP03	2.8				0.2	2.1, then >2.8	2.5			Soft clay 1.3m to 2.1m
TP04	2.9				0.2		>2.9			
TP05	2.5				0.2	1.8	>2.5			Soft clay 1.6m to 1.8m
TP06	2.7	1.6	0.3	1.6			>2.7			
TP07	2.4				0.2	1.4	>2.4			
TP08	3.2				0.3	1.4	>3.2			
TP09	2.7				0.3	1.2	>2.7			
BH01	5.45				0.2	4.0		>5.45		
BH02	6.35				0.35	2.0	5.0	5.9	5.9	Penetrated to 6.35m
BH03	5.45				0.4	1.95	1.45, then 4.0	>5.45		Soft clay1.45m to 1.95m

8 CONTAMINATION (ANALYSIS)

8.1 General

8.1.1 The site's former usage is considered unlikely to have given rise to any significant ground contamination. Furthermore, only localised made ground was encountered during the ground investigation. However, samples of topsoil have been recovered in order to confirm its suitability for re-use, along with a sample of the made ground.

8.1.2 An assessment of potential contaminants associated with the former uses has been undertaken; see Section 5.2.

8.1.3 In the context of risks to human health associated with residential redevelopment, the Tier 1 Soil Screening Values referenced in this report have been derived via the CLEA default conceptual site model (CSM) used for generating SGVs, but amended, where appropriate, to be more specific to redevelopment within the planning process.

8.1.4 Where available, Category 4 Screening Levels (C4SL) have also been referenced.

8.1.5 Generic Note 04 in Appendix A provides further details with respect to current guidance and the interpretation of analytical data.

8.2 Testing scheduled

8.2.1 Based on the above assessment, Lithos submitted a test schedule (summarised in the table below) to a UKAS accredited laboratory.

Type of sample	No. of samples	Determinands
Made ground	1	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc) & Asbestos ID Water soluble sulphate TOC, Speciated Polycyclic Aromatic Hydrocarbons (PAH)
Made Ground Topsoil	1	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc) & Asbestos ID Water soluble sulphate TOC, Speciated Polycyclic Aromatic Hydrocarbons (PAH)
Topsoil	6	
	2	PAAH pesticides

8.3 Soil contamination results

8.3.1 The soil contamination test results are summarised in the tables on page 12.

8.3.2 Laboratory test certificates as received from the laboratory are presented in Appendix H to this report.

Inorganic determinands

8.3.3 Of the 8 samples of Topsoil and Made Ground analysed for inorganic parameters, all can be classified as uncontaminated.

Asbestos

8.3.4 No asbestos fibres were identified in any of the 8 samples screened.

Organic determinands

8.3.5 This site is essentially greenfield and therefore for organic compounds, the Tier 1 Values used in this report have been derived with reference to a CSM that assumes a residential with gardens end use, with no clean soil cover will be placed in gardens/landscaped areas (Lithos Scenario A).

8.3.6 Lithos have used the CLEA model to derive risk-based screening values for hydrocarbons, in accordance with the methodology detailed by the TPHCWG, and reviewed by a UK workshop of experts with respect to UK adoption of the method.

8.3.7 However, these screening values assume a Soil Organic Matter (SOM) of 6% (equivalent to a TOC of 3.5%). Many organic contaminants are more mobile when the SOM is lower, and consequently comparison of soil results with lower screening values may be required.

8.3.8 In order to check the validity of Lithos' Tier 1 Soil Screening Values, the average TOC for each common fill type have been determined.

Fill type	Typical TOC (%)	Comparison of soil results with revised screening value necessary?
Topsoil	5%	No
Made Ground Topsoil	5.5%	No
Re-worked Glacial Deposits	1.7%	Yes, but no significant organic contamination was recorded in this soil type. All determinands well below "6%" screening value; most below limit of detection.

Polycyclic Aromatic Hydrocarbons (PAH)

8.3.9 There are numerous PAH compounds. The USEPA identified 16 PAHs that are considered to represent the most problematic in terms of toxicology, fate and behaviour. The UK have also focused on these 16 and these are included in the laboratory report where speciated PAH analysis has been scheduled.

8.3.10 Speciated PAH analysis has been undertaken in order to determine concentrations of the key "marker" compounds: benzo(a)pyrene (considered the most toxic of the PAHs); and naphthalene (the most mobile and volatile of the PAHs).

8.3.11 Speciated analysis has confirmed the absence of significant concentrations of both benzo(a)pyrene and naphthalene in the soils beneath this site.

Pesticides

8.3.12 Both of the topsoil samples scheduled for insecticide analysis (PAAH pesticides) yielded results for the various determinands below the laboratory limit of detection (0.01 mg/kg).

Summary of degree of soils contamination

Expl Hole	Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in BLUE and assume a **residential with gardens** end-use.													
			pH	As ∞	B ~	Cd ∞	Cr x	Cu♣$	Pb ∞	Hg *	Ni	Se	Zn $	PAH		Asbestos I.D.
														B(a)P ∞	Naphthalene	
				37	5	26	3000	200	200	169	127	350	200	5	8	
TP01	0.10	Topsoil	5.6	18	0.8	0.7	29	42	59	0.2	25	1.0	110	< 0.1	< 0.1	N.D.
TP03	0.10	Topsoil	6.1	16	1.2	0.9	28	34	96	0.1	26	1.2	130	0.1	< 0.1	N.D.
TP04	0.10	Topsoil	5.1	11	0.8	0.6	21	27	48	0.1	16	0.9	100	< 0.1	< 0.1	N.D.
TP05	0.10	Topsoil	5.4	13	1.0	0.7	25	29	51	0.1	21	0.9	110	< 0.1	< 0.1	N.D.
TP08	0.10	Topsoil	5.2	11	0.6	0.5	28	24	44	0.1	14	0.9	87	< 0.1	< 0.1	N.D.
TP09	0.10	Topsoil	5.8	12	0.8	0.8	23	30	50	0.1	15	1.0	100	0.2	< 0.1	N.D.
TP06	0.20	Made Ground Topsoil	7.4	14	0.9	1.5	27	36	97	0.2	29	1.3	130	0.8	< 0.1	N.D.
TP06	0.50	Re-worked Glacial Deposits	7.7	13	0.6	1.3	25	21	38	< 0.1	24	1.2	69	< 0.1	< 0.1	N.D.

Key	
36	Parameter tested for and found to be in excess of Tier 1 concentration
179	Parameter tested for and found to be > 5 x Tier 1 concentration
12	Parameter tested for but not found to be in excess of Tier 1 concentration
	Parameter not tested for
♣	Tier 1 Value is pH dependent
x	Assumes Cr is CrIII. If demonstrated Cr is CrVI screen would be 21mg/kg
*	Assumes mercury present as an inorganic compound (cf elemental metal or within organic compound). See Science Report SC050021/Mercury SGV.

Source of Guidance Trigger Level	
With the exception of those annotated with one of the symbols below (∞, $, ~), all Soil Screening Values in brackets above have been derived using CLEA v1.06. Values assume contaminants located in a sandy loam, with 6% soil organic matter (SOM).	
∞	Category 4 Screening Level – SP1010, December 2013 (CL:AIRE\Defra)
$	Ministry of Agriculture, Fisheries & Food. Code of Practice for Agricultural Practice for the Protection of Soil. 1998
~	Engineering judgement (Lithos). Boron is a phytotoxic, although most phytotoxic compounds can pose a risk to human health if sufficient concentrations are present. However, plants represent the most sensitive receptor, and a Tier 1 value which is protective of flora is therefore also protective of human health.
N.D.	Not detected, applicable to asbestos I.D. screen only

9 CONTAMINATION (QUALITATIVE RISK ASSESSMENT)

9.1 Topsoil

9.1.1 Topsoil, typically 300mm thick underlies the entire site. Testing suggests this material is chemically suitable for re-use.

9.1.2 Given the nature of the topsoil present on this site it would be expected to be suitable to support plant growth. However, no testing in accordance with BS3882:2015 Specification for Topsoil (N-P-K, clay content etc) has been undertaken to date.

9.2 Revised conceptual ground model (contamination)

9.2.1 No plausible contaminant linkages have been identified.

9.3 Waste classification

9.3.1 Some excess arisings may be generated by excavations for foundations, sewers etc.

9.3.2 As there is no WRAP protocol for soils, the characterisation, sampling and classification of soils arising from brownfield sites has been incorporated within the Environment Agency's Technical Guidance WM3[1]. Classification of soils as inert, non-hazardous or hazardous in accordance with WM3 is quite a complex process. However, all soil arisings generated by excavations at this site are likely to be classified inert.

9.3.3 Off-site disposal to landfill is not recommended. In accordance with the CL:AIRE Code of Practice[2] any excess natural soil arisings should be suitable for Direct Transfer to another development site, for use either as clean cover material, or bulk fill for use, without the need for waste legislation to be applied.

10 HAZARDOUS GAS

10.1 Methane & carbon dioxide

10.1.1 The site is not believed to be affected by sources of hazardous gas generation as it is:

- Not located within 250m of a known former or current landfill site or backfilled feature (e.g. quarry, pond, canal etc)
- Neither underlain by shallow mineworkings nor located in an area considered susceptible to mines gas emissions
- Not underlain by a significant thickness of made ground
- Not underlain by peat or shallow chalk deposits

10.2 Radon

10.2.1 Requirements with respect radon measures are set out in Building Regulations Approved Document C. Probability bandings (based on the proportion of properties in a given area that exceed the Action Level; currently 200 $Bq.m^{-3}$) are used to determine whether a property requires no, basic or full measures.

10.2.2 At present Approved Document C advocates basic measures for the probability banding 3% to 10% (full measures if >10%). However, Public Health England would like to see all new build include basic measures.

[1] Technical Guidance WM3 – Guidance on the classification and assessment of waste. Environment Agency 2015
[2] The Definition of Waste: Development Industry Code of Practice. CL:AIRE, 2011.

10.2.3 The Public Health England UK radon map and the Landmark report indicate that the site is in an area where between 10% and 30% of homes are estimated to be above the action level, and **full** radon protection measures are required in new dwellings.

10.2.4 In accordance with BR211:2015, full radon measures should comprise:

- use of 1,200-gauge* virgin polyethylene DPM/DPC, with suspended concrete floors or ground bearing floor slabs
- continuous membrane across cavity walls
- cavity tray in external walls
- fully sealed service entries/exits
- provision of a radon sump and short length of pipe beneath the floor slab or use of a suspended floor slab with a ventilated sub-floor void.

* *However, it is recommended that a minimum 2,000-gauge virgin polyethylene membrane be utilised in accordance with BS 8485:2015[3] as opposed to the minimum 1,200-gauge membrane advocated within the BRE Report BR211.*

10.2.5 It is especially important that attention should be paid to detailing and workmanship in jointing of the barrier. This ensures that the whole building is sealed, including the cavity walls.

10.2.6 In order to ensure the effectiveness of full radon protective measures, workmanship should be carried out by appropriately trained and qualified personnel, and independent certification is recommended.

11 GEOTECHNICAL TESTING

11.1 General

11.1.1 A total of 10 samples of natural soil were delivered to a suitably accredited laboratory with a schedule of geotechnical testing drawn up by Lithos.

11.1.2 The geotechnical laboratory test results are presented in Appendix I to this report.

11.2 Atterberg limits

11.2.1 The plasticity indices of 8 samples of natural soil have been determined; results are summarised below.

Soil type	No. samples tested	Moisture content range (average)	Range of Plasticity Indices* (average)	Shrinkability
Glacial Deposits	8	15-25 (20)	8-22 (15)	Low

* Modified where appropriate in accordance with Chapter 4.2 of the NHBC Standards

Note. The term Shrinkability is equivalent to the term Volume Change Potential used in Chapter 4.2.

11.2.2 All results (bar one) recorded modified shrinkability results of <20 (low shrinkability), with an average of 15. However, the 'raw' results (not modified by the minor constituents) yielded results of between 14 and 29, with an average of 22, and 6 of the results were 20 or above (medium shrinkability).

11.2.3 Given the above, for the purposes of foundation design, it is recommended that all cohesive soils be conservatively regarded as being of medium shrinkability.

11.2.4 It should be noted that one sample logged as 'very clayey, very sandy GRAVEL' in the field yielded a modified PI of 15.6, which NHBC regards as shrinkable.

[3] 8485:2015: *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.*

11.3 Particle size distribution

11.3.1 The grading of 4 samples of Glacial Till has been determined by wet sieving and the results are summarised in the table below:

Sample & depth	Field description	% passing 37.5mm sieve	% passing 20mm sieve	% passing 2mm sieve	% fines	Material description (based on grading & plasticity)
TP02 2.5m	Very clayey very sandy GRAVEL with high cobble content	77	67	45	22	Very clayey very sandy GRAVEL with medium cobble content
TP03 1.6m	Sandy gravelly CLAY with low cobble content	98	91	77	35	Very sandy gravelly CLAY
TP05 2.2m	Very clayey very gravelly SAND	100	96	74	38	Very clayey very gravelly SAND
TP09 1.8m*	Sandy slightly gravelly CLAY with medium cobble content and occasional boulders	88	75	53	25	Very sandy very clayey GRAVEL with medium cobble content

**log description (see Appendix F) changed based on lab result*

11.3.2 NHBC Chapter 4.2 considers shrinkable soils to be those containing more than 35% fines and having a Modified Plasticity Index greater than 10%.

11.3.3 The above results, along with the plasticity indices results (see Section 11.2) generally concur with engineering descriptions (except for TP09 @ 1.8m).

11.3.4 Given the difficulty in determining whether or not the soils are shrinkable based on visual description alone, and the highly variable ground encountered, it is recommended that all natural soils (with the exception of weathered Siltstone encountered at shallow depth in the far south west) are regarded as being of medium shrinkability.

11.4 Soluble sulphate and pH

11.4.1 In accordance with BRE Special Digest 1:2005, this site has been classified as greenfield with a mobile groundwater regime.

11.4.2 It is envisaged foundations will extend to depths of about 1m through made ground and natural strata and samples taken from this depth range have been submitted for pH and water-soluble sulphate (2:1 soil/water extract).

11.4.3 The concentrations of sulphate in the aqueous natural soil extracts of 6 samples were determined. In addition, one sample of made ground was tested as part of the contamination suite. The pH value of each sample has also been determined.

11.4.4 The highest water-soluble sulphate concentration and the lowest pH value for each soil type analysed are shown in the table below.

Soil type	No. samples tested	Lowest pH values	Highest soluble sulphate concentration (mg/l)
Made ground	1	7.7	<10
Glacial Till	5	5.5	20
Weathered Siltstone	1	8.0	<10

11.4.5 pH values were all above 5.5, therefore concentrations of chloride and nitrate are considered insignificant.

11.4.6 In accordance with Tables C1 and C2 of SD1, sub-surface concrete should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-2z.

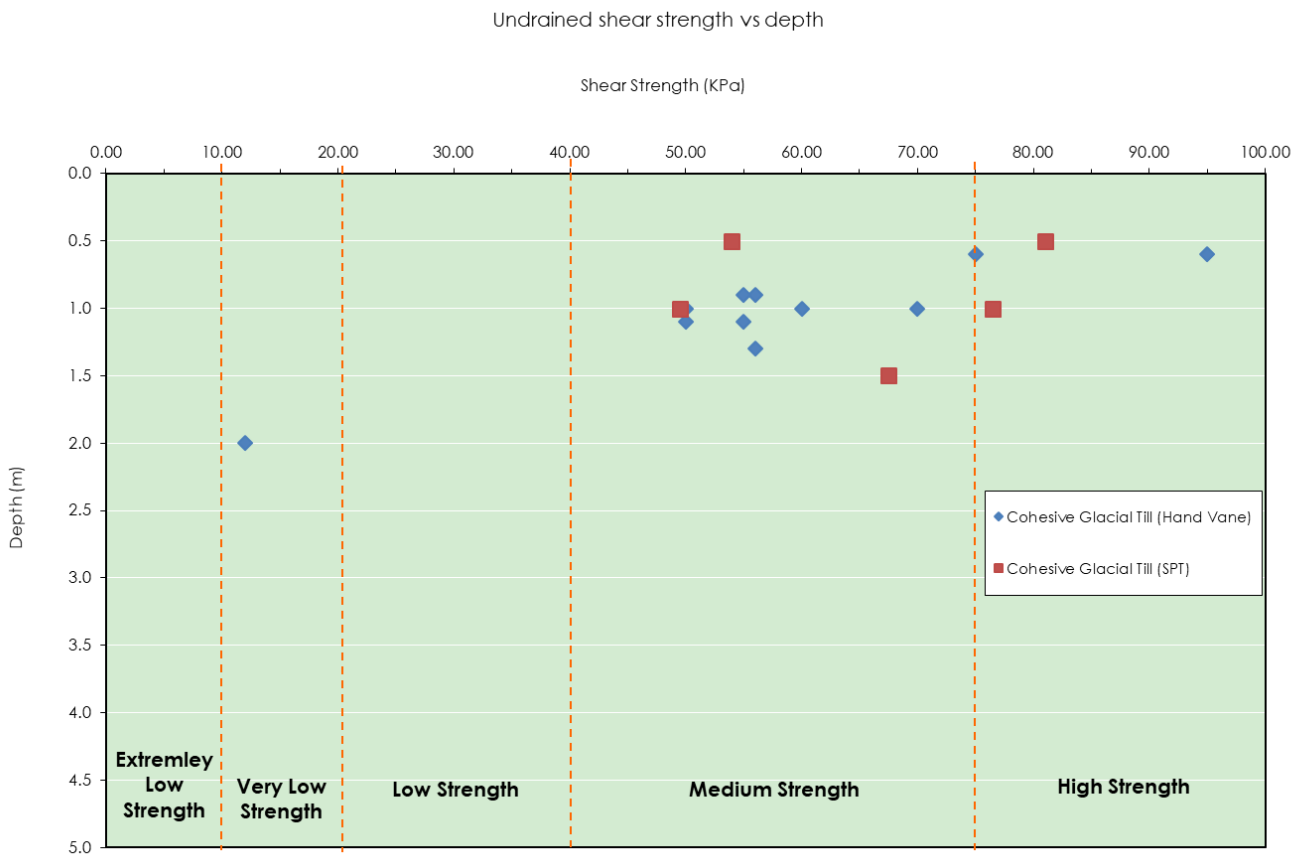
11.5 Undrained shear strength testing

Hand shear vane testing

11.5.1 Hand shear vane testing was undertaken within trial pits in-situ to around 1.2m depth and from larger blocks of excavated clay below that depth.

11.5.2 The results are summarised within the plot below. Results are typically around 50kPa to 70kPa (medium strength), with two readings of >75kPa (high strength). The single result within the 'very low strength' range (12kPa in TP1 @ 2.0m) was taken in a localised softer bed of clay (extending from 1.7m to 2.9m).

11.5.3 It should be noted that the Glacial Till was often too gravelly/sandy to obtain meaningful hand vane readings from, and that other beds of 'soft' material were recorded in TP2 (1.3m to 2.0m), TP3 (1.3m to 2.1m) and TP5 (1.6m to 1.8m).



11.6 Standard Penetration Test (SPT)

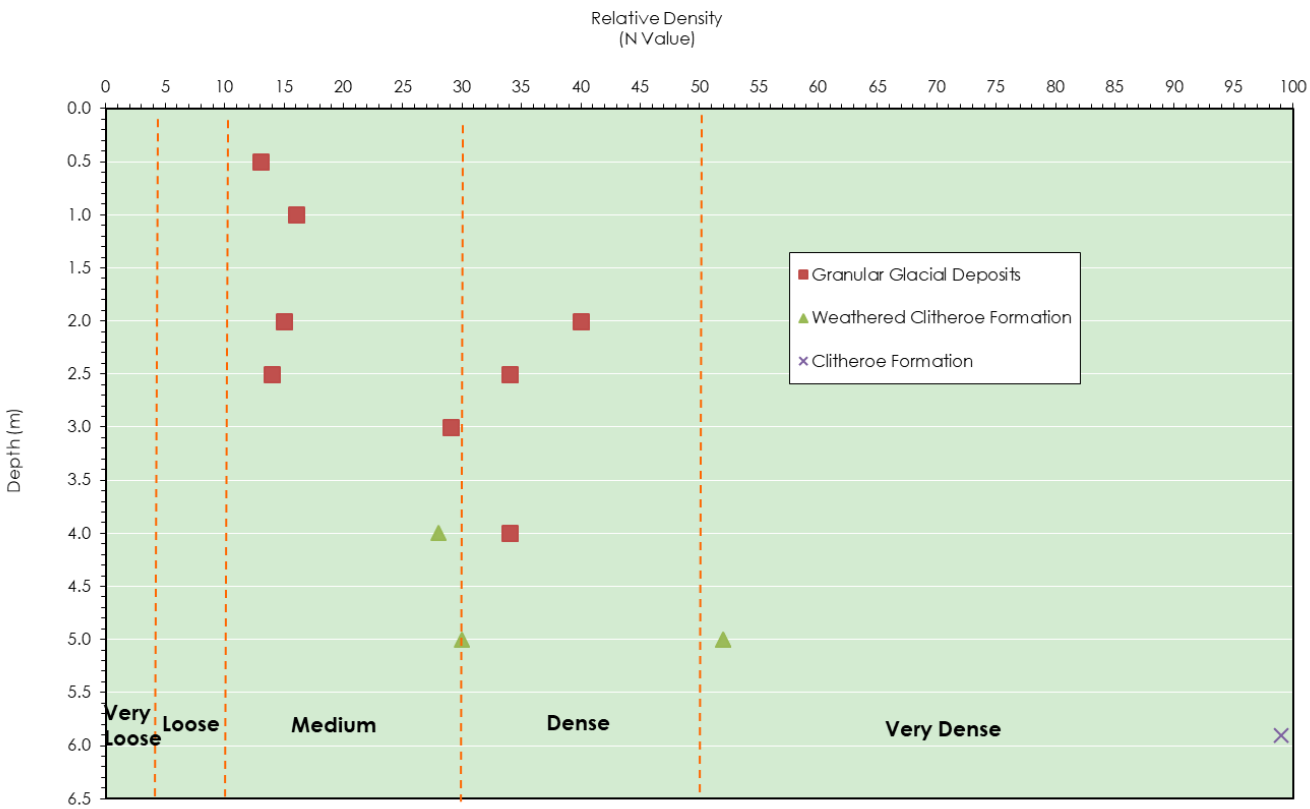
11.6.1 The in-situ relative density of granular soils was established by carrying out Standard Penetration Tests (SPTs) during the drilling of the cable percussion boreholes. In addition, SPT test results can be broadly equated to an undrained shear strength where carried out within cohesive deposits; these results have bee included within the summary of shear strengths plot above.

11.6.2 The SPT results are summarised in below:

Stratum	Ave. SPT 'N' value	Estimated density/strength	Remarks
Granular Glacial Till	24	Medium dense to dense	
Cohesive Glacial TIll	20	Medium strength	
Weathered siltstone bedrock	40.5	Medium dense to very dense	
Siltstone bedrock	99	Very dense	Only one SPT of bedrock taken

11.6.3 The reported blow counts suggest densities ranging from medium dense to very dense. However, boulders are considered to be the probable cause of high blow counts and true densities are more likely to fall within the medium dense range.

11.6.4 The plot below presents a summary of SPT 'N' values.



11.6.5 The above results show that all granular soils can be regarded as being of at least medium dense.

12 GEOTECHNICAL ISSUES

12.1 Conceptual site model

12.1.1 Typically, firm to stiff clay (Cohesive Glacial Till) was encountered to an average of 2.1m, becoming more gravelly/cobbly and softer with depth (likely due to the impact of groundwater), before grading into granular deposits (Granular Glacial Till).

12.1.2 'Soft' material was logged in TPs 1, 2, 3 & 5 and BH03 at depths ranging from 1.3m to 2.9m. These 'soft' clays are most likely a consequence of water flow as the material grades into a granular deposit. Indeed, SPT testing throughout the boreholes drilled yielded 'good' results of medium dense/medium strength and above, including where soft clays were encountered within BH03.

12.1.3 Cohesive deposits were locally absent in TPs 4 & 6, whilst granular deposits were absent from TPs 1 & 9 and BH01.

12.1.4 Weathered Siltstone (clayey gravel) was encountered from 2.9m depth in the far south-west trial pits and was encountered in all cable percussion boreholes.

12.2 Mining & quarrying

12.2.1 This site is located beyond the Coal Authority's defined coalfields.

12.2.2 There are no known quarries on, or within 50m of the site.

12.3 Site regrade and/or ground improvement

12.3.1 It is considered unlikely that development will take place on the steeply sloping land to the east of the culvert due to the proximity of the site's eastern boundary. Therefore, significant re-grade in this area is not anticipated.

12.3.2 Elsewhere, localised regrading may be required to create level development platforms for individual plots, but significant earthworks should not be required.

12.4 Foundation recommendations

General

12.4.1 It is understood that consideration is being given to redevelopment of the site with traditional two storey domestic dwellings, associated gardens, POS and adoptable roads and sewers. No site layout has been provided at this stage

12.4.2 Foundation recommendations assume that development will be two or three storey construction and that line loads will not exceed 90kN/m run. If this is not the case significant alteration to these recommendations will be required.

12.4.3 We have assumed that final development levels will not differ significantly from ground levels existing at the time of investigation. Any digital terrain modelling undertaken, or commissioned by, the developer should consider implications for the foundation recommendations outlined below.

12.4.4 Made ground is not considered a suitable foundation material and foundations should therefore be taken through these materials into underlying natural strata of adequate bearing capacity.

12.4.5 Sub-surface concrete in contact with the made and natural ground should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-2z.

12.4.1 At this stage, it is anticipated that all two or three storey residential properties constructed on this site will be founded on shallow strip or deepened trench fill footings within the medium/high strength clay or medium dense granular deposits.

Strip/trench fill footings

12.4.2 It is considered that shallow strip or deepened trench fill footings will be the most suitable foundation solution for the two or three storey houses constructed at the site.

12.4.3 Reinforcement, as a precaution against differential settlement, is recommended only where foundation excavations encounter significant lateral and vertical variations in strata. One layer of B385 mesh placed 75mm above the base of the footing is likely to provide suitable reinforcement, but further advice should be sought from the Structural Engineer. Given the variability of the Glacial Till across relatively short distances on this site, reinforcement is likely to be required in the majority of plots.

12.4.4 Foundations will be required to be placed below a line drawn up at 45° from the base of any service or similar excavation.

12.4.5 Overdeepened foundations should be stepped in accordance with NHBC Standards, Chapter 4.4.

12.4.6 In order to minimise softening and swelling of cohesive soils or loosening of granular soils, it is recommended that footings are cast as soon as formation level is reached (or alternatively formation could be blinded using concrete with as low a water:cement ratio as possible).

12.4.7 In addition to the above, the developer should review proposed plot designs and layouts, since deeper excavations for trench fill may be unstable where the centre-lines of parallel trenches are closer than about 2m (assuming 600mm widths). The developer should supervise their groundworker to ensure footings are excavated in a controlled and safe manner.

12.4.8 The developer or their groundworker should seek further advice from Lithos if unexpected ground conditions are encountered in foundation or sewer excavations, including any conflict between soft ground associated with a backfilled trial pit excavation and the line of a proposed footing.

12.4.9 Given the variability in ground conditions and the difficulty in distinguishing between cohesive and granular deposits, a minimum foundation depth of 0.9m (minimum for clay soils) should be applied across the whole site.

Clay (Cohesive Glacial Till)

12.4.10 In accordance with NHBC Standards, founding depths in cohesive soils should be taken from original or finished ground level, whichever is the lower, to the underside of the footing.

12.4.11 Foundations should be deepened near trees in accordance with NHBC Standards Chapter 4.2. It is estimated that up to 50% of the site may be affected by trees.

12.4.12 Trench fill foundations should be designed in accordance with NHBC Standards, Chapter 4.2. Heave precautions (a suitable approved compressible void former) should be used on the internal face of all external walls where the foundation is within the zone of influence of trees and greater than 1.5m deep.

12.4.13 Any trench fill foundation deeper than 2.5m will need to be designed by a Chartered Engineer, whose status is accepted by NHBC (NHBC Standards, Technical Requirement R5).

12.4.14 It would therefore be prudent to prepare a detailed foundation schedule and seek approval from NHBC in order to determine likely foundation abnormals.

12.4.15 A safe bearing capacity of around 150kPa, allowing a maximum foundation line load of 90kN/m run, can be assumed if the following are true

- A foundation length of 10m
- A foundation breadth of 0.6m
- A foundation thickness of 225mm
- A foundation depth of 0.9m
- An undrained shear strength of 50kPa for the firm clay (typical minimum recorded on site)

12.4.16 Assuming the foundation geometry detailed above, settlements of <25mm would be anticipated. This is considered likely to be acceptable.

Sand & gravels (Granular Glacial Till)

12.4.17 The granular soils are have a relative density of medium dense to dense (in accordance with BS5930:2015) as confirmed via borehole SPTs.

12.4.18 A safe bearing capacity of around 150kPa, allowing a maximum foundation line load of 90kN/m run, can be assumed if the following are true:

- A foundation length of 10m
- A foundation breadth of 0.6m
- A foundation thickness of 225mm
- A foundation depth of 0.9m
- An angle of shearing resistance of ϕ=31° for the granular deposits
- A groundwater depth of >1.5m bgl

12.4.19 Assuming the foundation geometry detailed above, settlements of <25mm would be anticipated. This is considered likely to be acceptable.

12.4.20 It should also be noted that the footing may require deepening or stepping in order to allow plot drainage to exit the plot footprint (either over or under the footing).

12.4.21 Further investigation should be commissioned if any apartment blocks with higher line loads (say >100kN/m run) are proposed. Such investigation would include cable percussion boreholes and geotechnical analysis (triaxial and oedometer testing) of recovered, undisturbed samples.

12.4.22 Where soft clay is encountered during a foundation excavation (such as the material is TPs 1 to 3, 5 7 BH03), the foundation should be deepened through this material and onto the competent medium/high strength clay or medium dense granular soils below.

12.4.23 The foundation solutions outlined in the above table assume that ground levels will not change significantly from those existing at present. If this is not to be the case, further advice should be sought from Lithos.

12.5 Floor slabs

12.5.1 Suspended floor slabs should be utilised where the depth of made ground or engineered stone exceeds 600mm in accordance with NHBC Standards Chapter 5.1 (to negate potential settlement problems).

12.5.2 Where foundations are within the influence of existing or proposed trees, NHBC require a suspended floor slab, with sub-floor void. The floor slab is most commonly a precast block and beam construction, but alternatively could comprise a suspended timber floor, or a slab cast on a suitable compressible void former. Ground-bearing and cast in-situ suspended slabs (other than those cast on a void former) are not acceptable where foundations are within the influence of trees.

12.5.3 In accordance with NHBC Standards Chapter 4.2, a minimum void height of 250mm should be adopted for a precast block and beam (or suspended timber) floor; this includes a 150mm ventilation allowance. If a suspended, cast in-situ slab (on a void former) is proposed, a minimum clear void height of 100mm should be adopted; of course, the actual thickness of the void former will be significantly greater.

12.5.4 Beyond the influence of existing or proposed trees, it is considered that the natural ground is generally suitable for the use of ground bearing floors. However, ground bearing slabs should not be cast on topsoil or made ground. Where plots are elevated for design reasons, the depth of engineered stone below a ground bearing slab should not exceed 600mm, in accordance with NHBC guidance.

12.5.5 The natural ground beneath this site includes cohesive soils and is therefore subject to seasonal variation in moisture content. If ground slabs were constructed on desiccated soil, heave of the slab would occur on re-hydration of the ground. If any significantly desiccated soil is present, a suspended floor slab, with sub-floor void will be required.

12.5.6 It should be noted that NHBC have suffered a significant number of claims resulting from the use of ground bearing floor slabs. Consequently, if ground bearing slabs are proposed, care should be taken to ensure correct and careful construction. For example, if fill to the internal face of the foundation excavation is not properly compacted, subsequent settlement can result in cracking of the slab.

12.6 Designated concrete mixes

12.6.1 Designated mixes are considered in BRE Special Digest SD1 and BS 8500 -1:2015+A1:2016. However, in addition to soil chemistry (sulphate class), there are a number of other considerations relating to structural design that need to be taken into account when determining an appropriate concrete mix.

12.6.2 Consequently, the developer should seek advice from their appointed Structural Engineer.

12.7 Excavations

12.7.1 Groundwater should be controlled in accordance with CIRIA report 113 "Control of Groundwater for Temporary Works".

12.7.2 Based on the results of the investigation, groundwater seepages/inflows may be encountered from around 2.0m depth within the vicinity of Green Bottom Beck.

12.7.3 Shallow excavations should remain stable in the short term but if left open for any significant period of time may require shoring most notably in granular soils and made ground. Excavations of greater than around 2.0m are likely to encounter significant difficulties with over-break due to the presence of boulders.

12.7.4 Some difficulty may be encountered when excavating though the natural soils due to the presence of boulders within the Glacial Till. Extreme care should be taken (trench support) if any excavations for drainage etc are undertaken close to locations of proposed foundations.

12.8 Drainage

12.8.1 Based on observations made during the investigation, soakaways will not provide a suitable drainage solution for surface water run-off at the site. Consequently, it will be necessary to consider alternative sustainable drainage systems (SUDS), and there may be a need for surface water balancing.

12.8.2 Alternative SUDS options (see CIRIA C753:2015 for further details) include:

- Pervious Pavements – provide a surface suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate into subsurface storage, with subsequent controlled discharge. Pavement could be porous (water able to infiltrate across entire surface material; e.g. reinforced grass), or permeable (water infiltrates via joints between concrete blocks).
- Ponds – designed to have permanent pool of water, but with capacity to provide temporary storage-controlled discharge.

12.8.3 Yorkshire Water have published a guide[4] for developers and designers outlining their design requirements for surface water attenuation assets.

12.8.4 With respect to detention basins, which should normally be dry, water table levels should be taken from borehole monitoring wells over 4 consecutive seasons, for at least 3 points in the basin area. Ground conditions must be suitable to allow free drainage from the detention basin all year round by having regard to groundwater levels, and impermeable liners are not to be used.

12.8.5 The guide also discusses required access to flow control chambers, large diameter (i.e. >900mm) surface water storage pipes, and surface water storage tanks.

12.8.6 It is recommended that the developer contact Yorkshire Water Services with respect to capacity in existing foul and surface water sewers in the vicinity of the development area.

12.9 Highways

12.9.1 The natural soils present at shallow depth (anticipated formation) are predominantly cohesive. Based on visual inspection of the natural materials and the recorded plasticity indices at the site, published tables5 indicate that the Glacial Till would be expected to provide a CBR value of at least 3%. This value should be verified prior to or during construction.

12.9.2 Whilst the CBRs estimated above should be achievable, significant deterioration during/after periods of significant rainfall and/or site trafficking is likely. Consequently, it would be prudent to consider flexibility in the groundworks programme to enable highway construction during prolonged dry/warm weather (typically between May and September) when formation will be least vulnerable to deterioration. Alternatively, a minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) could be placed along the line of proposed highways to protect formation during the construction phase.

12.10 External works

12.10.1 Any digital terrain modelling undertaken, or commissioned by the developer should be made available to their Engineering Designer prior to issue of an External Works Drawing.

[4] *Design Requirements for Surface Water Attenuation Assets, February 2017.*

[5] *Interim Advice Note 73/06 Revision 1 (2009), Chapter 5. Characterisation of Materials Design Guidance for Road Pavement Foundations - Draft HD25*

12.10.2 Depending on the final layout, retaining walls may be required in the far-east associated with the steep sloping land adjacent to Green Bottom Beck.

13 REDEVELOPMENT ISSUES

13.1 General

13.1.1 This report has presented options with respect to foundation solutions, re-use of topsoil etc that are considered technically feasible and in line with current good practice. Consequently, we would expect to obtain regulatory approval for whichever option is adopted, although this cannot be guaranteed. Copies of this report should be forwarded to the relevant regulatory authorities (Warranty Provider & Local Authority) for their comment/approval.

13.2 Control of excavation arisings

13.2.1 The groundworker should carefully segregate (and stockpile separately) made ground arisings from arisings of "clean" natural soils, in order that an excessive volume of unsuitable material is not generated.

13.2.2 It should be ensured that the groundworker understands the need for good materials management. Most notably the importance of not mixing different materials within a given stockpile; i.e. there should be separate stockpiles of: topsoil; made ground; excess clean, natural soil arisings; general construction waste etc.

13.2.3 Further characterisation of stockpiled materials is likely to be required if off-site disposal is proposed. See also comments in Section 9.3 regarding asbestos.

13.3 Good practice guidance

13.3.1 The construction phase groundworker should follow good environmental practice to minimise the risks of spillage, leakage etc with reference, but not limited, to the following documents:

- CIRIA C502 'Environmental Good Practice on Site'
- EA Pollution Prevention Guidelines[6]:
  - PPG6 - Working at construction and demolition sites
  - PPG2 - Above ground oil storage tank
  - PPG7 – The safe operation of refuelling facilities.
  - PPG21 – Incident Response Planning

13.4 New utilities

13.4.1 It is strongly recommended that all statutory service bodies are consulted at an early stage with respect to the ground conditions within which they will lay services in order to enable them to assess at an early stage any potential abnormal costs.

13.4.2 This site is greenfield, and no previous or current usage of the site or its immediate surroundings is likely to have resulted in ground contamination. Furthermore, only very localised made ground was encountered in the far south-east.

13.4.3 Consequently, the use of 'standard' polyethylene water supply pipes should be acceptable, although the developer should consult Yorkshire Water at the earliest opportunity to confirm this.

[6] *Whilst this has formally been withdrawn it can still be accessed via the EA archives and provides useful information on managing risks.*

13.5 Health & safety issues - construction workers

13.5.1 Access into excavations etc. must be controlled and undertaken in accordance with the CDM Regulations 2015, most notably Regulation 22, to mitigate risk of collapse or asphyxiation.

13.5.2 Before site operations are started, the necessary COSHH statements and Health & Safety Plan should be drafted in accordance with the CDM regulations.

13.6 Potential development constraints

13.6.1 Some deterioration of the surface is likely to be caused by trafficking, especially after topsoil has been stripped and during/after periods of significant rainfall. Consequently, it would be prudent to consider placement of a minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) along the line of proposed highways and any temporary haul roads to protect formation during the construction phase.

13.6.2 The underground Yorkshire Water main and sewer present potential development constraints unless they can be relocated. Additional enquiries are required to ascertain the feasibility of such diversionary works and the particular easement required by each service undertaker if they remain in-situ.

14 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

14.1 General

14.1.1 The site (0.46ha) comprises the northern parcel of a larger open field using for cattle grazing and is roughly rectangular, situated in east Embsay (3km north-east of Skipton).

14.1.2 It is understood that consideration is being given to redevelopment of the site with traditional two storey domestic dwellings, associated gardens, POS and adoptable roads and sewers. No site layout has been provided at this stage.

14.1.3 Typically, firm to stiff clay (Cohesive Glacial Till) was encountered beneath the topsoil to an average of 2.1m, becoming more gravelly/cobbly and softer with depth (likely due to the impact of groundwater), before grading into granular deposits (Granular Glacial Till).

14.1.4 'Soft' material was noted at the interface between cohesive and granular deposits; likely a result of localised groundwater flow.

14.1.5 Weathered Siltstone (clayey gravel) was encountered from 2.9m depth in the far south-west.

14.2 Mining

14.2.1 This site is located beyond the Coal Authority's defined coalfields.

14.2.2 There are no known quarries on, or within 50m of the site

14.3 Hazardous gas

14.3.1 The site is in an area where between 10% and 30% of homes are estimated to be above the radon action level, therefore full radon protection measures are required.

14.3.2 There are no known or suspected areas of landfilling within 250m, and the site is not in area considered susceptible to mines gas, nor is it underlain by shallow mineworkings.

14.4 Contamination & remediation

14.4.1 No contamination has been encountered therefore there is no need for remediation.

14.4.2 Topsoil is chemically suitable for re-use.

14.5 Foundations

14.5.1 All two or three storey residential properties constructed on this site will be founded on shallow strip or deepened trench fill footings, founding within medium to high strength clays or medium dense granular deposits.

14.5.2 Where soft clay is encountered, foundation excavations should be taken through this material and into the competent strata below.

14.6 Flooding

14.6.1 The EA indicate that the site is not located within an indicative floodplain.

14.6.2 The south-east of the site (within the vicinity of Green Bottom Beck) lies within a 1 in 30 year flood area relating to surface water.

14.6.3 The vast majority of the site lies within an area where there is considered to be potential for groundwater flooding to occur at surface.

14.7 Drainage

14.7.1 Soakaways will not provide a suitable drainage solution for surface water run-off at the site. Consequently, it will be necessary to consider alternative sustainable drainage systems (SUDS), and there may be a need for surface water balancing.

14.8 Highways

14.8.1 Based on visual inspection of the shallow natural materials and published guidance, the Glacial Till should provide a CBR value of at least 3%. This value should be verified prior to or during construction.

Appendix A

General Notes

01 - Environmental setting
Generic notes – geoenvironmental Investigations

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority, the Local Authority etc is presented in the "Search Responses" Appendix of this Geoenvironmental Report.

Geology, mining & quarrying

In order to establish the geological setting of a site, Lithos refer to BGS maps for the area, and the relevant geological memoir. Further information is sourced by reference to current and historical OS plans.

In July 2011, the Coal Authority (CA) formalised their requirements in relation to planning applications and introduced some new terminology. The CA, using its extensive records has prepared plans for all coalfield Local Planning Authorities, which effectively refines the defined coalfield areas into High Risk and Low Risk areas. High Risk areas are likely to be affected by a range of legacy issues that pose a risk to surface stability, including: mine entries; shallow coal workings; workable coal seam outcrops; mines gas; and previous surface mining sites. Low Risk areas comprise the remainder of the defined coalfield, and are areas where no known defined risks have been recorded; although there may still be unrecorded issues. Where a site lies within either a High or Low Risk area, a mining report is obtained from the CA.

Landfills

Lithos obtain data from Landmark or Groundsure, the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site. Historical OS plans are also inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite), and can move though fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, Lithos refer to BRE Report BR211[1], and the Public Health England website. Advice on the limitation of exposure of the population to radon in buildings was originally published in 1990 by the National Radiological Protection Board (NRPB), which joined the Health Protection Agency (HPA) in 2005; the HPA updated NRPB advice in July 2010[2]. The HPA became part of Public Health England in 2013.

The HPA recommended that the NRPB radon Action Level for homes be retained, and a new Target Level for radon in homes be introduced. The values of the Action Level and Target Level, expressed as the annual average radon concentration in the home, are 200 Bqm^{-3} and 100 Bqm^{-3} respectively. The Target Level was to provide an objective for remedial action in existing homes and preventive action in new homes.

The term 'radon Affected Area' is defined as those parts of the country with >1% of homes estimated to be above the Action Levels. The NRPB first indicated which parts of the country should be regarded as radon Affected Areas in 1990. A more detailed mapping method was developed by the HPA in conjunction with the British Geological Survey in 2007[3]. The level of protection needed is site-specific and can be determined by reference to this mapping on the Public Health England website, which indicates the highest radon potential within each 1km grid square. Each 1km grid square is classified on the basis of the percentage of existing homes within that grid square estimated to have radon concentrations above the Action Level. There are 6 'bands': <1%; 1 to 3%; 3 to 5%; 5 to 10%; 10 to 30%; and >30%.

The NRPB advised that action should be taken to reduce radon concentrations in existing homes if the radon concentration exceeded the Action Level of 200 Bqm^{-3} in room air averaged over a year; ten times the average UK domestic radon concentration. NRPB advice informed changes in the requirements for radon protection in new buildings.

- **Basic** preventive measures are required in new buildings, extensions, conversions and refurbishments if the probability of exceeding the Action Level is **>3%** in England and Wales, and >1% in Scotland and Northern Ireland.
- Provision for further preventive (**Full**) measures is required in new buildings if the probability of exceeding the Action Level is **>10%**.

At present Building Regulations Approved Document C advocates basic measures for the probability banding 3% to 10%, and full measures if >10%. However, Public Health England would like to see all new build include basic measures.

Action and Target Levels should also be applied to non-domestic buildings with public occupancy exceeding 2,000 hours per year and to all schools.

Hydrogeology

Lithos obtain information from the Environment Agency (EA), and Landmark or Groundsure with respect to:

- Groundwater quality
- Recorded pollution incidents
- Licensed groundwater abstractions

From April 2010 the EA's Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply), but also their role in supporting surface water flows and wetland ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey. The maps are split into two different types of aquifer designation:

- Superficial (Drift) - permeable unconsolidated (loose) deposits. For example, sands and gravels
- Bedrock - solid permeable formations e.g. sandstone, chalk and limestone

The maps display the following aquifer designations:

Principal aquifers: These are layers of rock or superficial deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Secondary aquifers: These include a wide range of rock layers or superficial deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into three types:

- Secondary A - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers
- Secondary B - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers
- Secondary undifferentiated - In most cases, this is because the rock type in question has previously been designated as both a minor and non-aquifer in different locations due to the variable characteristics.

[1] BRE Report BR211, 2015: "Radon: guidance on protective measures for new buildings.

[2] Limitation of Human Exposure to Radon, Documents of the Health Protection Agency - Radiation, Chemical and Environmental Hazards, RCE-15. July 2010.

[3] Miles JCH, Appleton JD, Rees DM, Green BMR, Adlam KAM and Myers AH (2007). Indicative Atlas of Radon in England and Wales. Chilton, HPA-RPD-033.

Unproductive strata: These are rock layers or superficial deposits with low permeability that have negligible significance for water supply or river base flow.

The EA maps only display the principal and secondary aquifers as coloured areas. All uncoloured areas on the map will be unproductive strata. However, for uncoloured areas on the superficial (drift) designation map it is not possible to distinguish between areas of unproductive strata and areas where no superficial deposits are present; to do this, it is necessary to consult the published geological survey maps.

For the purposes of the EA's Groundwater Protection Policy the following default position applies, unless there is site specific information to the contrary:

- If no superficial (drift) aquifers are shown, the bedrock designation is adopted
- In areas where the bedrock designation shows unproductive strata (the uncoloured areas) the superficial designation is adopted
- In all other areas, the more sensitive of the two designations is used (e.g. If secondary superficial overlies principal bedrock, an overall designation of principal is assumed)

The EA have also designated groundwater Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone is a function of the aquifer, volume of groundwater abstracted and the effective rainfall, and may vary from tens to several thousand hectares.

Hydrology

Lithos obtain information from the Environment Agency and Landmark or Groundsure with respect to:

- Surface water quality
- Recorded pollution incidents
- Licensed abstractions (groundwater & surface waters)
- Licensed discharge consents
- Site susceptibility to flooding

The EA have set water quality targets for all rivers. These targets are known as River Quality Objectives (RQOs). The water quality classification scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are 6 GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to flooding is assessed by reference to a Flood Map on the Environment Agency's website. These maps show natural floodplains - areas potentially at risk of flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas. There are two different kinds of area shown on the Flood Map:

1. Dark blue areas (Flood Zone 3) could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 100) or greater chance of happening each year
2. Light blue areas (Flood Zone 2) show the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Where there is no blue shading (Flood Zone 1), there is less than a 0.1% (1 in 1000) chance of flooding occurring each year.

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels, and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year, areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley, the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist who can advise on appropriate mitigating measures; i.e. raising slab levels, provision of storage etc. In accordance with Chapter 10 of the National Planning Policy Framework, a site-specific flood risk assessment is required for: proposals of 1 hectare or greater in Flood Zone 1, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and any new development in Flood Zones 2 and 3.

COMAH & explosive sites

Lithos obtain information from Landmark or Groundsure with respect to Control of Major Accident Hazards (COMAH) or explosive sites within 1km of the proposed development site. Lithos' report refers to any that are present, and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise its emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say, and they are likely to place more weight on advice from the HSE).

Preliminary conceptual site model

The site's environmental setting (and proposed end use) is used by Lithos to assess the significance of any contamination encountered during the subsequent ground investigation.

Assessment of contaminated land is based on an evaluation of pollutant linkages (source-pathway-receptor). Contaminants within the near surface strata represent a potential source of pollution. The environment (most notably groundwater), site workers and end users are potential receptors.

Potential pollutant linkages are shown on a preliminary conceptual site model (pCSM). A CSM is essentially a cross-section through a site that reflects both the surface topography and underlying geology, and shows surface features of interest. The most significant sources of contamination are then superimposed onto this cross-section together with potential receptors (human health & controlled waters), and plausible pathways between the two. In addition to environmental issues, the CSM should also highlight geotechnical issues.

A pCSM is prepared after consideration of all available "desk study" data, and before design of the ground investigation. Data reviewed should include historical plans (with superimposition on a current-day plan), previous SI reports, geological maps etc. The pCSM, in conjunction with knowledge of site constraints (buildings, services, slopes etc) is used to design the ground investigation.

The revised CSM takes account of data obtained during the ground investigation, including the distribution of made ground, the nature and distribution of contamination etc.

02 - Ground investigation fieldwork
Generic notes – geoenvironmental investigations

General

Lithos Ground Investigations are undertaken in accordance with current UK guidance including:

- BS5930:2015 "Code of practice for site investigation"
- Eurocode 7: BS EN 1997-1:2004. Geotechnical design - Part 1: General rules
- Eurocode 7: BS EN 1997-2:2007. Geotechnical design - Part 2: Ground investigation and testing
- BS10175:2013 "Code of practice for the identification of potentially contaminated sites"
- "Technical Aspects of Site Investigation" – EA R&D Technical Report P5-065/TR (2000)
- "Development of appropriate soil sampling strategies for land contamination" – EA R&D Technical Report P5-066/TR (2001)
- Contaminated Land Reports 1 to 6, most notably CLR Report No. 4 "Sampling strategies for contaminated land"
- "Guidance on the protection of housing on contaminated land" – NHBC & EA R&D Publication 66 (2000)
- AGS: 1996 "Guide to the selection of Geotechnical Soil Laboratory Testing"

Exploratory hole locations

Exploratory hole locations are selected by Lithos, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation techniques

Ground conditions can be investigated by a number of techniques; the procedures used are in general accordance with BS5930: 2015 and BS1377: 1990. Techniques most commonly used by Lithos include:

- Machine excavated trial pits, usually equipped with a backactor and a 0.6m wide bucket.
- Cable percussive (Shell & Auger) boreholes, typically using 150mm diameter tools and casing.
- Window or windowless sampling boreholes (dynamic sampling). Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material).
- Rotary percussive open-hole probeholes are typically drilled using a tri-cone rock roller or polycrystalline diamond compact (PDC) bit with air as the flushing medium. Probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse.

Where installed, gas\groundwater monitoring wells typically comprise a lower slotted section, surrounded by a filter pack of 10 mm non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter steel borehole helmet set in concrete. Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

In-situ testing

Relative densities of granular materials given on the trial pit logs are based on visual inspection only, they do not relate to any specific bearing capacities.

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPTs are carried out boreholes, in accordance with BS 1377 1990, Part 9 Section 3.3. Where full penetration (600mm) is not possible, N values are calculated by linear extrapolation and are shown on the logs as N* = x. The strength of cohesive deposits is determined using a hand shear vane.

Shear strength test results (hand vane readings) reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Typically Lithos collect at least three soil samples from each exploratory hole, although in practice a greater number are often taken. The collection of a sufficient number of samples provides a sound basis upon which to schedule laboratory analysis, ensuring:

- A sufficient number of samples from each (common) site material are tested
- Horizontal and vertical coverage of the site is adequate, thereby providing a robust data set for use in the conceptual ground model
- Any localised, significant, but non-pervasive conditions are considered

Made ground and natural soils encountered in the field during a ground investigation often contain a significant proportion of coarse grained material (e.g. brick etc). Soil samples obtained during most investigations are often only truly representative of the in-situ soil mass where there is an absence of particles coarser than medium gravel; i.e the entire soil mass would pass a 20mm sieve.

Representative bulk samples of the **soil mass** are retrieved from coarse soils for specific geotechnical tests (most notably grading and compaction); this typically requires the collection of at least 10kg of soil, and occasionally >50kg. However, in the context of assessing land contamination, it is generally accepted that samples should be representative of the **soil matrix** of the stratum from which they are taken. Consequently, truly representative samples of coarse soils for subsequent contaminant analysis are not obtained - only the finer fraction is placed in sample containers. Coarse constituents not sampled would typically comprise any 'particles' with an average diameter greater than about 20mm (i.e. coarse gravel, cobble and boulder).

At present, neither ISO/IEC 17025 nor MCERTS specify sample pre-treatment with respect to stone removal. Unsurprisingly therefore UKAS accredited testing laboratories do not adopt the same approach to stones[1] – some crush and test the "as received" soil, whilst others sieve out stones and analyse only the residual soil (the sieve size used varies depending on the laboratory).

[1] *Mark Perrin. Stoned – Sample Preparation for Soils Analysis. Ground Engineering, April 2007.*

In essence, samples taken from coarser soils for contaminant analysis are "screened" by the geoenvironmental engineer in the field, and often sieved again by the laboratory during sample preparation. Geoenvironmental engineers do not typically re-calculate soil mass contaminant concentrations by taking account of the unsampled coarse fraction. Likewise, laboratories that remove stones typically report contaminant concentrations based on the dry weight of soil passing the sieve. In the context of land contamination and human health risk assessment, this is considered reasonable, because it is the soil matrix which is of greatest concern. Stones are unlikely to:

- Provide a significant source for plant uptake (consumption of vegetables)
- Remain on vegetables after washing (consumption of vegetables)
- Be eaten (accidentally by an adult, or deliberately by a child)
- Be whipped-up by the wind for dust generation (inhalation)
- Stick to the skin for any length of time (dermal contact)
- Yield toxic vapour (inhalation)

Consequently, Lithos instruct labs to remove all stones >10mm, and to report the results as dry-weight based on the mass of matrix tested. However, the laboratory are given site-specific instruction where coarse stones are coated in say oil, or impregnated with mobile contaminants such as diesel. Where the stones are predominantly natural, or inert (e.g. brick, concrete etc), removal will clearly result in higher reported concentrations, than if the stones were crushed and added to the matrix.

Where the stones include a significant proportion of contaminant-rich material (e.g. slag, fragments of galvanised metal etc) an argument could be made for crushing and analysing. However, provided the stones are stable (i.e. unlikely to disintegrate or degrade) they should not pose a significant risk to human health for the reasons stated above.

Sometimes it is necessary to obtain samples that are not representative of the wider soil matrix, for example when investigating localised, significant, but non-pervasive conditions. Any such unrepresentative samples are annotated with the suffix '*' (eg 2D*, or 4G*). Lithos' site engineer describes both the unrepresentative sample, and the soil mass from which it was been taken.

Sample Containers (for contaminant analysis). Samples of soil for contaminant testing are placed into appropriate containers (see below). Soil samples for organic analysis are stored in cool boxes, at a temperature of approximately 4ºC, until delivery to the selected laboratory.

Anticipated testing	Container(s)
Asbestos identification	500ml plastic tub
pH & metals, and non-volatile organics	500ml glass jar
Speciated TPH	500ml & 50ml glass jars
VOCs (incl. naphthalene and\or GRO)	50ml glass jar

Sample Containers (for geotechnical analysis). The majority of samples are only scheduled for PI and sulphate testing, for which 500g of sample is required (a full 0.5-litre plastic tub). However, bulk bags are taken where scheduling of compaction or grading tests is proposed.

Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork. Long-term monitoring of standpipes or piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during this investigation.

Description of strata

Soils encountered during a Lithos investigation are described (logged) in general accordance with BS 5930:2015. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section within the main body of text. The materials encountered in the trial pits are logged, samples taken, and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

Key to exploratory hole logs

Keys to logs are presented in the Appendix containing the logs. There are two Keys – Symbols & Legends and Terms & Definitions.

03 – Geotechnical laboratory testing
Generic notes – geoenvironmental investigations

General

Soil samples are delivered to the laboratory for testing along with a schedule of testing drawn up by Lithos. All tests are carried out in accordance with BS 1377:1990. The following laboratory testing is routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

Where soft, cohesive soils are encountered, one-dimensional consolidation tests are scheduled in order to assess settlement characteristics, and unconsolidated undrained triaxial compression tests to assess shear strength.

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading
- Compaction tests
- Particle density

Test results are presented as received in an Appendix to the Geoenvironmental Report.

Atterberg limits & moisture content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each "type" of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. Lithos typically only consider a soil to be shrinkable if the proportion finer than 63µm is >35%. PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003), which advocates the use of modified Plasticity Index (I'p), defined as:

I'p = Ip * (%< 425µm/100)

i.e. if PI is 30%, but the soil contains 80% < 425µm, then: I'p = 30 * 80/100 = 24%.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425µm sieve is routinely reported by testing labs. Lithos apply engineering judgment where PI results are spread over a range of classifications. Consideration is given to:

- The average values for each particular soil type (ie differentiate between residual soil and alluvium)
- The number of results in each class and
- The actual values

Unless the judgment strongly indicates otherwise, Lithos typically adopts a conservative approach and recommends assumption of the higher classification.

Soluble sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

Lithos refer to BRE Special Digest 1 (SD1) "Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment" (2005). SD 1 provides definitions of:

- The nature of the site (greenfield, brownfield or pyritic)
- The groundwater regime (static, mobile or highly mobile)
- The design sulphate class (DS class) and
- The aggressive chemical environment for concrete (ACEC class)

Lithos reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of "representative" sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test results can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Oedometer (Consolidation) tests

Oedometer tests measure a soil's consolidation properties, and are performed by applying different loads to a soil sample and measuring the deformation response. Typically the sample is subject to 5 incremental pressures (4 loading & 1 unloading), and the convention is for each subsequent pressure to be double the previous pressure. BS1377 suggests the **initial** pressure should be:

a) For stiff soils the effective overburden pressure*

b) For firm soils "somewhat less" than the effective overburden pressure

c) For soft soils "appreciably less" than the effective overburden pressure, usually 25 kPa or less

d) For very soft soils very low, typically 5 kPa or 10 kPa

* Effective **overburden pressure** (kNm^{-2}) = depth (m) x soil bulk unit weight (kNm^{-3})

Results from these tests are used to predict how a soil in the field will deform in response to a change in effective stress.

Triaxial tests

This test measures the mechanical properties of a soil by placing the sample between two parallel platens which apply stress in one (usually vertical) direction, with fluid used to apply a confining pressure in the perpendicular directions. During the test, the surrounding fluid is pressurized, and then stress on the platens is increased until the material in the cylinder fails.

From triaxial test data, it is possible to extract fundamental material parameters, including its angle of shearing resistance, apparent cohesion, and dilatancy angle. These parameters are then used in computer models to predict how the material will behave in a larger-scale engineering application.

Quick (single stage, Unconsolidated, Undrained tests) are most appropriate for foundation design. This is because load is applied relatively quickly, and shear strength of the clay will be lowest initially; after the applied load causes some consolidation of the ground (after drainage results in dissipation of short-term excess pore water pressure), the in-situ clays will become progressively stronger and hence the factor of safety will increase. Confining pressure is specified as equivalent to overburden pressure (kNm^{-2}).

Foundations on granular soils would use effective shear strength parameters (c' and phi') to assess safe bearing capacity, as the soil would fully drain quickly. These effective shear strength parameters could be determined from Consolidated Undrained (or sometimes the more expensive Consolidated Drained) triaxial tests, but often correlations to the SPT are used.

Unconsolidated Undrained triaxial tests are most appropriate for assessment of the stability of fill slopes on clays. Similar to foundations, the application of load gradually increases the strength of the clays and hence the critical case is the short term undrained condition.

Consolidated Undrained (or sometimes **Consolidated Drained**) triaxial tests are most appropriate for assessment of the stability of cut slopes in clays. This is because unloading of the ground leads to short term reduction in pore pressures that approximately balance the unloading, hence the soil strength is largely unchanged. Over time the reduced pore pressures suck water in, which leads in to the progressive increase in pore pressure and loss of strength. The fully drained state is critical, which must be modelled using effective strength parameters and a reasonable estimate of the long term water table conditions.

Slopes formed in granular soils would use effective shear strength parameters (c' and phi') to assess safe bearing capacity, as the soil would fully drain quickly. These effective shear strength parameters could be determined from Consolidated Undrained (or sometimes the more expensive Consolidated Drained) triaxial tests, but often correlations to the SPT are used.

Determination of analytical suite

An assessment of potential contaminants associated with the former usages of the site is undertaken with reference to CLR 8 "Potential contaminants for the assessment of land" and the relevant DETR Industry Profile(s).

Common contaminants

Common **Inorganic** Contaminants include:

- Metals, most notably cadmium, copper, chromium, mercury, lead, nickel, and zinc
- Semi-metals, most notably arsenic, selenium, and (water soluble) boron
- Non-metals, most notably sulphur
- Inorganic anions, most notably cyanides (free & complex), sulphates, sulphides, and nitrates

With respect to the terminology used by most analytical laboratories:

Total cyanide = Free cyanide + Complex cyanide

Total cyanide (CN) is determined by acid extraction; whereas free cyanide is the water soluble fraction. Complex cyanide is "bound" in compounds and is hard to breakdown. Laboratory determination of complex CN involves subjecting the sample to UV digestion for determination of both free and total CN.

Thiocyanate (SCN) is a different species combined with sulphur.

Elemental sulphur (S) and free sulphur are the same. Total sulphur is all forms, including that present in sulphates (SO_4), sulphides etc.

There are 2 forms of chromium (Cr), chromium VI and chromium III. Chromium VI is the more toxic of these. In soils, total chromium is determined by a strong aqua regia acid digestion. Chromium VI is an empirical method based on a water extract test.

Common **Organic** Contaminants include hydrocarbons, phenols, and polychlorinated biphenyls.

Petroleum is a mixture of hydrocarbons produced from the distillation of crude oil, and includes aliphatics (alkanes, alkenes and cycloalkanes), aromatics (benzene and derivatives) and hydrocarbon-like compounds containing minor amounts of oxygen, sulphur or nitrogen. Petroleum hydrocarbons can be grouped based on the carbon number range:

- GRO – Gasoline Range Organics (typically C_6 to C_{10}). Also referred to as PRO – Petroleum Range Organics
- DRO – Diesel Range Organics (typically C_{10} to C_{28})
- LRO - Lubricating Oil Range Organics (typically C_{28} to C_{40})
- MRO – Mineral Oil Range Organics (typically C_{18} to C_{44})

However, it should be borne in mind that the terms "GRO" and "DRO" analysis are purely descriptive terms, the exact definition of which varies. Total Petroleum Hydrocarbons (TPH) is also a poorly defined term; some testing laboratories regard TPH as hydrocarbons ranging from C_5-C_{40}, whereas others define TPH as C_{10}-C_{30}.

The composition of a TPH plume migrating through the ground can vary significantly; this is primarily dictated by the nature of the source (eg petrol, diesel, engine oil etc). Furthermore, different hydrocarbons are affected differently by weathering processes, and this can result in further variation in the chemical composition of the TPH.

Gasoline contains light aliphatic hydrocarbons (especially within the C_4 to C_5 range) that are volatile. The aromatic hydrocarbons in gasoline are primarily benzene, toluene, ethylbenzene and xylenes, referred to as BTEX. Small amounts of polycyclic aromatic hydrocarbons (PAHs) such as benzo(a)pyrene may also be present. Diesel and light fuel oils have higher molecular weights than gasoline. Consequently, they are less volatile and less water soluble. About 25 to 35% is composed of aromatic hydrocarbons. BTEX concentrations are generally low.

Heavy Fuel Oils are typically dark in colour and considerably more viscous than water. They contain 15 to 40% aromatic hydrocarbons. Polar nitrogen, sulphur and oxygen-containing compounds (NSO) compounds are also present. Lubricating Oils are relatively viscous and insoluble in groundwater. They may contain 10 to 30% aromatics, including the heavier PAHs. NSO compounds are also common.

Polycyclic Aromatic Hydrocarbons (PAHs) have more than two fused benzene rings as a structural characteristic. PAH compounds are present in both petrol and diesel, although in significantly lower concentrations than in coal tars. Certain PAH compounds are carcinogenic (benzo(a)pyrene) and\or mobile in the environment (naphthalene).

Volatile Organic Compounds (VOCs) are organic chemicals, and most are liquids that readily evaporate on exposure to air. Examples include benzene, toluene, xylene, chloroform etc. Semi-Volatile Organic Compounds (sVOCs) include phenol and benzo(a)pyrene, and have relatively low boiling points. Both groups of chemicals are readily absorbed through skin and some, such as benzene, are believed to be linked to tumour growth.

Phenols are compounds that have a hydroxyl group (-OH) attached to an aromatic ring (ie include a benzene ring and an –OH group). Most are colourless solids. A solution of phenol in water is known as carbolic acid, and is a powerful antiseptic. However, phenol vapour is toxic, and skin contact can result in burns.

Polychlorinated Biphenyls (PCBs) were used in pre-1974 transformers as dielectric fluids. PCB's are of increasing toxicity relative to the degree of chlorination. Acute symptoms of PCB poisoning are irritation of the respiratory tract leading to coughing and shortness of breath. Nausea, vomiting and abdominal pain are caused by ingestion of PCB's.

Dioxins and furans (polychlorinated dibenzodioxins and polychlorinated dibenzofurans) are some of the most toxic chemicals known; in the environment, they tend to bio-accumulate in the food chain. Dioxin is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment. The most toxic compound is 2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD.

Dioxin is formed by burning chlorine-based chemical compounds with hydrocarbons. The major source of dioxin in the environment comes from waste-burning incinerators and also from backyard burn-barrels. Dioxin pollution is also affiliated with paper mills which use chlorine bleaching in their process and with the production of Polyvinyl Chloride (PVC) plastics and with the production of certain chlorinated chemicals (like many pesticides).

Methods of analysis (organic compounds)

TPH by GC-FID is an analytical technique which only detects hydrocarbons (aliphatic and aromatic) in the range C_{10} to C_{40} (volatiles, heavy tars, humic material and sulphur are not detected). The laboratory can provide a broad, 'banded' breakdown of the TPH results into gasoline range organics (GRO), diesel range organics (DRO) and heavier lubricating oil range organics (LRO), or fully speciated results with the reporting of hydrocarbon concentrations in 14 specific carbon bandings based upon behavioural characteristics, e.g. aliphatic C_6 to C_8, aromatic C_{10} to C_{12} etc.

Speciated VOC (by GC-MS) analysis quantifies the concentrations of 30 USA-EPA priority compounds. These include chlorinated alkanes and alkenes (in the molecular weight range chloroethane to tetrachloroethane); trimethylbenzenes; dichlorobenzenes; and the 4 BTEX compounds (benzene, ethyl-benzene, toluene & xylene).

Speciated sVOC by (GC-MS) analysis quantifies the concentrations of a variety of organic compounds, including the 16 USA-EPA priority PAHs, phenols, 7 USA EPA priority PCB congeners, herbicides & pesticides.

Note: PAHs are hydrocarbons and consequently (where present) will be picked-up when scheduling TPH by GC-FID.

Note: Risk assessment models require physiochemical properties (solubilities, toxicities etc) of compounds in order to model their behaviour in the environment. These physiochemical properties cannot be derived from a single "TPH", "GRO" or "DRO" value. However, the carbon banded fractions can be used in risk assessment models.

Current UK guidance

The UK approach to contaminated land is set out in Contaminated Land Report No. 11 (2004) "Model Procedures for the Management of Land Contamination". The approach is based upon risk assessment, where risk is defined as the combination of the probability of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

In the context of land contamination, there are three essential elements to any risk: (1) a contaminant source; (2) a receptor (eg controlled water or people); and (3) a pathway linking (1) and (2). Risk can only exist where all three elements combine to create a pollutant linkage. Risk assessment requires the formulation of a conceptual model which supports the identification and assessment of pollutant linkages.

Lithos adopt a tiered approach to risk assessment, consistent with UK guidance and best practice. The initial step of such a risk assessment (or Tier 1) is the comparison of site data with appropriate UK guidance levels, Lithos risk-derived screening values, or remedial targets. It should be noted that exceedance of Tier 1 does not necessarily mean that remedial action will be required.

Soil screening values used by Lithos

In March 2002 DEFRA and the Environment Agency published a series of technical papers (R&D Publications CLR 7, 8, 9 and 10) outlining the UK approach to the assessment of risk to human health from land contamination. In 2008 CLR 7, 9 and 10 and all corresponding SGV and Tox reports were withdrawn and superseded by new guidance including:

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008
- Evaluation of models for predicting plant uptake of chemicals from soil - Science Report – SC050021/SR
- Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2
- Updated technical background to the CLEA model - Science Report: SC050021/SR3
- CLEA Software Handbook (Version 1.071), Science report: SC050021/SR4
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

The approach set out in these documents represents current scientific knowledge and thinking; and includes the Contaminated Land Exposure Model (CLEAv1.06). The Environment Agency are in the process of using this updated approach to regenerate a selection of Soil Guideline Values (SGVs).

CLEA SGVs were derived for standard land use scenarios predominantly in the context of Part IIA, using a conceptual site model (CSM) defined in SR3. Lithos have incorporated amendments to the CSM used to derive SGVs, that more accurately reflect redevelopment within the planning regime; consequently, Lithos have not adopted any published SGV as a screening value.

The CLEA conceptual site model assumes a source located in a sandy loam, with 6% soil organic matter (SOM) - equivalent to 3.5% total organic carbon (TOC). However, where the average TOC value for a particular soil type is significantly lower than the 3.5%, evaluation of Lithos Screening Values should be undertaken and a site specific risk assessment will usually be required. Other CLEA default characteristics adopted by Lithos are:

Sandy Loam characteristics (source)	Default values adopted
Total porosity (fraction)	0.53
Water filled porosity (fraction)	0.33
Air filled porosity (fraction)	0.2

Lithos have derived Screening Values for four different CSMs (scenarios); these are:

A - Residential with gardens, but no cover (or only up to 300mm)

B - Residential with gardens and 600mm 'clean' cover

C - Residential apartments with landscaping (i.e. no home grown produce)

D - Commercial/industrial with landscaping

E – Importation of soil cover

The **exposure** pathways considered for each scenario are detailed in the table below.

Scenario	Land use	Pathways	Justification
A	Residential with garden, but no cover (or only up to 300mm)	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	Minimal cover – insufficient to break any pathways therefore all exposure pathways are relevant.
B	Residential with garden minimum 600mm cover	• Inhalation of indoor vapours • Inhalation of outdoor vapours	The 600mm cover removes the risk from all pathways other than inhalation.
C	Residential apartments with landscaped areas and minimum 300mm cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. However consumption of home grown produce not included as unlikely to be grown in landscaped areas. Where vegetables are to be grown site specific QRA may be required.
D	Commercial/ industrial with landscaped areas no cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. Assumed the commercial development consists of offices to provide a conservative assessment.
E	Importation of soil for cover in garden and landscaped areas	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of outdoor vapours and dust	Material used as cover to break existing pathways therefore all direct and indirect pathways relevant; however cover is **not** placed below plots therefore indoor inhalation is not relevant.

Lithos have assumed the source of contamination is directly below the building foundations; i.e. a depth to source of 0.15m as opposed to the CLEA default of 0.65m. This assumption provides for a more conservative approach than the UK default. This adjustment has been included to account for sites where made ground is re-engineered to enable new buildings to be established on raft foundations. In such situations contamination may lie directly beneath the foundation.

The Soil Screening Values referred to in this document are **not** intended to be used when considering potential risks associated with:

- Existing land uses in the context of Part IIA of the Environment Protection Act 1990;
- End uses such as allotments, sports fields, children's playgrounds, care homes, hospitals etc; and
- Controlled waters.

In December 2013 Defra published the results of research project SP1010 – Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination. The objective of this project was provide technical guidance in support of Defra's revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 (Part 2A). The revised Statutory Guidance, published in April 2012, introduced a new four-category system for classifying land under Part 2A where Category 1 includes land where the level of risk is clearly unacceptable, and Category 4 includes land where the level of risk posed is acceptably low. Project SP1010 aimed to deliver:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and
- Demonstration of the methodology, via derivation of C4SLs for 6 substances – arsenic, cadmium, chromium IV, lead, benzene & benzo(a)pyrene.

The methodology for deriving both the previous Soil Guideline Values and the new Category 4 Screening Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology. Development of C4SLs has been achieved by modifying the toxicological and\or exposure parameters used within CLEA (while maintaining current exposure parameters).

The Part 2A Statutory Guidance was developed on the basis that C4SLs could be used under the planning regime. However, policy responsibility for the National Planning Policy Framework falls to the Department for Communities and Local Government. Defra anticipate that, where they exist, C4SLs will be used as generic screening criteria, and Lithos consider C4SLs to be suitable for use as Tier 1 Screening Values. Lithos have discussed this matter with both NHBC and YAHPAC (collection of Yorkshire & Humberside local authorities) and received confirmation that they are satisfied with this approach.

With respect to **inorganic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Inorganic contaminant	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
As	32	37	37	Use (A) in SI Report for initial "screen". If >5 x A, then consider increase of cover to 1,000mm	40	640	37	C4SL adopted
Cd	10	26	26		149	410	26	C4SL adopted
Cr			3,000		3,000	30,000	3,000	Assumes Cr is CrIII
Pb	450	200	200		310	2,330	200	C4SL adopted
Ni	130		127		127	1,700	127	Assessment of health risk only
Se	350		350		595	13,000	434	
Hg	170		169		238	3,640	199	Assumes in an inorganic compound
B			5		5	5	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependant)
Cu			80-200		80-200	80-200	80-200	
Zn			200		200	200	200	

With respect to **organic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Organic contaminant (all sourced via CLEA)	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
Benzene	0.33	0.87	0.9	0.9	3.3	98	N/A	C4SL adopted
Toluene	610		600	3,000	2,700	5,000	N/A	Calculated value over 10,000
Ethyl Benzene	350		350	932	843	5,000	N/A	
Xylenes	240		246	327	321	5,000	N/A	
Phenol	420		412	2,400	519	5,000	N/A	
PCBs			2	8	2	38	N/A	Based on toxicity of EC7
Benzo(a)pyrene		5	5	25	5.3	76	5	C4SL adopted. Where source is not a coal tar
Naphthalene			8	9	9	1,000	12	
Gasoline Range Organics			30	34	34	5,000	45	See 3-step assessment of TPH below
Diesel Range Organics			151	156	154	5,000	219	
Lubricating Range Org			1,000	5,000	2,000	5,000	1,000	

* *For a residential end use*

The significance of PAHs can be determined by considering indicator compounds. In most cases benzo(a)pyrene (BaP) is adopted as an indicator due to the amount of toxicological data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. A surrogate marker approach can be used to estimate the toxicity of a mixture of PAHs in soil using toxicity data for individual indicator compounds within that mixture. Exposure to the surrogate marker is assumed to represent exposure to all PAHs in that matrix. The surrogate marker approach relies on a number of assumptions:

- Surrogate marker (bap) must be present in all soil samples
- Profile of the different pah relative to bap should be similar in all samples
- PAH profile in the soil samples should be similar to that used in the pivotal toxicity study[1]

[1] SP1010 Appendix E, Provisional C4SIs for benzo(a)pyrene as a surrogate marker for PAHs, CL:AIRE 2013

To assess the PAH profile in a soil sample, the ratio of the seven genotoxic PAHs (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene), relative to BaP, should be calculated. The ratio relative to BaP should lie within an order of magnitude above and below the mean ratio to BaP.

Naphthalene should also be considered separately against its generic screen. Whilst classed as a PAH, naphthalene is more volatile and mobile in the environment than most other PAHs. As such the significance of naphthalene cannot be considered within the surrogate marker approach.

Similarly, **TPH** cannot be assessed as a single "total" value, and reference has been made to the Environment Agency's document P5-080/TR3, "The UK approach for evaluating human health risks from petroleum hydrocarbons in soils". This document supports the assumptions and recommendations made by the US Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG). The TPHCWG have broken down "TPH" into representative constituent fractions or "EC Bandings". The TPHCWG have derived a series of physiochemical and toxicological parameters for each of the bandings.

The significance of speciated TPH results can be assessed by following the 3 steps outlined in the tables below.

Step	Result	Action
1. Consider indicator compounds: Are BTEX, naphthalene, benzo(a)pyrene above their respective Tier 1 values?	Yes	Remediation or dQRA required
	No	Proceed to Step 2
2. Consider individual TPH fractions: are they above respective screening values?	Yes	Remediation or dQRA required
	No	Proceed to Step 3
3. Assess Cumulative effects: Is the calculated Hazard Index for each source >1	Yes	Remediation or dQRA required
	No	TPH compounds pose no significant risk

Step 1 - Assessing indicator compounds

TPH fraction Indicator compound	End use specific screening value (mg/kg)			
	A: Residential no cover	B: Residential with 600mm cover	C: Residential no gardens	D: Commercial\ industrial
Benzene	0.9	0.9	3.3	98
Toluene	600	3,000	2,700	5,000
Ethyl Benzene	350	932	843	5,000
Xylenes	246	327	321	5,000
Naphthalene	8	9	9	1,000
Benzo(a)pyrene	5	25	5.3	76

Step 2 - Assessing individual TPH fractions

TPH fraction		End use specific screening value (mg/kg)			
		A: Residential no cover	B: Residential with 600mm cover	C: Residential with no gardens	D: Commercial/ industrial
Aliphatic 5-6	GRO	41	41	42	5,000^ per fraction
Aliphatic 6-8	GRO	125	125	125	
Aliphatic 8-10	GRO	31	31	32	
Aliphatic 10-12	DRO	151	156	154	
Aliphatic 12-16	DRO	500^	500^	500^	
Aliphatic 16-21	DRO	1,000^	5,000#	1,000^	
Aliphatic 21-35	LRO	1,000^	5,000#	1,000^	
Aromatic 5-7	GRO	100	123	122	
Aromatic 7-8	GRO	30	34	34	
Aromatic 8-10	GRO	47	50	50	
Aromatic 10-12	DRO	215	287	266	
Aromatic 12-16	DRO	689	1,000*	1,000*	
Aromatic 16-21	DRO	1,000^	5,000#	1,000^	
Aromatic 21-35	LRO	1,000^	5,000#	1,000^	

* Calculated Screening Value exceeded soil saturation limit and could indicate free product, therefore calculated soil saturation limit adopted as a target

^ Calculated Screening Value close to soil saturation limit, screening value selected by Lithos considering visual and olfactory impacts.

\# Five times the screening value for Scenario A.

Step 3 - Assessing Cumulative Effects

$$HI = \sum_{F_i=1}^{16} HQ\ F_i = \frac{Measured\ concentration\ F_i\ (mg\,kg^{-1})}{SGV\ F_i\ (mg\,kg^{-1})}$$

where HI = Hazard Index
HQ = Hazard Quotient
F_i = Fraction $_i$
SGV = Soil Guideline Value

Other screening values used by Lithos

Tier 1 risk assessment of **hazardous gas** is undertaken through reference to the following documents (and further information is presented in Generic Note No. 5 – Hazardous Gas):

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2007) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating "traffic lights". Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2007) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2015 – Code of Practice for the characterisation & remediation from ground gas in affected developments

With respect to the assessment of potential **phytotoxic effects** of contaminants, Lithos refer to "The Soil Code" (MAFF, 1998) for copper and zinc. The CLEA SGV is adopted for nickel due to its human health effects.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Concrete in aggressive ground', 2005.

With respect to the interpretation of the **calorific values**, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that: "*In general … it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn*".

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate or groundwater concentrations with the appropriate water quality standard. Tier 1 Screening Values have been discussed with the Environment Agency, and typically those in **bold** below are adopted.

Analyte	Source of Tier 1 Screening Value (µg/l)			
	Surface water (Abstraction for drinking) 1996	Water Supply Regulations 2000	Water Framework Directive	EA Advice
Arsenic	50	10	**50**	
Selenium	10	**10**		
Cadmium	5	5	**1.5**	
Chromium	50	50	**32**	
Copper	50	2,000	**28**	
Lead	50	10	**7.2**	
Nickel		20	**20**	
Zinc	3,000		**125**	
Boron		**1,000**		
Mercury	1	1	**0.07**	
Petroleum Hydrocarbons				**10**
1,1,1-Trichloroethane			**100**	
1,1 Dichloroethane				**100**
1,2-Dichloroethane		3	**10**	
1,1-Dichloroethene				**100**
Benzene		1	**10**	
Ethylbenzene				**10**
Tetrachloroethene		10	**10**	
Toluene			**50**	
Trichloroethene		10	**10**	
Vinyl Chloride		**0.5**		
Trichloromethane			**2.5**	
Xylenes			**30**	
Chloroethane				**100**

Waste classification & WAC

In the context of waste soils generated by remediation and\or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated 'natural' soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds)
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds)

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

Landfill operators require Waste Acceptance Criteria (WAC) laboratory data, if soil waste is classified as **hazardous**, and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Lithos typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated, for example where redevelopment proposals include basement construction etc. If off-site disposal of soils classified as hazardous waste during redevelopment is anticipated, then WAC analysis should be scheduled at an early stage in the remediation programme. However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous, and these contaminants can often be dealt with by alternative technologies (eg by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (eg WAC) is required.

Possible action in event of Tier 1 exceedance

Should any of the Tier 1 criteria detailed above be exceeded, then three potential courses of action are available. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or landfill gas).

1. Undertake further statistical analysis following the approach set out in "*Guidance on Comparing Soil Contamination Data* with *a Critical Concentration - CL:AIRE and CIEH, May 2008*" in order to determine whether contaminant concentrations of inorganic contaminants within soil\fill actually present a risk (only applicable to assessing the risk to human health).
2. Carry out a more detailed quantitative risk assessment in order to determine whether contamination risks actually exist.
3. Based on a qualitative risk assessment, advocate an appropriate level of remediation to "break" the pollutant linkage - for example the removal of the contaminated materials or the provision of a clean cover.

Prior to undertaking any statistical analysis the issue of the **averaging area** requires further consideration. The CL:AIRE\CIEH document still refers to CLR 7, which suggests averaging area should reflect receptor behaviour and therefore might be a single garden, or an open area used by the local community as a play area. This approach to averaging areas is considered applicable within the context of Part IIA of the Environmental Protection Act (EPA) 1990, in terms of an existing residential development.

However, Lithos consider the concept of a single garden as an averaging area to be inappropriate with respect to brownfield redevelopment, which is regulated by the planning regime. In this context, contamination across the entire site needs to be characterised by reference to the Conceptual Site Model. Consequently, Lithos gather and analyse sample results by fill type, and\or by former use in a given sub-area of the site, before undertaking statistical analysis; ie the averaging area is associated with the extent of a particular fill type, or an area affected by spillage\leakage.

In terms of brownfield redevelopment, this is considered a more appropriate methodology which provides a more representative sample population for statistical analysis. As such the entire site is considered in terms of the proposed end use, be this residential with, or without gardens.

Analysis by soil\fill type is appropriate for essentially immobile contaminants associated with a particular fill type, for example arsenic in colliery spoil, metals in ash & clinker, sulphate in plaster-rich demolition rubble etc.

Analysis by former use is appropriate where more mobile contaminants have entered the ground, for example diesel associated with leakage from a former fuel tank, downward migration of leachable metals through granular materials, various soluble contaminants present in a wastewater leaking into the ground via a fractured sewer etc. In these circumstances, it may be appropriate to undertake statistical analysis of sample results from a variety of different soil\fill types. However, consideration would have to be given to factors such as porosity which might influence impregnation of a mobile contaminant into the soil mass, ie contamination would normally be more pervasive and significant in granular soils than cohesive soils

Appendix B

Drawings

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CLIENT	JOB TITLE	DRAWING TITLE
THE DEVONSHIRE GROUP	SHIRES LANE, EMBSAY	SITE LOCATION PLAN

DRAWN	DATE
MJT	24/09/2018
CHECKED REG	DATE 25/09/2018

STATUS: FOR COMMENT ☐ FOR APPROVAL ☐ DRAFT ☐ FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:25,000	A4	3161/1	

NOTES

POND/SURFACE WATER

GRASS & OVERGROWN AREAS

LINE OF WATER UTILITY

LINE OF SEWER/DRAINAGE UTILITY

LINE OF BT/TELECOMMS UTILITY

NOTE THAT UTILITY LOCATIONS SHOULD NOT BE RELIED UPON FOR CONSTRUCTION PURPOSES, NOR SHOULD IT BE ASSUMED THAT ALL UTILITIES BENEATH THE SITE ARE SHOWN ON THIS PLAN. THERE MAY BE UTILITIES UNKNOWN TO LITHOS. THIS DRAWING IS NOT AN ALTERNATIVE TO VISUAL INSPECTION, USE OF A CAT DETECTION TOOL AND CAREFUL EXCAVATION.

APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

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

Tel 01937 545330

CLIENT

THE DEVONSHIRE GROUP

JOB TITLE

SHIRES LANE, EMBSAY

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
MJT	24/09/2018	FOR COMMENT ☐
		FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
REG	24/09/2018	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:750	A3	3161/3	

NOTES

APPROXIMATE SITE BOUNDARY

LOCATION & ORIENTATION OF PHOTOGRAPH

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

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www.lithos.co.uk

Tel 01937 545330

CLIENT

THE DEVONSHIRE GROUP

JOB TITLE

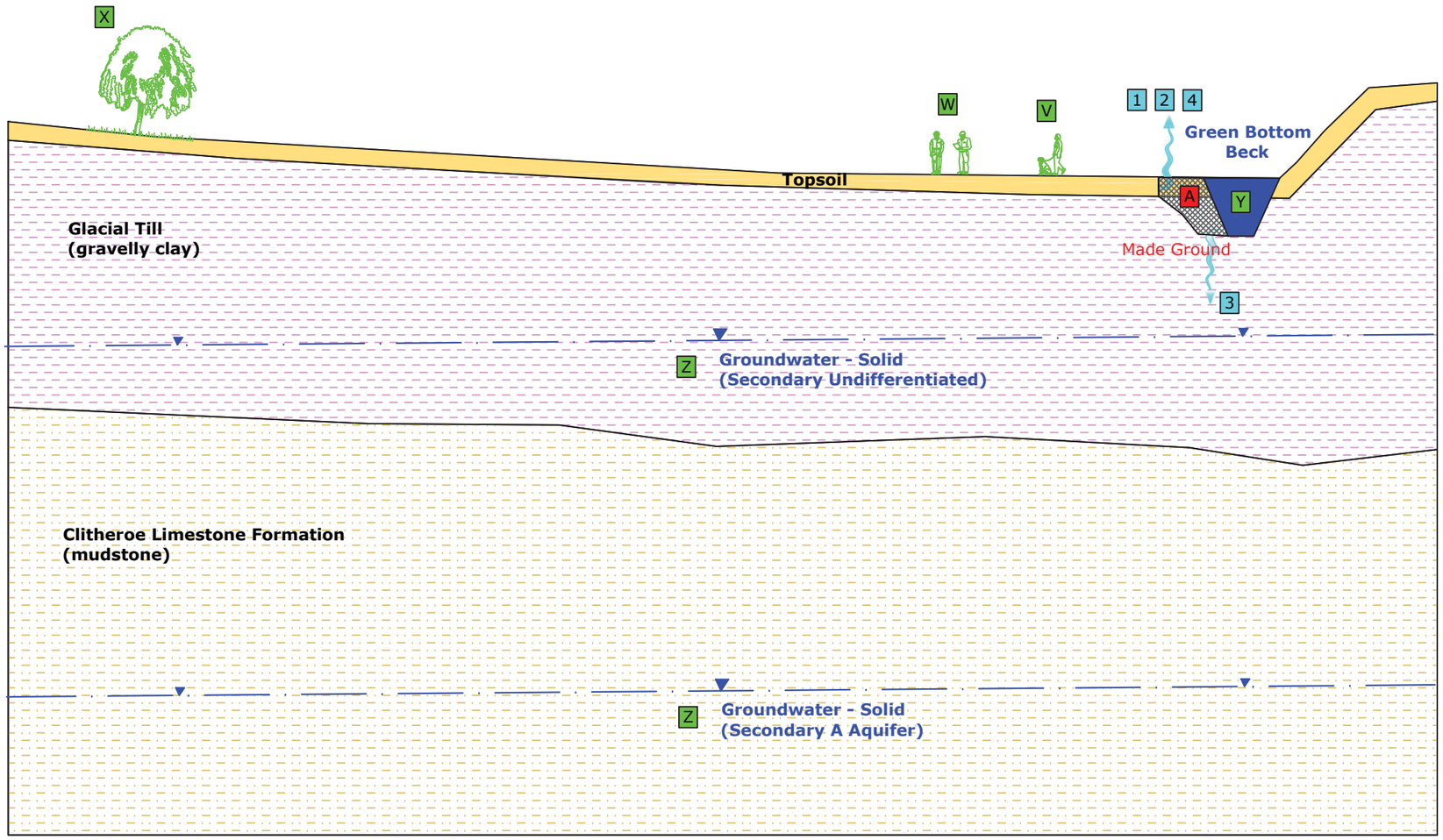
SHIRES LANE, EMBSAY

DRAWING TITLE

SITE PHOTOGRAPHS

DRAWN	DATE	STATUS
MJT	24/09/2018	FOR COMMENT ☐
		FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
REG	25/09/2018	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
NOT TO SCALE	A3	3161/4	



SOURCES
A MADE GROUND (INORGANICS/ORGANICS)

PATHWAYS
1 DERMAL CONTACT
2 INGESTION/INHALATION
3 LEACHING OF CONTAMINANTS
4 VOLATILISATION

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

NOTES

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

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Tel 01937 545330

CLIENT

THE DEVONSHIRE GROUP

JOB TITLE

SHIRES LANE, EMBSAY

DRAWING TITLE

PRELIMINARY CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
MJT	24/09/2018	FOR COMMENT ☐
CHECKED: REG	DATE: 25/09/2018	FOR APPROVAL ☐
		DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
Not to scale	A3	3161/5	

NOTES

TRIAL PIT LOCATION

GRASS & OVERGROWN AREAS

CABLE PERCUSSION LOCATION

LINE OF WATER UTILITY

LINE OF SEWER/DRAINAGE UTILITY

LINE OF BT/TELECOMMS UTILITY

NOTE THAT UTILITY LOCATIONS SHOULD NOT BE RELIED UPON FOR CONSTRUCTION PURPOSES, NOR SHOULD IT BE ASSUMED THAT ALL UTILITIES BENEATH THE SITE ARE SHOWN ON THIS PLAN. THERE MAY BE UTILITIES UNKNOWN TO LITHOS. THIS DRAWING IS NOT AN ALTERNATIVE TO VISUAL INSPECTION, USE OF A CAT DETECTION TOOL AND CAREFUL EXCAVATION.

APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE
B	BOREHOLE LOCATIONS ADDED (MJT)	21/11/2018
A	TOPOGRAPHICAL INFORMATION ADDED (MJT)	24/09/2018

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www.lithos.co.uk

Tel 01937 545330

CLIENT

THE DEVONSHIRE GROUP

JOB TITLE

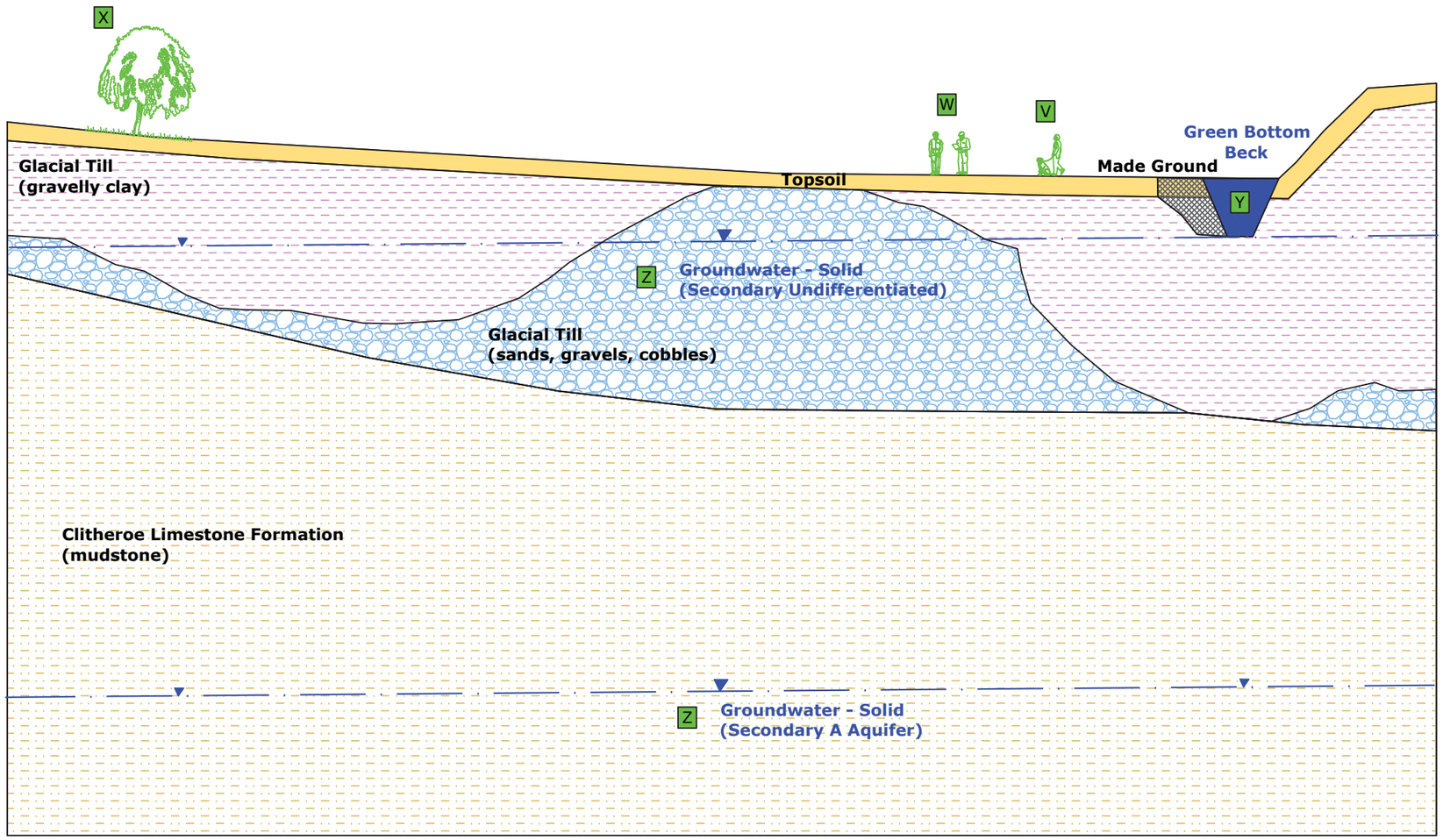
SHIRES LANE, EMBSAY

DRAWING TITLE

EXPLORATORY HOLE LOCATIONS

DRAWN	DATE	STATUS
MJT	21/11/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	21/11/2018	DRAFT ☑
		FINAL ☐

SCALE	SHEET	DRAWING NO.	REVISION
1:750	A3	3161/6	C



SOURCES	PATHWAYS	RECEPTORS
NONE IDENTIFIED	NONE IDENTIFIED	V END USERS (RESIDENTS) W SITE WORKERS X VEGETATION Y SURFACE WATERS Z GROUNDWATER

NOTES

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

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

Tel 01937 545330

CLIENT
THE DEVONSHIRE GROUP

JOB TITLE
SHIRES LANE, EMBSAY

DRAWING TITLE
REVISED CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
MJT	24/09/2018	FOR COMMENT ☐
CHECKED REG	DATE 25/09/2018	FOR APPROVAL ☐
		DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
Not to scale	A3	3161/7	

Appendix C

Commission

002/3161/MJT

17th July 2018

Registered in England 07068066

Parkhill
Wetherby
West Yorkshire
LS22 5DZ

T 01937 545 330

www.lithos.co.uk

Mr A Byrne
The Devonshire Group
The Estate Office
Edensor
Bakewell
Derbyshire
DE45 1PJ

Dear Andrew

Shires Lane, Embsay

Further to your recent invitation, please find attached our proposal for undertaking a site investigation on the above land. We understand that your proposed development will include traditional 2 storey domestic dwellings with associated gardens, POS and adoptable roads and sewers; although no layout is available yet.

Review of the information supplied suggests that the site consists of a single parcel of land of approximately 0.5 hectares off Shires Lane. Review of Google Maps suggests the site comprises rough grazing land.

Brief review of Old Maps and Environment Agency data suggests the site:

- Appears to have remained undeveloped throughout its history;
- Is not located within 250m of a known landfill site; and,
- Is not within a groundwater source protection zone.

Brief examination of the relevant geological map suggests the site is underlain by Glacial Till, with mudstone of the Clitheroe Limestone formation below. This site is located beyond the Coal Authority's defined coalfields, therefore a mining report is not required.

We will need a Promap or topo survey in CAD format, to provide a base plan for technical drawings etc. If you do not have one, we could obtain at cost plus £**.

Our site investigation will be undertaken in accordance with UK good practice (as outlined in BS5930, BS10175, CLR11 etc). Our Report may not be fully compliant with Eurocode 7 (EC7) and will not purport to be a Ground Investigation Report, nor a Geotechnical Design Report as defined by EC7. Our ground appraisal is intended to assist others as they proceed with design of the proposed development.

This proposal allows for the following works:

Desk study: Environmental search data and historical maps (obtained from Landmark or Groundsure), will be reviewed in order to determine whether past land uses have had any effect on the proposed development. In addition, published geological plans of the area will be examined.

This site is underlain by limestone bedrock, so we will obtain a natural ground stability report from BGS in order to check whether or not bedrock is considered prone to dissolution (but likely very low risk).

We will also visit site to undertake a walkover survey.

Fieldwork: We have allowed for a day's trial pitting, all supervised and logged by an experienced geoenvironmental engineer.

Based on anticipated ground, soakaways are considered unlikely to provide a satisfactory solution for surface water drainage, but testing would remove any ambiguity with respect to Yorkshire Water queries. However, no allowance has been made for soakaway testing at this stage. If required, or considered feasible based on the ground actually encountered, soakaway tests could be undertaken for an additional fee of about £*** (if carried out on the same day as the trial pitting).

In line with current UK guidance, (most notably BRE365 and CIRIA C697:2007) soakaways should not be advocated where the seasonally high groundwater table lies within 1m of the soakaway base. Consequently, if the initial soakaway tests yield satisfactory results, it will be necessary to install groundwater monitoring wells to depths of around 5m in at least boreholes.

Monitoring well design (depth, drilling technique etc) would best be determined after completion of the pitting, since it might be that (relatively cheap) dynamic sample boreholes will suffice. At this stage, it would be prudent to allow £*** to £*** (cost dependent on drilling technique required).

Representative soil samples of natural and man-made ground, including any contaminated samples, will be taken during the works. In-situ shear strengths of any cohesive soils encountered will be determined by the use of a hand-held shear vane.

We will make every effort to compact arisings and 'sweep' them over each pit. However, you should be aware that on completion of the investigation, "graves" of spoil (each about 3m long by 1m wide) unsuitable for trafficking, will be left up to 400mm proud at each trial pit location. At this stage, no allowance has been made for any further reinstatement such as removal of excess arisings, replacement of turf.

If the pitting encounters significant thicknesses of very soft/loose deposits (neither considered likely), boreholes may be required to obtain geotechnical data from greater depth. We will advise you of any need for boreholes within 2 days of completion of the pitting.

This proposal has been put together without a visit to the site and it has been assumed that access is available for a JCB-type excavator.

Testing: This will comprise routine geotechnical soils analysis, including 6 moisture content & Atterberg limits, and 6 pH & water-soluble sulphate.

This site is greenfield and therefore we could obtain in-situ CBR values from plate tests on site. However, at this stage routes, formation level and total length, of proposed estate roads are unknown. Consequently, we will simply estimate CBR values from strata descriptions and classification test results.

The site is understood to be essentially Greenfield, and therefore testing of potentially contaminated samples should only be required if made ground is encountered in the exploratory holes. However, we have allowed for analysis of topsoil (6 samples) to confirm its suitability for re-use. The test suite will include heavy metals and speciated PAH; samples will also be analysed for pesticides, and If required, visible contaminants, sharps and the clay/sand/silt content of topsoil samples could be determined to check compliance with BS3882 requirements at a cost of £** per sample.

Within in our proposal we have allowed for the screening (ID) of 6 samples for asbestos. In the event that positive IDs are reported, it is likely that we will need to schedule further analysis (asbestos quantification), in order to determine the significance of the results. Asbestos quantification is currently a relatively expensive test and consequently we have not allowed for it at this stage. We will inform you immediately after receipt of results if we consider asbestos quantification is required.

Reporting & timescales: In order to provide you with sufficient information to enable assessment of abnormal costs at the earliest opportunity we will issue a concise overview report within 3 days of fieldwork completion.

On completion of the desk study, fieldwork and laboratory testing a comprehensive bound, factual and interpretative report will be issued. This will contain detailed engineering records, laboratory test results, copies of all relevant correspondence and drawings of the site. The report will include qualitative risk assessment with respect to both controlled waters and human health. The report will also include consideration of foundation types.

Fieldwork could be commenced within 2 weeks of receipt of your written instruction to proceed. Our comprehensive geoenvironmental appraisal report will be issued within 4 weeks of fieldwork completion.

Invoicing: The attached proposal provides a breakdown of the costs associated with this project. This breakdown is for information only and the proposal can be regarded as a lump sum price of £**** plus VAT. Variation will only occur in the event that a given item is not undertaken or that substantial additional works are recommended, in which case we will inform you immediately, provide costs for the required works, and seek your prior consent.

Our proposal allows for submission of the report to the Local Authority and NHBC, and for submission of a single piece of subsequent correspondence with each regulator to address any queries they may have. Any further meetings, correspondence etc, would be chargeable.

We will submit our invoice for this project with the final report.

Health, safety & welfare: The works outlined above will be carried out in accordance with Lithos' task- and site- specific Risk Assessments and Method Statements.

Details of welfare will be included within the Method Statements, however, this investigation is expected to be completed within 1 working day and therefore it is not considered reasonably practicable to provide formal welfare facilities, and our proposal makes no allowance for so doing.

Utility plans are required in order to protect operatives from the hazards associated with striking buried services and avoid potentially substantial disruption\repair costs. We will make every effort not to damage any services (including review of utility plans and use of a CAT detector). However, Lithos cannot accept liability for damage to any underground services that are not accurately marked on plans made available to us prior to commencement of our field investigation, or have not been accurately marked on the ground by a responsible third party (e.g. utility company, site owner).

Most developers have copies of the necessary utility plans (including electricity, gas, water, drainage & telecom), and it would be appreciated if you could forward these prior to the proposed fieldworks. However, if you do not have the necessary plans, Lithos will obtain them direct from each of the utility companies.

Under the CDM Regulations 2015, Lithos must be provided with pre-construction information already in your possession, or information that can reasonably be obtained through sensible enquiry. This information must be relevant to the project, have an appropriate level of detail, and be proportionate to the nature of the risks.

Terms & conditions: This work will be undertaken in accordance with our Standard Terms and Conditions, a copy of which are enclosed.

It is hoped the above is sufficient for your present needs. However, should you require any further information, please contact the undersigned.

Yours sincerely

Matt Thompson
Principal Engineer
for and on behalf of
LITHOS CONSULTING LIMITED

1 DEFINITIONS AND INTERPRETATION

1.1 In this Agreement, unless the context otherwise requires, the following words and expressions have the following meanings:

"Agreement" shall mean these Terms (entitled "Terms and Conditions for the Appointment of Lithos Consulting"), the Proposal, any document recording the Client's unequivocal acceptance of the Proposal and any other documents or parts of other documents expressly referred to in any of the foregoing:

"Client" shall mean the party for whom the Services are being provided by Lithos;

"Documents" shall mean all documents of any kind and includes plans, drawings, reports, programmes, specifications, Bills of Quantities, calculations, letters, e-mails, faxes, memoranda, films and photographs (including negatives), or any other form of record prepared or provided or received by, or on behalf of Lithos, and whether in paper form or stored electronically or on disk, or otherwise;

"Lithos" shall mean Lithos Consulting Limited whose registered office is at Parkhill, Walton Road, Wetherby, West Yorkshire, LS22 5DZ.

"Intellectual Property" includes all rights to, and any interests in, any patents, designs, trade marks, copyright, know-how, trade secrets and any other proprietary rights or forms of intellectual property (protectable by registration or not) in respect of any technology, concept, idea, data, programme or other software (including source and object codes), specification, plan, drawing, schedule, minutes, correspondence, scheme, programme, design, system, process logo, mark, style, or other matter or thing, existing or conceived, used, developed or produced by any person;

"Parties" shall mean the Client and Lithos

"Project" shall mean the project described in the Proposal and any enquiry from the Client on which Lithos has based its Proposal;

"Proposal" means the offer document prepared by Lithos in response to an enquiry or otherwise, in connection with the proposed provision of the Services;

"Services" means the work and services relating to the Project to be provided by Lithos pursuant to the Agreement and as set out in the Proposal and shall include any additions or amendments thereto made in accordance with these Terms;

"Terms" means these terms entitled "Lithos Consulting Terms of Appointment".

1.2 Words importing the singular only shall also include the plural and vice versa, where the context requires.

1.3 Words importing persons or parties shall include firms, corporations and any organisation having legal capacity and vice versa, where the context requires; and words importing a particular gender include all genders.

1.4 The sub-headings to the clauses of these Terms are for convenience only and shall not affect the construction of the Agreement.

1.5 A reference to legislation includes that legislation as from time to time amended, re-enacted or substituted and any Orders in Council, orders, rules, regulations, schemes, warrants, by-laws, directives or codes of practice issued under any such legislation.

1.6 In the event of conflict between the documents forming part of the Agreement, the Proposal shall prevail, followed by the Terms.

2 APPOINTMENT

2.1 The Client agrees to engage Lithos and Lithos agrees to provide the Services in accordance with the provisions of the Agreement.

3 OBLIGATIONS OF LITHOS

3.1 Lithos shall perform the Services using the reasonable standard of skill and care normally exercised by similar professional Environmental firms in performing similar services under similar conditions.

3.2 Lithos shall use all reasonable endeavours to perform the Services in accordance with all relevant environmental and safety legislation.

4 OBLIGATIONS OF THE CLIENT

4.1 Throughout the period of this Agreement the Client shall afford to Lithos or procure the affording to Lithos of access to any site where access is required for the performance of the Services.

4.2 The Client accepts responsibility for ensuring that Lithos is notified in writing of all special site and/or plant conditions, including without prejudice to the generality of the foregoing, the existence and precise location of all underground services, cables, pipes, drains or underground buildings, constructions or any hazards known or suspected by the Client, which the Client shall clearly mark on the ground or identify on accurate location plans supplied to Lithos prior to the commencement of the Services. The Client shall also inform Lithos in writing of any relevant operating procedures including any site safe operating procedures and any other regulations relevant to the carrying out of the Services. The Client shall indemnify Lithos against all costs, claims, demands and expenses arising as a result of any non-disclosure in this respect, including but not limited to indemnification against any action brought by the owner of the land or otherwise.

4.3 If the Client discovers any conflict, defect or other fault in the information or designs provided by Lithos pursuant to the Agreement, he will advise Lithos in writing of such defect, conflict or other fault and Lithos shall have the right to rectify the same or where necessary, to design the solution for rectification of any works carried out by others pursuant the conflicting, defective or in any other way faulty information or designs.

5 INTELLECTUAL PROPERTY

5.1 The copyright in all Intellectual Property prepared by or on behalf of Lithos in connection with the Project for delivery to the Client shall remain vested in Lithos.

5.2 The Client shall have a non-exclusive licence to copy and use such Intellectual Property for purposes directly related to the Project. Such licence shall enable the Client to copy and use the Intellectual Property but solely for its own purposes in connection with the Project and such use shall not include any licence to reproduce any conceptual designs or professional opinions contained therein nor shall it include any license to amend any drawing, design or other Intellectual Property produced by Lithos.

5.3 Should the Client wish to use such Intellectual Property in connection with any other works or for any other purpose not directly related to the Project or wish to pass any Intellectual Property to any third party, it must obtain the prior written consent of Lithos. The giving of such consent shall be at the discretion of Lithos and shall be upon such terms as may be required by Lithos. Lithos shall not be liable for the use by any person of such Intellectual Property for any purpose other than that for which the same were prepared by or on behalf of Lithos.

5.4 Ownership of any proposals submitted to the Client that are not subsequently confirmed as part of the Services to be provided for the Client remain with Lithos and such proposals must not be used as the basis for any future work undertaken by the Client or a third party and no liability can be accepted howsoever arising from such proposals.

5.5 In the event of the Client being in default of payment of any fees or other amounts due, Lithos may suspend further use of the licence on giving 2 days' notice of the intention to do so. Use of the licence may be resumed on receipt of the outstanding amounts.

6 TITLE

6.1 Lithos shall transfer only such title or rights in respect of the Documents as it has, and if any part is purchased from a third party Lithos shall transfer only such title or rights as that party had and has transferred to Lithos.

6.2 Title in the Documents shall remain with and shall not pass to the Client until the amount due under the invoice(s) (including interest and costs) has been paid in full.

6.3 Until title passes, the Client shall hold the Documents as bailee for Lithos and shall store or mark them so that they can at all times be identified as the property of Lithos.

6.4 At any time before title passes (save and except where payment is not due), but only after prior consultation with the Client, Lithos may without any liability to the Client repossess and use or sell all or any of part of the Documents and by doing so terminate the right of the Client to use, sell or otherwise deal in the Documents.

6.5 Lithos may maintain an action for the price of the Documents notwithstanding that title in them has not passed to the Client.

7 CONFIDENTIALITY AND DATA PROTECTION

7.1 Lithos undertakes not to divulge or disclose to any third party without the written consent of the Client information which is designated confidential by the Client or which can reasonably be considered to be confidential and arises during the performance of the Services unless required to do so by law or necessary in the proper performance of its duties in relation to the Project, or in order to make full frank and proper disclosure to its insurers or intended insurers, or to obtain legal or accounting advice.

7.2 Subject to the above and Lithos' Privacy Policy which can be found on www.lithos.co.uk, Lithos shall be permitted to use information related to the Services it provides in connection with the Project for the purposes of marketing its services and in proposals for work of a similar type.

8 THIRD PARTIES

8.1 The Agreement or any part thereof or any benefit or interest thereunder may not be assigned by the Client without the prior written consent of Lithos. The giving of such consent shall be at the discretion of Lithos and Lithos will only agree to an assignment on its terms and in return for payment of a fee by the Client to Lithos to cover Lithos' legal and other costs associated with any assignment.

8.2 The Agreement shall not confer and shall not purport to confer on any third party any benefit or any right to enforce any term of this Agreement for the purposes of the Contracts (Rights of Third Parties) Act 1999 or otherwise.

8.3 Lithos will consider and may consent to any request from the Client for Lithos to enter a collateral warranty with a third party with regard to the Services provided under the Agreement. The giving of such consent shall be at the discretion of Lithos and Lithos will only enter a collateral warranty on its terms and in return for payment of a fee by the Client to Lithos to cover Lithos' legal and other costs associated with any collateral warranty.

9 INSURANCE

9.1 Lithos warrants to the Client that there is in force a policy of Professional Indemnity insurance covering its liabilities for negligence under this Agreement, with a limit of indemnity of £5,000,000 (FIVE MILLION POUNDS) any one claim, save for pollution and contamination claims and asbestos claims both of which carry £2,000,000 (TWO MILLION) in the aggregate cover. This policy is annually renewable and whilst renewal is not automatic, Lithos agrees to use reasonable endeavours to maintain such insurance at all times until six years from the date of the completion (or termination) of the Services under the Agreement, provided such insurance is available at commercially reasonable rates having regard, inter alia, to premiums required and policy terms obtainable.

9.2 If for any period such insurance is not available at commercially reasonable rates, Lithos shall forthwith inform the Client and shall obtain in respect of such period such reduced level of Professional Indemnity insurance as is available and as would be fair and reasonable in the circumstances for Lithos to obtain.

10 LIMITATIONS ON LIABILITY

10.1 Unless otherwise agreed in writing, Lithos' liability under or in connection with the Agreement whether in contract, tort, negligence, breach of statutory duty or otherwise (other than in respect of personal injury or death) shall be limited to and shall not exceed the lesser of either five million pounds in the aggregate (unless it is a pollution, contamination or asbestos claim in which case it is two million pounds in the aggregate) or 10 times the total value of invoices issued to the Client for consultancy work instructed under the Agreement.

10.2 No action or proceedings under or in respect of the Agreement whether in contract, tort, negligence, under statute or otherwise shall be commenced against Lithos after the expiry of a period of six years from the date of the completion (or termination) of the Services under the Agreement.

10.3 Whilst Lithos will scan all potential exploratory locations with a Cable Avoidance Tool, Lithos shall not be liable for any damage to underground services, cables, pipes, drains or underground buildings, constructions and the like which were either not marked on site or for which accurate plans were not provided.

10.4 Lithos shall not be liable for the cost of rectifying any defect, conflict or other fault in the information or designs provided by Lithos or for the cost of designing a solution for and rectifying any subsequent works carried out by others pursuant to the conflicting, defective or in any other way faulty information or designs, unless Lithos has been advised in writing of the same by the Client and has been given the opportunity to rectify the same or where necessary, to design the solution for rectification of any subsequent works carried out by others pursuant to the same.

11 PAYMENT

11.1 Invoices for services rendered will be submitted for payment in accordance with the Proposal.

11.2 The due date for payment is the date of the invoice and the final date for payment is 28 days from the date of the invoice.

11.3 If the Client disputes the amount included for payment in an invoice a written notice must be served on Lithos by the Client not later than 14 days before the final date for payment. If no notice is given the amount due shall be the amount stated in the invoice.

11.4 In the event of failure on the part of the Client to pay any monies in accordance with the foregoing payment provisions, Lithos will be entitled to charge interest on any monies owed to it by the Client, such interest to be at a rate of 8% above the base rate of a clearing bank from time to time calculated from the final date for payment to the date of actual payment on a compound basis.

12 DELAY

12.1 Lithos will comply with any timescale agreed for completion of the Services unless delayed or prevented by circumstances beyond its reasonable control and in the event of any such circumstances arising Lithos undertakes to complete the Services within a reasonable period, but will not be liable to the Client for any delay as a result.

13 TERMINATION

13.1 The Agreement may be terminated by either party in the event of the other making a composition or arrangement with its creditors, becoming bankrupt, or being a company, making a proposal for a voluntary arrangement for a composition of debts, or has a provisional liquidator appointed, or has a winding-up order made, or passes a resolution for voluntary winding-up (except for the purposes of a bona fide scheme of amalgamation or reconstruction), or has an administrator or an administrative receiver appointed to the whole or any part of its assets. Notice of termination must be given to the party which is insolvent by the other party.

13.2 If for any reason the performance of the Services by Lithos is suspended for a period in excess of three calendar months then Lithos shall be entitled to terminate its appointment in respect of the Services by seven days written notice to the Client.

13.3 If the Client shall fail to pay in full any sum due under the terms of the Agreement by the final date for payment for that sum and no effective notice of intention to withhold payment has been issued, Lithos may serve written notice on the Client demanding payment within 14 days of such notice. If the Client shall fail to comply with such notice, Lithos shall be entitled to terminate its employment under the Agreement forthwith.

13.4 Any termination of the appointment of Lithos howsoever caused shall be without prejudice to the right of Lithos to require payment for all services performed up to the date of such termination including but not limited to payment of a fair and reasonable proportion of any figure identified in the Proposal or otherwise for fees in respect of a particular service which Lithos has started, but not completed.

14 NOTICES

14.1 Any notice provided for in the Agreement shall be in writing and shall be deemed to be properly given if delivered by hand or sent by first class post to the address of the relevant party as may have been notified by each party to the other or, in the absence of notification, to the address of Lithos set out above or to the registered address of the Client.

14.2 Such notice shall be deemed to have been received on the day of delivery if delivered by hand or on the second working day after the day of posting if sent by first class post.

15 ENTIRE AGREEMENT

15.1 The Agreement constitutes the complete and entire agreement between the Client and Lithos with respect to the Services and supersedes any prior oral and/or written warranties, terms, conditions, communications and representations, whether express or implied and any claim against Lithos in respect of the Services can only be made in contract under the provisions of the Agreement and not otherwise under the law or tort or otherwise.

15.2 No amendments, modifications or variation of the Agreement shall be valid unless made in writing and agreed to by both the Client and Lithos; such agreement must be recorded in writing by at least one of the Parties.

15.3 Lithos will not be bound by any standard or printed terms or conditions furnished by the Client in any of its documents unless Lithos specifically states in writing separately from such documents that it intends such terms and conditions to apply.

16 DISPUTES AND GOVERNING LAW

16.1 The Agreement shall be governed by and construed in accordance with English law and the Parties irrevocably and unconditionally submit to the jurisdiction of the English Courts.

16.2 Where the Housing Grants, Construction and Regeneration Act 1996 applies, any dispute between the Parties may be referred to adjudication in accordance with The Scheme for Construction Contracts Regulations 1998 or any amendment or modification thereof being in force at the time of the dispute, as applicable to England, Wales, Scotland and Northern Ireland.

Morning Matt

Just to confirm.

You are ok for access to both sites

High Shann has sheep on at the moment, and there are no locked gates, but do please shut any gates once you enter.

Our tenant is: John Smith – (T) 01535 66 53 32 or (m) 07831 670 820

Embsay has c20 cows on at the moment, no locked gates but again do please shut any gates once you enter.

Our tenant is Andrew Ayrton (T) 01756 793 400 or (m) 07815 071 151

Both tenants are aware that you will be on site, and have my number for contact.

Any problems please call me on the mobile

All the best

Andy

Andrew Byrne
Property Development Director
The Devonshire Group

M: 07918 759 295

From: Matt Thompson <Matt.thompson@lithos.co.uk>
Sent: 15 August 2018 16:27
To: Andrew Byrne <Andrew.Byrne@devonshiregroup.co.uk>
Cc: James Brown <James.Brown@lithos.co.uk>; Julie Wileman <Julie.Wileman@lithos.co.uk>
Subject: High Shann (3162) & Embsay (3161)

Andy,

We've programmed in High Shann and Embsay for the following dates:

- High Shann – Trial pitting: 29th & 30th August, drilling (1 day) to follow once the technique is confirmed. Hopefully, we can arrange it for the following day.
- Embsay – Trial pitting: 29th August.

Would you like soakaway testing at High Shann (including as an E/O on the quote letter). I didn't allow for any at Embsay as we're anticipating clays.

Many thanks,

Matt Thompson
Principal Engineer
Lithos Consulting Ltd

Parkhill
Walton Road
Wetherby, LS22 5DZ

M 07814 436 247
DD 01937 545 337

www.lithos.co.uk

Appendix D

Historical OS Plans

LITHOS CONSULTING

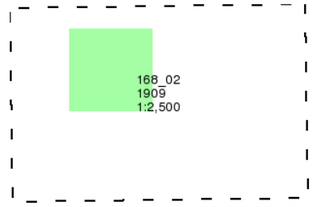
Yorkshire

Published 1909

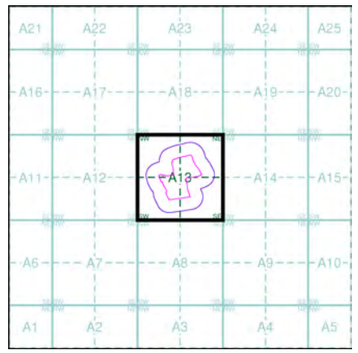
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



N

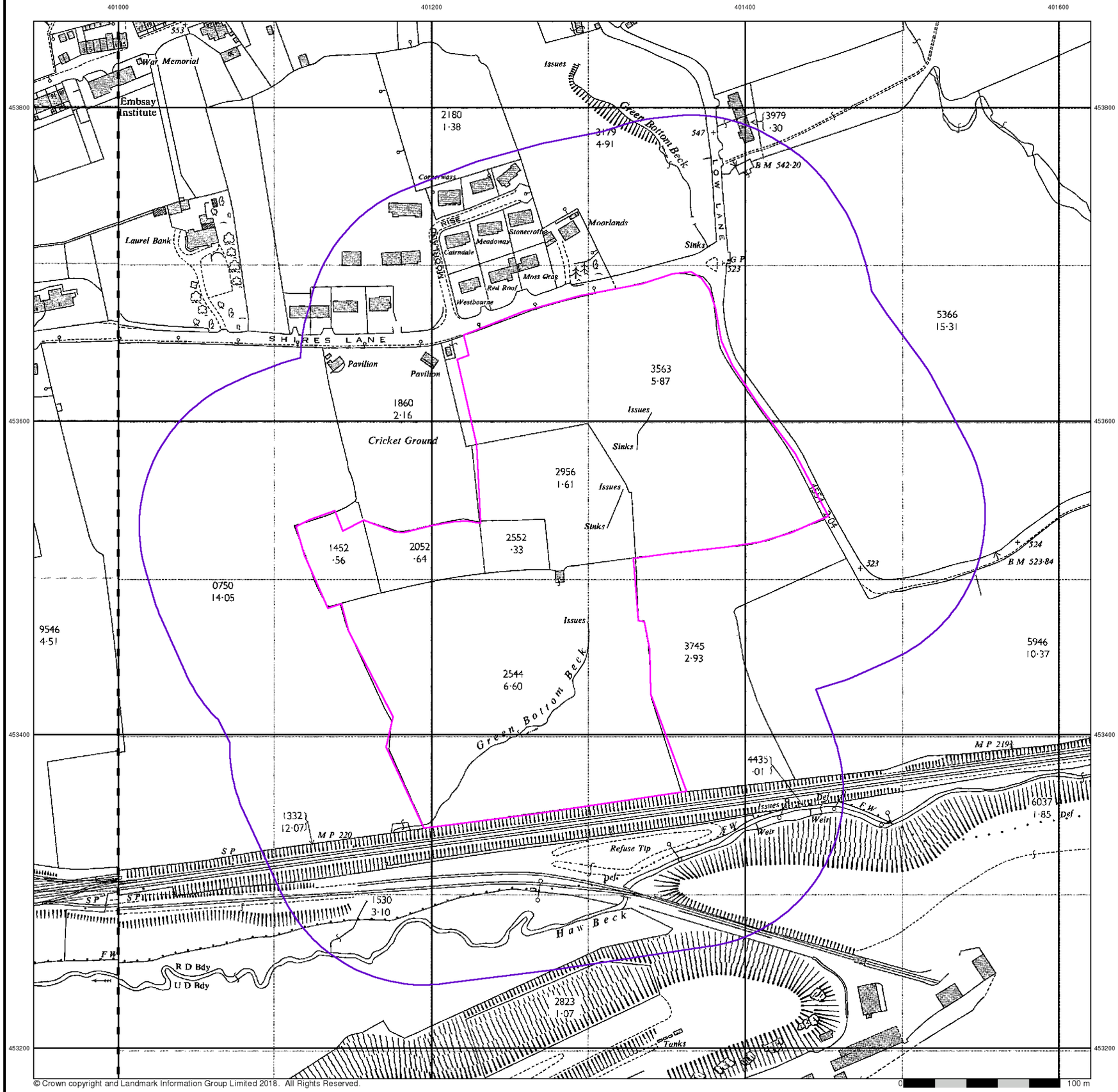
Order Details

Order Number:	177455525_1_1
Customer Ref:	PO13443/JW/3161
National Grid Reference:	401290, 453510
Slice:	A
Site Area (Ha):	6.32
Search Buffer (m):	100

Site Details

Shires Lane, Embsay, BD23 6SB

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



0 100 m

LITHOS CONSULTING

Ordnance Survey Plan

Published 1965

Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

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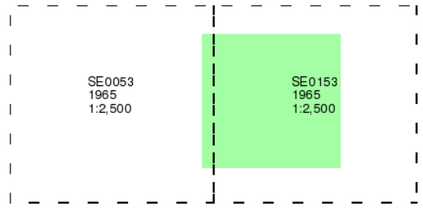
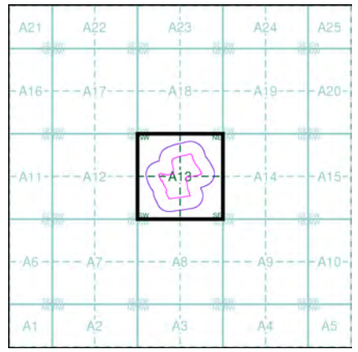


Historical Map - Segment A13



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National Grid Reference:	401290, 453510
Slice:	A
Site Area (Ha):	6.32
Search Buffer (m):	100

Site Details

Shires Lane, Embsay, BD23 6SB

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Appendix E

Search Responses

Envirocheck® Report:

Datasheet

Order Details:

Order Number:
177455525_1_1

Customer Reference:
PO13443/JW/3161

National Grid Reference:
401290, 453510

Slice:
A

Site Area (Ha):
6.32

Search Buffer (m):
1000

Site Details:

Shires Lane
Embsay
BD23 6SB

Client Details:

Mr M Perrin
Lithos Consulting Ltd
Parkhill
Walton Road
Wetherby
LS22 5DZ

Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Agency & Hydrological					
BGS Groundwater Flooding Susceptibility	pg 1	Yes	Yes	Yes	n/a
Contaminated Land Register Entries and Notices					
Discharge Consents	pg 5	1		2	9
Prosecutions Relating to Controlled Waters			n/a	n/a	n/a
Enforcement and Prohibition Notices					
Integrated Pollution Controls					
Integrated Pollution Prevention And Control	pg 8				3
Local Authority Integrated Pollution Prevention And Control					
Local Authority Pollution Prevention and Controls	pg 8		1	3	2
Local Authority Pollution Prevention and Control Enforcements					
Nearest Surface Water Feature		Yes			
Pollution Incidents to Controlled Waters	pg 9		4	4	17
Prosecutions Relating to Authorised Processes	pg 14			1	
Registered Radioactive Substances					
River Quality	pg 14		1		3
River Quality Biology Sampling Points					
River Quality Chemistry Sampling Points	pg 15				2
Substantiated Pollution Incident Register	pg 16				1
Water Abstractions	pg 17		7	5	13 (*9)
Water Industry Act Referrals					
Groundwater Vulnerability	pg 25	Yes	n/a	n/a	n/a
Drift Deposits	pg 25	1	n/a	n/a	n/a
Bedrock Aquifer Designations	pg 25	Yes	n/a	n/a	n/a
Superficial Aquifer Designations	pg 25	Yes	n/a	n/a	n/a
Source Protection Zones					
Extreme Flooding from Rivers or Sea without Defences	pg 25	Yes		n/a	n/a
Flooding from Rivers or Sea without Defences	pg 25	Yes		n/a	n/a
Areas Benefiting from Flood Defences				n/a	n/a
Flood Water Storage Areas				n/a	n/a
Flood Defences				n/a	n/a
OS Water Network Lines	pg 26	7	15	17	66

Summary

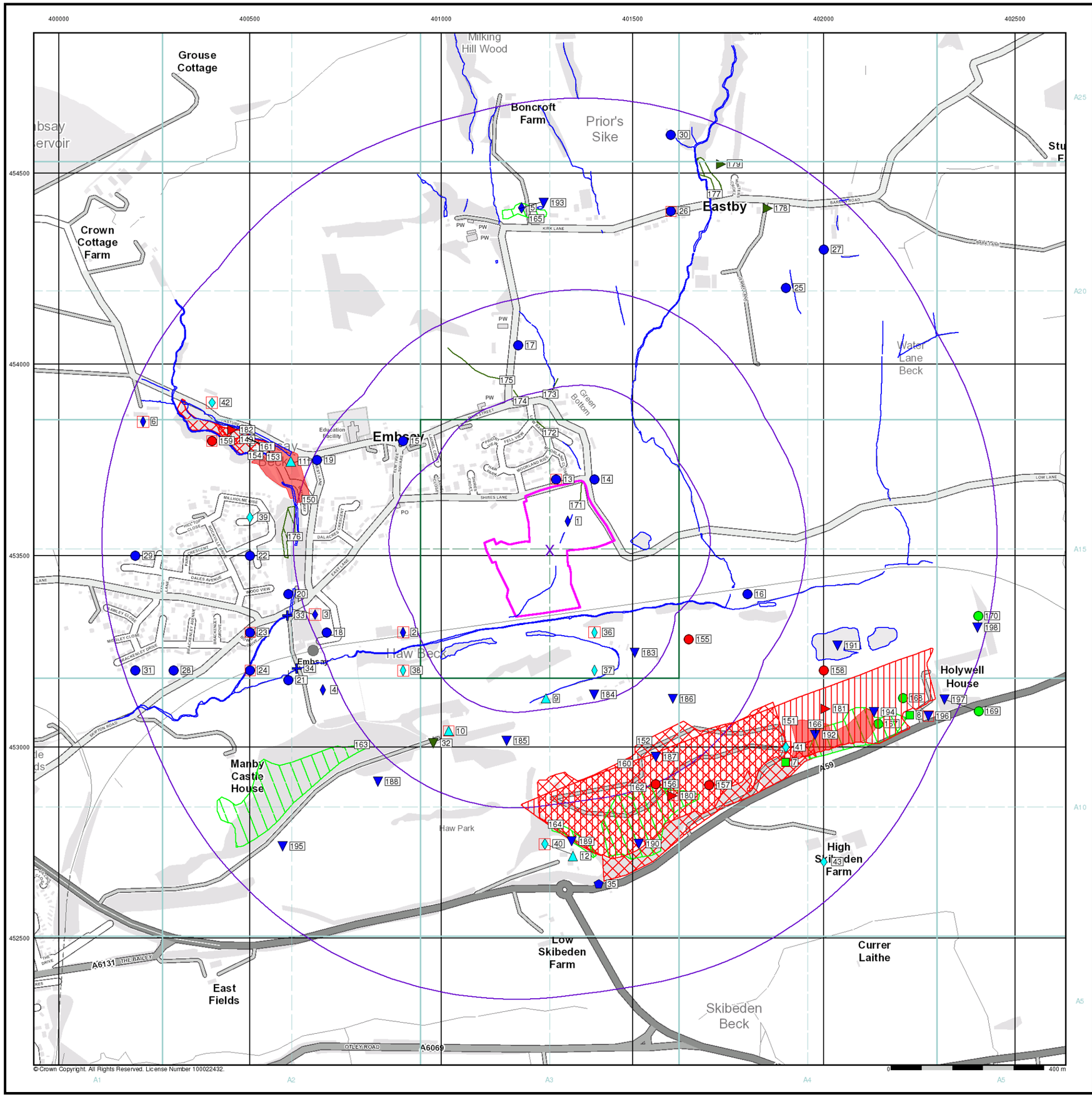
Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Waste					
BGS Recorded Landfill Sites	pg 38				1
Historical Landfill Sites	pg 38			1	1
Integrated Pollution Control Registered Waste Sites					
Licensed Waste Management Facilities (Landfill Boundaries)	pg 38			1	2
Licensed Waste Management Facilities (Locations)	pg 39			1	5
Local Authority Landfill Coverage	pg 40	2	n/a	n/a	n/a
Local Authority Recorded Landfill Sites	pg 40			1	1
Potentially Infilled Land (Non-Water)	pg 40			1	8
Potentially Infilled Land (Water)	pg 41	1	3	2	3
Registered Landfill Sites	pg 42				4
Registered Waste Transfer Sites					
Registered Waste Treatment or Disposal Sites					
Hazardous Substances					
Control of Major Accident Hazards Sites (COMAH)					
Explosive Sites					
Notification of Installations Handling Hazardous Substances (NIHHS)					
Planning Hazardous Substance Consents					
Planning Hazardous Substance Enforcements					

Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Geological					
BGS 1:625,000 Solid Geology	pg 45	Yes	n/a	n/a	n/a
BGS Estimated Soil Chemistry	pg 45	Yes	Yes	Yes	Yes
BGS Recorded Mineral Sites	pg 47		2	3	12
BGS Urban Soil Chemistry					
BGS Urban Soil Chemistry Averages					
CBSCB Compensation District			n/a	n/a	n/a
Coal Mining Affected Areas			n/a	n/a	n/a
Mining Instability	pg 50	Yes	n/a	n/a	n/a
Man-Made Mining Cavities	pg 50			1	
Natural Cavities					
Non Coal Mining Areas of Great Britain	pg 50	Yes		n/a	n/a
Potential for Collapsible Ground Stability Hazards	pg 50	Yes		n/a	n/a
Potential for Compressible Ground Stability Hazards				n/a	n/a
Potential for Ground Dissolution Stability Hazards	pg 50		Yes	n/a	n/a
Potential for Landslide Ground Stability Hazards	pg 50	Yes		n/a	n/a
Potential for Running Sand Ground Stability Hazards	pg 50	Yes		n/a	n/a
Potential for Shrinking or Swelling Clay Ground Stability Hazards	pg 50	Yes		n/a	n/a
Radon Potential - Radon Affected Areas			n/a	n/a	n/a
Radon Potential - Radon Protection Measures			n/a	n/a	n/a
Industrial Land Use					
Contemporary Trade Directory Entries	pg 52		1	5	9
Fuel Station Entries	pg 53				1
Points of Interest - Commercial Services	pg 53			2	3
Points of Interest - Education and Health					
Points of Interest - Manufacturing and Production	pg 53		9	8	8
Points of Interest - Public Infrastructure	pg 55				12
Points of Interest - Recreational and Environmental					
Gas Pipelines	pg 57			1	
Underground Electrical Cables					

Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Sensitive Land Use					
Ancient Woodland	pg 58				1
Areas of Adopted Green Belt					
Areas of Unadopted Green Belt					
Areas of Outstanding Natural Beauty					
Environmentally Sensitive Areas					
Forest Parks					
Local Nature Reserves					
Marine Nature Reserves					
National Nature Reserves					
National Parks	pg 58		1		
Nitrate Sensitive Areas					
Nitrate Vulnerable Zones					
Ramsar Sites					
Sites of Special Scientific Interest					
Special Areas of Conservation					
Special Protection Areas					
World Heritage Sites					



LITHOS CONSULTING

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Map ID
- Several of Type at Location

Agency and Hydrological

- Contaminated Land Register Entry or Notice (Location)
- Contaminated Land Register Entry or Notice
- Discharge Consent
- Enforcement or Prohibition Notice
- Integrated Pollution Control
- Integrated Pollution Prevention Control
- Local Authority Integrated Pollution Prevention and Control
- Local Authority Pollution Prevention and Control
- Local Authority Pollution Prevention and Control Enforcement
- Pollution Incident to Controlled Waters
- Prosecution Relating to Authorised Processes
- Prosecution Relating to Controlled Waters
- Registered Radioactive Substance
- River Network or Water Feature
- River Quality Sampling Point
- Substantiated Pollution Incident Register
- Water Abstraction
- Water Industry Act Referral

Hazardous Substances

- COMAH Site
- Explosive Site
- NIHHS Site
- Planning Hazardous Substance Consent
- Planning Hazardous Substance Enforcement

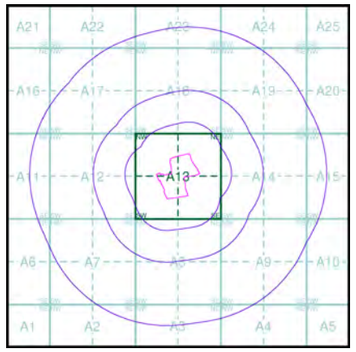
Geological

- BGS Recorded Mineral Site

Waste

- BGS Recorded Landfill Site (Location)
- BGS Recorded Landfill Site
- EA Historic Landfill (Buffered Point)
- EA Historic Landfill (Polygon)
- Integrated Pollution Control Registered Waste Site
- Licensed Waste Management Facility (Landfill Boundary)
- Licensed Waste Management Facility (Location)
- Local Authority Recorded Landfill Site (Location)
- Local Authority Recorded Landfill Site
- Potentially Infilled Land (Non-water)
- Potentially Infilled Land (Non-water)
- Potentially Infilled Land (Non-water)
- Potentially Infilled Land (Water)
- Potentially Infilled Land (Water)
- Potentially Infilled Land (Water)
- Registered Landfill Site
- Registered Landfill Site (Location)
- Registered Landfill Site (Point Buffered to 100m)
- Registered Landfill Site (Point Buffered to 250m)
- Registered Waste Transfer Site (Location)
- Registered Waste Transfer Site
- Registered Waste Treatment or Disposal Site (Location)
- Registered Waste Treatment or Disposal Site

Site Sensitivity Map - Slice A



Order Details

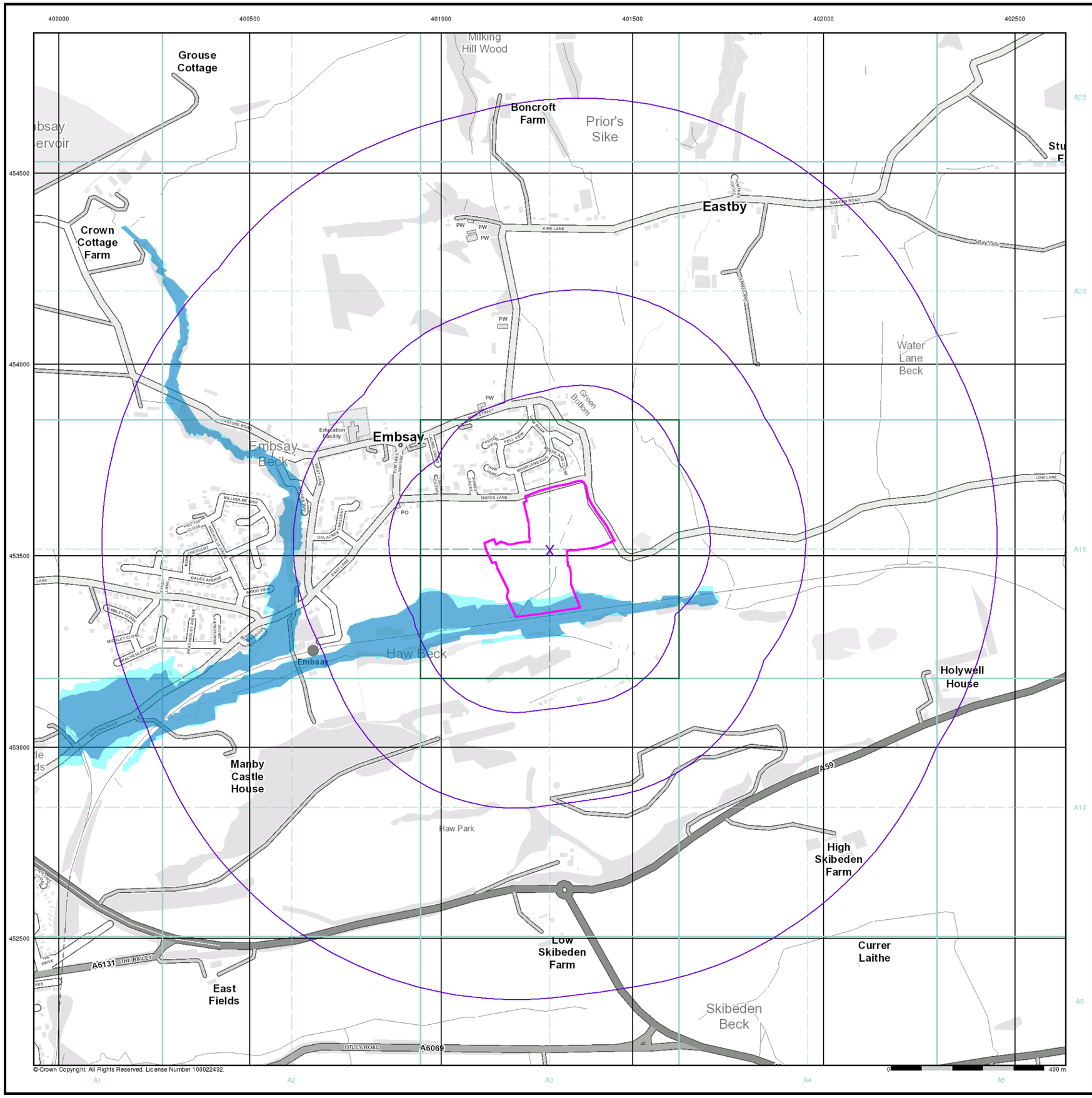
Order Number:	177455525_1_1
Customer Ref:	PO13443/JW/3161
National Grid Reference:	401290, 453510
Slice:	A
Site Area (Ha):	6.32
Search Buffer (m):	1000

Site Details

Shires Lane, Embsay, BD23 6SB

Landmark INFORMATION GROUP

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LITHOS CONSULTING

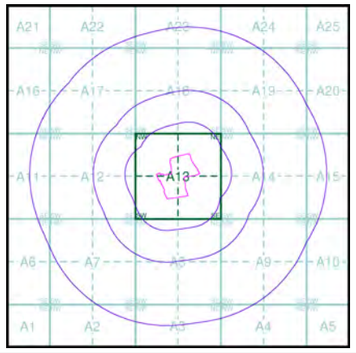
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

Agency and Hydrological (Flood)

- Extreme Flooding from Rivers or Sea without Defences (Zone 2)
- Flooding from Rivers or Sea without Defences (Zone 3)
- Area Benefiting from Flood Defence
- Flood Water Storage Areas
- Flood Defence

Flood Map - Slice A



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Order Details

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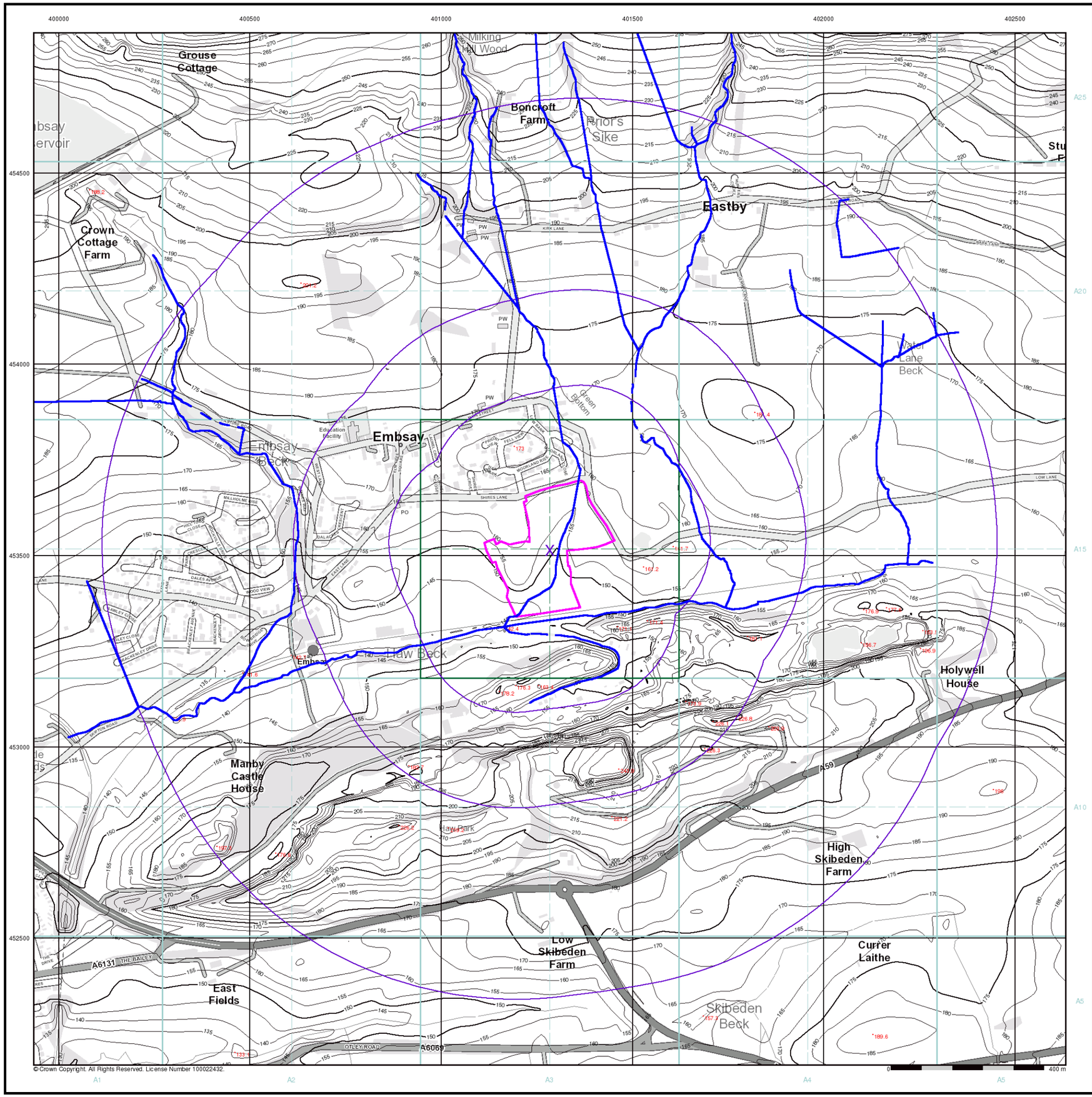


LITHOS CONSULTING

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

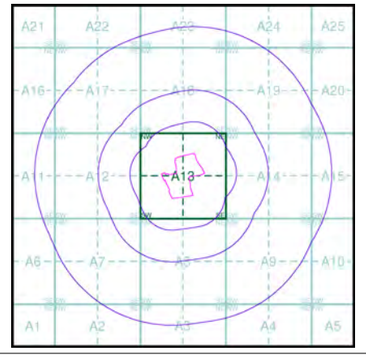
OS Water Network Data

- Canal
- Reservoir
- Foreshore
- Marsh
- Tidal River
- Inland River
- Drain
- Other
- Lake
- Transfer
- Lock Or Flight Of Locks
- Sea

Contours (height in meters)

- Standard Contour (105, 100, 95)
- Master Contour
- Spot Height (167.3)
- MLW Mean Low Water
- MHW Mean High Water

OS Water Network Map - Slice A



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Order Details

Order Number:	177455525_1_1
Customer Ref:	PO13443/JW/3161
National Grid Reference:	401290, 453510
Slice:	A
Site Area (Ha):	6.32
Search Buffer (m):	1000

Site Details

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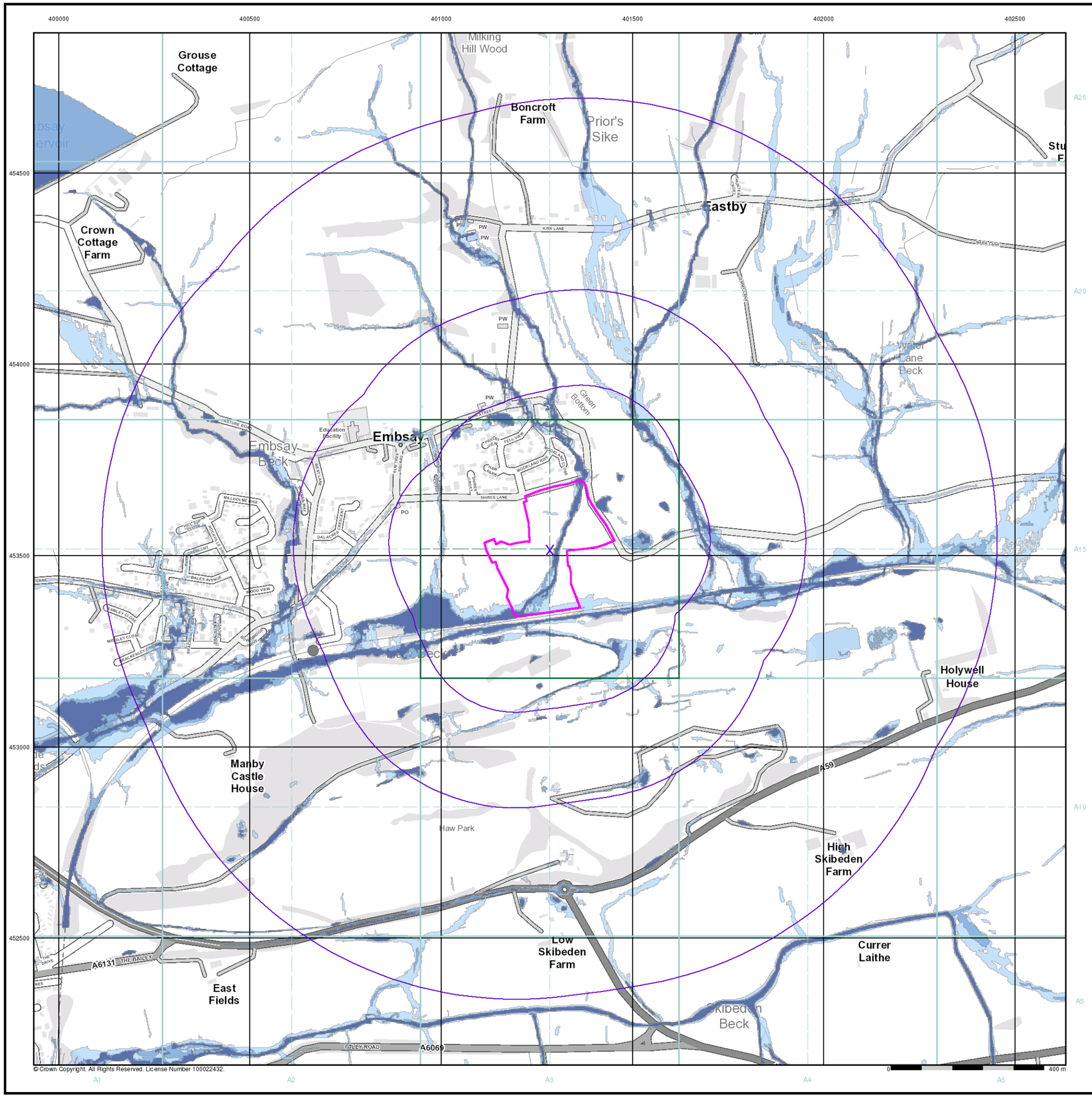


LITHOS CONSULTING

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

Risk of Flooding from Surface Water

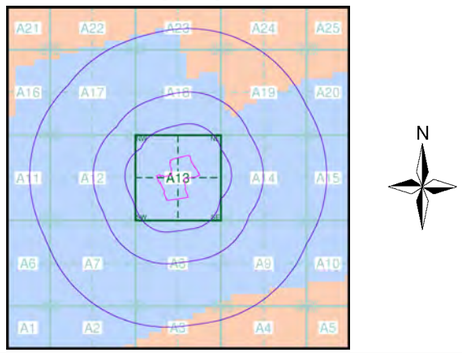
- High - 30 Year Return
- Medium - 100 Year Return
- Low - 1000 Year Return

Suitability

See the suitability map below

- National to county
- County to town
- Town to street
- Street to parcels of land
- Property

EA/NRW Suitability Map - Slice A



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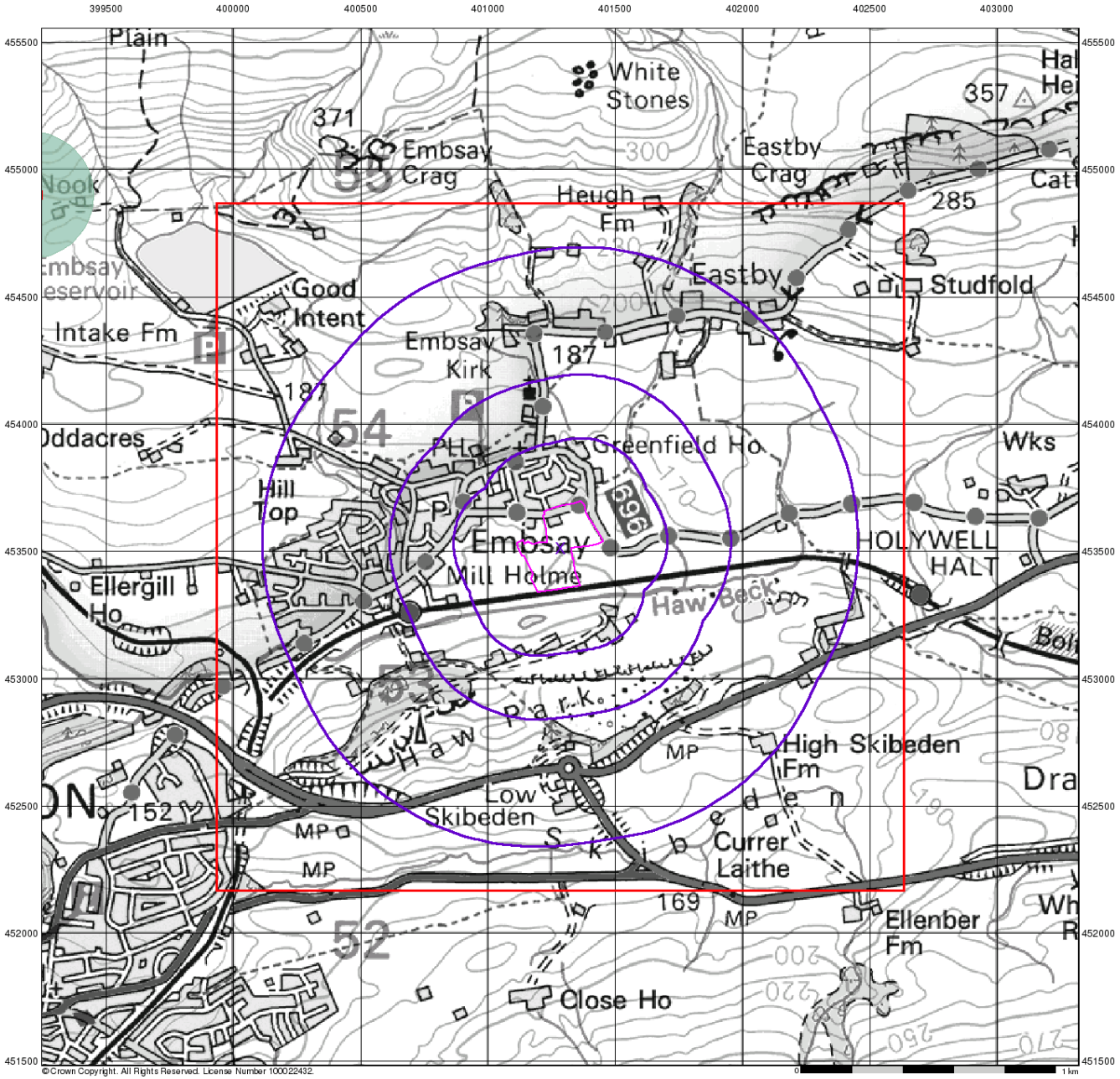


LITHOS CONSULTING

Source Protection Zones

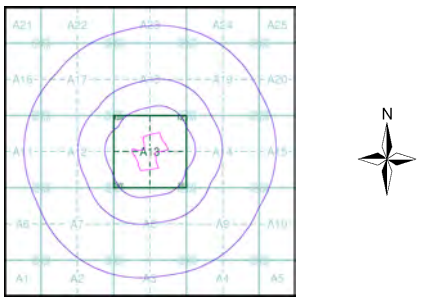
General

Specified Site
Specified Buffer(s)
Bearing Reference Point
Slice
Map ID

Agency and Hydrological

- Inner zone (Zone 1)
- Inner zone - subsurface activity only (Zone 1c)
- Outer zone (Zone 2)
- Outer zone - subsurface activity only (Zone 2c)
- Total catchment (Zone 3)
- Total catchment - subsurface activity only (Zone 3c)
- Special interest (Zone 4)

Site Sensitivity Context Map - Slice A



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Slice:	A
Site Area (Ha):	6.32
Search Buffer (m):	1000

Site Details

Shires Lane, Embsay, BD23 6SB

Appendix F

Trial Pit Logs

Trial Pit Log

LITHOS CONSULTING			Trialpit No **TP01** Sheet 1 of 1
Project Name: Shires Lane	Project No. 3161	Co-ords: 401242.00 - 453600.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6 Depth 3.60	Scale 1:20
Client: The Devonshire Group			Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description	
	0.10	J&T					TOPSOIL: Blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded, fine of mixed lithologies. (TOPSOIL)	
				0.30			Firm orangish brown slightly sandy slightly gravelly CLAY with low cobble content. Gravel and cobbles are predominantly subrounded to rounded, fine to coarse of mixed lithologies. (COHESIVE GLACIAL TILL)	
			HVP=56					
	1.00	D						1
			HVP=56					
				1.70			Soft dark brown and orange slightly gravelly CLAY with medium cobble and boulder content. Gravel is rounded fine to coarse of mixed lithologies. Boulders typically c. 0.4m diameter, subrounded. (COHESIVE GLACIAL TILL) *Damp from 1.7m. Some slight spalling when excavating through boulders.* *Boulder c.0.4m wide at 1.9m.*	
			HVP=12					2
				2.30			Soft dark brown, ocacasionally stained black, gravelly slightly sandy CLAY with medium boulder and cobble content. Cobbles and gravel are angular to rounded of mixed lithologies, predominantly MUDSTONE. (COHESIVE GLACIAL TILL) *Cobble sized lenses of wet course SAND.*	
				2.90			Dark grey clayey angular fine GRAVEL of very weak siltstone. (WEATHERED CLITHEROE FORMATION)	3
				3.30			Dark grey horizontally orientated medium to coarse angular GRAVEL of very weak SILTSTONE. (WEATHERED CLITHEROE FORMATION)	
	3.40	D						
				3.60			End of pit at 3.60 m	4

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. Spalling occurred between 2.9m and 3.3m depth during excavation.

AGS

Trial Pit Log

Trialpit No **TP02**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401278.00 - 453611.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6	Scale 1:20
Client: The Devonshire Group		Depth 3.40	Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.25			TOPSOIL: Friable blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded fine of mixed lithologies. (TOPSOIL)
	0.60	D		0.70			Firm orangish brown sandy slightly gravelly CLAY. Gravel is fine to coarse rounded of mixed lithologies. (COHESIVE GLACIAL TILL)
			HVP=55	1.30			Firm orange and purplish brown slightly gravelly slightly sandy CLAY. Gravel is fine to coarse angular to rounded of mixed lithologies with low cobble content. (COHESIVE GLACIAL TILL)
	2.50	D&B		2.00			Soft purplish brown gravelly slightly sandy CLAY with low cobble content. Gravel and cobbles are fine to coarse, angular to rounded of mixed lithologies. (COHESIVE GLACIAL TILL) *Too gravelly for vane at 1.3m.* *Occasional boulder sized lenses of SAND.*
				3.40			Dark grey very clayey very sandy angular to rounded fine to coarse GRAVEL of mixed lithologies with high cobble content. Occasional boulders upto c. 0.5m. (GRANULAR GLACIAL TILL) End of pit at 3.40 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. The sides of the trial pit remained stable during excavation.

Trial Pit Log

Trialpit No **TP03**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401236.00 - 453653.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6 Depth 2.80	Scale 1:20
Client: The Devonshire Group			Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J&T		0.20			TOPSOIL: Blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded, fine of mixed lithologies. (TOPSOIL)
	0.80	D	HVP=70				Firm dark brown slightly sandy slightly gravelly CLAY with low cobble content. Gravel is fine to coarse angular to rounded of mixed lithologies. (COHESIVE GLACIAL TILL) *Rare boulders upto c.0.6m diameter.*
	1.60	D		1.30			Soft greyish brown sandy gravelly CLAY with low cobble content and occasional lenses of black stagnant staining. (COHESIVE GLACIAL TILL) *Feels damp 1.3m to 2.1m.*
				2.10			Greyish brown very clayey very gravelly fine SAND. Gravel is predominantly mudstone with some mixed lithologies, predominantly fine and subangular. One angular boulder of strong mudstone. (GRANULAR GLACIAL TILL)
	2.60	D		2.50 2.80			Very stiff mottled grey and orange friable slightly gravelly CLAY. Gravel is fine to coarse of mixed lithologies including sandstone. (COHESIVE GLACIAL TILL) *Too stiff for hand vane at 2.5m.* End of pit at 2.80 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. The sides of the trial pit remained stable during excavation.

Trial Pit Log

Trialpit No **TP04**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401285.00 - 453667.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6 Depth 2.90	Scale 1:20
Client: The Devonshire Group			Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J&T		0.20			TOPSOIL: Friable blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded fine of mixed lithologies. (TOPSOIL)
	0.60	D		0.70			Friable orange and brown very clayey very gravelly fine SAND. Gravel is fine to coarse angular to rounded of mixed lithologies. (GRANULAR GLACIAL TILL)
	1.00	D		2.00			Orangish brown very clayey very sandy angular to rounded fine to coarse GRAVEL AND COBBLES with locally a very sandy clay. Clay matrix feels stiff. (GRANULAR GLACIAL TILL)
				2.90			Greyish brown slightly clayey medium to coarse SAND AND subrounded to angular fine to coarse GRAVEL of mixed lithologies with high cobble content. (GRANULAR GLACIAL TILL) *From 2.4m, very sandy GRAVEL and COBBLES with rare boulders c. 0.3m.* End of pit at 2.90 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. The sides of the trial pit remained stable during excavation.

Trial Pit Log

Trialpit No **TP05**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401313.00 - 453640.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6 Depth 2.50	Scale 1:20
Client: The Devonshire Group			Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J&T		0.20			TOPSOIL: Blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded, fine of mixed lithologies. (TOPSOIL)
				0.60			Firm dark grey and brown friable sandy slightly gravelly CLAY with rootlets. Gravel is fine to coarse angular of mixed lithologies. (SUBSOIL)
	1.00	D	HVP=50 HVP=60	1.60			Firm to stiff light grey and orangish brown slightly sandy slightly gravelly CLAY with low cobble content. Gravel is angular to rounded fine to coarse of mixed lithologies. (COHESIVE GLACIAL TILL)
	2.20	D		1.80			Soft greyish brown gravelly slightly sandy CLAY. Gravel is predominantly medium to coarse angular of mixed lithologies including mudstone. (COHESIVE GLACIAL TILL) *Feels damp 1.6m to 1.8m.*
				2.50			Dark grey very clayey very gravelly fine SAND. Gravel is fine to coarse angular to subrounded of mixed lithologies with low cobble content and frequent cobble sized lenses of sandy clay. (GRANULAR GLACIAL TILL) *At 1.8m - 2 boulders, difficult to excavate c. 0.6m wide* End of pit at 2.50 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. The sides of the trial pit remained stable during excavation.

Trial Pit Log

Trialpit No **TP06**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401342.00 - 453619.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6 Depth 2.70	Scale 1:20
Client: The Devonshire Group			Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.20	J&T					MADE GROUND: Blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded, fine of mixed lithologies including occasional fragments of brick. (MADE GROUND TOPSOIL) *From 0m to 0.6m in south face, lenses of white ash.*
				0.30			MADE GROUND: Firm dark grey and brown slightly gravelly slightly sandy CLAY with medium cobble content. Gravel and cobble is angular to rounded of mixed lithologies including brick, terracotta pipe, sandstone and mudstone. Occasional subrounded boulders (c. 0.4m diameter). (RE-WORKED GLACIAL TILL) *At 0.6m, land drain running east-west.*
	0.50	J&T					*From 1.0m, becoming a very clayey gravel and cobble with medium boulder content.*
				1.60			Wet dark grey very clayey medium to coarse SAND and subangular to rounded fine to coarse GRAVEL with high cobble content. Gravel and cobble is of mixed lithologies, predominantly sandstone. Some cobble sized lenses of sandy clay. (GRANULAR GLACIAL TILL)
▼				2.70			*At 2.7m, slight groundwater seepage.* End of pit at 2.70 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. A groundwater seepage was encountered at 2.7m. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. Some slight overbreak occurred when excavating through the made ground strata.

Trial Pit Log

LITHOS CONSULTING			Trialpit No **TP07** Sheet 1 of 1
Project Name: Shires Lane	Project No. 3161	Co-ords: 401359.00 - 453655.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6 Depth 2.40	Scale 1:20
Client: The Devonshire Group			Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.20			TOPSOIL: Blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded, fine of mixed lithologies. (TOPSOIL)
			HVP=75	1.00			Stiff dark grey with organge gleying sandy slightly gravelly CLAY with low cobble content. Gravel is predominantly of sandstone. (COHESIVE GLACIAL TILL)
	1.10	D	HVP=55	1.40			Firm dark grey slightly sandy slightly gravelly CLAY. Gravel is medium to coarse angular to subangular of mixed lithologies. (COHESIVE GLACIAL TILL)
				2.40			Orange and brown very clayey very sandy fine to coarse subangular to subrounded GRAVEL AND COBBLES with medium boulder content. Mixed lithologies. (GRANULAR GLACIAL TILL)
							Unable to excavate beyond 2.4m due to boulders. End of pit at 2.40 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. The sides of the trial pit remained stable during excavation.

AGS

Trial Pit Log

Trialpit No **TP08**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401383.00 - 453633.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6 Depth 3.20	Scale 1:20
Client: The Devonshire Group			Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J&T					TOPSOIL: Friable blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded fine of mixed lithologies. (TOPSOIL)
				0.30			Stiff friable orangish brown sandy slightly gravelly CLAY with low cobble content. (COHESIVE GLACIAL TILL)
				0.60			Firm dark brown sandy gravelly CLAY with low cobble content. (COHESIVE GLACIAL TILL)
	1.00	D	HVP=50				
				1.40			Brownish grey very silty fine SAND with occasional pockets of very clayey sand and occasional fine to medium subrounded gravel of mixed lithologies. (GRANULAR GLACIAL TILL)
	2.00	D					*From 2.2m, with low cobble and boulder content.*
							Difficult to excavate beyond 2.5m.
				3.20			End of pit at 3.20 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. The sides of the trial pit remained stable during excavation.

Trial Pit Log

Trialpit No **TP09**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401339.00 - 453684.00 Level:	Date 29/08/2018
Location: Embsay		Dimensions (m): 2.5 × 0.6	Scale 1:20
Client: The Devonshire Group		Depth 2.70	Logged MJT

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J&T					TOPSOIL: Blackish brown sandy slightly gravelly CLAY with rootlets. Gravel is rounded, fine of mixed lithologies. (TOPSOIL)
				0.30			Stiff dessicated orangish brown sandy slightly gravelly CLAY with low cobble content. (COHESIVE GLACIAL TILL)
			HVP=95				
	0.80	D					*High cobble content from 1m.*
				1.20			Orangish brown very sandy very clayey GRAVEL with medium cobble content and occasional boulders. (GRANULAR GLACIAL TILL)
							Feeling softer from 1.5m.
							Boulders (c. 0.7 diameter) at 1.5m in the east and west faces, difficult to excavate.
	1.80	B					
				2.70			End of pit at 2.70 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Exploratory hole surveyed in using hand-held GPS.

Stability: 1. The sides of the trial pit remained stable during excavation.

Appendix G

Cable Percussion Borehole Logs

Borehole Log

LITHOS CONSULTING			Borehole No. **BH01** Sheet 1 of 1
Project Name: Shires Lane	Project No. 3161	Co-ords: 401261.00 - 453603.00	Hole Type CP
Location: Embsay		Level:	Scale 1:50
Client: The Devonshire Group		Dates: 23/10/2018 - 23/10/2018	Logged By CC

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
					0.20			Blackish brown slightly sandy slightly gravelly CLAY. Gravel is round, fine to medium of mixed lithologies. (TOPSOIL)
		0.50		N=18 (7,6/5,4,5,4)				Firm dark brown very sandy, gravelly CLAY. Gravel is sub rounded to sub angular, fine to coarse of mixed lithologies including mudstone, siltstone and sandstone lithorelicts. (COHESIVE GLACIAL DEPOSITS)
		1.00		N=17 (5,6/4,5,4,4)				
		1.50		N=24 (5,7/6,5,6,7)				
		2.00		N=26 (7,5/5,7,7,7)				
		2.50		N=29 (5,7/6,7,8,8)				
		3.00		N=28 (5,5/6,7,7,8)				
		4.00		N=28 (5,7/5,7,7,9)	4.00			Medium dense (becoming very dense) dark grey clayey, sandy fine to coarse, angular GRAVEL of weak siltstone (WEATHERED CLITHEROE FORMATION)
		5.00		N=52 (7,8/10,12,14,16)				
					5.45			End of borehole at 5.45 m

Remarks
1. Prior to drilling a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during drilling.

AGS

Borehole Log

LITHOS CONSULTING			Borehole No. **BH02** Sheet 1 of 1
Project Name: Shires Lane	Project No. 3161	Co-ords: 401340.00 - 453645.00	Hole Type CP
Location: Embsay		Level:	Scale 1:50
Client: The Devonshire Group		Dates: 23/10/2018 - 24/10/2018	Logged By CC

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
					0.35			Blackish brown sandy slightly gravelly CLAY. Gravel is rounded, fine of mixed lithologies. (TOPSOIL)
		0.50		N=12 (3,2/3,2,3,4)				Firm orangish brown sandy, slightly gravelly CLAY. Gravel is rounded to angular, fine to medium of mixed lithologies including sandstone and mudstone. (COHESIVE GLACIAL DEPOSITS) *No recovery between 1m and 1.45m.*
		1.00		N=11 (3,5/2,3,3,3)				
		1.50		N=23 (3,5/7,4,5,7)	1.45			Firm dark brown sandy, gravelly CLAY . Gravel is rounded to angular, fine to coarse of mixed lithologies including sandstone, mudstone and siltstone. (COHESIVE GLACIAL DEPOSITS)
		2.00		N=40 (3,5/7,17,8,8)	2.00			
		2.50		N=34 (12,10/7,8,9,10)	2.50			Medium dense dark brown very clayey, sandy rounded to angular, fine to coarse GRAVEL of mixed lithologies with high cobble content. Cobbles are recovered as medium to coarse gravel sized angular fragments of siltstone. (GRANULAR GLACIAL DEPOSITS)
		3.00		0 (8,12/,,,)				
		4.00		N=34 (5,7/7,7,10,10)				Medium dense dark brown very clayey SAND AND GRAVEL with high cobble content. Gravel is angular to sub angular, fine to coarse of mixed lithologies. Cobbles are recovered as medium to coarse gravel sized angular fragments of siltstone (GRANULAR GLACIAL DEPOSITS) *SPT refusal at 3m due to cobble around 3.1m.*
		5.00		N=30 (6,7/7,7,7,9)	5.00			Medium dense dark grey clayey angular medium GRAVEL of weak mudstone. (WEATHERED CLITHEROE FORMATION) *No recovery between 5m and 5.45m* *Becomes harder to drill around 5.5m.*
		5.90		N=99 (5,6/16,16,17,50)	5.90			Dark grey MUDSTONE recovered as a slightly clayey angular medium gravel. (CLITHEROE FORMATION)
					6.35			End of borehole at 6.35 m

Remarks
1. Prior to drilling a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during drilling.

AGS

Borehole Log

Borehole No. **BH03**

Sheet 1 of 1

Project Name: Shires Lane	Project No. 3161	Co-ords: 401279.00 - 453664.00	Hole Type CP
Location: Embsay		Level:	Scale 1:50
Client: The Devonshire Group		Dates: 23/10/2018 - 23/10/2018	Logged By CC

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
		0.50		N=13 (3,3/4,3,3,3)	0.40			Blackish brown sandy slightly gravelly CLAY. Gravel is rounded, fine of mixed lithologies (TOPSOIL)
		1.00		N=16 (3,4/5,4,4,3)				Medium dense dark brown very clayey, very gravelly SAND. Gravel is angular to sub angular, fine to medium of mixed lithologies including sandstone. (GRANULAR GLACIAL DEPOSITS)
		1.50		N=15 (4,5/4,3,4,4)	1.45			Soft dark brown sandy, gravelly CLAY. Gravel is sub angular to angular, fine to medium of sandstone. (COHESIVE GLACIAL DEPOSITS)
		2.00		N=15 (3,4/4,3,4,4)	1.95			Medium dense dark brown very clayey, gravelly SAND. Gravel is angular to rounded, fine to medium of sandstone and feldspar. (GRANULAR GLACIAL DEPOSITS)
		2.50		N=14 (3,4/3,4,4,3)				
		3.00		N=29 (8,7/6,7,8,8)	3.00			*Large amount of angular, medium sized gravel around 2.85m.* Medium dense dark brown clayey SAND AND GRAVEL. Gravel is angular to rounded, fine to coarse of mixed lithologies. (GRANULAR GLACIAL DEPOSITS)
					4.00			Very dense dark grey clayey, sandy sub angular to angular, fine to coarse GRAVEL of moderately strong siltstone (WEATHERED CLITHEROE FORMATION) *SPT at 4m to 4.09m is 25 for 50mm, 50 for 40mm.*
		5.00		N=52 (10,12/12,14,12,14)				
					5.45			End of borehole at 5.45 m

Remarks

1. Prior to drilling a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during drilling.

Appendix H

Chemical Results

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING 2183

Final Report

Report No.:	18-26491-1		
Initial Date of Issue:	17-Sep-2018		
Client	Lithos Consulting		
Client Address:	Walton Road Wetherby LS22 5DZ		
Contact(s):	Matthew Thompson		
Project	Shires Lane		
Quotation No.:		**Date Received:**	03-Sep-2018
Order No.:	PO13488 (001/MJT/3161-Chem)	**Date Instructed:**	03-Sep-2018
No. of Samples:	8		
Turnaround (Wkdays):	11	**Results Due:**	17-Sep-2018
Date Approved:	17-Sep-2018		

Approved By:

Details: Robert Monk, Technical Manager

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Shires Lane

Client: Lithos Consulting				**Chemtest Job No.:**	18-26491	18-26491	18-26491	18-26491	18-26491	18-26491	18-26491	18-26491
Quotation No.:				**Chemtest Sample ID.:**	681533	681534	681535	681536	681537	681538	681539	681540
				Client Sample ID.:	1	1	1	1	1	1	1	1
				Sample Location:	TP01	TP03	TP04	TP05	TP08	TP09	TP06	TP06
				Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.50
				Date Sampled:	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018
				Asbestos Lab:	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM
Determinand	**Accred.**	**SOP**	**Units**	**LOD**								
ACM Type	U	2192		N/A	-	-	-	-	-	-	-	-
Asbestos Identification	U	2192	%	0.001	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Moisture	N	2030	%	0.020	20	16	22	20	14	15	16	20
pH	U	2010		N/A	5.6	6.1	5.1	5.4	5.2	5.8	7.4	7.7
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.80	1.2	0.79	1.0	0.62	0.83	0.88	0.62
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010								< 0.010
Chloride (Water Soluble)	U	2220	g/l	0.010								< 0.010
Nitrate (Water Soluble)	N	2220	g/l	0.010								< 0.010
Magnesium (Extractable)	N	2400	mg/l	2.0								75
Arsenic	U	2450	mg/kg	1.0	18	16	11	13	11	12	14	13
Cadmium	U	2450	mg/kg	0.10	0.67	0.86	0.59	0.71	0.47	0.77	1.5	1.3
Chromium	U	2450	mg/kg	1.0	29	28	21	25	28	23	27	25
Copper	U	2450	mg/kg	0.50	42	34	27	29	24	30	36	21
Mercury	U	2450	mg/kg	0.10	0.16	0.13	0.14	0.11	0.11	0.10	0.19	< 0.10
Nickel	U	2450	mg/kg	0.50	25	26	16	21	14	15	29	24
Lead	U	2450	mg/kg	0.50	59	96	48	51	44	50	97	38
Selenium	U	2450	mg/kg	0.20	0.95	1.2	0.89	0.94	0.88	1.0	1.3	1.2
Zinc	U	2450	mg/kg	0.50	110	130	100	110	87	100	130	69
Chromium (Trivalent)	N	2490	mg/kg	1.0	29	28	21	25	28	23	27	25
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Total Organic Carbon	U	2625	%	0.20	3.9	5.8	4.5	5.0	4.5	4.8	5.5	1.7
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	0.14	< 0.10	< 0.10	< 0.10	0.10	0.36	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.15	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	0.15	0.47	0.22	0.18	0.34	0.56	1.6	< 0.10
Pyrene	U	2800	mg/kg	0.10	0.13	0.48	0.22	0.18	0.32	0.50	1.4	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.12	0.52	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	0.14	< 0.10	< 0.10	< 0.10	0.19	0.81	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	0.24	< 0.10	< 0.10	< 0.10	0.24	1.0	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.32	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	0.14	< 0.10	< 0.10	< 0.10	0.16	0.77	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.50	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.51	< 0.10

Results - Soil

Project: Shires Lane

Client: Lithos Consulting				**Chemtest Job No.:**	18-26491	18-26491	18-26491	18-26491	18-26491	18-26491	18-26491	18-26491
Quotation No.:				**Chemtest Sample ID.:**	681533	681534	681535	681536	681537	681538	681539	681540
				Client Sample ID.:	1	1	1	1	1	1	1	1
				Sample Location:	TP01	TP03	TP04	TP05	TP08	TP09	TP06	TP06
				Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.50
				Date Sampled:	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018	29-Aug-2018
				Asbestos Lab:	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM
Determinand	**Accred.**	**SOP**	**Units**	**LOD**								
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	7.9	< 2.0
2,4-D	N	2845	mg/kg	0.50	< 0.50					< 0.50		
Dichlorprop	N	2845	mg/kg	0.50	< 0.50					< 0.50		
MCPA	N	2845	mg/kg	0.50	< 0.50					< 0.50		
MCPB	N	2845	mg/kg	0.50	< 0.50					< 0.50		
Mecoprop	N	2845	mg/kg	0.50	< 0.50					< 0.50		
2,4,5-T	N	2845	mg/kg	0.50	< 0.50					< 0.50		

Chemtest
The right chemistry to deliver results

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2220	Water soluble Chloride in Soils	Chloride	Aqueous extraction and measuremernt by 'Aquakem 600' Discrete Analyser using ferric nitrate / mercuric thiocyanate.
2400	Cations	Cations	ICP-MS
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2845	Acid Herbicides	Acid Herbicides	Solvent extraction / Derivitisation / GCMS detection

Chemtest
The right chemistry to deliver results

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Appendix I

Geotechnical Test Results

TERRA TEK
SITE INVESTIGATION & LABORATORY SERVICES

Lithos Consulting Ltd
Parkhill
Walton Road
Wetherby
Leeds
LS22 5DZ
For the attention of Matt Thompson

Report No: B21836
Issue No 01

LABORATORY TEST REPORT

Project Name	**SHIRES LANE**		
Project Number	**B21836**	Date samples received	03/09/2018
Your Ref	3161	Date written instructions received	03/09/2018
Purchase Order	PO 13489	Date testing commenced	03/09/2018

Please find enclosed the results as summarised below

Figure / Table	Test Quantity	Description	ISO 17025 Accredited
1	~	Summary of Geotechnical Tests	See report
2	6	BRE Suite - Soil	Yes
3-10	8	Atterberg Limit	Yes
11-14	4	Particle Size Distribution	Yes
App S1	~	Sample Descriptions - Soil	N/A
App S2	~	Deviating Samples - Soil	N/A
App S3	~	Summary of In-House Analytical Test Methods - Soil	N/A

Remarks :

Issued by : Stephen Langman Date of Issue : 11/09/2018

Approved Signatories : S. Langman 11/09/2018

G Wilson (JMD/Laboratories Director), S Langman (Laboratory Coordinator)

Key to symbols used in this report
S/C : Testing was sub-contracted

Unless we are notified to the contrary, samples will be disposed after a period of one month from this date.
The results reported relate to samples received in the laboratory only.
All results contained in this report are provisional unless signed by an approved signatory
This report should not be reproduced except in full without the written approval of the laboratory.
Under multisite accreditation the testing contained in this report may have been performed at another Terra Tek laboratory.
The enclosed results remain the property of Terra Tek Limited and we reserve the right to withdraw
our report if we have not received cleared funds in accordance with our standard terms and conditions
Only those results indicated in this report are UKAS accredited and any opinions or interpretations expressed are outside the scope of UKAS accreditation.
Feedback on the this report may be left via our website www.terratek.co.uk/contact-us

mCERTS
UKAS TESTING 0126
25 YEARS 1990-2015

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Offices in Airdrie, Birmingham, Belfast and Chesham
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TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: SHIRES LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 3161

Sample Identification							Atterberg limits						Density		Total Stress			
Exploratory Hole	Depth m	Sample Ref	Sample Type	Lab Sample ID	Non Engineering Sample Description	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	Percentage retained 425µm %	Atterberg Classification	Particle Density Mg/m³	Bulk Mg/m³	Dry Mg/m³	Shear Strength kPa	Apparent Cohesion C kPa	Angle of Shearing Resistance Phi	Other Tests
TP01	1.00	2	D	453771	Brown silty CLAY with som fine to medium gravel	21	50	21	29	23	CI							BRE SD1 Suite
TP01	3.40	3	D	453788														BRE SD1 Suite
TP02	2.50	3	B	453782	Grey fine to coarse GRAVEL and COBBLES with much very clayey sand.	20	46	22	24	35	CI							PSD
TP03	1.60	3	B	453774	Grey very clayey SAND with some gravel. Gravel is fine to coarse.	20	36	16	20	36	CI							PSD,BRE SD1 Suite
TP04	0.60	2	D	453784														BRE SD1 Suite
Notes	Opinions and interpretations are outside the scope of UKAS accreditation					Test details are given on the 'Notes on Laboratory Procedures' sheet												See individual report sheets
					UKAS Accredited Test Y/N	Y	Y	Y	Y	Y	-	Y	Y	Y	Y	Y	Y	

Originator	Approved
PM	S. Langman 11/09/2018

SUMMARY OF GEOTECHNICAL TESTS

Figure 1

Sheet 1 of 2

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: SHIRES LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 3161

Sample Identification							Atterberg limits						Density		Total Stress			
Exploratory Hole	Depth m	Sample Ref	Sample Type	Lab Sample ID	Non Engineering Sample Description	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	Percentage retained 425µm %	Atterberg Classification	Particle Density Mg/m³	Bulk Mg/m³	Dry Mg/m³	Shear Strength kPa	Apparent Cohesion C kPa	Angle of Shearing Resistance Phi	Other Tests
TP05	1.00	2	D	453776	Brown snady CLAY with some fine to medium gravel	21	40	20	20	21	CI							
TP05	2.20	3	B	453777	Grey very sandy CLAY with much gravel. Gravel is fine to coarse.	15	32	18	14	44	CL							PSD,BRE SD1 Suite
TP07	1.10	1	D	453778	Brown CLAY with occasional fine to medium gravel and some organics	25	40	21	19	8	CI							
TP08	1.00	2	D	453779	Brown CLAY with occasional fine to coarse gravel	23	51	24	27	29	CH							
TP09	1.80	3	B	453781	Grey very sandy CLAY with much gravel. Gravel is fine to cobble sized.	15	42	19	23	56	CI							PSD,BRE SD1 Suite
Notes	Opinions and interpretations are outside the scope of UKAS accreditation					Test details are given on the 'Notes on Laboratory Procedures' sheet												See individual report sheets
					UKAS Accredited Test Y/N	Y	Y	Y	Y	Y	-	Y	Y	Y	Y	Y	Y	

Originator	Approved
PM	S. Langman 11/09/2018

SUMMARY OF GEOTECHNICAL TESTS

Figure 1

Sheet 2 of 2

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: SHIRES LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 3161

Sample Identification				Lab Sample ID	Sulphate (water soluble in 2:1 extract) as SO4 g/l	pH
Hole	Depth m	Sample Ref	Sample Type			
TP01	1.00	2	D	453771	0.02	5.5
TP01	3.40	3	D	453788	<0.01	8.0
TP03	1.60	3	B	453774	<0.01	8.0
TP04	0.60	2	D	453784	0.01	6.4
TP05	2.20	3	B	453777	<0.01	8.1
TP09	1.80	3	B	453781	<0.01	8.0
Limits of Detection					0.01	~
Terra Tek Analysis Method					TP169	TP019
Accreditation M=Mcerts U=UKAS N=No accreditation					M	M

Originator	Checked & Approved
TH	S. Langman 11/09/2018

BRE SD1 SUITE - SOIL

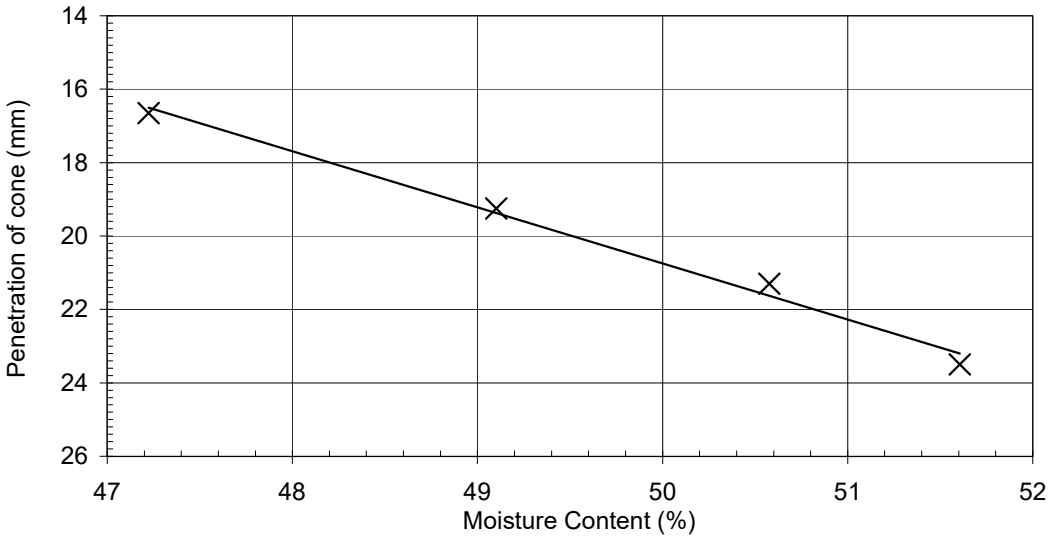
Figure 2

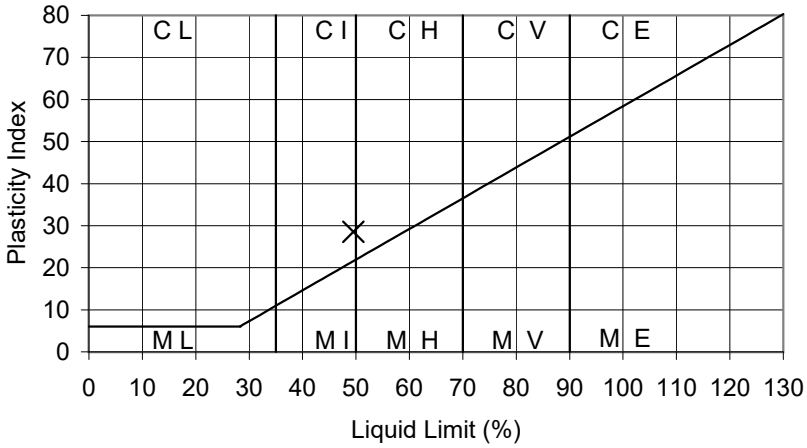
Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP01
	Engineer		Sample Ref	2
			Depth (m)	1.00
			Sample Type	D

Non Engineering Description : Brown silty CLAY with some gravel. Gravel is fine to medium.

Preparation : Sample washed and air dried





Results :

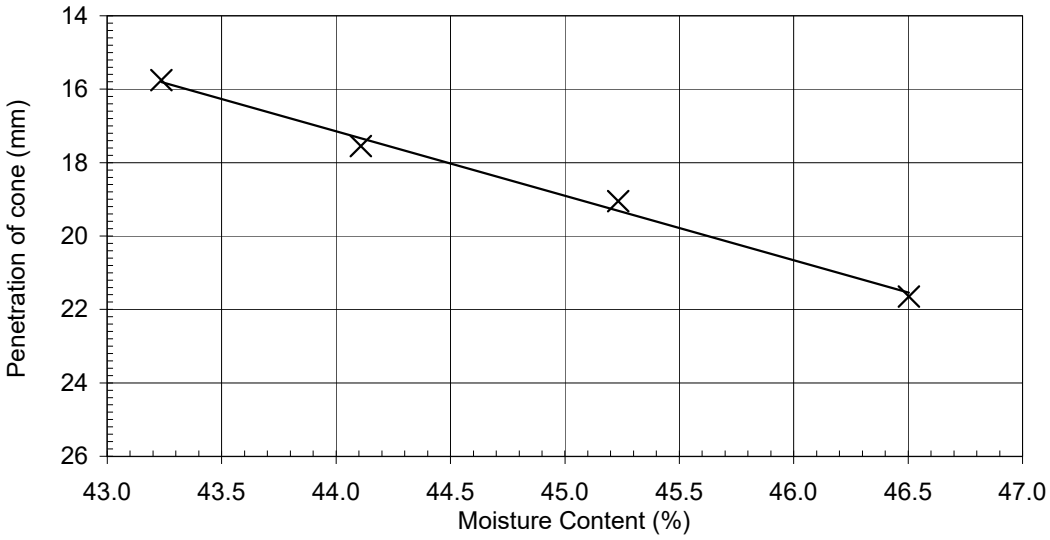
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	21 %
Percentage retained on 425µm sieve :	23 %
Liquid Limit :	50 %
Plastic Limit :	21 %
Plasticity Index :	29
Equivalent moisture content of material passing 425µm sieve :	27 %
Liquidity Index :	0.21

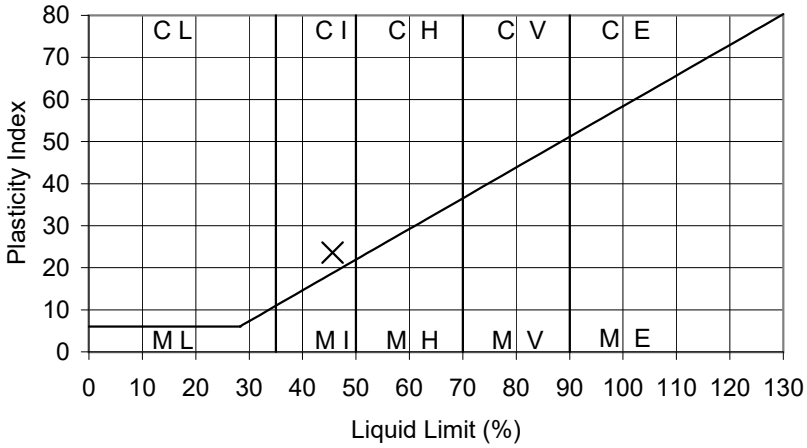
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 3
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP02
	Engineer		Sample Ref	3
			Depth (m)	2.50
			Sample Type	B

Non Engineering Description : Grey fine to coarse GRAVEL and COBBLES with much very clayey sand.

Preparation : Sample washed and air dried





Results :

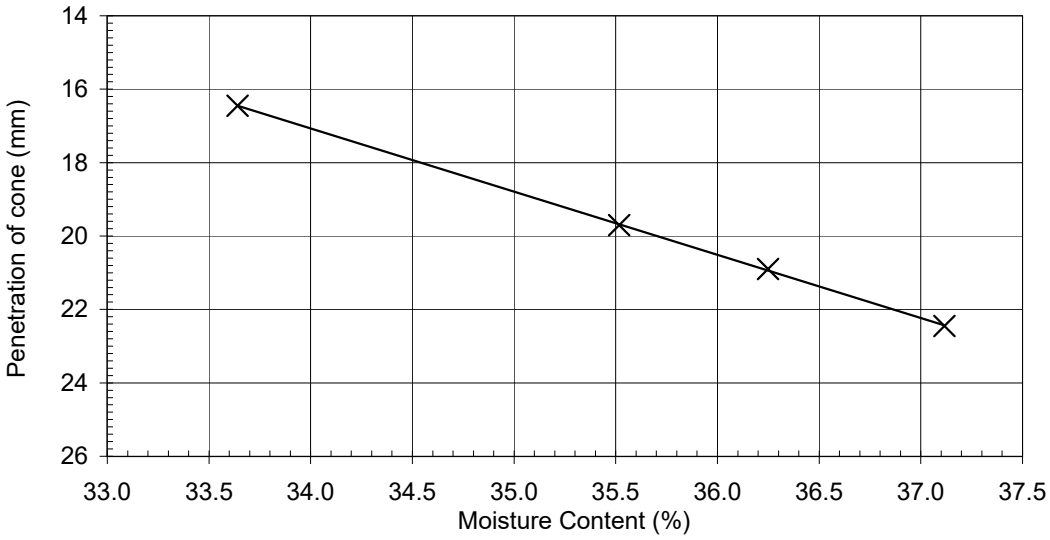
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	20 %
Percentage retained on 425µm sieve :	35 %
Liquid Limit :	46 %
Plastic Limit :	22 %
Plasticity Index :	24
Equivalent moisture content of material passing 425µm sieve :	31 %
Liquidity Index :	0.38

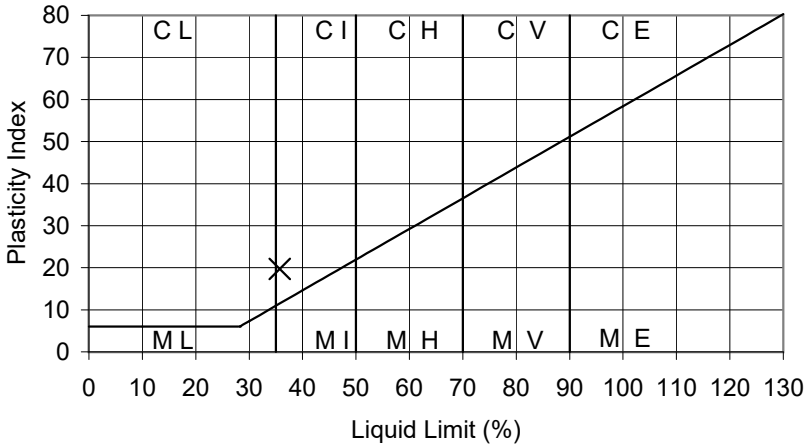
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 4
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP03
	Engineer		Sample Ref	3
			Depth (m)	1.60
			Sample Type	B

Non Engineering Description : Grey very clayey SAND with some gravel. Gravel is fine to coarse.

Preparation : Sample washed and air dried





Results :

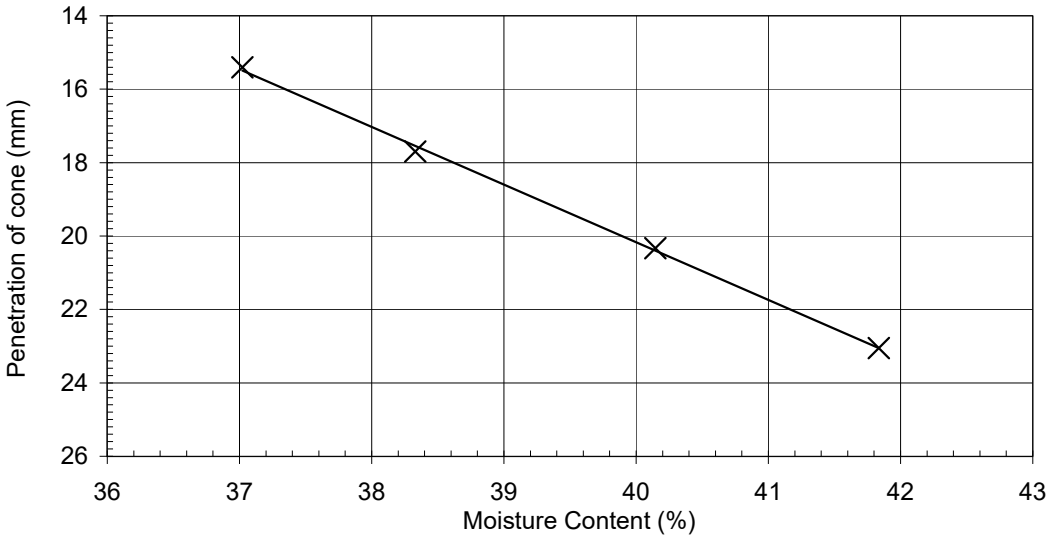
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	20 %
Percentage retained on 425µm sieve :	36 %
Liquid Limit :	36 %
Plastic Limit :	16 %
Plasticity Index :	20
Equivalent moisture content of material passing 425µm sieve :	31 %
Liquidity Index :	0.75

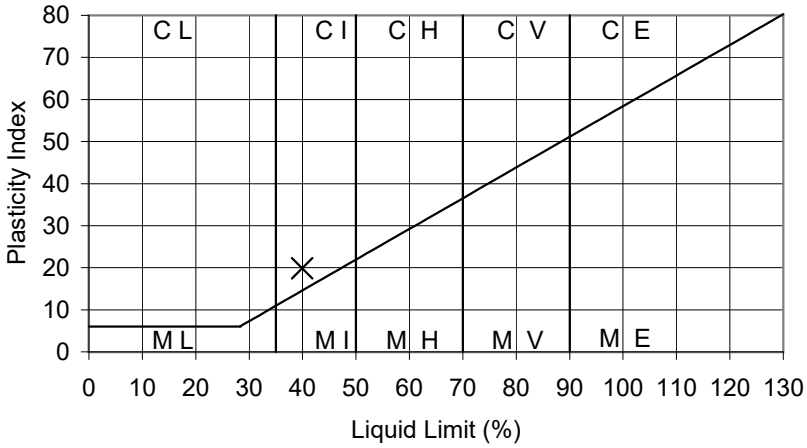
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 5
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP05
	Engineer		Sample Ref	2
			Depth (m)	1.00
			Sample Type	D

Non Engineering Description : Brown sandy CLAY with some gravel. Gravel is fine to medium.

Preparation : Sample washed and air dried





Results :

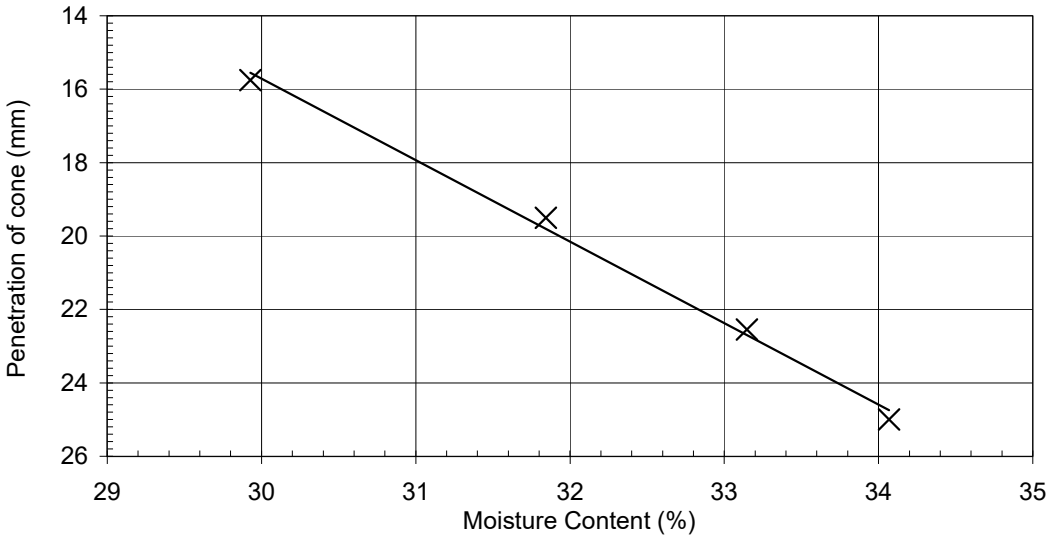
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	21 %
Percentage retained on 425µm sieve :	21 %
Liquid Limit :	40 %
Plastic Limit :	20 %
Plasticity Index :	20
Equivalent moisture content of material passing 425µm sieve :	27 %
Liquidity Index :	0.35

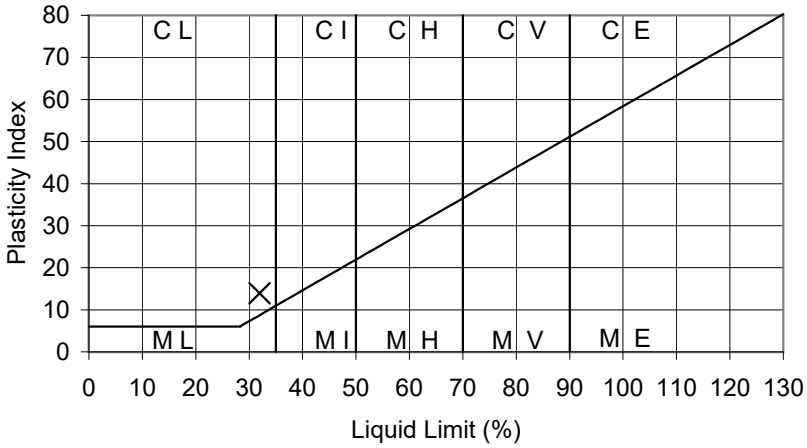
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 6
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP05
	Engineer		Sample Ref	3
			Depth (m)	2.20
			Sample Type	B

Non Engineering Description : Grey very sandy CLAY with much gravel. Gravel is fine to coarse.

Preparation : Sample washed and air dried





Results :

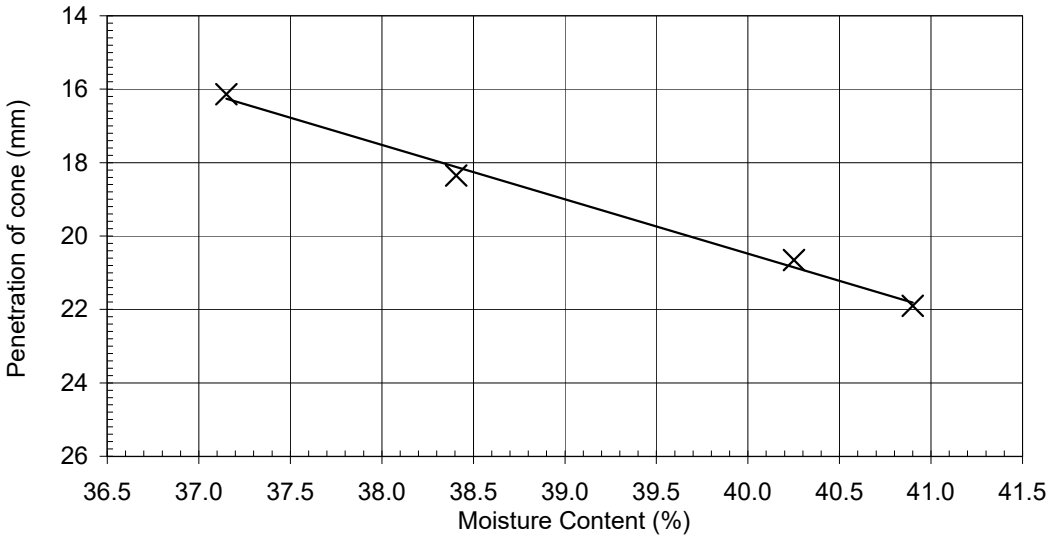
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	15 %
Percentage retained on 425µm sieve :	44 %
Liquid Limit :	32 %
Plastic Limit :	18 %
Plasticity Index :	14
Equivalent moisture content of material passing 425µm sieve :	27 %
Liquidity Index :	0.64

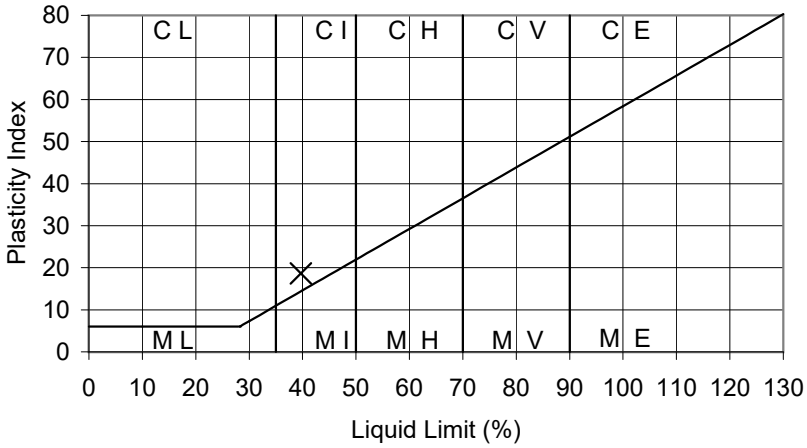
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 7
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP07
	Engineer		Sample Ref	1
			Depth (m)	1.10
			Sample Type	D

Non Engineering Description : Brown CLAY with some gravel. Gravel is fine to medium.

Preparation : Sample washed and air dried





Results :

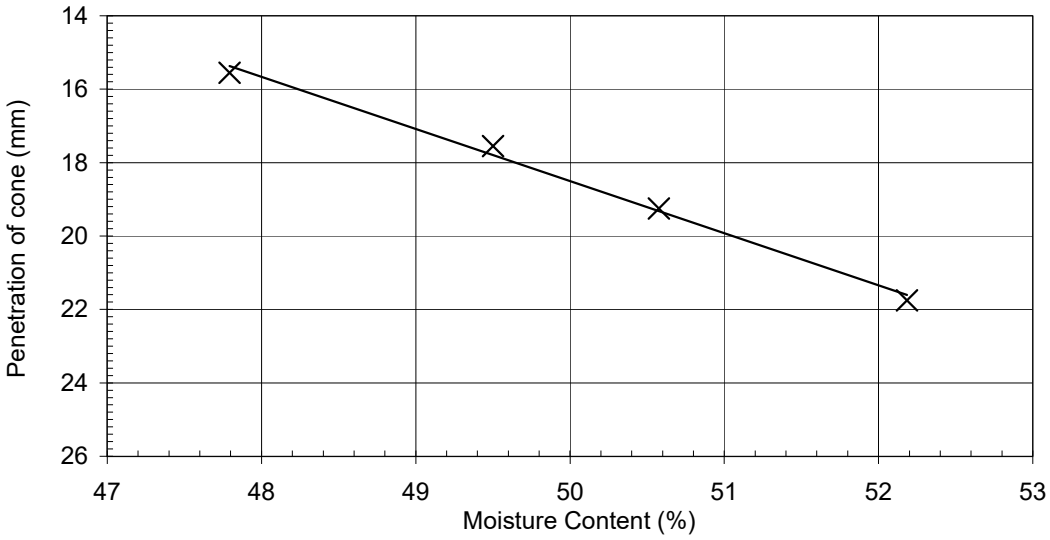
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	25 %
Percentage retained on 425µm sieve :	8 %
Liquid Limit :	40 %
Plastic Limit :	21 %
Plasticity Index :	19
Equivalent moisture content of material passing 425µm sieve :	27 %
Liquidity Index :	0.32

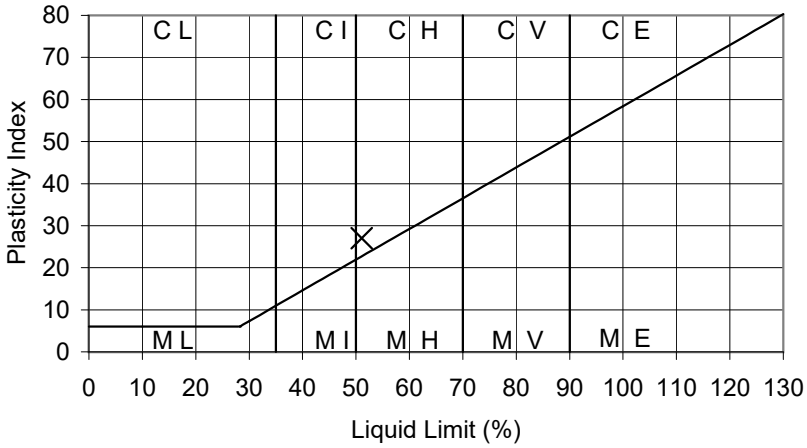
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 8
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP08
	Engineer		Sample Ref	2
			Depth (m)	1.00
			Sample Type	D

Non Engineering Description : Brown CLAY with much gravel. Gravel is fine to coarse.

Preparation : Sample washed and air dried





Results :

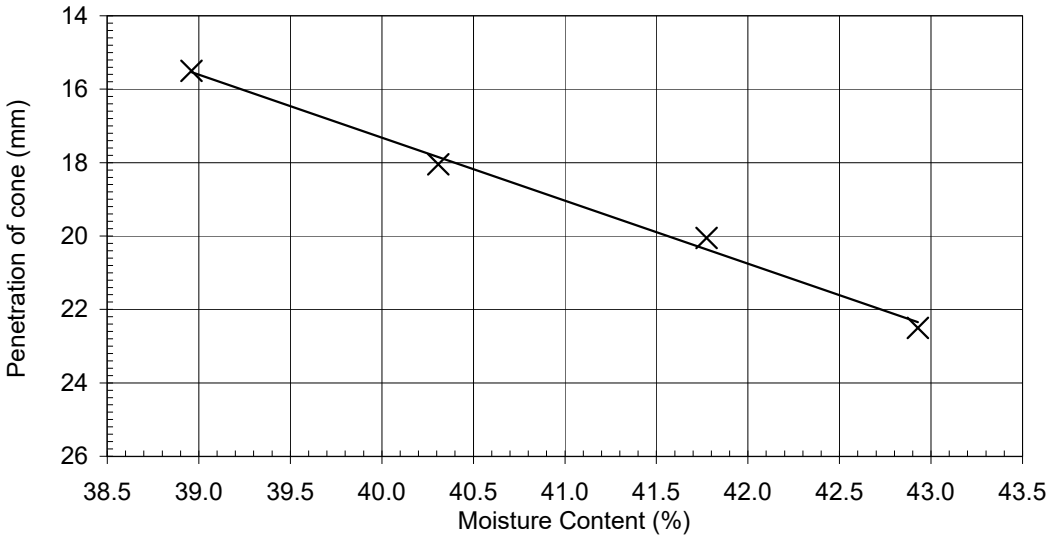
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	23 %
Percentage retained on 425µm sieve :	29 %
Liquid Limit :	51 %
Plastic Limit :	24 %
Plasticity Index :	27
Equivalent moisture content of material passing 425µm sieve :	32 %
Liquidity Index :	0.30

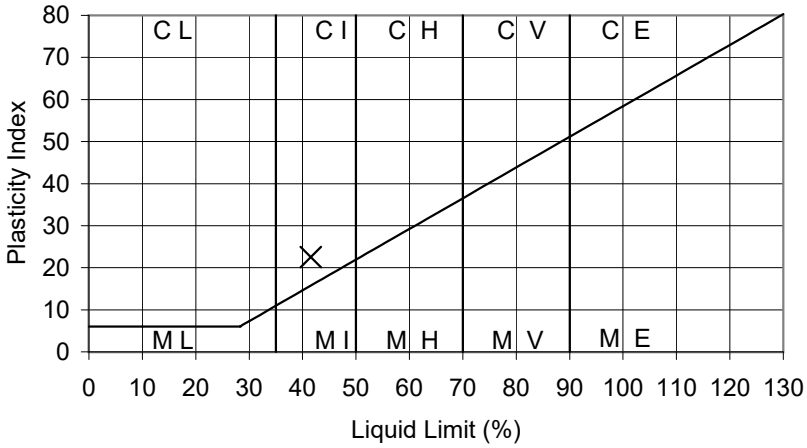
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 9
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	SHIRES LANE	Contract No.	3161
	Client	Lithos Consulting Ltd	Hole ID	TP09
	Engineer		Sample Ref	3
			Depth (m)	1.80
			Sample Type	B

Non Engineering Description : Grey very sandy CLAY with much gravel. Gravel is fine to cobble sized.

Preparation : Sample washed and air dried





Results :

As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	15	%
Percentage retained on 425µm sieve :	56	%
Liquid Limit :	42	%
Plastic Limit :	19	%
Plasticity Index :	23	
Equivalent moisture content of material passing 425µm sieve :	34	%
Liquidity Index :	0.65	

Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index	Figure 10
AT	S. Longmuir 11/09/2018	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site	SHIRES LANE	**Contract No**	**3161**
Client	Lithos Consulting Ltd	Hole	TP02
Engineer		Sample Ref	3
		Depth (m)	2.50
		Sample Type	B

Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	86
63.0 mm	86
50.0 mm	82
37.5 mm	77
28.0 mm	74
20.0 mm	67
14.0 mm	64
10.0 mm	60
6.30 mm	56
5.00 mm	54
3.35 mm	49
2.00 mm	45
1.18 mm	40
600 µm	35
425 µm	32
300 µm	29
212 µm	27
150 µm	25
63 µm	22

Non Engineering Description

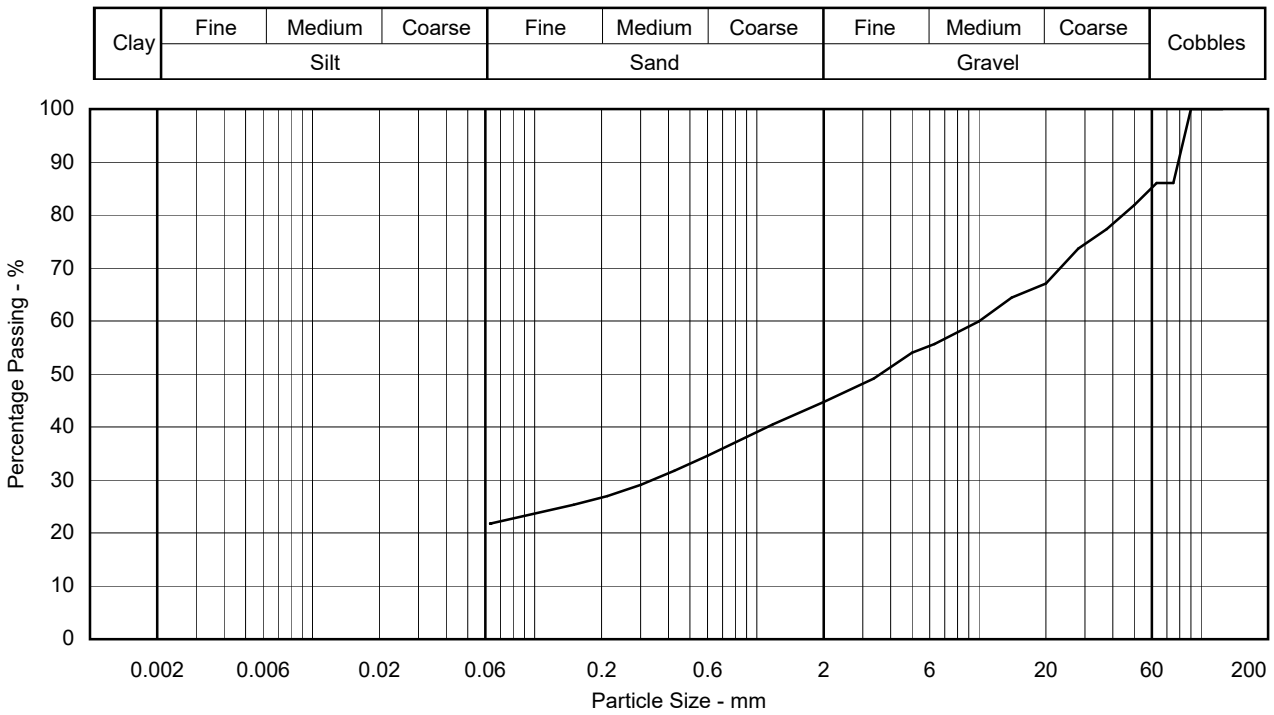
Grey fine to coarse GRAVEL and COBBLES with much very clayey sand.

Sample Proportions - %	
Cobbles	14.9
Gravel	40.3
Sand	23.0
Silt & Clay	21.8

Particle Diameter - mm	
D100	90
D60	10
D10	
Uniformity Coefficient	N/A

Notes

Sample does not comply with BS1377 minimum mass requirements



Originator	Checked & Approved
JH/ME	11/09/2018

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 11

Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site	SHIRES LANE	**Contract No**	**3161**
Client	Lithos Consulting Ltd	Hole	TP03
Engineer		Sample Ref	3
		Depth (m)	1.60
		Sample Type	B

Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	98
28.0 mm	95
20.0 mm	91
14.0 mm	89
10.0 mm	87
6.30 mm	84
5.00 mm	82
3.35 mm	80
2.00 mm	77
1.18 mm	73
600 µm	62
425 µm	50
300 µm	47
212 µm	41
150 µm	38
63 µm	35

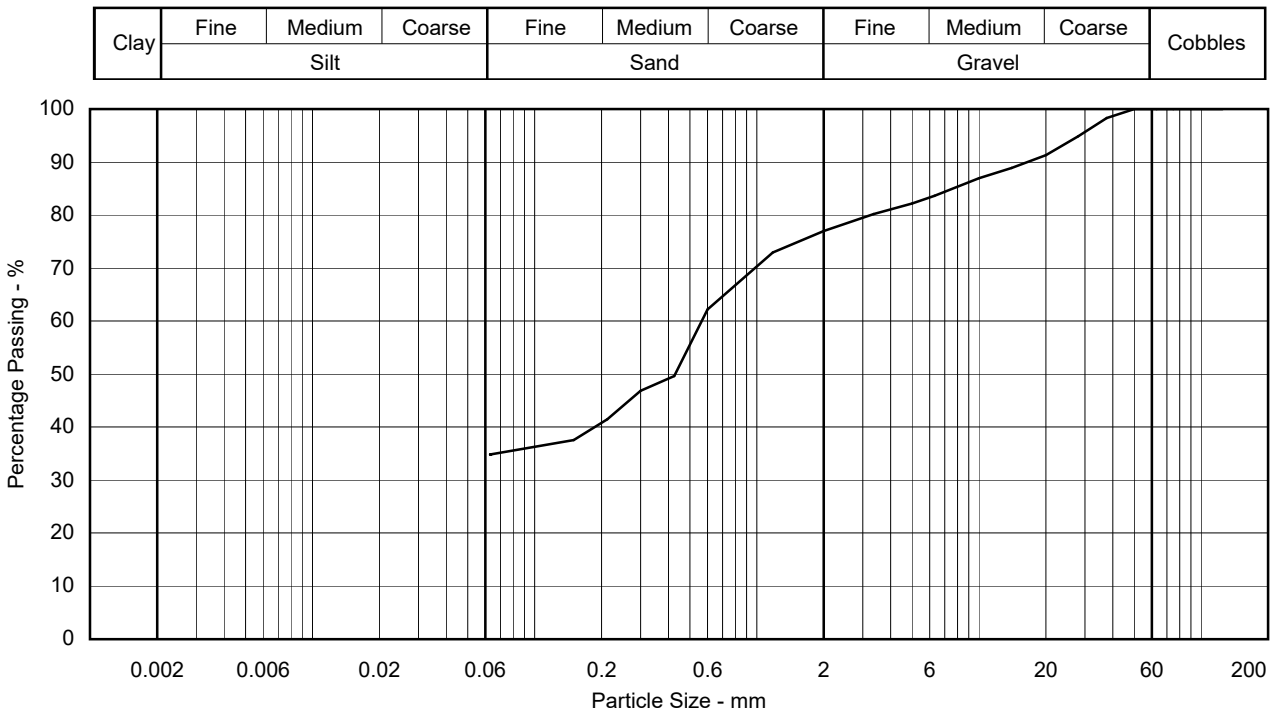
Non Engineering Description

Grey very clayey SAND with some gravel. Gravel is fine to coarse.

Sample Proportions - %	
Cobbles	0.0
Gravel	23.0
Sand	42.2
Silt & Clay	34.8

Particle Diameter - mm	
D100	50
D60	0.57
D10	
Uniformity Coefficient	N/A

Notes



Originator	Checked & Approved
JH/ME	11/09/2018

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 12

Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site	SHIRES LANE	**Contract No**	**3161**
Client	Lithos Consulting Ltd	Hole	TP05
Engineer		Sample Ref	3
		Depth (m)	2.20
		Sample Type	B

Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	98
20.0 mm	96
14.0 mm	93
10.0 mm	90
6.30 mm	85
5.00 mm	83
3.35 mm	79
2.00 mm	74
1.18 mm	70
600 µm	61
425 µm	57
300 µm	54
212 µm	50
150 µm	47
63 µm	38

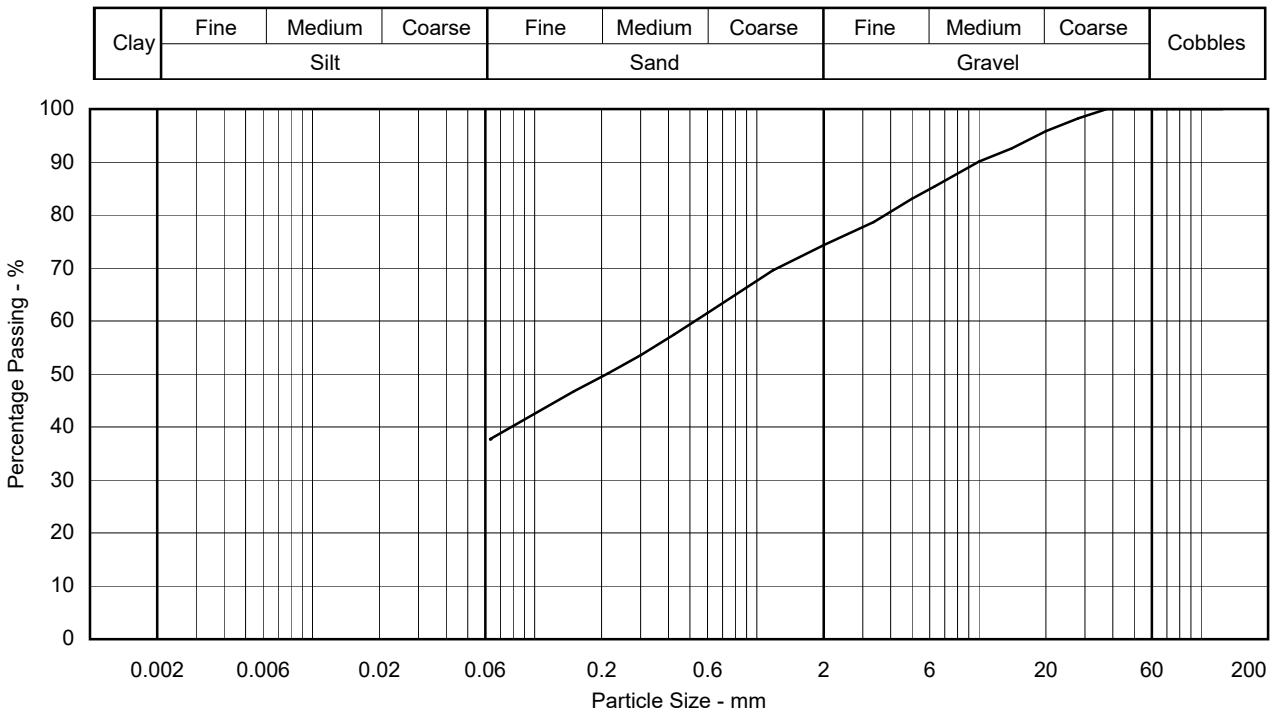
Non Engineering Description

Grey very sandy CLAY with much gravel. Gravel is fine to coarse.

Sample Proportions - %	
Cobbles	0.0
Gravel	25.7
Sand	36.6
Silt & Clay	37.7

Particle Diameter - mm	
D100	38
D60	0.53
D10	
Uniformity Coefficient	N/A

Notes



Originator	Checked & Approved
TH/ME	11/09/2018

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 13

Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site	SHIRES LANE	**Contract No**	**3161**
Client	Lithos Consulting Ltd	Hole	TP09
Engineer		Sample Ref	3
		Depth (m)	1.80
		Sample Type	B

Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	95
50.0 mm	93
37.5 mm	88
28.0 mm	82
20.0 mm	75
14.0 mm	72
10.0 mm	69
6.30 mm	64
5.00 mm	62
3.35 mm	59
2.00 mm	53
1.18 mm	46
600 µm	37
425 µm	33
300 µm	31
212 µm	30
150 µm	28
63 µm	25

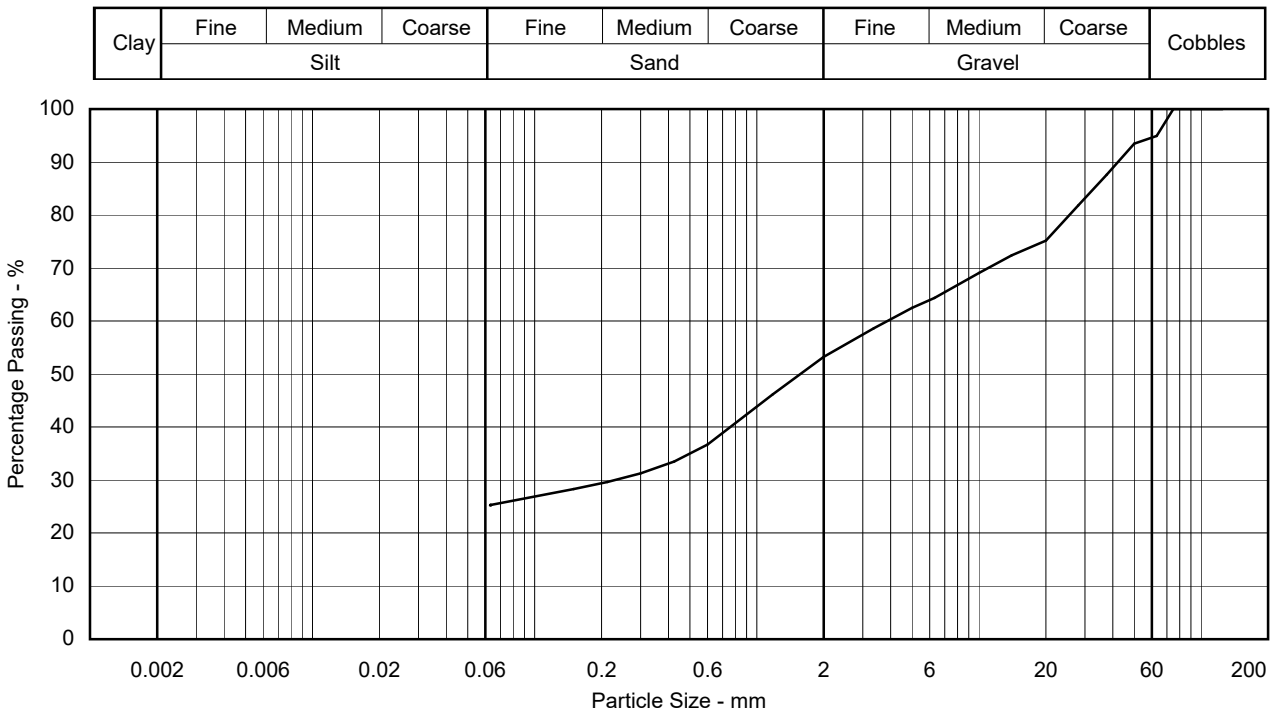
Non Engineering Description

Grey very sandy CLAY with much gravel. Gravel is fine to cobble sized.

Sample Proportions - %	
Cobbles	5.4
Gravel	41.4
Sand	28.0
Silt & Clay	25.3

Particle Diameter - mm	
D100	75
D60	3.9
D10	
Uniformity Coefficient	N/A

Notes



Originator	Checked & Approved
ME	11/09/2018

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 14

Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: SHIRES LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No **E13009/1**

Sample Identification											
Exploratory Hole	Depth m	Sample Ref	Sample Type	Lab Sample ID	Date Sampled	Temperature on receipt °C	PRIMARY MATRIX	Secondary Matrix	Additional matrix	% Loss at 30C	% Retained 2mm
TP01	1.00	2	D	453771	29/08/18		CLAY	Fine to medium gravel		19.0	16.8
TP03	1.60	3	B	453774	29/08/18		Sandy CLAY	Fine to medium gravel		13.8	33.4
TP05	2.20	3	B	453777	29/08/18		Clayey SAND	Fine to medium gravel		12.4	33.9
TP09	1.80	3	B	453781	29/08/18		Sandy CLAY	Fine to medium gravel		13.9	43.4
TP04	0.60	2	D	453784	29/08/18		Clayey SAND	Fine to medium gravel		14.1	26.4
TP01	3.40	3	D	453788	29/08/18		SANDSTONE	Fine to medium gravel		15.8	35.7

Notes

Terra Tek are accredited for clay, sand and loam matrix types only, where they constitute the major component of the sample. Other coarse granular materials such as gravel, are not accredited where they comprise the major component of the sample.

Results are expressed on a dry-weight basis (samples dried at 30°C ± 5°C) except where stated.

The laboratory removes any material > 2mm prior to analysis. The quantity and nature of the material is shown as the secondary and additional matrix types in the above table.

Where a parameter cannot be determined in house it is our policy to use a UKAS/MCERTS accredited laboratory wherever possible. Terra Tek will assume responsibility for the quality of subcontracted tests and the performance of the subcontractor chosen. Where there is no known UKAS/MCERTS laboratory for a particular parameter, a laboratory listed within the Terra Tek Approved Subcontractors List, which is subject to performance assessment, will be selected.

Originator	Checked & Approved	SAMPLE DESCRIPTIONS	Appendix S1
TGH	S. Langman 11/09/2018		Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: SHIRES LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 3161

Sample Identification						Deviating conditions						
Exploratory Hole	Depth m	Sample Ref	Sample Type	Lab Sample ID	Date Sampled	Sampling date has not been provided	Exceeded maximium holding time for selected test(s)	Presence of headspace in sample vial	Poorly fitting cap or lid	Damaged container		Preservatives used
TP01	1.00	2	D	453771	29/08/18							
TP03	1.60	3	B	453774	29/08/18							
TP05	2.20	3	B	453777	29/08/18							
TP09	1.80	3	B	453781	29/08/18							
TP04	0.60	2	D	453784	29/08/18							
TP01	3.40	3	D	453788	29/08/18							

NOTES
1. Results reported for samples classified as deviating may be compromised. Deviation types are shown as "X" or "Yes" in the table above.
2. The absence of "X" or "Yes" in the table above indicates no reported deviations.
3. Deviations due to use of incorrect sample container are shown on result tables.
4. Deviating results are indicated within result tables.

Originator	Checked & Approved
TGH	S. Langman 11/09/2018

DEVIATING SAMPLES - SOIL

Appendix S2

Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: SHIRES LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 3161

Method Code	Reference	Description of Method	ISO17025 Accredited	MCERTS Accredited	Wet/Dry Sample Tested
GP001	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Preparation of soil samples for chemical analysis	Yes	Yes	N/A
GP012	BS EN 12457-3: Characterisation of Waste - Compliance test for leaching of granular waste materials and sludges (two-stage batch test)	Preparation of soil samples for two-stage leachate test			Dry
TP019	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of pH in 2.5:1 water/soil extract using pH meter.	Yes	Yes	Dry
TP029	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of acid soluble sulfate by gravimetry.	Yes	Yes	Dry
TP032	MAFF Book 427: The Analysis of Agricultural Materials: Method 8	Determination of water soluble boron by colorimetry	Yes		Dry
TP033	APHA/AWWA, 19th edition: Method 5520E	Determination of Toluene Extractable Matter by soxhlet extraction.	Yes		Dry
TP040	APHA/AWWA, 19th edition: Method 3500Cr-D	Determination of hexavalent chromium by colorimetry.	Yes		Dry
TP041	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of organic matter by titrimetry.	Yes		Dry
TP042	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of loss on ignition at 50-440°C by gravimetry	Yes	Yes	Dry
TP043	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of water soluble sulfate in 2:1 water/soil extract	Yes	Yes	Dry
TP045	GACHAMJA A.M. Chromatography and Analysis: 1992 9-11 (modified)	Determination of polyaromatic hydrocarbons extractable in dichloromethane, by GC/MS	Yes	Yes	Dry
TP046	MEWAM method: Phenols in water and Effluents: 4-aminoantipyrine method	Determination of monohydric phenols by steam distillation/colorimetry	Yes	Yes	Dry
TP047	MEWAM method: Cyanide in Waters etc	Determination of Free Cyanide by steam distillation/colorimetry	Yes		Dry
TP048	MEWAM method: Cyanide in Waters etc	Determination of total cyanide by steam distillation/colorimetry.	Yes	Yes	Wet
TP049	MEWAM method: Cyanide in Waters etc	Determination of complex cyanide by calculation	Yes		Dry
TP050	MEWAM method: Determination of Thiocyanate ,1985	Determination of thiocyanate by colorimetry	Yes	Yes	Dry
TP051	USEPA Method 9030B	Determination of acid soluble sulfides by steam distillation/colorimetry.	Yes	Yes	Dry
TP052	BS1881: Part 324, 1988: Testing Concrete	Determination of elemental sulfur by soxhlet extraction and titrimetry.	Yes		Dry
TP067	TNRCC Method 1005: 2001 (modified)	Determination of pentane/acetone extractable petroleum hydrocarbons (C8 - C40) by GC/FID	Yes	Yes	Wet
TP072	In-house documented method	Determination of ammoniacal nitrogen by colorimetry.			Dry

Notes

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2. Results are expressed on a dry-weight basis (samples dried at 30°C ± 5°C) except where stated.
3. The laboratory removes any material >2mm prior to analysis. The quantity and nature of any material removed from samples is recorded and the information is available on request.
4. The laboratory records the date of analysis of each parameter. This information is available on request.
5. Where a parameter cannot be determined in house it is our policy to use a UKAS/MCERTS accredited laboratory wherever possible. Terra Tek will assume responsibility for the quality of subcontracted tests and the performance of the subcontractor chosen. Where there is no known UKAS/MCERTS laboratory for a particular parameter, a laboratory listed within the Terra Tek Approved Subcontractors list, which is subject to performance assessment, will be selected.

Originator	Checked & Approved
N/A	N/A

SUMMARY OF IN-HOUSE ANALYTICAL TEST METHODS (SOIL)

Appendix S3

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: SHIRES LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 3161

Method Code	Reference	Description of Method	ISO17025 Accredited	MCERTS Accredited	Wet/Dry Sample Tested
TP073	In-house documented method	Determination of anionic detergent (MBAS) by colorimetry			Dry
TP074	In-house documented method	Determination of water soluble fluoride by ion selective electrode			Dry
TP098	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of acid soluble chloride by titrimetry			Dry
TP099	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of water soluble chloride by titrimetry	Yes	Yes	Dry
TP100	Wisconsin DNR Modified GRO method, Method for Determining Gasoline Range Organics	Determination of Volatile Petroleum Hydrocarbons/GRO.	Yes	Yes	Wet
TP110	USEPA Methods 8082A & 3665A	Determination of Total & Speciated 7 PCB Congeners by GC/MS SIM	Yes	Yes	Wet
TP114	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of carbonate in soil (rapid titration method)			Dry
TP126	TNRCC Method 1006 (modified)	Extracted petroleum hydrocarbons from TP067 split into aromatic and aliphatic fractions. Analysed by GC/FID.	Yes		Wet
TP134	In-house documented method	Determination of water soluble chloride by titrimetry	Yes	Yes	Dry
TP135	USEPA Methods 8100 & 8270D. In-house method TP045	Determination of polyaromatic hydrocarbons extractable in dichloromethane, by GC/MS (with concentration stage)			Dry
TP137	BS7755: Section 3.9: 1995/ISO 11466:1995	Determination of acid extractable metals in soil by ICP-OES	Selected	Selected	Dry
TP145	USEPA Methods 3550C & 8270D	Determination of Semi-Volatile Organic Compounds by GC/MS	Yes	Yes	Wet
TP147	USEPA Methods 8082A & 3665A	Determination of total & speciated WHO 12 PCB Congeners by GC/MS SIM.			Wet
TP150	USEPA Methods 8081B & 8141B	Determination of pesticides and herbicides in soil by GC/MS SIM			Wet
TP152	USEPA Method 556	Determination of carbonyls by GC/MS.			Wet
TP154	USEPA Method 5021. Wisconsin DNR modified GRO method	Determination of volatiles in by GC/MS headspace	Yes	Selected	Wet
TP158	USEPA Method 1671	Determination of glycols by GC/FID DI			Wet

Notes

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Originator	Checked & Approved
N/A	N/A

SUMMARY OF IN-HOUSE ANALYTICAL TEST METHODS (SOIL)

Appendix S3