REPORT C7728
DECEMBER 2018

GEOENVIRONMENTAL APPRAISAL

of
HARRAS MOOR, WHITEHAVEN

Prepared for
MICHAEL LITTLE

Sirius Geotechnical

REPORT TYPE:	**GEOENVIRONMENTAL APPRAISAL**
REPORT NUMBER:	**C7728** **REPORT STATUS: FINAL**
REPORT DATE:	**DECEMBER 2018**
SITE NAME:	**HARRAS MOOR, WHITEHAVEN**
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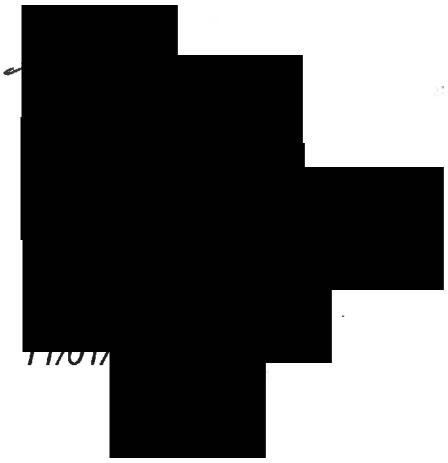

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EXECUTIVE SUMMARY

Introduction	Sirius Geotechnical Ltd. (Sirius) was commissioned by Michael Little to undertake a geoenvironmental appraisal of Harras Moor, Whitehaven (the "site"). It is understood that consideration is being given to development for a residential with gardens end use.
Site Details	The site is located at National Grid reference 298861, 518389, north of Harras Road, west of Red Lonning and east of an unnamed farm access road, c.1.5km northwest of Whitehaven. The site is irregular in shape, with approximate maximum dimensions of 240m by 300m. Site cover generally comprises rough grass, with areas of mature and immature trees and one small area of tarmac.
Site History	Earliest edition OS maps suggest the north of the site was once part of a racecourse; with small unlabelled structures toward the middle of the site; a coal shaft close to the eastern boundary, approximately commensurate with the location of the aforementioned concrete plinth; and an unlabelled feature, possibly a pond or reservoir, in the west. With the exception of the shaft, these features appear to have gradually been removed by the 1960s. It is understood that the site was opencast, as part of the Moresby and Keekle opencast site, in the 1980s. The shaft feature remains recorded on OS maps until at least 2002.
Fieldwork	Excavation of 10 No. machine-excavated trial pits to a maximum depth of 3.5m. Excavation of 7 No. machine-excavated trial trenches to a maximum depth of 2.7m. Drilling of 3 No. cable percussive boreholes to a maximum depth of 16.55m bgl. Drilling of 6 No. rotary openhole boreholes to a maximum depth of 51m bgl. Gas and groundwater monitoring wells were installed in cable percussive and rotary boreholes, and a programme of monitoring is ongoing.
Laboratory Testing	Samples of soil were submitted for analysis of a range of metal, other inorganic and organic contaminants. Geotechnical testing was scheduled on selected samples. All testing was undertaken at MCERTS and/ or UKAS accredited laboratories.
Ground Conditions	The investigation has identified topsoil/made ground topsoil overlying superficial deposits of firm to stiff sandy gravelly clay within the south east and westernmost areas of the site. Made ground was encountered beneath made ground topsoil across the majority of the central area of the site, generally comprising a sandy gravelly clay overlying clayey sandy gravel and cobbles with occasional boulders. Bedrock within the opencast was proven at one location at a depth of 22m bgl, with the opencast anticipated to extend to a maximum depth of c.41m at its western extents. Outwith the opencast, weathered bedrock was encountered at depths from 0.5m to 2m bgl and bedrock was encountered from depths of 1.5m to 3.1m bgl.
Ground Stability	Made ground and superficial soils should be assumed to be unstable in the short term within excavations, and appropriate support provided to all excavations.

	No coal seams or evidence of workings within bedrock beneath the opencast were recorded. Notwithstanding, there is considered to be a moderate risk of unrecorded workings within the shallowest seam beneath the opencast which could affect surface stability of the site within the area of the former opencast. Additional, thin seams were recorded at shallow depth outwith the opencast. It is therefore considered there is a moderate risk of unrecorded workings at shallow depth outwith the opencast. It would therefore be prudent to undertake further rotary boreholes in the west and south of the site, outwith the area of the opencast, to confirm the presence or absence of workings within the shallow seams beneath the site and within the area of the former opencast to confirm the depth, thickness and presence or absence of workings within the Black Metal beneath the opencast. One mine entry is recorded within the east of the site which appears to be marked by a concrete plinth. Treatment of the mineshaft is likely to be required, and/or provision of an engineered capping solution in addition to a development standoff from the mineshaft. It is possible that other unrecorded mine entries, including potential bell pitting/crop workings, also exist within the site.
Soakaways	Based on the ground conditions encountered during the site investigation, soakaway drainage is considered unlikely to be viable at the site.
Foundations and Floor Slabs	Outwith the area of the opencast, conventional spread foundations are considered to be suitable where natural soils were encountered at shallow depth. For structures to be built within the area of former opencast workings an alternative foundation solution will be required comprising either raft or piled foundations. A value engineering exercise should be undertaken to determine the most cost effective solution for the site however at this stage it is considered unlikely that piles will be economically viable for the site.
Sulphate Class	Based on the samples tested, a Design Sulphate Class of DS-1 and an ACEC Class of AC-3z should be used for buried concrete structures in contact with topsoil/made ground topsoil, made ground and superficial deposits.
Contamination	The revised CSM has not identified any potential pollutant linkages from soils which could result in an unacceptable risk to end users and construction workers, and no remedial action is deemed to be necessary for the protection of human health or environmental receptors.
Asbestos	ACMs were not observed within the soils encountered during this investigation and no asbestos was identified during laboratory testing.
Ground Gas	Gas monitoring undertaken to date indicates the site to fall within CS4 conditions. Further monitoring is currently ongoing, and a full ground risk assessment will be issued upon completion of the monitoring. Notwithstanding, it is recommended immediate discussion with the Contaminated Land Officer and/or NHBC takes place to obtain their opinion on development of a site which falls into this hazard potential category. No radon protective measures are required.
Invasive Species	No invasive species were identified during the investigation, however, an ecological survey should be carried out to confirm, or otherwise, the absence of this and any other invasive species.

The executive summary is an overview of the key findings and conclusions of the report. There may be other information contained in the body of the report which puts into context the findings of the executive summary. No reliance should be placed on the executive summary in isolation, particularly when deriving design detail/abnormal costs.

1. INTRODUCTION

Sirius Geotechnical Ltd. (Sirius) was commissioned by Michael Little to undertake a geoenvironmental appraisal of Harras Moor, Whitehaven (the "site"). It is understood that consideration is being given to development for a residential with gardens end use.

The objectives of this appraisal were to:

- Establish the historical development of the site and surrounding area from a review of available plans;
- Establish the environmental setting of the site;
- Investigate soil and groundwater conditions;
- Determine the potential risks posed by any ground contamination and provide recommendations on remedial measures to manage such risks;
- Establish the risks associated with hazardous ground gas;
- Evaluate whether past mining or other extractive industries could have an influence on the site;
- Provide advice relating to geotechnical issues associated with the site;
- Provide foundation recommendations.

The desk study element of this investigation includes an assessment of information provided by Landmark Information Group (Envirocheck® Report), the British Geological Survey (BGS), the Coal Authority (CA) and/or other referenced sources.

Fieldwork was undertaken from 1st October to 5th October 2018 and comprised the excavation of 10 No. trial pits and 7 No. trial trenches, the drilling of 3 No. cable percussion boreholes and drilling of 6 No. rotary openhole boreholes, including one following on from a cable percussion borehole.

This report, which was designed to meet the requirements of relevant current guidance, presents the factual information available during this appraisal, an interpretation of the data obtained and recommendations relevant to the defined objectives.

It has been assumed in the production of this report that the site is to be developed for a residential with gardens end use. In addition, it is assumed that ground levels will not change significantly from those described in this report. If these are not the case, then amendments to the recommendations made in this report may be required.

Where the report refers to the potential presence of invasive plants (such as Japanese Knotweed) or asbestos-containing materials (ACMs), such observations are for information only and should be verified by a suitably qualified expert.

The comments and opinions presented in this report are based on the findings of the desk study, ground conditions encountered during intrusive investigation works performed by Sirius and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the site which have not been revealed by this investigation and which have not been taken into account by this report. Responsibility cannot be accepted for any conditions not revealed by this investigation. Any diagram or opinion on the possible configuration of strata, contamination or other spatially variable features between or beyond investigation positions is conjectural and given for guidance only. Confirmation of ground conditions between exploratory holes should be undertaken if deemed necessary. Evaluation of ground gas and groundwater is based on observations made at the time of the investigation and monitoring visits. It should be noted that ground gas and groundwater levels and quality may vary due to seasonal and other effects.

This report has been prepared for the sole use of Michael Little. No other third party may rely upon or reproduce the contents of this report without the written approval of Sirius. If any unauthorised third party comes into possession of this report, they rely on it entirely at their own risk and the authors do not owe them any Duty of Care or Skill.

2. SITE DETAILS AND DESCRIPTION

Table 2.1 Current Site Overview

Location	A site location plan is provided as Drawing No. C7728/01 within Appendix A. The site is located north of Harras Road, west of Red Lonning and east of an unnamed farm access road, c.1.5km northwest of Whitehaven.
National Grid Reference (NGR)	298861, 518389.
Topography and Features	The site currently comprises rough pasture, used for livestock grazing, with approximate maximum dimensions of 240m by 300m. The site is irregularly shaped, with an area of c.5.7 hectares. Ground levels are generally level, although sloping gently down to the south-west with a fall of circa 6m across the site, commensurate with surrounding land, although the site is approximately 2m lower than adjacent roads in the vicinity of the junction of Red Lonning and Harras Road in the south east. Within a narrow strip adjacent to the eastern boundary reedy grasses, symptomatic of wet conditions, predominate. It was noted that surface ground conditions throughout the site are very soft, with deep ruts and some areas of standing water. A partially buried area of concrete, approximately 5m by 5m, with a concrete plinth approximately 1.5m high is present in the east of the site. The plinth appears to have previously been inset with a plaque, which is no longer present. An overhead electricity line supported on metal pylon is present in the northeast corner of the site.
Approximate Site Area	5.7ha

Site Boundaries	The western and part of the southern site boundaries are marked by a dry stone wall. The eastern and remainder of the southern boundary comprises post and wire and wooden fencing. The northern site boundary comprises hedgerow and wooden fencing.
Current Land Use	Agricultural/pastoral fields.
Invasive Plant Species	An ecological survey should be carried out by a suitably qualified specialist to confirm if any invasive, protected or sensitive species or habitats are present.
Adjacent Land Uses	Predominantly agricultural land, with the village of Harras Moor present to the west of the site, and a golf course present to the east.

The main site features are shown on Drawing No. C7728/03 within Appendix A.

3. PREVIOUS INVESTIGATION FINDINGS

A Phase 1: Desk Top Study Report (Preliminary Environmental Risk Assessment), undertaken by Geo Environmental Engineering, reference 2015-1558, dated 23rd July 2015 and a Coal Mining Risk Assessment Report, undertaken by Elliott Environmental Surveyors, reference EES15-174, dated 6th June 2016 have previously been prepared for North Associates.

These reports should be read in conjunction with this report to provide full details on the environmental and geological setting of the site. However, a brief summary of the environmental setting is provided in Table 3.1 below.

Table 3.3.1 Summary of Environmental Setting

Site History	Earliest edition OS maps suggest the north of the site was once part of a racecourse; with small unlabelled structures toward the middle of the site; a coal shaft close to the eastern boundary, approximately commensurate with the location of the concrete plinth in the east of the site; and an unlabelled feature, possibly a pond or reservoir, in the west. With the exception of the shaft, these features appear to have gradually been removed by the 1960s. It is understood that the site was opencast, as part of the Moresby and Keekle opencast site, in the 1980s. The shaft feature remains recorded on OS maps until at least 2002.
Anticipated Ground Conditions	The site is recorded to have been subject to opencast coal mining, in the 1980s. Information contained within the CMRA, including limited intrusive trial trenching within the site, suggests that the extents of the opencast cover circa 75% of the site area, although records suggest extraction of coal took place across circa 50% of the site. The area of opencast is approximately centred on a line drawn north – south through the centre of the site. Within the area of extraction, made ground is anticipated to extend to depths of circa 20m below ground level in the east, up to circa 40m below ground level in the west. The opencast highwall appears to have been battered back over a 10m to 20m perimeter around the area of extraction. Trial trenching, undertaken as part of a coal mining risk assessment produced by Elliott Environmental Surveyors, identified its southern and western boundaries as being approximately 30m to 50m from the site boundaries. Made ground within the former opencast area is likely to comprise typical opencast backfill comprising reworked natural materials, although the possibility of other material having been placed during backfilling cannot be discounted. Outwith the perimeter of the opencast area, localised areas of made ground are also anticipated, associated with former small structures, a possible backfilled pond/ reservoir in the west and the mineshaft in the east. Natural superficial soils, outwith the opencast and below any made ground, is recorded on BGS mapping to comprise glacial till. Rockhead is recorded to comprise Carboniferous Coal Measures strata. Depth to rockhead will vary considerably owing to opencast activities. Three seams of coal are recorded on BGS 1:50000 scale mapping to subcrop within the site, each of which appears to have been opencast, together with a fourth seam of coal which is conjectured to subcrop to the east of the site.
Mining & Quarrying	The risk of surface instability resulting from past coal working (both underground and surface) is considered to be **high**. A large proportion of the site has been subject to opencast extraction of up to 4 No. seams and opencast backfill is expected to extend to depths of up to circa 40m within

	that area. At this stage, it is considered that the presence of such made ground could result in significant amounts of subsidence as a consequence of a number of settlement mechanisms. At this stage, it is not possible to give accurate estimates of the rate or magnitude of settlement, although values are likely to be substantial. In addition, a mineshaft is recorded in the east of the site. Whilst the CA suggests that this shaft may have been 'partially or totally removed', this does not appear to accord with data available for the opencast working, nor the concrete plinth observed at approximately the recorded location of that shaft. At this stage, it must be assumed that the shaft still remains, with no record of any formal backfilling or capping. Whilst shallow coal seams appear to have been removed from the central area of the site via opencast working, there remains the potential for shallow seams around the perimeter of the opencast area, to have been worked historically, particularly given the presence of the former shaft on site. Any such working could have an influence on surface stability. In addition, the possibility of unrecorded mineworkings at shallow depth below the base of the opencast resulting in instability of bedrock at the base of the opencast workings cannot be fully discounted.
Landfill	Other than the opencast mentioned above, none recorded within 250m of the site. However, it is identified that the site and adjacent surrounding land have been subject to extensive opencast activity. Additional areas of infilling may also be present within the site, associated with the former reservoir/ pond in the east of the site.
Gas Risk	The current perceived risk from hazardous ground gas is considered to be **moderate to high**. This risk pertains to the potential for generation of hazardous gases in underground mineworkings and subject to the nature of placed material also potentially in opencast backfill, within and adjacent to the site. Such gases have the potential to migrate through faults and fissures in bedrock, through granular opencast backfill and via the on site shaft (if still present to surface). Allowance should be made at this stage for measures commensurate with a CS3 across at least 50% of the site, with measures commensurate with CS2 conditions across the remainder of the site. No protective measures are required for radon.

4. PRELIMINARY CONCEPTUAL SITE MODEL

Based on the desk study information and the results of previous intrusive investigations undertaken at the site, a combined preliminary conceptual site model and conceptual exposure model (CSM) has been developed for the proposed future land use (residential with gardens). This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors to assess potential contaminant linkages.

A qualitative risk assessment has also been made of each contaminant linkage operating following the methodology described in Appendix B.

The preliminary CSM is presented in schematic form in Drawing No. C7728/02 in Appendix A.

In summary, the following potential contaminant linkages have been assessed as posing a potentially unacceptable level of risk (defined as being greater than “low” risk) in the proposed end-use:

- Direct and indirect ingestion, inhalation and dermal contact with heavy metals, organic and inorganic contaminants including asbestos in topsoil and made ground associated with the backfilled opencast across the site, presenting a potential moderate risk to site end users and construction/ maintenance workers.

- Direct and indirect ingestion, inhalation and dermal contact with heavy metals, organic and inorganic contaminants including asbestos in topsoil and made ground associated with the former structures and former pond on site presenting a potential low to moderate risk to site end users and construction/ maintenance workers.

- Generation of asphyxiant and/ or explosive ground gases within disused coal mine workings beneath the site. These gases have the potential to migrate vertically upward through superficial deposits and potential fractured bedrock, through the mineshaft within the east of the site or through the backfilled opencast within the site and then laterally through superficial deposits into confined spaces within the development, and could present a moderate to high risk to construction workers, end users and the built environment.

- Generation of hazardous gases from deep made ground within the backfilled opencast within the site. These gases have the potential to migrate into confined spaces within the development, and could present a moderate to high risk to construction workers, end users and the built environment.

- Potential combustibility/ smouldering of pockets of soils with high calorific value within the backfilled opencast, presenting a potential low-moderate risk to construction workers, the built environment and end users.

5. FIELDWORK

5.1. Scope of Investigation

The information contained in this report is limited to areas of land accessible during the investigation within the site boundary, as indicated on the site plan presented in Appendix A as Drawing No. C7728/03.

The investigation, which was supervised by a Sirius Geoenvironmental Engineer, took place from 1st to 5th October 2018 and comprised:

- Excavation of 10 No. machine-excavated trial pits (TP01-TP10) to a maximum depth of 3.5m below ground level (bgl);
- Excavation of 7 No. machine-excavated trial trenches (TT01-TT07) to a maximum depth of 2.7m below ground level (bgl);
- Drilling of 3 No. cable percussive boreholes (CP01-CP03) to a maximum depth of 16.55m bgl;
- Drilling of 6 No. rotary openhole boreholes (RO1-RO5 and CPR02) to a maximum depth of 51m bgl. One rotary borehole (CPR02) was drilled as follow on from cable percussive borehole CP02.

Permanent monitoring installations for combined groundwater and ground gas monitoring were installed in cable percussion and selected rotary boreholes.

5.2. Exploratory Hole Locations

The exploratory hole locations were selected using the findings of the preliminary conceptual site model in order to achieve general site coverage, target specific areas of interest and resolve key uncertainties, as detailed in Table 5.1. The principles given in BS 10175:2011+A1:2013 and BS EN 1997:2007 were followed when determining exploratory hole locations.

Table 5.1 Exploratory Hole Rationale

Exploratory Hole	Rationale
TP01 - TP10	General site coverage.
TT01 - TT07	To investigate the opencast highwall.
CP01-CP03	To investigate the depth and nature of the backfill within the opencast.
CPR02	To investigate the depth of the opencast and confirm the presence/absence of coal seams and potential workings beneath the opencast.
R01-R06	To confirm the presence or absence of workings within coal seams outwith the opencast.

Exploratory hole locations are shown on Drawing No. C7728/03 in Appendix A of this report.

5.3. Strata Description

Strata descriptions were logged in accordance with Eurocode 7. Detailed descriptions of strata and groundwater observations made during investigation works, together with samples recovered and the results of all *in situ* field testing, are presented on the Engineer's records in Appendix C. The depths of strata on the record sheets are recorded from current ground levels at each location, unless indicated otherwise.

5.4. Geotechnical Testing

Geotechnical laboratory testing on selected samples was carried out under subcontract by Professional Soils Laboratory (PSL), a UKAS-accredited laboratory.

Geotechnical and geochemical test results are included within Appendix D of this report.

5.5. Chemical Testing

Selected samples of the made ground and natural soils were tested for a range of potential contaminants under subcontract with Concept Life Sciences (CLS), a UKAS and MCERTS-accredited laboratory.

The potential contaminants of concern identified by the preliminary conceptual site model were selected as the analytes for the samples recovered from the site. The results of soil and waste acceptance criteria analysis, as received from the laboratory, are presented in Appendix D of this report.

6. GROUND CONDITIONS AND MATERIAL PROPERTIES

6.1. Strata Profile

A summary of the strata profile encountered is provided in Table 6.1. Descriptions and intermediate depths of superficial deposits, including made ground, are derived from cable percussion boreholes and trial pits, as the method of drilling of rotary openhole boreholes does not permit accurate recording of superficial strata.

Table 6.1 Strata Profile

Strata	Depth Range (Thickness Range)	Description and Comments
Topsoil/Made Ground Topsoil	Ground Level (0.3 – 0.5m)	Encountered across the site and comprised a brown sandy gravelly clay.
Made Ground (Opencast Backfill)	Ground Level (0.6 – 21.7m*)	Encountered across the majority of the central site area. Generally comprised a firm and stiff brown sandy gravelly clay to depths between 0.9 and 2.4m; overlying grey clayey sandy gravel and cobbles of sandstone and mudstone with occasional boulders. Cable percussion drilling was unable to prove total thickness of made ground due to the very coarse nature of the material below approximately 15m.
Cohesive Superficial Strata	0.3 – 0.9m (0.2 – 1.8m)	Encountered outwith the opencast, i.e. within the south, east and westernmost site areas and generally comprised a firm to stiff medium to high strength orange brown mottled grey sandy gravelly clay.
Weathered Bedrock	0.5 – 2.0m (0.8 – 1.4m)	A destructured sandstone or mudstone was encountered within a number of exploratory boreholes outwith the opencast, comprising a silty gravelly sand or a sandy gravelly clay.
Bedrock	1.9 – 22m* (NP)	Bedrock comprised mudstone and siltstone with intact coal seams.

NP - not proven * Maximum depth within deeper area of opencast not proven

6.2. Coal Seams and Mine Workings

A number of coal seams are anticipated beneath the site outwith the area of the former opencast, named as Unnamed 'E', Brassy, Unnamed 'C', Unnamed 'G' and Black Metal based on information shown on the completion plan (CP 2073) for the former opencast. The opencast is recorded to have worked Unnamed 'G', Unnamed 'E', Brassy, and Unnamed 'C', with the Black Metal seam anticipated to be present beneath the base of the opencast. The typical section shown on the opencast completion plan indicates the Unnamed 'G', Brassy and Black Metal seams are split into multiple seams. The unnamed 'G' seam is indicated to have previously subcropped beneath the central area of the site prior to opencast operations and is therefore not anticipated to be present within the east of the site.

The Phase 1 report undertaken by Geo Environmental Engineering and the Coal Mining Risk Assessment Report, undertaken by Elliott Environmental Surveyors, report that Unnamed 'E' seam is c.0.2m thick and the Brassy seam is c.0.85m thick.

No broken ground or evidence of workings was recorded within the rotary boreholes across the site.

A summary of the pertinent findings of the rotary boreholes is given in Table 7.2 below.

Table 6.2 Summary of Coal Seams Encountered

Exploratory Hole	Depth to rockhead (m bgl)	Depth to workings (m bgl) (thickness m)	Depth to intact coal (m bgl) (thickness m)	Description
RO1	2.0	NA	3 – 3.3 (0.3)	Intact coal
		NA	6.2 – 6.6 (0.4)	Intact coal
		NA	8.3 – 8.6 (0.3)	Intact coal
		NA	27.3 – 27.6 (0.3)	Intact coal
		NA	46.6 – 47.4 (0.8)	Intact coal
RO2	2.2	NA	22.6 – 23.4 (0.8)	Intact coal
RO3	3.0	NA	6.7 – 7.0 (0.3)	Intact coal
		NA	9.4 – 9.7 (0.2)	Intact coal
		NA	16.8 – 17.1 (0.3)	Intact coal
		NA	28.1 – 28.9 (0.8)	Intact coal
		NA	48 – 48.9 (0.9)	Intact coal
RO4	2.0	NA	5.5 – 5.9 (0.4)	Intact coal
		NA	13.2 – 13.9 (0.7)	Intact coal
		NA	29.5 – 29.8 (0.3)	Intact coal
		NA	34.8 – 35.9 (1.1)	Intact coal
		NA	40.1 – 40.4 (0.3)	Intact coal
RO5	3.1	NA	13.6 – 14.3 (0.7)	Intact coal
		NA	17.0 – 17.5 (0.5)	Intact coal
		NA	19.1 – 19.5 (0.4)	Intact coal
CPR02	22.0	NA	NA	No coal encountered

NA = Not Applicable – no workings present.

6.3. Opencast Workings

An area of opencast coal extraction is recorded across the majority of the central area of the site on completion plans formerly obtained for the site and within the Coal Authority report for the site.

Trial trenches were excavated around the perimeter of the recorded extent of extraction, and cable percussive and one follow on rotary borehole have been drilled within the recorded area of extraction. Records of the findings of the exploratory holes are included within Appendix C.

The completion plans for the opencast indicate the opencast to extend to a depth of c. 21.3m bgl in the east to a depth of 40.7m bgl in the west.

Cable percussive boreholes CP01 and CP03 terminated within the opencast backfill on obstructions which are considered likely to be boulders.

CPR02 in the northeast of the opencast encountered rockhead at 22m bgl, which is commensurate with the depth of the opencast recorded on the completion plan.

Trial trenching undertaken around the perimeter of the opencast identified a steeply dipping/sub-vertical highwall along the western and southern extents, generally concordant with its known position. It was not possible to investigate the eastern boundary of the opencast due to the presence of a large diameter water main running parallel to the eastern boundary of the site. However, trial pits excavated to the west and east of the pipeline suggest that the extent of the opencast is likely to be in the position recorded on completion plans. TT02, undertaken within the north of the site, encountered opencast backfill and confirmed that the opencast extended northwards beyond the site boundary.

The batter plane recorded within trial trenches TT01 and TT05 in the west and southwest generally followed the angle of the highwall. The batter plane of made ground within TT07 was found to extend c. 6m further south than the opencast highwall.

The conjectured extent of the batter plan is indicated on Drawing No. C7728/05 within Appendix A.

6.4. Material Properties

Topsoil/ Made Ground Topsoil

Water soluble sulphate (SO_4^{2-}) analyses performed on eight samples of topsoil/made ground topsoil recorded concentrations of <50mg/l, together with recorded pH ranging from 5.4 to 7.9. These results indicate a design sulphate class of DS-1 and an ACEC class of AC-3z, in accordance with BRE

Special Digest 1 (2005) for the design of buried concrete, based on brownfield site designation and mobile groundwater conditions.

Made Ground

Water soluble sulphate (SO_4^{2-}) analyses performed on up to five samples of made ground recorded concentrations of between <50mg/l and 60mg/l, together with recorded pH ranging from 4.9 to 7.9. These results indicate a design sulphate class of DS-1 and an ACEC class of AC-3z, in accordance with BRE Special Digest 1 (2005) for the design of buried concrete, based on brownfield site designation and mobile groundwater conditions.

The results of 4 No. in situ Standard Penetration Tests (SPTs) carried out in cohesive made ground soils at a depth of 1m to 2m bgl ranged from N=12 to N=51, with a mean=23 and median of N=15. Thirty-six SPTs were undertaken within granular made ground (gravel and cobbles) with highly variable SPT N values, which ranged from N=6 to over 50. SPT results in excess of 50, recorded at depths between 12m and 16.55m bgl, are considered likely to be due to the presence of boulders within the made ground. Excluding these results, the SPT N values ranged from N=6 to over 44 (Mean N=23 and Median N=22) generally indicative of medium dense strata, with one result indicative of loose granular strata. Seven results were indicative of dense strata, generally recorded below 12m bgl, with two results indicative of dense strata recorded at 7.5m bgl.

Drift Deposits

Water soluble sulphate (SO_4^{2-}) analyses performed on one sample of natural superficial deposits recorded a concentration of <50mg/l, together with a recorded pH of 4.7. These results indicate a design sulphate class of DS-1 and an ACEC class of AC-3z, in accordance with BRE Special Digest 1 (2005) for the design of buried concrete, based on brownfield site designation and mobile groundwater conditions.

Hand shear vane results undertaken in cohesive superficial strata at depths of between 0.6m and 1m bgl ranged between 73kPa and 83kPa, indicative of medium to high strength soils.

Atterberg Limit determination undertaken on four samples of superficial strata indicate the material to be clay of intermediate plasticity, with liquid limits ranging between 41% and 47%, plastic limits ranging between 21% and 23%, and plasticity indices of between 20% and 25%.

Calculation of the modified Plasticity Index, in accordance with NHBC standards, indicates these soils to have a low and medium volume change potential. The Consistency Index (I_c) values for the samples tested ranged from 0.79 to 0.95 indicating the material to be of stiff consistency.

Weathered Bedrock

One hand shear vane result undertaken in weathered bedrock (destructured mudstone) at a depth of 1.8m bgl gave a result of 85kPa, indicative of high strength soils.

Atterberg Limit determination undertaken on three samples of weathered bedrock indicate the material to be clay of low and intermediate plasticity, with liquid limits ranging between 33% and 41%, plastic limits ranging between 18% and 22%, and plasticity indices of between 15% and 21%.Calculation of the modified Plasticity Index, in accordance with NHBC standards, indicates these soils to have a low and medium volume change potential. The Consistency Index (I_c) values for the samples tested ranged from 0.90 to 1.53 indicating the material to be of stiff and very stiff consistency.

6.5. Obstructions

Cobbles and boulders were frequently encountered within the opencast backfill. The cable percussive boreholes undertaken within the opencast terminated on obstructions, presumed to be boulders, at depths of between 14.4m and 16.55m bgl.

6.6. Ground Stability

Trial pits and boreholes were recorded to be stable during excavation/drilling.

6.7. Groundwater

Groundwater strikes recorded during the Sirius ground investigation are summarised in Table 6.3.

Table 6.3 Summary of Groundwater Encountered

Exploratory Hole	Depth Encountered (m bgl)	Description	Stratum
TP04	1.9	Seepage	Boundary between weathered bedrock and bedrock.
TT04	1.4	Standing water	Made ground.

6.8. Visual / Olfactory Evidence of Contamination

During our works, there was no olfactory or visual evidence of hydrocarbon or similar contamination.

6.9. Ground Gas

Ground gas monitoring has been carried out on four occasions to date, and the results are summarised in Table 6.4. Full details of ground gas monitoring results are included in Appendix E.

Table 6.4 Summary of Gas Monitoring (4 visits only)

Well	Methane (peak range) %v/v	Carbon Dioxide (steady state range) %v/v	Oxygen (range) %v/v	Peak Flow (range) litres/hr	Steady State Flow (range) litres/hr
CP01	ND	17.4 – 49.4	0.4 – 2.4	ND	ND
CPR02	ND	0.7 – 26.2	0.4 – 20.4	-40.8 – 0.1	ND
CP03	ND	ND – 29.5	0.7 – 20.4	ND - 25.2	ND – 11.5
R05	ND	2.4 – 15.5	0.1 – 7.2	-9.3 – 1.7	ND – 1.6
R03	ND	0.4 – 12.9	3.4 – 18.9	-2.9 – 6.6	ND
R02	5.2 - 25.9	11.9 – 17.4	0.8 – 2.1	ND – 0.1	ND

ND - Not Detected

The monitoring programme comprises 6 visits over a 3 month period. On completion of this monitoring, a full set of results will be issued in an addendum letter.

7. RESULTS OF CHEMICAL TESTING

The results of chemical analysis are provided in full within Appendix D.

7.1. Assessment Methodology

Soil Data

The laboratory test data for the relevant soil strata were reviewed for completeness and consistency. Those determinands that represent potential contaminants of concern were subject to further evaluation.

For each potential contaminant of concern, analytical data for soil samples were evaluated against the relevant Generic Assessment Criterion (GAC), taking account of the Soil Organic Matter (SOM) content. For this site, measured values were compared to GACs derived for a residential with gardens end use. Source data for all GACs are provided in Appendix F.

If any samples recorded contaminant concentrations that exceeded that GAC, then consideration was given to the applicability of statistical data evaluation in line with the methods described for the Planning Scenario in CL:AIRE & CIEH “Guidance on Comparing Soil Contamination Data with a Critical Concentration”, May 2008.

Waste Acceptance Criteria testing was carried out on selected samples and the results are included within Appendix D.

7.2. Soil Analysis

Topsoil/Made Ground Topsoil

Table 7.1 presents a summary of the analytical results obtained and their evaluation against the applicable GACs.

Table 7.1 Summary of Total Soil Concentrations – Topsoil/Made Ground Topsoil

Determinand	No. of Samples Tested	Range of Results (mg/kg unless specified)	US95	GAC (5% SOM)	No. of Samples >GAC	Exceedances
Metals						
Inorganic Arsenic	8	11 - 24		37	0	
Cadmium	8	<1.0		11	0	
Chromium (III)	8	17 - 20		910	0	
Lead	8	35 - 55		200	0	
Inorganic Mercury	8	<1.0		40	0	
Selenium	8	<3.0		250	0	
Copper	8	19 - 31		200	0	
Nickel	8	14 - 23		130	0	
Zinc	8	38 - 65		450	0	
Inorganics						
pH	8	5 – 7.9		<5 or >9	0	
Water Sol. Sulphate	8	<0.05		0.5 g/l	0	
Speciated PAH						
Acenaphthene	8	<0.1		920	0	
Anthracene	8	<0.1 – 0.2		9400	0	
Acenaphthylene	8	<0.1		760	0	
Benzo(a)anthracene	8	<0.1 - 1.1		B(a)P**	**	
Benzo(b)fluoranthene	8	<0.1 – 0.8		B(a)P**	**	
Benzo(k)fluoranthene	8	< 0.1 – 0.9		B(a)P**	**	
Benzo(g,h,i)perylene	8	<0.1 – 0.4		B(a)P**	**	
Benzo(a)pyrene	8	<0.1 – 0.8		2.2	0	
Chrysene	8	<0.1 – 1.1		B(a)P**	**	
Dibenzo(a,h)anthracene	8	<0.1 – 0.2		B(a)P**	**	
Fluoranthene	8	<0.1 – 1.7		820	0	
Fluorene	8	<0.1		730	0	
Indeno(1,2,3-cd)pyrene	8	<0.1 – 0.4		B(a)P**	**	
Naphthalene	8	<0.1		4.6	0	
Pyrene	8	<0.1 – 1.5		1900	0	
Phenanthrene	8	<0.1 - 1		380	0	
Others						

Determinand	No. of Samples Tested	Range of Results (mg/kg unless specified)	US95	GAC (5% SOM)	No. of Samples >GAC	Exceedances
Phenol	8	<0.1		330	0	
TOC	8	0.9 – 8.3		3 w/w%	7	Multiple
Asbestos	8	Asbestos not detected		Fibres present	0	

** Assessed using benzo(a)pyrene as a surrogate marker
Table based on a Residential with Gardens end use.
US95 - 95th percentile estimate of the mean value; GAC -generic assessment criterion; NA - not applicable.

Metals and Metalloids

No metals recorded concentrations above the relevant GAC.

Other Inorganic Analytes

No other inorganics recorded concentrations above the relevant GAC.

Organics

Seven samples recorded a concentration of TOC above the relevant GAC. TOC is a measure of organic carbon within the material and is not a determinand that directly poses a risk to human health. These results are used to determine the classification of material for removal from site to a licensed disposal facility. The TOC is also used to derive the relevant SOM for the soils, necessary to derive an appropriate GAC for some organic determinands. TOC is therefore not considered further in respect of human health risk assessment.

No other organics recorded concentrations above the relevant GAC.

Table 7.2 Summary of Total Soil Concentrations – Made Ground

Error! Reference source not found.2 presents a summary of the analytical results obtained and t heir evaluation against the applicable GACs.

Determinand	No. of Samples Tested	Range of Results (mg/kg unless specified)	US95	GAC (2.5% SOM)	No. of Samples >GAC	Exceedances
Metals						
Inorganic Arsenic	3	9 - 13		37	0	
Cadmium	3	<1.0		11	0	
Chromium (III)	3	18 - 23		910	0	
Lead	3	15 - 28		200	0	
Inorganic Mercury	3	<1.0		40	0	
Selenium	3	<3.0		250	0	
Copper	3	24 - 33		200	0	
Nickel	3	18 - 22		130	0	
Zinc	3	28 - 39		450	0	
Inorganics						
pH	5	4.9 – 7.9		<5 or >9	1	TP02 – 0.6m
Water Sol. Sulphate	3	<0.05 – 0.06		0.5 g/l	0	
Speciated PAH						
Acenaphthene	5	<0.1 – 0.1		490	0	
Anthracene	5	<0.1 – 0.5		5300	0	
Acenaphthylene	5	<0.1		400	0	
Benzo(a)anthracene	5	<0.1 – 1.2		B(a)P**	**	
Benzo(b)fluoranthene	3	<0.1 – 0.8		B(a)P**	**	
Benzo(k)fluoranthene	3	<0.1 – 0.9		B(a)P**	**	
Benzo(g,h,i)perylene	5	<0.1 – 0.4		B(a)P**	**	
Benzo(a)pyrene	5	<0.1 – 0.8		2.1	0	
Chrysene	5	<0.1 – 1.3		B(a)P**	**	
Dibenzo(a,h)anthracene	5	<0.1 – 0.2		B(a)P**	**	
Fluoranthene	5	<0.1 – 1.9		560	0	
Fluorene	5	<0.1 – 0.2		390	0	
Indeno(1,2,3-cd)pyrene	5	<0.1 - 0.4		B(a)P**	**	
Naphthalene	5	<0.1		2.3	0	
Pyrene	5	<0.1 – 1.6		1200	0	
Phenanthrene	5	<0.1 – 1.8		220	0	
Others						
Phenol	3	<0.1		190	0	
TOC	5	1.1 – 2.1		3 w/w%	0	
Calorific Value	5	<0.1 – 0.4		2 MJ/kg	0	
Asbestos	3	Asbestos not detected		Fibres present	0	

** Assessed using benzo(a)pyrene as a surrogate marker
Table based on a Residential with Gardens end use.
US95 - 95th percentile estimate of the mean value; GAC -generic assessment criterion; NA - not applicable.

Metals and Metalloids

No metals recorded concentrations above the relevant GAC.

Other Inorganic Analytes

One sample recorded a concentration of pH below the adopted lower GAC, with a detected value of 4.9. With consideration to the range of values detected, pH is not considered likely to present a significant risk to end users.

No other inorganics recorded concentrations above the relevant GAC.

Organics

No organics recorded concentrations above the relevant GAC.

Calorific Value

No samples had a calorific value exceeding GAC. In the absence of any more applicable and recent research or guidance, this GAC has been applied based on guidance given in the Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) document 61/84 2nd Edition (July 1986). That document states that "In general, it seems likely that materials whose CVs exceed 10MJ/kg are almost certainly combustible, while those with values below 2 MJ/kg are unlikely to burn. Within this range of values, there are likely to be a large number of potentially combustible materials". Calorific value is not a determinand that directly poses a risk to human health and the soils are not considered likely to be combustible on the basis of the results obtained. Calorific value is therefore not considered further in respect of human health risk assessment.

Natural Ground

One sample of natural ground was also tested. No concentrations of determinands exceeded the relevant GAC with the exception of pH. With consideration to the range of values detected, pH is not considered likely to present a significant risk to end users.

8. REVISED CONCEPTUAL SITE MODEL

The preliminary combined conceptual site model and conceptual exposure model, developed from the desk study information and presented in Section 4, has been revised in light of the ground investigation and the chemical analysis results presented above.

The revised conceptual model has been developed for the proposed future land use (residential with gardens). This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors.

The revised conceptual model is presented in schematic form in Appendix A, Drawing No. C7728/04.

8.1. Summary of Residual Contaminant Linkages

The qualitative risk assessment of identified contaminant linkages has also been revised, following the methodology described in Appendix B. In summary, the revised CSM has identified the following residual contaminant linkages (defined as being greater than “low” risk) that could result in an unacceptable risk in the proposed end-use:

- Generation of asphyxiant and/ or explosive ground gases within disused coal mine workings beneath the site. These gases have the potential to migrate vertically upward through superficial deposits and potential fractured bedrock, through the mineshaft within the east of the site or through the backfilled opencast within the site and then laterally through superficial deposits into confined spaces within the development, and could present a moderate to high risk to construction workers, end users and the built environment.

- Generation of hazardous gases from deep made ground within the backfilled opencast within the site. These gases have the potential to migrate into confined spaces within the development, and could present a moderate to high risk to construction workers, end users and the built environment.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1. General

This geoenvironmental appraisal has been performed for Harras Moor, Whitehaven.

It has been assumed in the production of this report that the site is to be developed for a residential with gardens end use. In addition, it has been assumed that ground levels will not change significantly from those described in this report. If these are not the case, then amendments to the interpretation and conclusions in this report may be required.

9.2. Flood Risk

The Envirocheck report and Environment Agency website indicate that the site does not lie within an indicative flood plain (Zone 2 and 3) and is not recorded to be at risk of flooding from surface waters.

Notwithstanding, given the area of the site is >1 Ha, a flood risk assessment is likely to be required, and further advice sought be sought from a suitably qualified expert.

9.3. Geotechnical

Mining and Quarrying

Mine Entries

One mine entry is recorded within the east of the site which appears to be marked by a concrete plinth. No details are known about any potential treatment or capping of the shaft. The Coal Authority report notes that the shaft may have been partially or totally removed as it is located in an area worked by opencast mining. However, this does not appear to accord with data available for the opencast working, nor the actual location of the concrete plinth observed at approximately the recorded location of that shaft. At this stage, it must be assumed that the shaft still remains, with no record of any formal backfilling or capping.

Based on available information, it is recommended the mineshaft is investigated and in turn treated if required, including provision of an engineered capping solution in addition to a development standoff from the mineshaft. Based on the depth to rockhead in this area of the site and an assumed shaft diameter of 2-3m the development standoff zone is, at this stage, anticipated to be c.10m diameter.

The proposed treatment of the mineshaft will require further discussion with and approval from the Coal Authority and other regulatory authorities/ interested parties including the NHBC.

Given the underlying geology and mining history of the site, the possibility of encountering further unrecorded mine entries, including potential bell pitting/crop workings, should not be discounted. It is recommended that all excavations are examined for evidence of mine entries. If a mine entry is suspected, advice should be sought immediately from a suitably qualified engineer.

Coal Mining

Recorded Workings

Based on the Coal Authority report previously obtained for the site, there is considered to be a low risk of recorded coal mining beneath the site affecting the surface stability of the site.

Unrecorded Workings

Rotary hole CPR02 located within the opencast did not encounter any coal seams or clear evidence of workings within bedrock beneath the opencast. Notwithstanding, there is considered to be a moderate risk of unrecorded workings within the shallowest seam beneath the opencast (the Black Metal) which could affect surface stability of the site within the area of the former opencast.

A number of thin coal seams have been identified during rotary drilling of the site within boreholes located outwith the opencast. Additionally, workings on the eastern edge of the Unnamed G seam have been recorded on the completion plan for the opencast, confirming the presence of unrecorded workings on the site. It is therefore considered that there is a moderate risk of unrecorded workings beneath the site which could affect surface stability of the site outwith the area of the former opencast.

It would therefore be prudent to undertake further rotary boreholes to establish the possibility or absence of shallow abandoned underground coal workings with a greater degree of confidence within the area of the former opencast, extending to sufficient depth beneath the opencast to confirm the depth, thickness and presence or absence of workings within the Black Metal beneath the opencast. It would also be prudent to undertake further rotary boreholes in the west and south of the site, outwith the area of the opencast to confirm the presence or absence of workings within the shallow seams beneath the site.

CIRIA Special Publication 32, Construction Over Abandoned Mine Workings (2002) states that the maximum height of collapse of shallow abandoned mine workings, is often taken as five to ten times

the seam thickness. This is further reiterated in the Garrard and Taylor paper 'Collapse mechanisms of shallow coal-mine workings from field measurement', 1988. It is normal engineering practise to assume that there is a risk of surface instability, if there is less than ten times seam thickness in competent cover above any worked coal seam. Pending approval of CIRIA C758 "Abandoned mine workings", it should be noted that competent cover does not normally include superficial deposits such as glacial till and residual soil. Table 9.1 below summarised the coal seams encountered and thickness of competent cover above each seam.

Table 9.1 Summary of Coal Seams Encountered and Cover Thickness

Exploratory Hole	Depth to rockhead (m bgl)	Depth to workings (m bgl) (thickness m)	Depth to intact coal (m bgl) (thickness m)	Description	Cover Thickness (m)	Sufficient Competent Cover?
RO1	2.0	NA	3 – 3.3 (0.3)	Intact coal	1.0	No
		NA	6.2 – 6.6 (0.4)	Intact coal	4.2	Yes
		NA	8.3 – 8.6 (0.3)	Intact coal	6.3	Yes
		NA	27.3 – 27.6 (0.3)	Intact coal	25.3	Yes
		NA	46.6 – 47.4 (0.8)	Intact coal	44.6	Yes
RO2	2.2	NA	22.6 – 23.4 (0.8)	Intact coal	20.4	Yes
RO3	3.0	NA	6.7 – 7.0 (0.3)	Intact coal	3.7	Yes
		NA	9.4 – 9.7 (0.2)	Intact coal	6.4	Yes
		NA	16.8 – 17.1 (0.3)	Intact coal	13.8	Yes
		NA	28.1 – 28.9 (0.8)	Intact coal	25.1	Yes
		NA	48 – 48.9 (0.9)	Intact coal	45	Yes
RO4	2.0	NA	5.5 – 5.9 (0.4)	Intact coal	3.5	No
		NA	13.2 – 13.9 (0.7)	Intact coal	11.2	Yes
		NA	29.5 – 29.8 (0.3)	Intact coal	27.5	Yes
		NA	34.8 – 35.9 (1.1)	Intact coal	32.8	Yes
		NA	40.1 – 40.4 (0.3)	Intact coal	38.1	Yes
RO5	3.1	NA	13.6 – 14.3 (0.7)	Intact coal	10.5	Yes
		NA	17.0 – 17.5 (0.5)	Intact coal	13.9	Yes
		NA	19.1 – 19.5 (0.4)	Intact coal	16.0	Yes
CPR02	22.0	NA	NA	No coal encountered	NA	NA

Two seams are considered to have insufficient competent cover. These seams are considered to be thin and discontinuous across the site and no evidence of workings was encountered. Notwithstanding the above, given the preliminary nature of this investigation, the scope of rotary drilling was limited and therefore the absence of workings within these seams across the site, outwith the opencast, cannot be confirmed. Therefore it is considered that there is a low to moderate risk that these seams have been worked by underground methods beneath the site.

The workings recorded on the completion plan on the eastern edge of the Unnamed G seam may have potentially been worked from surface, if not worked via underground methods, via bell pitting/ crop working methods as the workings are recorded close (c.2-3m bgl) to ground level and are not

extensive, indicating the coal was only mined close to crop which is typical of bell pitting/crop workings. With cognisance to the depth to rockhead beneath the site, and the presence of the coal seams at shallow depth below rockhead, it is considered likely that the shallow seams in the east of the site may have also been worked by bell pitting/ crop working. It is recommended that further rotary drilling and/or a soil strip is undertaken in advance of development to investigate the potential presence of bell pitting/ crop workings.

Foundations

The investigation has identified topsoil/made ground topsoil overlying superficial deposits of firm to stiff medium to high strength sandy gravelly clay within the south east and westernmost areas of the site.

Made ground was encountered beneath topsoil/made ground topsoil across the majority of the central area of the site, generally comprising a sandy gravelly clay to depths of between 0.9m and 2.4m overlying clayey sandy gravel and cobbles with occasional boulders. Bedrock within the opencast was proven at one location at a depth of 22m bgl. However opencast abandonment plans indicate the opencast could be as deep as c. 41m at its western extents.

Outwith the opencast, weathered bedrock was encountered at depths from 0.5m to 2m bgl and bedrock was encountered from depths of 1.5m to 3.1m bgl.

Shallow Foundations (outwith the former opencast)

Although no made ground was noted to the west and south and relatively thin made ground observed east of the opencast, it is considered that the topsoil and made ground soils are unsuitable as bearing strata for structural loads owing to the potential for excessive total and differential settlements. On the assumption these parts of the site are not underlain by shallow abandoned mineworkings (in particular within the Unnamed ‘G’ and ‘E’ seams) structural loads associated with the proposed development could be supported on conventional spread foundations (such as strip/trench fill) taken down through any made ground into the underlying natural ground of adequate bearing resistance.

The underlying superficial soils are considered to have a characteristic undrained shear strength (C_u) of 70kPa at a founding depth of 0.9m bgl. At this stage, there is no detailed foundation design for the site. However, by way of example, indicative calculations indicate that a 0.6m wide strip bearing on the superficial soils at a depth of 0.9m bgl, can impose a maximum line load of 100kN/m run. In light of the overconsolidated nature of the superficial deposits underlain by materials

comprising residual soils, the application of such a pressure is expected to limit settlements to 25mm or less.

For reasons of design and construction simplicity, this value may also be applied to the underlying weathered bedrock should this be encountered at normal foundation depths. If foundation excavations encounter weathered bedrock, then it is recommended that all of the foundation for an individual plot be deepened in order to bear upon a consistent stratum and thus limit the potential for unacceptable differential settlements.

Foundations should not be founded in coal, should coal be encountered in any foundation excavation, the foundation should be taken through the coal seam (subject to regulatory approval). It would be good practice to remove any coal exposed within a foundation trench by around 1m from the trench face. This approach should also be discussed with the Coal Authority. Similar action should be undertaken around all heat sources, such as electric cables, where coal is encountered.

The cohesive soils on this site have been found to be of low and medium volume change potential as defined in NHBC Standards, Chapter 4.2. Foundations placed into cohesive soils should be a minimum of 900mm deep (below finished or original ground levels, whichever is the lower), locally deepened within the zone of influence of existing or proposed trees.

A tree survey was beyond the scope of this investigation but should be undertaken to enable production of a detailed foundation schedule. The removal of trees during development of the site may cause heave of cohesive soils and heave protection measures should be adopted in foundation design where appropriate.

The above calculations are based on theoretical foundations. Settlements of foundations upon granular and cohesive materials are dependent on foundation loading and dimensions. It is therefore recommended that foundation settlements are reviewed once final loading arrangements and foundation sizes are known.

Alternative Foundations (within the former opencast)

The made ground within the area of the former opencast is anticipated to extend to depths of c.20m to c.41m. Conventional spread foundations (i.e. strips, pads and trench fill type solutions) are therefore not considered feasible due to the excessive depth of excavation required to reach competent predictable natural strata. For structures to be built within the area of former opencast workings, an alternative foundation solution will be required comprising either raft or if economically

and technically feasible, piled foundations. A value engineering exercise should be undertaken to determine the most cost effective solution for the site.

Piled foundations could be considered within the area of former opencast workings and associated highwalls, advanced to bear onto underlying competent bedrock. A specialist piling contractor should be consulted regarding appropriate pile design, who should take account of the potential for settlement of the backfill material and as such make adequate allowance for negative skin friction. Notwithstanding the above, use of piles maybe precluded owing to the depth to bedrock in addition to the presence of cobbles and boulders within the backfill which may necessitate pre-drilling to enable pile installation. In addition, consideration of possible workings within the Black Metal coal seam beneath the site needs to be made. Piles are particularly sensitive to subsidence associated with collapsing underground abandoned mine workings. As discussed earlier, particularly if piling is the preferred foundation solution, it is recommended supplementary rotary drilling is undertaken to investigate the Black Metal seam, to give confidence the seam is either worked, or not. An adequate cover of competent rock cover will be required from base of the rock socket to the seam/ workings.

Raft foundations may be a viable option for construction of residential properties within the opencast area. However, this solution would be subject to detailed consideration of potential total and differential settlement of the opencast backfill. Standoff zones for construction of raft foundations maybe required in the vicinity of buried high walls, in order to avoid excessive rotational movements as a result of differential settlements either side of the highwall.

It is generally recommended that plots supported upon rafts are not constructed in locations which straddle the opencast high wall owing to the high potential for differential settlements. A suitable easement from the opencast high wall should be applied between structures adjacent to, but outwith, the opencast area. As this stage, this could typically comprise a line drawn up at 45° from the top of the high wall, at rockhead level, to the base of any proposed services or foundations.

If this cannot be accommodated in the layout design, then foundations to structures which span the highwall should be fully piled and socketed into competent rockhead to limit the potential for settlement, should a piling foundation solution be adopted.

In addition, it is currently understood that NHBC do not recommend use of hybrid foundation solutions (i.e. part use of strips outwith the opencast, combined with use of piles within for an individual plot) for dwellings spanning quarry/ opencast highwalls. If a hybrid foundation solution is to be proposed and/or if the plots are proposed to straddle the highwall, discussion will be required with the NHBC to gain their approval in advance of development works.

Further consideration should also be given to the propensity for differential settlement of the surface around such plots and which could affect finished ground levels, roads, drives, service connections etc. To mitigate the risk of excessive settlement of external areas in the opencast area, measures such as flexible service connections and reinforcement of external pavements and roads are recommended. Such actions are, however, unlikely to fully preclude settlement of the surface across the site.

On the basis that the opencast operations were completed in the late 1980s as suggested by the Durham Mining Museum, the opencast backfill material may be considered to have been placed for a maximum of 30 years. BRE document 427 (Part 1), provides indicative parameters for the likely amount of creep settlement of materials such as opencast backfill. In accordance with guidance given within that document, the likely amount of creep settlement taking place over an assumed design lifetime of the development of 50 years from 2018, could be up to c.100mm where backfill is thickest i.e. in the west of the opencast, gradually decreasing to around half this amount with reduced thickness of backfill toward the east.

Notwithstanding the above, other mechanisms such as inundation settlement, which can be the most damaging settlement mechanism, could also act on the material at some time in the future if, for example, groundwater levels rise above the current equilibrated levels. In light of the fact the backfill has been in place for around 30 years, groundwater is expected to have reached equilibrium levels, the site has been exposed to precipitation during this time, backfilling took place relatively recently and it is expected to has been compacted in a controlled manner (though this is not proven), at the time of writing collapse compression mechanism is not expected to pose a highly significant risk to this development. However, based on Sirius's experience of working on numerous backfilled opencast sites, it would be prudent to quantitatively prove this assumption to be the case. This could be confirmed by an investigation to assess the potential for, and likely magnitude of settlement of raft foundations to inundation by in situ testing.

Consolidation settlement within the cohesive made ground present within the area of the opencast to a maximum depth of 1.4m bgl is anticipated to be in the order of 15mm, assuming a load of 50kN/m^2, raft dimensions of 10m x 10m and an m_v of 0.3 MN/m^2.

General

Foundations should be taken below a line drawn up at 45° from the base of any existing or proposed services.

The layout of foundations should consider any relict foundations, substructures or other potential obstructions on site.

If greater structural loads are anticipated alternative foundation solutions may be required.

It should be noted that any groundwater encountered may have an adverse effect on foundation construction and performance (such as softening/loosening of founding materials, instability of excavation walls, etc.), particularly in winter months. This should be considered when designing foundations.

Floors

In accordance with NHBC Standards 2008 (Chapters 4.2, 4.6 and 5.1), suspended ground floor slabs are required in the following situations:

- Made Ground greater than 600mm thick.
- Where soil swelling may occur.
- Where vibratory ground improvement has been carried out.
- Where the ground has insufficient bearing capacity.

It is likely that the majority of plots within the former opencast area will be constructed on a raft foundation with associated floor construction. Suspended floors will be required if a piled solution is adopted.

Outwith the area of the former opencast it is possible that ground bearing floor slabs could be considered.

Floor design will be subject to the requirement for ground gas protection measures as detailed below.

Sulphate Attack

Based on the samples tested, a Design Sulphate Class of DS-1 and an ACEC Class of AC-3z should be used for buried concrete structures in contact with topsoil/made ground topsoil, made ground and superficial deposits.

Groundworks, Excavation Stability and Groundwater Dewatering

Excavations into existing made ground and the underlying natural soils should be assumed to be unstable. No personnel entry into unsupported excavations shall be allowed without an appropriate risk assessment. Reference to CIRIA report 97 (1983) should be made to establish suitable means of support or battering of excavation sides.

Based on the results of this investigation, significant groundwater seepages or inflows within shallow excavations (<1.4m) are considered unlikely across the site. However, if groundwater is encountered at shallow depth then it should be possible to deal with seepages through normal site pumping practices for any shallow excavations open for short periods of time. For deeper excavations a point dewatering system may be required. Disposal/discharge of water will require appropriate treatment/consent.

It is recommended that an adequate drainage system for surface water be installed by a competent contractor in order to prevent surface water ponding or collecting both during and post construction, as this may lead to deterioration of the founding stratum.

To reduce the possibility of softening or swelling of cohesive soils at the base of foundation trenches, these should be suitably blinded with concrete.

Pavements and Highways

Based on the results of the laboratory testing undertaken on natural cohesive soils, a CBR value of 3% could be assumed for preliminary pavement design within these soils at this stage.

Untreated made ground in the former opencast area should be assumed to have a CBR value of <2.5% unless proven otherwise via in situ testing. Highways Agency document HD25 Interim Advice Note 73/06 states that where a subgrade has a CBR value lower than 2.5%, it is considered unsuitable support for a pavement foundation since it would tend to deform under construction traffic, and must be improved.

Based on Sirius's experience of working within other opencast sites, it is clear normal pavement construction would be unsuitable to withstand predicted settlements (in this instance via creep settlement) within the opencast. It is therefore recommended that the highway is improved and stiffened to resist/ mitigate differential settlements along highway alignments. It is therefore proposed that made ground to a depth of at least 1.0m below subgrade level/ 0.5m below invert level of main site drainage, whichever is the deepest, is excavated, sorted and classified in accordance with Series

600 (Earthworks) of the Highways Agency "Specification for Highways Works". Following the above, any suitable material which can be used as part of highway construction should be compacted in accordance with the aforementioned earthworks specification, incorporating a layer of reinforcement at the base of the excavation.

There is a potential for differential settlement where any proposed highways extend across the former quarry highwall. **Appropriately designed reinforcement of highways will be required if highways are proposed to cross the high wall, or are proposed within the area of the former opencast, in order to mitigate the potential for differential movements.**

It is recommended that in-situ CBR testing is carried out following completion of the enabling works, when final site levels will be known.

Notwithstanding the above, all road design should be discussed with the relevant local authority if highways are to be subject to a Section 38 agreement. The above design in relation to external areas of plots, in particular driveways, should also be discussed with the NHBC.

Soakaways

Based on the ground conditions encountered during the site investigation i.e. presence of made ground and low permeability cohesive natural soils at shallow depths across the site, soakaway drainage is considered unlikely to be viable at the site.

9.4. Asbestos-Containing Materials

ACMs were not observed within the soils encountered during this investigation.

However, the possibility of asbestos sheeting, used as shuttering, and/or fragments of asbestos-containing materials within made ground or shallow natural soils cannot be discounted. If encountered, advice should be sought from an appropriately qualified asbestos specialist and an appropriate strategy developed for the safe removal and disposal of the material.

9.5. Soil and Groundwater Contamination

Risk Evaluation for the Proposed Land Use (Residential with Gardens)

The revised CSM has not identified any potential pollutant linkages from soils which could result in an unacceptable risk to end users and construction workers, and no remedial action is deemed to be necessary for the protection of human health or environmental receptors.

Notwithstanding the above, it is possible that areas of more significant contamination, not identified to date, may be encountered on site during excavation and construction works. If any areas of noxious, odorous, brightly coloured, fibrous, liquid or other potential contamination are encountered, then further advice should be sought from a suitably qualified consultant.

Given the presence of made ground soils within the opencast backfill across the majority of the site, there is likely to be some requirement for importation of suitable subsoil/topsoil for use garden/landscaped areas.

Controlled Waters Receptors

No potential contamination linkages that could result in an unacceptable risk to controlled waters receptors has been identified on the site.

Utilities

It is recommended that the results of the chemical testing and details of the proposed remedial works are provided to the appropriate utility companies to determine the necessity for service protection.

Construction and Maintenance Workers

Contamination may pose a short-term (acute) or long-term (chronic) risk to workers during construction and maintenance. The potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation. Site practices must conform to the specific legislative requirements and follow appropriate guidance (e.g., HSE, 1991; CIRIA, 1996).

No specific potential exposure risks to construction workers from soils have been identified in the revised conceptual site model.

Notwithstanding the above, appropriate PPE and hygiene precautions and good working and soil management practices should be adopted. It is recommended that procedures outlined in the HSE document “Protection of Workers and the General Public during Remediation of Contaminated Land” be followed. There will be a requirement to comply with the COSHH (Control of Substances Hazardous to Health) Regulations and the CDM (Construction Design and Management 2007) Regulations during any works.

Given that significantly depleted concentrations of oxygen were recorded during ground gas monitoring, precautions should also be taken to protect workers entering and/or working in confined spaces.

This report should be forwarded to any organisations undertaking groundworks in order for them to assess the risk to their personnel.

9.6. Ground Gas

Summaries of the gas results to date within each area of the site are provided below. Calculated Q_{hg} (Quantity of Hazardous Gas) and Gas Screening Values (GSVs) are provisional only and may be subject to change based on future monitoring data.

The results to date have revealed maximum peak methane concentrations 25.9% v/v and maximum steady state carbon dioxide concentrations of 49.4% v/v. Maximum recorded peak and steady flow rates have been -40.8 litre/hour and 11.5 litre/hour. Based on these data, Q_{hg} values of 10.567 litres/hour for methane and 5.681 litres/hour for carbon dioxide have been calculated as a worst case. If these values are applied as provisional GSVs for the site, then the results are indicative of a worst case check of a moderate to high hazard potential, characterised as Characteristic Situation 4 (CS4), as defined in Table 2 of BS8485:2015. BS8485:2015 notes that *"residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations."* As stated in BS8485:2015, in order to reduce the hazard potential further monitoring, e.g. continuous monitoring, should be carried out in order to accurately quantify the risk. It is strongly recommended that immediate discussion with the Contaminated Land Officer and and/or NHBC takes place to obtain their opinion on development of a site which falls into this hazard potential category.

Table 4 of BS8485:2015 indicates that CS4 conditions require a minimum gas protection score of 6.5 for a residential end-use. This score cannot currently be achieved using traditional construction methods and materials and alternative protective systems, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, as discussed in BS8485:2015, will need to be considered.

The above indicative assessment must be regarded as interim. A further two ground gas monitoring visits are planned and the full results, and an interpretation of these, will be issued as an addendum letter on completion of the monitoring programme.

Radon protection measures are not required by current guidance for the proposed development on this site.

9.7. Invasive Plants

Invasive plant species were not observed on this site at the time of investigation.

It is recommended that the presence or absence of invasive plant species is confirmed by qualified consultant ecologist and their advice taken on appropriate treatment. The treatment of any invasive species should take place in advance of the proposed construction works.

9.8. Disposal of Soils

Any materials removed from site should be undertaken in accordance with current Duty of Care requirements and the Environment Agency Technical Guidance Document WM3, dated 2015. The waste may also be subject to Waste Acceptance Criteria (WAC) testing.

As part of this investigation WAC testing was undertaken on samples of cohesive made ground. In light of the regulations it is recommended that these results, in addition to the results of the other soil testing carried out, are discussed with landfill operators at an early stage.

10. REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigation. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other relevant organisations for their comment and approval prior to undertaking any works on site.

APPENDIX A

FIGURES AND DRAWINGS

NOTES

○ Site Location

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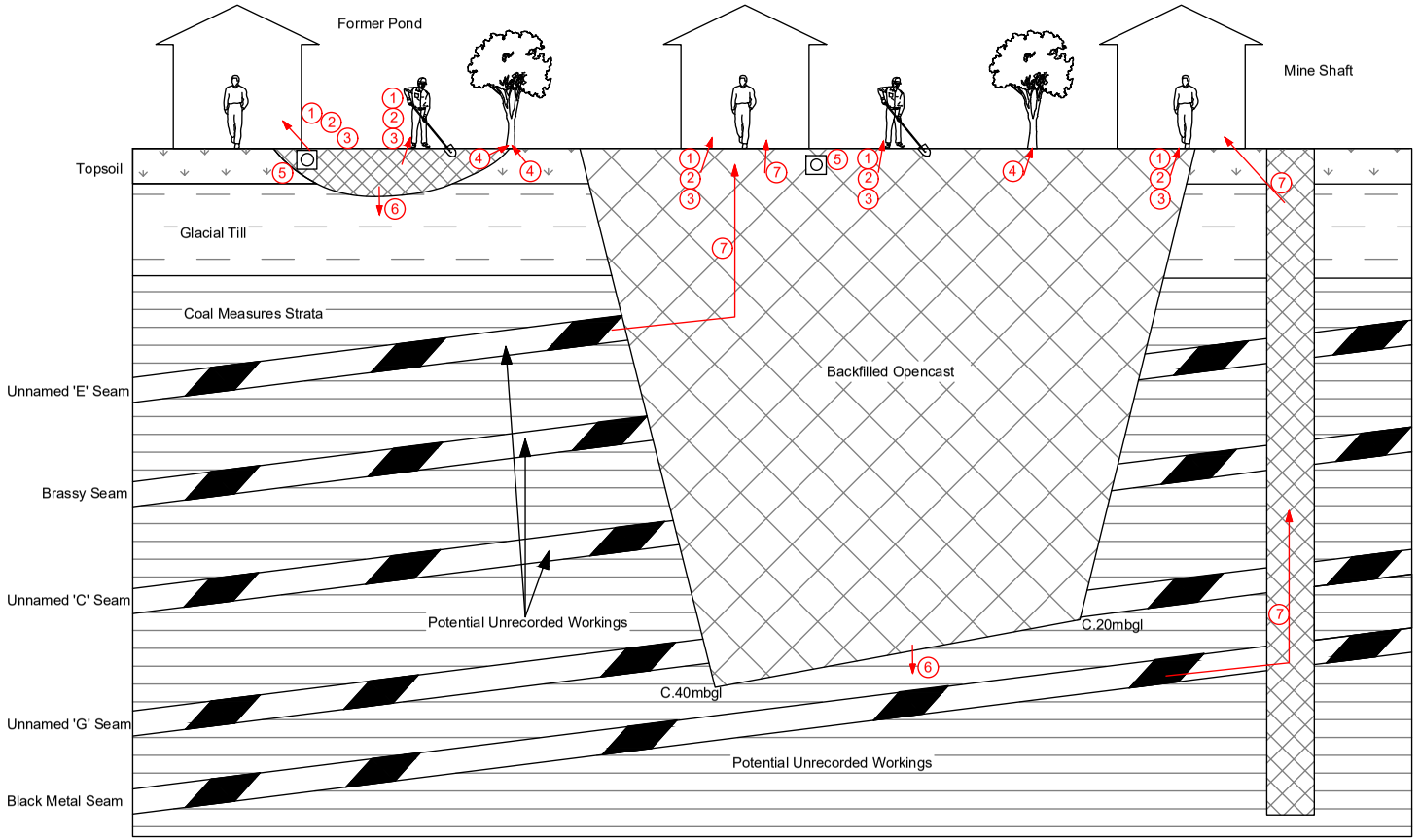
CLIENT	DRAWING NO.	REVISION NO.
Michael Little	C7728/01	0
SITE: Harras Moor	DRAWN BY: MF	APPROVED BY: GA
DRAWING TITLE: Site Location Plan	DATE: Jan 2019	SCALE: 1:25,000

A4



Contamination Source	Contamination Pathway	Potential Receptors	Potential Risk
Metal, metalloid, organic and inorganic contaminants including asbestos fibres in topsoil and made ground associated with the backfilled opencast across the site.	1. Direct/indirect ingestion	End users	Moderate
		Construction & maintenance workers	Moderate
	2. Inhalation	End users	Moderate
		Construction & maintenance workers	Moderate
	3. Dermal contact	End users	Moderate
		Construction & maintenance workers	Moderate
	4. Plant uptake	Gardens and landscaping	Low - Moderate
	5. Direct contact with construction materials	Construction products including buried concrete and plastics	Low
	6. Leaching	Controlled waters	Low
Metal, metalloid, organic and inorganic contaminants including asbestos products in topsoil and made ground associated with the former structures and former pond on site.	1. Direct/indirect ingestion	End users	Low - Moderate
		Construction & maintenance workers	Low - Moderate
	2. Inhalation	End users	Low - Moderate
		Construction & maintenance workers	Low - Moderate
	3. Dermal contact	End users	Low - Moderate
		Construction & maintenance workers	Low - Moderate
	4. Plant uptake	Gardens and landscaping	Low - Moderate
	5. Direct contact with construction materials	Construction products including buried concrete and plastics	Low
	6. Leaching	Controlled waters	Low
Generation and migration of hazardous gases within disused coal mine workings beneath the site.	7. Migration through soils, potential fractured bedrock and the mineshaft within the site, and subsequent accumulation within confined spaces in proposed structures.	End users (asphyxiation/explosion)	Moderate – High
		Construction workers (asphyxiation/explosion)	Moderate – High
		Built environment (explosion)	Moderate – High
Generation and migration of hazardous gases within deep made ground within the site.	7. Migration through soils, and subsequent accumulation within confined spaces in proposed structures.	End users (asphyxiation/explosion)	Moderate – High
		Construction workers (asphyxiation/explosion)	Moderate – High
		Built environment (explosion)	Moderate - High
Potential combustibility/ smouldering of pockets of soils with high calorific value within the backfilled quarry in the northwest corner of the site	Migration of fire/heat through soils and potential for migration of subsequent vapours through soils, and subsequent accumulation within confined spaces in proposed structures.	End users (asphyxiation/explosion)	Low - Moderate
		Construction workers (asphyxiation/explosion)	Low - Moderate
		Built environment, including services	Low - Moderate

NOTES

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CLIENT

Michael Little

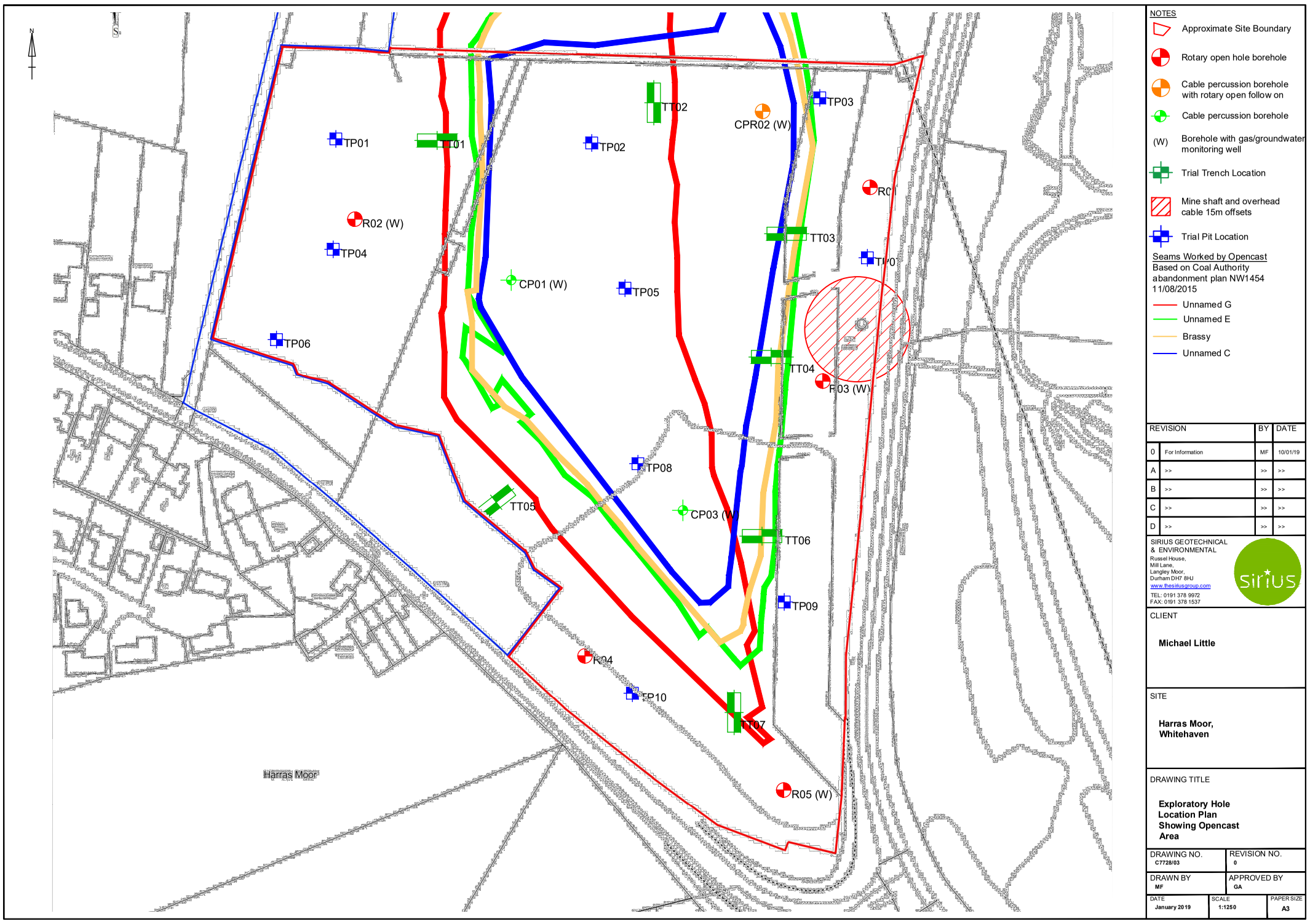
SITE

Harras Moor

DRAWING TITLE

Preliminary Conceptual Site Model

DRAWING NO.	REVISION NO.
C7728/02	0
DRAWN BY: MF	APPROVED BY: GA
DATE: January2019	SCALE: NTS
PAPER SIZE: A3	



NOTES

- Approximate Site Boundary
- Rotary open hole borehole
- Cable percussion borehole with rotary open follow on
- Cable percussion borehole
- (W) Borehole with gas/groundwater monitoring well
- Trial Trench Location
- Mine shaft and overhead cable 15m offsets
- Trial Pit Location

Seams Worked by Opencast
Based on Coal Authority abandonment plan NW1454 11/08/2015

- Unnamed G
- Unnamed E
- Brassy
- Unnamed C

REVISION		BY	DATE
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CLIENT

Michael Little

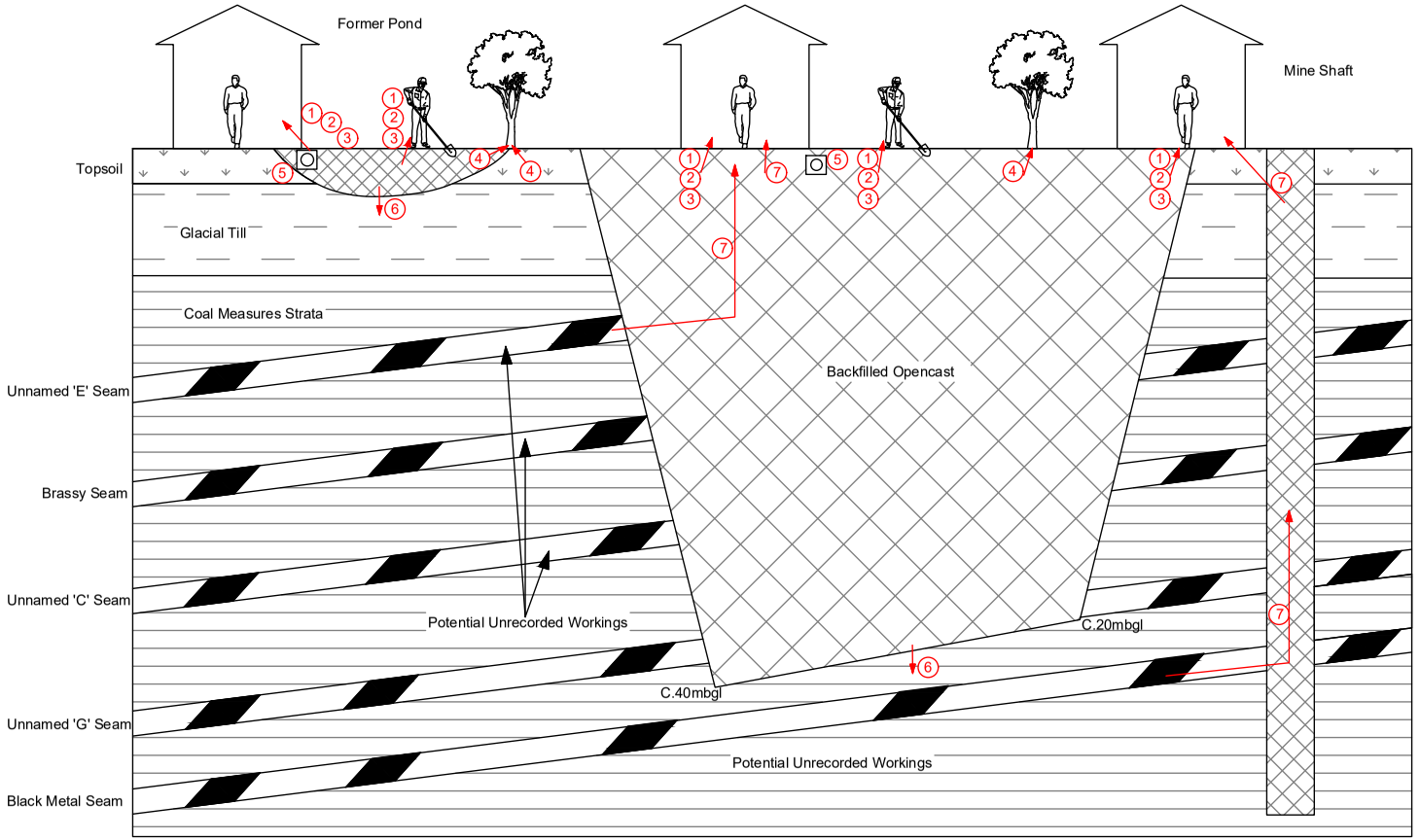
SITE

Harras Moor, Whitehaven

DRAWING TITLE

Exploratory Hole Location Plan Showing Opencast Area

DRAWING NO.	REVISION NO.
C7728/03	0
DRAWN BY: MF	APPROVED BY: GA
DATE: January 2019	SCALE: 1:1250
PAPER SIZE: A3	



Contamination Source	Contamination Pathway	Potential Receptors	Potential Risk
Metal, metalloid, organic and inorganic contaminants including asbestos fibres in topsoil and made ground associated with the backfilled opencast across the site.	1. Direct/indirect ingestion	End users	Low
		Construction & maintenance workers	Low
	2. Inhalation	End users	Low
		Construction & maintenance workers	Low
	3. Dermal contact	End users	Low
		Construction & maintenance workers	Low
	4. Plant uptake	Gardens and landscaping	Low
	5. Direct contact with construction materials	Construction products including buried concrete and plastics	Low
	6. Leaching	Controlled waters	Low
Metal, metalloid, organic and inorganic contaminants including asbestos products in topsoil and made ground associated with the former structures and former pond on site.	1. Direct/indirect ingestion	End users	Low
		Construction & maintenance workers	Low
	2. Inhalation	End users	Low
		Construction & maintenance workers	Low
	3. Dermal contact	End users	Low
		Construction & maintenance workers	Low
	4. Plant uptake	Gardens and landscaping	Low
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	6. Leaching	Controlled waters	Low
Generation and migration of hazardous gases within disused coal mine workings beneath the site.	7. Migration through soils, potential fractured bedrock and the mineshaft within the site, and subsequent accumulation within confined spaces in proposed structures.	End users (asphyxiation/explosion)	Moderate – High
		Construction workers (asphyxiation/explosion)	Moderate – High
		Built environment (explosion)	Moderate – High
Generation and migration of hazardous gases within deep made ground within the site.	7. Migration through soils, and subsequent accumulation within confined spaces in proposed structures.	End users (asphyxiation/explosion)	Moderate – High
		Construction workers (asphyxiation/explosion)	Moderate – High
		Built environment (explosion)	Moderate - High
Potential combustibility/ smouldering of pockets of soils with high calorific value within the backfilled quarry in the northwest corner of the site	Migration of fire/heat through soils and potential for migration of subsequent vapours through soils, and subsequent accumulation within confined spaces in proposed structures.	End users (asphyxiation/explosion)	Low
		Construction workers (asphyxiation/explosion)	Low
		Built environment, including services	Low

NOTES

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CLIENT

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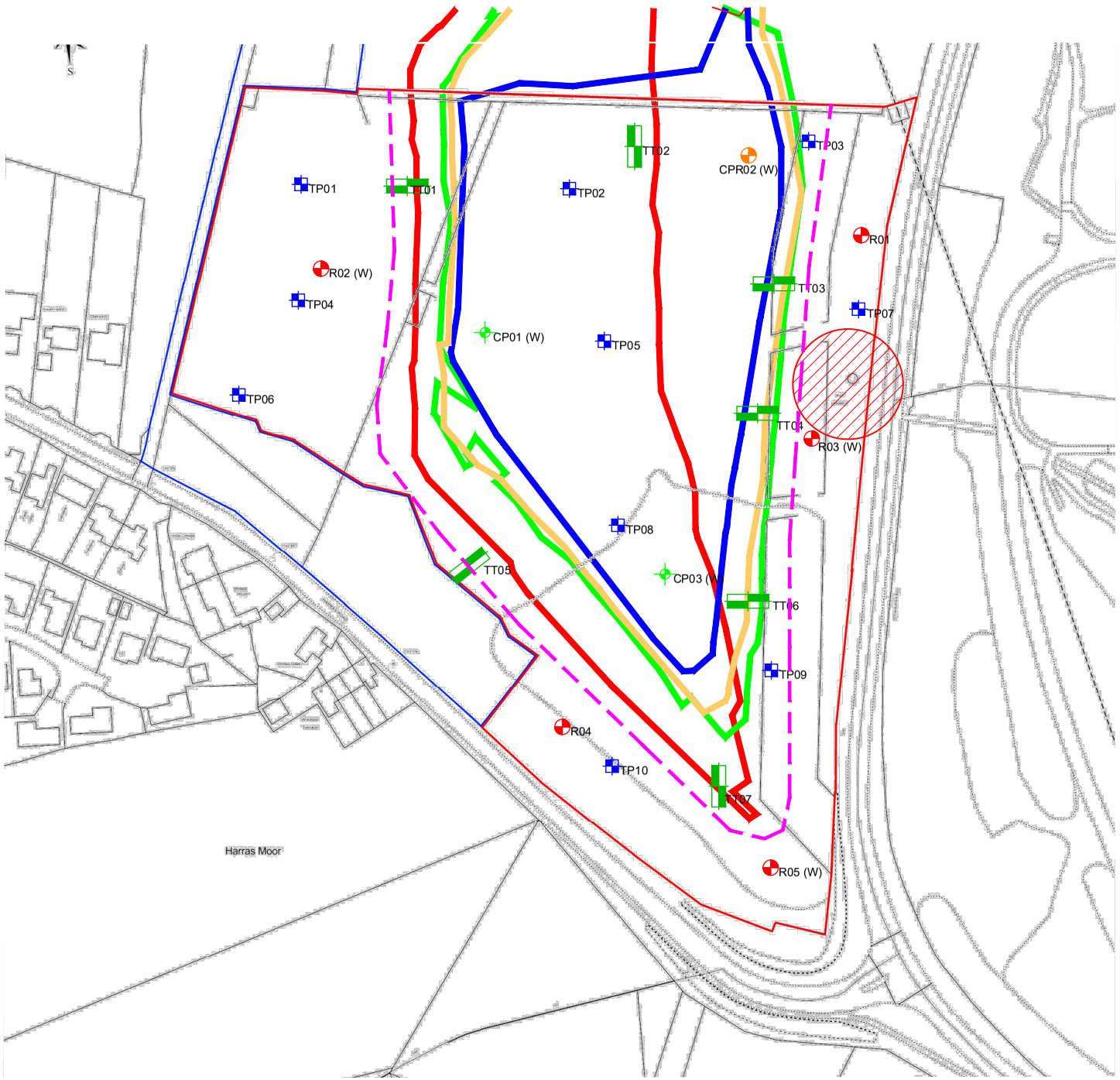
SITE

Harras Moor

DRAWING TITLE

Revised Conceptual Site Model

DRAWING NO.	REVISION NO.
C7728/04	0
DRAWN BY: MF	APPROVED BY: GA
DATE: January 2019	SCALE: NTS
PAPER SIZE: A3	



NOTES

- Approximate Site Boundary
- Rotary open hole borehole
- Cable percussion borehole with rotary open follow on
- Cable percussion borehole
- (W) Borehole with gas/groundwater monitoring well
- Trial Trench Location
- Mine shaft and overhead cable 15m offsets
- Trial Pit Location
- Conjectured batter plane of high wall
- Opencast made ground

Seams Worked by Opencast
Based on Coal Authority abandonment plan NW1454 11/08/2015

- Unnamed G
- Unnamed E
- Brassy
- Unnamed C

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SITE

Harras Moor, Whitehaven

DRAWING TITLE

Extents of Opencast Made Ground

DRAWING NO.	REVISION NO.
C7728/05	0
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MF	GA
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APPENDIX B

RISK ASSESSMENT METHODOLOGY

Qualitative Risk Assessment Methodology

The approach adopted by Sirius for the qualitative assessment of risk is based upon that given in Annex 4 of NHBC-Environment Agency-CIEH "Guidance for the Safe Development of Housing on Land Affected by Contamination" (2008) and is consistent with other current guidance.

The risk posed by viable contaminant linkages is based upon the consideration of both:

a) the magnitude of the potential consequence (i.e. its severity); and,

b) the probability (likelihood) of that consequence being realised.

The classifications used in this report for consequence and probability are given in Tables 1 and 2, respectively. The derived risk classifications are defined in Table 3.

Where there is no viable contaminant linkage there is no potential risk.

Table 1. Classification of Consequence

Classification	Definition
Severe	Contaminant concentrations at the receptor that are likely to result in "significant harm" to human health (as defined in Part 2A of the Environmental Protection Act 1990). Major pollution of controlled waters that could have persistent and/or extensive effects on water quality, for example fish kills, closure of an abstraction, or substantial deterioration in quality of the receiving water body. Major impact on receptor amenity value or major damage to agriculture or commerce. Major damage to an ecosystem that is likely to result in a substantial adverse change in its functioning or harm to a species of special interest that endangers the long-term maintenance of the population. Catastrophic damage to crops, buildings or property.
Medium	Elevated concentrations at the receptor that might result in "significant harm" to human health (as defined in Part 2A of the Environmental Protection Act 1990). A pollution incident that has significant effect on water quality or abstraction potential. An incident that has a marked effect on receptor amenity value, agriculture or commerce. Damage to an ecosystem that may result in a substantial adverse change in its functioning or harm to a species of special interest that may endanger the long-term maintenance of the population. Significant damage to crops, buildings or property.

Classification	Definition
Mild	Potential human health impact at the receptor point but unlikely to be classified as "significant harm" (as defined in Part 2A of the Environmental Protection Act 1990). Pollution of water that will have a small or short-lived effect on water quality and marginal effects on its amenity or resource value or its use in agriculture or commerce. Minor or short-lived damage to ecosystems, which is unlikely to result in a substantial adverse change Minor damage to crops, buildings or property
Minor	No potential measurable detrimental human health impacts at the receptor point. Impact on water that will have no or minimal effect on water quality or use. No or minor and easily repairable effects on buildings, structures and services.

Table 2. Classification of Probability

Classification	Definition
High	An impact is already occurring or is very likely in the short-term and almost inevitable over the long-term.
Medium	It is probable that an event would occur. This is not inevitable but possible in the short-term and likely over the long-term.
Low	Circumstances are possible under which an event could occur. However, it is by no means certain that an event will take place, even over the long-term.
Unlikely	Circumstances are such that it is improbable that an event would occur even over the very long-term.

Table 3. Risk Classification

	Consequence			
Probability	***Severe***	***Medium***	***Mild***	***Minor***
High	Very High	High	Moderate	Low
Medium	High	Moderate	Low to Moderate	Low
Low	Moderate	Low to Moderate	Low	Very Low
Unlikely	Low to Moderate	Low	Very Low	Negligible

Table 4 provides a context for interpretation of the risk classification categories. The definitions provided are based on those given in CIRIA (2001) "Contaminated Land Risk Assessment. A Guide to Good Practice", Report C552.

Table 4. Interpretation of Risk Classification Categories

Risk Classification	Definition
Very High	There is a high probability that severe harm to one or more identified receptors could occur or there is evidence that this is already happening. This risk is likely to result in a substantial liability. Urgent investigation and remediation are likely to be required.
High	Harm is likely to be caused to one or more identified receptors. Realisation of the risk is likely to present a substantial liability. Urgent investigation is required and remedial works may be necessary in the short-term and are likely over the longer term.
Moderate	It is possible that harm could be caused to one or more identified receptors. However, it is relatively unlikely that such harm would be severe. Investigation is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low	It is possible that harm could be caused to one or more identified receptors but it is likely that this harm, if realised, would normally be mild. No further investigation is considered necessary to assess risk or environmental liability but investigations could be undertaken if desired to confirm 'baseline' conditions for the purposes of liability management. Remedial works are unlikely to be required.
Very Low	There is a low probability that harm could be caused to one or more identified receptors. In the event of such harm being realised, it is likely to be mild, at worst. No further investigation is considered necessary to assess risk or environmental liability but investigations could be undertaken if desired to confirm 'baseline' conditions for the purposes of liability management. Remedial works are very unlikely to be required.
Negligible	It is unlikely that harm could be caused to one or more identified receptors. In the event of harm being realised, it is likely to be minor. No further investigation is considered necessary to assess risk or environmental liability. Remedial works are not expected.

APPENDIX C

EXPLORATORY HOLE LOGS AND FIELD TEST RESULTS

BOREHOLE RECORD

BH No. **CP01** Sheet 1 of 2

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date(s): 02/10/2018 - 03/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools.

Scale: 1:50

Logged By: DG Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS				STRATA RECORD			
Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend / Well
				MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.			
				MADE GROUND: Firm to stiff orange brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.40		
D ES D	1.00 1.00 1.00 - 1.45	N=13 (3,3/3,3,4,3)	1				
D ES D	2.00 2.00 2.00 - 2.45	N=51 (8,16/17,10,13, 11)	2				
				MADE GROUND: Medium dense (occasionally dense) grey very clayey very sandy gravel and cobbles of angular and sub angular fine to coarse mudstone and sandstone. High content of cobbles and boulders of sandstone and mudstone.	2.40		
D ES	3.00 3.00		3				
D ES D	4.00 4.00 4.00 - 4.45	N=11 (2,3/2,3,3,3)	4				
D ES D	5.00 5.00 5.00 - 5.45	N=23 (3,4/7,4,5,7)	5				
D D	6.00 6.00 - 6.45	N=25 (4,5/6,6,7,6)	6				
D	7.00		7				
D	7.50 - 7.95	35 (4,11/35 for 170mm)					
D	8.00		8				
D	9.00 - 9.45	N=21 (5,5/5,6,5,5)	9				
				Continued next sheet			

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (mAOD)

Easting: 298820.00

Northing: 518436.00

Fig No. CP01

BOREHOLE RECORD

BH No. **CP01** Sheet 2 of 2

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date(s): 02/10/2018 - 03/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools.

Scale: 1:50

Logged By: DG Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
D	10.00		10	MADE GROUND: Medium dense (occasionally dense) grey very clayey very sandy gravel and cobbles of angular and sub angular fine to coarse mudstone and sandstone. High content of cobbles and boulders of sandstone and mudstone.				
D	10.50 - 10.95	N=21 (3,3/4,5,7,5)	11					
D	11.50							
		N=43 (5,4/8,11,10,14)	12	*From 12.0m to 14.4m: Becomes very dense, and with numerous cobbles and boulders.*				
D	12.45 - 12.95		13					
B	13.00 - 13.50							
D	13.50 - 13.70	50 (25 for 110mm/50 for 295mm)						
D	14.00		14					
D	14.20	50 (50 for 0mm/50 for 0mm)						
D	14.40	50 (50 for 0mm/50 for 0mm)		End of Borehole at 14.40m	14.40			
			15					
			16					
			17					
			18					
			19					

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (mAOD)

Easting: 298820.00

Northing: 518436.00

Fig No. CP01

BOREHOLE RECORD

BH No. **CP03** Sheet 1 of 2

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date(s): 03/10/2018 - 04/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools.

Scale: 1:50

Logged By: DG Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS				STRATA RECORD			
Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend / Well
B	0.00 - 0.50			MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.	0.40		
D ES D	1.00 1.00 1.00 - 1.45	N=12 (2,3/3,3,3,3)	1	MADE GROUND: Firm to stiff orange brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.			
D ES D	2.00 2.00 2.00 - 2.45	N=12 (3,4/3,2,4,3)	2	MADE GROUND: Medium dense grey very clayey very sandy gravel and cobbles of angular and sub angular fine to coarse mudstone and sandstone. High content of cobbles and boulders of sandstone and mudstone.	2.00		
D ES D	3.00 3.00 3.00 - 3.45	N=10 (1,2/2,3,2,3)	3				
D ES D	4.00 4.00 4.00 - 4.45	N=15 (3,4/4,3,4,4)	4				
D ES D B	5.00 5.00 5.00 - 5.45 5.00 - 6.00	N=13 (2,4/2,4,3,4)	5				
D	6.00 - 6.45	N=14 (2,3/3,4,5,2)	6				
			7				
D	7.50 - 7.95	N=13 (3,3/3,3,4,3)	8				
D	8.50						
D	9.00 - 9.45	N=19 (4,4/3,5,5,6)	9				
				Continued next sheet			

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (mAOD)

Easting: 298885.00

Northing: 518349.00

Fig No. CP03

BOREHOLE RECORD

BH No. **CP03** Sheet 2 of 2

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date(s): 03/10/2018 - 04/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools.

Scale: 1:50

Logged By: DG Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
D	10.00		10	MADE GROUND: Medium dense grey very clayey very sandy gravel and cobbles of angular and sub angular fine to coarse mudstone and sandstone. High content of cobbles and boulders of sandstone and mudstone.				
D	10.50 - 10.95	N=19 (4,5/3,7,4,5)						
			11					
B	11.00 - 12.00							
D	12.00 - 12.13	50 (25 for 1mm/50 for 305mm)	12	*From 12.0m to 16.55m: Becomes very dense and dense, and with numerous cobbles and boulders.*				
D	13.00		13					
D	13.50 - 13.95	N=33 (21,9/8,11,7,7)						
			14					
D	14.50							
D	15.00 - 15.45	N=44 (6,7/5,12,11,16)	15					
			16					
B	15.90 - 16.35							
D	16.35 - 16.45	50 (25 for 0mm/50 for 20mm)						
D	16.55	50 (50 for 0mm/50 for 0mm)	17	End of Borehole at 16.55m	16.55			
			18					
			19					

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (mAOD)

Easting: 298885.00

Northing: 518349.00

Fig No. CP03

BOREHOLE RECORD

BH No. **CPR02** Sheet 1 of 5

Site: Harras Moor, Whitehaven | Contract No: C7728

Client: Michael Little | Date(s): 03/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools, and a tracked rotary drilling rig. | Scale: 1:50

Logged By: DG | Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS				STRATA RECORD				
Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
				MADE GROUND: Topsoil				
				MADE GROUND: Firm to stiff orange brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.30			
D ES D	1.00 1.00 1.00 - 1.45	N=17 (3,4/4,4,5,4)	1					
D ES D	2.00 2.00 2.00 - 2.45	N=25 (5,5/6,6,7,6)	2	MADE GROUND: Medium dense and dense grey very clayey sandy gravel and cobbles of sandstone and occasional mudstone. High content of cobbles and boulders of sandstone and mudstone.	2.00			
D ES D	3.00 3.00 3.00 - 3.45	N=12 (3,6/3,3,3,3)	3					
D ES D	4.00 4.00 4.00 - 4.45	N=28 (4,6/7,8,6,7)	4					
D ES D	5.00 5.00 5.00 - 5.45	N=29 (3,4/5,8,9,7)	5					
D D	6.00 6.00 - 6.45	N=12 (2,2/3,3,3,3)	6					
D	7.00		7					
D	7.50 - 7.95	N=38 (4,4/6,11,11,10)	8					
B	8.00 - 9.00							
D	9.00 - 9.45	N=6 (1,1/1,2,2,1)	9	*From 9.0m to 10.0m: Becomes loose.*				
				Continued next sheet				

Remarks and Groundwater Observations:

1. Groundwater not encountered. 2. Cable percussion drilling to 15.8m, rotary open hole drilling thereafter.

GL (mAOD)

Easting: 298915.00

Northing: 518500.00

Fig No. CPR02

BOREHOLE RECORD

BH No. **CPR02** Sheet 2 of 5

Site: Harras Moor, Whitehaven | Contract No: C7728

Client: Michael Little | Date(s): 03/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools, and a tracked rotary drilling rig. | Scale: 1:50

Logged By: DG | Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
			10	MADE GROUND: Medium dense and dense grey very clayey sandy gravel and cobbles of sandstone and occasional mudstone. High content of cobbles and boulders of sandstone and mudstone.				
D	10.50	N=23 (3,8/7,4,8,8,4)						
D	10.50 - 10.95		11					
D	11.50							
D	12.00 - 12.45	N=28 (4,8/8,7,6,7)	12					
			13					
B	13.00 - 13.50							
D	13.50 - 13.95	N=43 (6,11/11,10,12, 10)		*From 13.5m to 15.0m: Becomes very dense.*				
			14					
D	14.50							
		28 (5,7/28 for 5mm)	15					
		50 (25 for 30mm/50 for 30mm)						
		50 (25 for 0mm/50 for 0mm)	16	MADE GROUND: Grey colliery backfill, numerous boulders.	15.80			
			17					
			18					
			19					
				Continued next sheet				

Remarks and Groundwater Observations:

1. Groundwater not encountered. 2. Cable percussion drilling to 15.8m, rotary open hole drilling thereafter.

GL (mAOD)

Easting: 298915.00

Northing: 518500.00

Fig No. CPR02

BOREHOLE RECORD

BH No. **CPR02**
Sheet 3 of 5

Site: Harras Moor, Whitehaven
Contract No: C7728

Client: Michael Little
Date(s): 03/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools, and a tracked rotary drilling rig.
Scale: 1:50

Logged By: DG
Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS				STRATA RECORD			
Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend / Well
				MADE GROUND: Grey colliery backfill, numerous boulders.			
				Grey silty MUDSTONE.	22.00		
				Continued next sheet			

Remarks and Groundwater Observations:

1. Groundwater not encountered. 2. Cable percussion drilling to 15.8m, rotary open hole drilling thereafter.

GL (mAOD)

Easting: 298915.00

Northing: 518500.00

Fig No. CPR02

BOREHOLE RECORD

BH No. **CPR02** Sheet 4 of 5

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date(s): 03/10/2018

Method: Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools, and a tracked rotary drilling rig.

Scale: 1:50

Logged By: DG Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
				Grey silty MUDSTONE.				
				Dark grey MUDSTONE.	34.00			
				Grey MUDSTONE.	37.50			
				Continued next sheet				

Remarks and Groundwater Observations:

1. Groundwater not encountered. 2. Cable percussion drilling to 15.8m, rotary open hole drilling thereafter.

GL (mAOD)

Easting: 298915.00

Northing: 518500.00

Fig No. CPR02

BOREHOLE RECORD

BH No. **CPR02** Sheet 5 of 5

Site:	Harras Moor, Whitehaven	Contract No:	C7728
Client:	Michael Little	Date(s):	03/10/2018
Method:	Hole advanced with a Dando 2000 cable percussion drilling rig using 200mm tools, and a tracked rotary drilling rig.	Scale:	1:50
		Logged By:	DG
		Checked By:	CR
		Driller:	Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	SPT (N), (ppm), (Cu Peak), Vane Result (kN/m2)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
				Grey MUDSTONE.				
				Solid - no returns.	42.00			
				End of Borehole at 45.00m	45.00			

Remarks and Groundwater Observations:

1. Groundwater not encountered. 2. Cable percussion drilling to 15.8m, rotary open hole drilling thereafter.

GL (mAOD)

Easting: 298915.00

Northing: 518500.00

Fig No. CPR02

BOREHOLE RECORD

BH No. **R01** Sheet 1 of 2

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date(s): 04/10/2018

Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.

Scale: 1:150

Logged By: DG | Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
						TOPSOIL.	0.30			
						Brown sandy gravelly CLAY.				
						Grey brown MUDSTONE.	2.00			
						COAL.	3.00			
						Grey SILTSTONE.	3.30			
						COAL.	6.20			
						Grey MUDSTONE.	6.60			
						COAL.	8.30			
						Grey MUDSTONE.	8.60			
						Dark grey MUDSTONE.	24.00			
						COAL.	27.30			
						Grey MUDSTONE.	27.60			
						Grey SANDSTONE.	29.00			

TCR SCR RQD FI

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298954.00

Northings: 518473.00

Fig No. R01

BOREHOLE RECORD

BH No. **R01** Sheet 2 of 2

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date(s): 04/10/2018

Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.

Scale: 1:150

Logged By: DG | Checked By: CR

Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
					31	Grey SANDSTONE.				
					32					
					33	Grey MUDSTONE.	32.70			
					34					
					35					
					36					
					37					
					38					
					39					
					40					
					41					
					42					
					43					
					44					
					45					
					46					
					47	COAL.	46.60			
					48	Grey MUDSTONE.	47.40			
					49					
					50	Dark grey MUDSTONE.	50.00			
					51	End of Borehole at 51.00m	51.00			
					52					
					53					
					54					
					55					
					56					
					57					
					58					
					59					
					60					
					61					
	TCR	SCR	RQD	FI						

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298954.00

Northings: 518473.00

Fig No. R01

BOREHOLE RECORD

BH No. **R02** Sheet 1 of 1

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date(s): 05/10/2018
Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.	Scale: 1:150
	Logged By: DG Checked By: CR
	Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
						TOPSOIL.	0.30			
					1	Soft brown sandy gravelly CLAY.				
					2		2.20			
					3	Pink grey MUDSTONE.				
					4					
					5					
					6					
					7					
					8					
					9					
					10					
					11					
					12					
					13					
					14					
					15					
					16					
					17					
					18					
					19					
					20					
					21					
					22					
					23	COAL.	22.60			
					24	Grey MUDSTONE with occasional sandstone bands.	23.40			
					25					
					26					
					27					
					28					
					29					
					30	End of Borehole at 30.00m	30.00			
	TCR	SCR	RQD	FI						

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298760.00

Northings: 518459.00

Fig No. R02

BOREHOLE RECORD

BH No. **R03** Sheet 1 of 2

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date(s): 04/10/2018
Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.	Scale: 1:150
	Logged By: DG — Checked By: CR
	Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
						TOPSOIL.	0.30			
					1	Brown sandy gravelly CLAY.				
					2					
					3	Grey MUDSTONE.	3.00			
					4					
					5					
					6					
					7	COAL.	6.70			
						Grey MUDSTONE.	7.00			
					8					
					9					
						COAL.	9.40			
					10	Grey MUDSTONE.	9.70			
					11					
					12					
					13					
					14					
					15					
					16					
					17	COAL.	16.80			
						Grey MUDSTONE.	17.10			
					18					
					19					
					20					
					21					
					22					
					23					
					24	Dark grey MUDSTONE.	24.00			
					25					
					26					
					27					
					28	COAL.	28.10			
					29	Grey MUDSTONE.	28.90			
					30					
	TCR	SCR	RQD	FI						

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298938.00

Northings: 518398.00

Fig No. R03

BOREHOLE RECORD

BH No. **R03** Sheet 2 of 2

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date(s): 04/10/2018
Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.	Scale: 1:150
	Logged By: DG — Checked By: CR
	Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
					31	Grey MUDSTONE.				
					32					
					33					
					34					
					35					
					36					
					37					
					38					
					39					
					40					
					41					
					42					
					43					
					44					
					45					
					46					
					47					
					48		48.00			
						COAL.	48.90			
					49	Grey MUDSTONE.				
					50					
					51	End of Borehole at 51.00m	51.00			
					52					
					53					
					54					
					55					
					56					
					57					
					58					
					59					
					60					
					61					
	TCR	SCR	RQD	FI						

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298938.00

Northings: 518398.00

Fig No. R03

BOREHOLE RECORD

BH No. **R04** Sheet 1 of 2

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date(s): 03/10/2018
Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.	Scale: 1:150
	Logged By: DG Checked By: CR
	Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
						TOPSOIL.	0.30			
					1	Brown sandy gravelly CLAY.				
					2	Grey silty MUDSTONE.	2.00			
					3					
					4					
					5					
							5.50			
					6	COAL	5.90			
						Grey MUDSTONE.				
					7					
					8					
					9					
					10					
					11					
					12					
					13		13.20			
						COAL.	13.90			
					14	Grey SILTSTONE.				
					15					
					16					
					17					
					18					
					19					
					20		20.00			
						Dark grey MUDSTONE.				
					21					
					22					
					23					
					24					
					25					
					26					
					27					
					28					
					29					
							29.50			
					30	COAL.	29.80			
	TCR	SCR	RQD	FI						

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298844.86

Northings: 518291.94

Fig No. R04

BOREHOLE RECORD

BH No. **R04** Sheet 2 of 2

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date(s): 03/10/2018
Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.	Scale: 1:150
	Logged By: DG Checked By: CR
	Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
					31	Grey SILTSTONE.				
					32					
					33					
					34					
					35	COAL.	34.80			
					36	Grey MUDSTONE.	35.90			
					37					
					38					
					39					
					40	COAL.	40.10			
					41	Dark grey MUDSTONE.	40.40			
						Grey MUDSTONE.	41.00			
					42					
					43					
					44					
					45					
					46					
					47					
					48	Dark grey MUDSTONE.	48.00			
					49					
					50					
					51	End of Borehole at 51.00m	51.00			
					52					
					53					
					54					
					55					
					56					
					57					
					58					
					59					
					60					
					61					
	TCR	SCR	RQD	FI						

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298844.86

Northings: 518291.94

Fig No. R04

BOREHOLE RECORD

BH No. **R05** Sheet 1 of 1

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date(s): 05/10/2018
Method: Hole advancced with a Beratta T44 rotary drilling rig, using air flush.	Scale: 1:150
	Logged By: DG — Checked By: CR
	Driller: Infosoil Ltd.

SAMPLE DETAILS | STRATA RECORD

Depth From - To(m)	TCR	SCR	RQD	FI	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Well
						TOPSOIL.	0.30			
						Brown sandy gravelly CLAY.				
						Pink grey MUDSTONE.	3.10			
						Dark grey MUDSTONE.	6.50			
						COAL.	13.60			
						Grey MUDSTONE.	14.30			
						COAL.	17.00			
						Grey MUDSTONE.	17.50			
						COAL.	19.10			
						Grey MUDSTONE.	19.50			
						Dark grey MUDSTONE.	24.00			
						Grey MUDSTONE.	26.50			
						End of Borehole at 30.00m	30.00			

Remarks and Groundwater Observations:

1. Groundwater not encountered.

GL (m AOD)

Eastings: 298923.86

Northings: 518242.66

Fig No. R05

TRIAL PIT RECORD

TP No. **TP01** Sheet 1 of 1

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date: 02/10/2018

Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.

Scale: 1:25

Logged By: DG Checked By: CR

SAMPLE DETAILS				STRATA RECORD				
Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.10			Firm brown sandy gravelly CLAY (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
					0.40			
B	0.70			Firm to stiff medium to high strength orange brown mottled grey sandy gravelly CLAY of intermediate plasticity. Gravel is sub angular to rounded fine to coarse sandstone and occasional coal. Occasional rounded and sub rounded cobbles of sandstone and slate.				
D	0.70							
		75.0	1					
					1.20			
D	1.40			Red brown slightly clayey silty very gravelly fine to coarse SAND (Destructured sandstone). Gravel is angular and sub angular fine to coarse sandstone. High content of angular cobbles of sandstone.				
			2					
D	2.40			Weak red brown silty fine to coarse SANDSTONE.	2.40			
				End of trial pit at 2.70m	2.70			
			3					
			4					
			5					

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298753.61

Northing: 518490.32

Fig No. TP01

TRIAL PIT RECORD

TP No. **TP02** Sheet 1 of 1

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date: 02/10/2018
Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.	Scale: 1:25
	Logged By: DG Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.20			MADE GROUND: Firm brown sandy very gravelly CLAY (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.	0.30			
D	0.50			MADE GROUND: Firm to stiff orange brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.				
ES	0.60							
			1					
					1.20			
D	1.50			MADE GROUND: Grey clayey very sandy gravel and cobbles of angular and sub angular fine to coarse sandstone and occasional mudstone. High content of angular and sub angular cobbles and boulders of sandstone and mudstone.				
			2	*From 2.0m to 2.6m: Approximately 50% of the material is cobbles and boulders.*				
				End of trial pit at 2.60m	2.60			
			3					
			4					
			5					

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298850.88

Northing: 518488.78

Fig No. TP02

TRIAL PIT RECORD

TP No. **TP03** Sheet 1 of 1

Site:	Harras Moor, Whitehaven
Client:	Michael Little
Method:	Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.

Contract No: C7728

Date: 02/10/2018

Scale: 1:25

Logged By: DG Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.10			MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
				MADE GROUND: Firm to stiff orange brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.30			
D	0.90		1					
				MADE GROUND: Grey clayey very sandy gravel and cobbles of angular and sub angular fine to coarse sandstone and occasional mudstone. High content of angular and sub angular cobbles and boulders of sandstone and mudstone.	1.40			
D	1.50							
D	2.00		2					
				End of trial pit at 2.30m	2.30			
			3					
			4					
			5					

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298942.00

Northing: 518488.00

Fig No. TP03

TRIAL PIT RECORD

TP No. **TP04** Sheet 1 of 1

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date: 02/10/2018

Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.

Scale: 1:25

Logged By: DG Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.20			Firm brown sandy gravelly CLAY (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
					0.40			
D	0.50			Firm to stiff high strength orange brown mottled grey sandy gravelly CLAY of intermediate plasticity. Gravel is sub angular to rounded fine to coarse sandstone and occasional coal. Occasional rounded and sub rounded cobbles of sandstone and slate.				
ES	0.50							
		83.0						
			1					
					1.10			
D	1.20			Red brown slightly clayey very gravelly fine to coarse very clayey SAND (Destructured sandstone). Gravel is angular and sub angular fine to coarse sandstone. High content of angular cobbles of sandstone.				
					1.90			
			2	Weak red brown silty fine to coarse SANDSTONE.	2.00			
				End of trial pit at 2.00m				
			3					
			4					
			5					

Remarks and Groundwater Observations

1. Seepage of groundwater observed at 1.9m. 2. Pit remained stable.

GL (m AOD)

Easting: 298752.00

Northing: 518448.00

Fig No. TP04

TRIAL PIT RECORD

TP No. **TP05** Sheet 1 of 1

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date: 02/10/2018
Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.	Scale: 1:25
	Logged By: DG Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.10			MADE GROUND: Firm brown sandy very gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.	0.30			
ES	0.50			MADE GROUND: Firm to stiff orange brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.90			
ES	0.50							
D	1.20		1	MADE GROUND: Grey clayey very sandy gravel and cobbles of angular and sub angular fine to coarse sandstone and occasional mudstone. High content of angular and sub angular cobbles and boulders of sandstone and mudstone.				
			2					
D	2.40			*From 2.5m to 3.1m: Approximately 50% of the material is cobbles and boulders.*				
			3	End of trial pit at 3.10m	3.10			
			4					
			5					

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298863.54

Northing: 518433.54

Fig No. TP05

TRIAL PIT RECORD

TP No. **TP06** Sheet 1 of 1

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date: 02/10/2018

Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.

Scale: 1:25

Logged By: DG Checked By: CR

SAMPLE DETAILS				STRATA RECORD				
Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.10			Firm brown sandy gravelly CLAY (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
ES	0.40			Firm to stiff orange brown mottled grey sandy gravelly CLAY of low plasticity (field estimate). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal. Occasional rounded and sub rounded cobbles of sandstone and slate.	0.30 0.50			
D	0.80			Red brown slightly clayey silty very gravelly fine to coarse SAND (Destructured sandstone). Gravel is angular and sub angular fine to coarse sandstone. High content of angular cobbles of sandstone.				
D	1.80			Moderately strong grey silty fine to coarse SANDSTONE.	1.90			
				End of trial pit at 2.10m	2.10			

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298731.05

Northing: 518414.00

Fig No. TP06

TRIAL PIT RECORD

TP No. **TP07** Sheet 1 of 1

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date: 02/10/2018

Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.

Scale: 1:25

Logged By: DG | Checked By: CR

SAMPLE DETAILS				STRATA RECORD			
Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend / Backfill
ES	0.20			Firm brown sandy gravelly CLAY (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.			
					0.50		
				Stiff medium strength brown mottled grey sandy CLAY of intermediate plasticity.			
D	0.90	73.0					
			1				
D	1.50						
			2				
				COAL	2.30		
				Very weak grey distinctly weathered MUDSTONE.	2.40		
D	2.50						
				End of trial pit at 2.70m	2.70		
			3				
			4				
			5				

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298949.00

Northing: 518440.00

Fig No. TP07

TRIAL PIT RECORD

TP No. **TP08** Sheet 1 of 1

Site: Harras Moor, Whitehaven

Contract No: C7728

Client: Michael Little

Date: 02/10/2018

Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.

Scale: 1:25

Logged By: DG Checked By: CR

SAMPLE DETAILS				STRATA RECORD			
Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend / Backfill
ES	0.10			MADE GROUND: Firm brown sandy very gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.			
ES	0.40			MADE GROUND: Firm to stiff orange brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.40		
D	0.60						
			1				
				MADE GROUND: Grey clayey very sandy gravelly cobbles and boulders of angular and sub angular fine to coarse sandstone and occasional mudstone.	1.30		
D	1.50						
B	2.00		2				
				End of trial pit at 2.20m	2.20		
			3				
			4				
			5				

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298868.47

Northing: 518366.79

Fig No. TP08

TRIAL PIT RECORD

TP No. **TP09** Sheet 1 of 1

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date: 02/10/2018
Method: Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.	Scale: 1:25
	Logged By: DG Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.10			MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
					0.30			
				MADE GROUND: Firm dark brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone and occasional mudstone and coal. Occasional cobbles of sandstone and mudstone.				
ES	0.60							
					0.90			
D	1.00	78.0	1	Stiff high strength brown mottled grey sandy gravelly CLAY of intermediate plasticity. Gravel is sub angular to rounded fine to coarse sandstone, coal and slate.				
					1.70			
		85.0		Stiff high strength red brown sandy gravelly CLAY of intermediate plasticity (Destructured mudstone). Gravel is sub angular fine to coarse mudstone.				
D	2.00		2					
					2.50			
				Very weak grey distinctly weathered MUDSTONE.				
D	2.80		3					
				End of trial pit at 3.50m	3.50			
			4					
			5					

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298931.47

Northing: 518313.70

Fig No. TP09

TRIAL PIT RECORD

TP No. **TP10** Sheet 1 of 1

Site:	Harras Moor, Whitehaven
Client:	Michael Little
Method:	Excavated with a Case CX210B 360 degree excavator, with a 900mm smooth bucket.

Contract No: C7728

Date: 02/10/2018

Scale: 1:25

Logged By: DG Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
ES	0.10			Firm brown sandy gravelly CLAY (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.	0.30			
D	0.60	80.0		Very stiff high strength red brown very sandy slightly gravelly CLAY. Occasional sub rounded and rounded cobbles of sandstone.	1.10			
D	1.30			Red brown and grey gravelly fine to coarse very sandy CLAY (Destructured sandstone).	2.00			
D	2.20			Very weak grey fine to coarse SANDSTONE.	2.40			
				End of trial pit at 2.40m				

1
2
3
4
5

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298857.66

Northing: 518276.29

Fig No. TP10

TRIAL PIT RECORD

TP No. **TT02**
Sheet 1 of 1

Site:	Harras Moor, Whitehaven
Client:	Michael Little
Method:	Excavated with a Case CX210B 360 degree excavator, with a 1500mm toothed bucket.

Contract No: C7728

Date: 01/10/2018

Scale: 1:25

Logged By: DG | Checked By: CR

SAMPLE DETAILS				STRATA RECORD				
Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
				MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
				MADE GROUND: Firm to stiff brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.30			
				MADE GROUND: Grey clayey very sandy gravelly cobbles and occasional boulders of angular and sub angular fine to coarse sandstone and occasional mudstone.	1.20			
				End of trial pit at 1.50m	1.50			

1
2
3
4
5

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298874.51

Northing: 518504.08

Fig No. TT02

TRIAL PIT RECORD

TP No. **TT03** Sheet 1 of 1

Site:	Harras Moor, Whitehaven
Client:	Michael Little
Method:	Excavated with a Case CX210B 360 degree excavator, with a 1500mm toothed bucket.

Contract No: C7728

Date: 01/10/2018

Scale: 1:25

Logged By: DG Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
				MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
				MADE GROUND: Firm to stiff brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.40			
				At 0.9m: 100mm ceramic field drain.				
				MADE GROUND: Grey clayey very sandy gravelly cobbles and occasional boulders of angular and sub angular fine to coarse sandstone and occasional mudstone.	1.40			
				End of trial pit at 1.60m	1.60			

1 2 3 4 5

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

GL (m AOD)

Easting: 298925.02

Northing: 518454.25

Fig No. TT03

TRIAL PIT RECORD

TP No. **TT04** Sheet 1 of 1

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date: 01/10/2018
Method: Excavated with a Case CX210B 360 degree excavator, with a 1500mm toothed bucket.	Scale: 1:25
	Logged By: DG — Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
				MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
				MADE GROUND: Firm to stiff brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.40			
				MADE GROUND: Grey clayey very sandy gravelly cobbles and occasional boulders of angular and sub angular fine to coarse sandstone and occasional mudstone.	1.20			
				End of trial pit at 1.60m	1.60			

1 2 3 4 5

Remarks and Groundwater Observations

1. Groundwater encountered at 1.4m - standing. 2. Pit remained stable.

GL (m AOD)

Easting: 298919.09

Northing: 518407.36

Fig No. TT04

TRIAL PIT RECORD

TP No. **TT06**
Sheet 1 of 1

Site: Harras Moor, Whitehaven	Contract No: C7728
Client: Michael Little	Date: 01/10/2018
Method: Excavated with a Case CX210B 360 degree excavator, with a 1500mm toothed bucket.	Scale: 1:25
	Logged By: DG — Checked By: CR

SAMPLE DETAILS | STRATA RECORD

Type	Depth From - To(m)	Vane Results (kN/m2) (ppm)	Ground -water	Description	Depth (m)	Level (m AOD)	Legend	Backfill
				MADE GROUND: Firm brown sandy gravelly clay (Topsoil). Gravel is sub angular to rounded fine to coarse sandstone and occasional coal.				
				MADE GROUND: Firm to stiff brown sandy gravelly clay. Gravel is angular to rounded fine to coarse sandstone, mudstone, coal and occasional brick. Low cobble content of angular and sub angular sandstone.	0.50			
				At 0.9m: 100mm ceramic field drain.				
				MADE GROUND: Grey clayey very sandy gravelly cobbles and occasional boulders of angular and sub angular fine to coarse sandstone and occasional mudstone.	1.90			
				End of trial pit at 2.20m	2.20			

Remarks and Groundwater Observations

1. Groundwater not observed. 2. Pit remained stable.

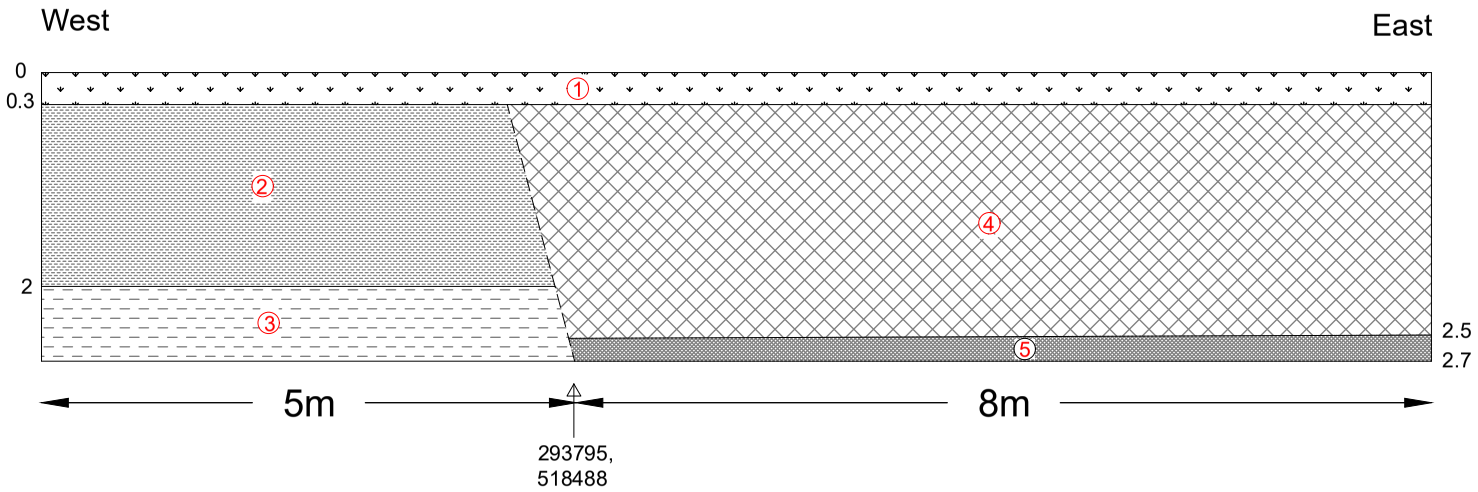
GL (m AOD)

Easting: 298915.64

Northing: 518339.24

Fig No. TT06

TT01



① Topsoil: Brown sandy slightly gravelly CLAY.
② Firm to stiff orange, brown and brown sandy gravelly CLAY.
③ Stiff to very stiff red, brown sandy gravelly CLAY (weathered mudstone)
④ MADE GROUND: Firm to stiff brown, sandy, gravelly clay.
⑤ MADE GROUND; Grey, very clayey, sandy, gravel and COBBLES of mudstone and sandstone.

NOTES

REVISION		BY	DATE
0	For Information	MF	17/10/18
A	>>	>>	>>
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CLIENT

Michael Little

SITE

Harras Moor, Whitehaven

DRAWING TITLE

TT01

DRAWING NO.	REVISION NO.
C7728/TT01	0
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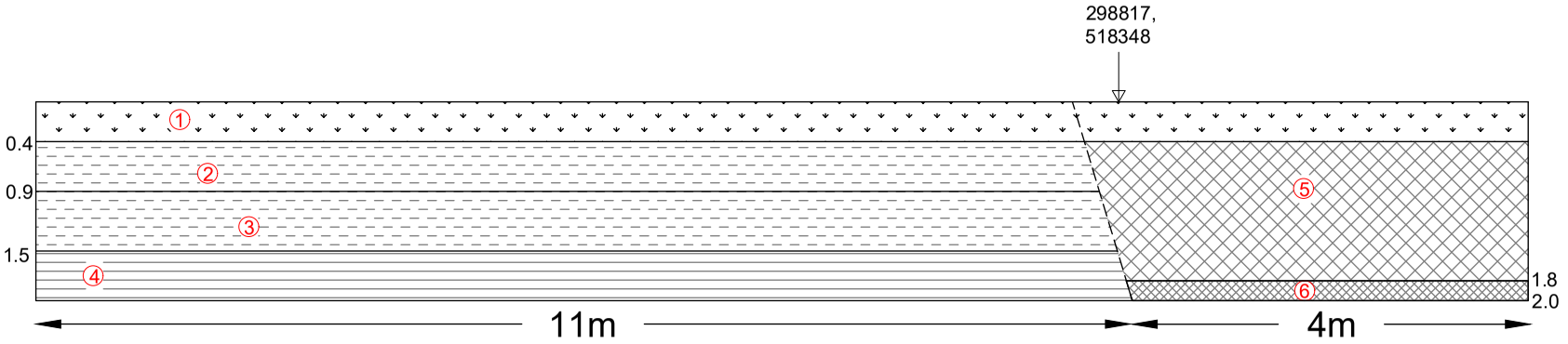
DATE: October 2018	SCALE: 1:50
PAPER SIZE: A3	

TT05

South West

North East



① Topsoil: Brown sandy slightly gravelly CLAY.
② Firm to stiff orange, brown, mottled, grey, sandy, gravelly CLAY.
③ Stiff red, brown, sandy, gravelly, friable CLAY.
④ Grey, brown weathered SILTSTONE.
⑤ MADE GROUND: Firm to stiff brown, sandy, gravelly clay.
⑥ MADE GROUND; Grey, very clayey, sandy, GRAVEL and COBBLES of mudstone and sandstone.

NOTES

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Michael Little

SITE

**Harras Moor,
Whitehaven**

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TT05

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C7728/TT05	0
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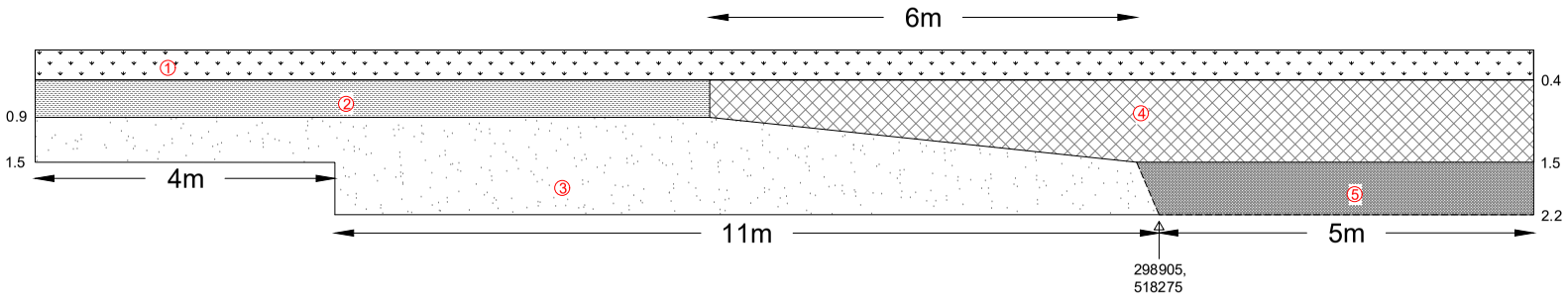
October 2018	1:50	A3

TT07

South

North



① Topsoil: Brown sandy slightly gravelly CLAY.
② Firm to stiff orange, brown and brown sandy gravelly CLAY.
③ Destructured red, brown silty sandstone
④ MADE GROUND: Firm to stiff brown, sandy, gravelly clay.
⑤ MADE GROUND; Grey, very clayey, sandy, gravel and COBBLES of mudstone and sandstone.

NOTES

REVISION		BY	DATE
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TT07

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APPENDIX D

LABORATORY TEST RESULTS

CONCEPT LIFE SCIENCES
DELIVERING SCIENCE

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Concept Life Sciences

Certificate of Analysis

Hadfield House
Hadfield Street
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M16 9FE
Tel : 0161 874 2400
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Report Number: 773858-1

Date of Report: 19-Oct-2018

Customer: Sirius Geotechnical & Environmental Ltd
Suite 2
Russel House
Mill Road
Langley Moor
Durham
DH7 8HJ

Customer Contact: Mr Dan Gallagher

Customer Job Reference: C7728
Customer Purchase Order: 17605/C7728/DG
Customer Site Reference: Harras Moor, Whitehaven
Date Job Received at Concept: 11-Oct-2018
Date Analysis Started: 11-Oct-2018
Date Analysis Completed: 19-Oct-2018

The results reported relate to samples received in the laboratory and may not be representative of a whole batch.

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

This report should not be reproduced except in full without the written approval of the laboratory

Tests covered by this certificate were conducted in accordance with Concept Life Sciences SOPs

All results have been reviewed in accordance with Section 25 of the Concept Life Sciences, Analytical Services Quality Manual

UKAS TESTING
1549

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

Report checked and authorised by :
Aleksandra Pacula
Senior Customer Service Advisor

Issued by :
Aleksandra Pacula
Senior Customer Service Advisor

Waste Acceptance Criteria

Customer Sample Reference : TP05
Our Sample Reference : 773858 002
Project Site : Harras Moor, Whitehaven
Customer Reference : C7726
Test Portion Mass (g) : 175
Wet Sample in Dish Weight : 100
Top Depth : 0.5
Sample in Dish @ 105C : 80.9
Empty Dish Weight : 0
Date Sampled : 02-OCT-2016
Matrix Class : Clay

Soil					Result	Inert Waste Landfill	Stable non reactive	Hazardous Waste Landfill
Determinand	Technique	LOD	Units	Symbol				
Total Organic Carbon	OX/IR	0.1	%	N	1.5	3.0	5.0	6.0
Loss on Ignition	Grav	0.1	%	N	5.6			10.0
BTEX (Sum)	Calc	0.040	mg/kg	U	<0.040	6.0		
PCB EC7 (Sum)	Calc	0.007	mg/kg	M	<0.007	1.0		
Total Petroleum Hydrocarbons C10-C40 (Sum)	Calc	1	mg/kg	N	(13) 4	500.0		
PAH (Sum)	Calc	1.6	mg/kg	N	<1.6	100.0		
pH	Probe			M	8.0		> 6.0	
Acid Neutralising Capacity (pH 4)	Titration	2	Mol/kg	N	<2			
Acid Neutralising Capacity (pH 7)	Titration	2	Mol/kg	N	<2			

Data for BS EN 12457-2 (10:1)					Result	Inert Waste Landfill	Stable non reactive	Hazardous Waste Landfill
Determinand	Technique	LOD	Units	Symbol				
Antimony	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.06	0.7	5.0
Arsenic	Calc WAC ICP/MS	0.0020	mg/kg	N	<0.0020	0.5	2.0	25.0
Barium	Calc WAC ICP/MS	0.010	mg/kg	N	0.058	20.0	100.0	300.0
Cadmium	Calc WAC ICP/MS	0.00020	mg/kg	N	<0.00020	0.04	1.0	5.0
Chloride	Calc (W)	10	mg/kg	N	<10	800.0	15000.0	25000.0
Chromium	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.5	10.0	70.0
Copper	Calc WAC ICP/MS	0.0050	mg/kg	N	<0.0050	2.0	50.0	100.0
Dissolved Organic Carbon	Calc	10	mg/kg	N	<10	500.0	800.0	1000.0
Fluoride	Calc (W)	0.50	mg/kg	N	<0.50	10.0	150.0	500.0
Lead	Calc WAC ICP/MS	0.0030	mg/kg	N	<0.0030	0.5	10.0	50.0
Mercury	Calc WAC ICP/MS	0.00050	mg/kg	N	<0.00050	0.01	0.2	2.0
Molybdenum	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.5	10.0	30.0
Nickel	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.4	10.0	40.0
Phenols (Total-Mono)	Calc	1.0	mg/kg	N	<1.0	1.0		
Selenium	Calc WAC ICP/MS	0.0050	mg/kg	N	<0.0050	0.1	0.5	7.0
Sulphate	Calc (W)	5	mg/kg	N	56	1000.0	20000.0	50000.0
Total Dissolved Solids	Calc	1000	mg/kg	N	<1000	4000.0	60000.0	100000.0
Zinc	Calc WAC ICP/MS	0.020	mg/kg	N	0.041	4.0	50.0	200.0

Following the recommendation from the Environment Agency (England and Wales)*, the leachate preparation in this report has been carried out to BS EN 12457-2 : One Stage batch test at a liquid to solid ratio of 10 l/kg. This is also compliant with Schedule 10 of the Environmental Permitting Regulations 2010.

Note : This is the minimum amount of testing which is required.

Further testing may be required if :

- evidence of immediately leachable parameters becomes available.
- evidence to indicate that the sample could be classified as hazardous under H1-H14 of the Waste(England and Wales) Regulations 2011(as amended) becomes available.

Acceptance of waste at landfill is always at the discretion of the Landfill Operator.

*** Waste Sampling and Testing for Disposal at Landfill, EBPRI 11507B, Environment Agency (England and Wales) March 2013**

As detailed in- Waste Classification. Guidance on the classification and assessment of waste. Technical Guidance WM3:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427077/LIT_10121.pdf

Landfill WAC analysis (specifically leaching test results) should not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Waste Acceptance Criteria

Customer Sample Reference : TP02
Our Sample Reference : 773858 018
Project Site : Harras Moor, Whitehaven
Customer Reference : C7726
Top Depth : 0.6
Wet Sample in Dish Weight : 100
Test Portion Mass (g) : 175
Empty Dish Weight : 0
Sample in Dish @ 105C : 84.8
Date Sampled : 02-OCT-2018
Matrix Class : Sandy Soil

Soil					Result	Inert Waste Landfill	Stable non reactive	Hazardous Waste Landfill
Determinand	Technique	LOD	Units	Symbol				
Total Organic Carbon	OX/IR	0.1	%	N	1.1	3.0	5.0	6.0
Loss on Ignition	Grav	0.1	%	N	4.5			10.0
BTEX (Sum)	Calc	0.040	mg/kg	U	<0.040	6.0		
PCB EC7 (Sum)	Calc	0.007	mg/kg	M	<0.007	1.0		
Total Petroleum Hydrocarbons C10-C40 (Sum)	Calc	1	mg/kg	N	(13) 3	500.0		
PAH (Sum)	Calc	1.6	mg/kg	N	<1.6	100.0		
pH	Probe			M	4.9		> 6.0	
Acid Neutralising Capacity (pH 4)	Titration	2	Mol/kg	N	<2			
Acid Neutralising Capacity (pH 7)	Titration	2	Mol/kg	N	<2			

Data for BS EN 12457-2 (10:1)					Result	Inert Waste Landfill	Stable non reactive	Hazardous Waste Landfill
Determinand	Technique	LOD	Units	Symbol				
Antimony	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.06	0.7	5.0
Arsenic	Calc WAC ICP/MS	0.0020	mg/kg	N	<0.0020	0.5	2.0	25.0
Barium	Calc WAC ICP/MS	0.010	mg/kg	N	0.13	20.0	100.0	300.0
Cadmium	Calc WAC ICP/MS	0.00020	mg/kg	N	<0.00020	0.04	1.0	5.0
Chloride	Calc (W)	10	mg/kg	N	<10	800.0	15000.0	25000.0
Chromium	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.5	10.0	70.0
Copper	Calc WAC ICP/MS	0.0050	mg/kg	N	0.014	2.0	50.0	100.0
Dissolved Organic Carbon	Calc	10	mg/kg	N	26	500.0	800.0	1000.0
Fluoride	Calc (W)	0.50	mg/kg	N	<0.50	10.0	150.0	500.0
Lead	Calc WAC ICP/MS	0.0030	mg/kg	N	<0.0030	0.5	10.0	50.0
Mercury	Calc WAC ICP/MS	0.00050	mg/kg	N	<0.00050	0.01	0.2	2.0
Molybdenum	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.5	10.0	30.0
Nickel	Calc WAC ICP/MS	0.010	mg/kg	N	0.011	0.4	10.0	40.0
Phenols (Total-Mono)	Calc	1.0	mg/kg	N	<1.0	1.0		
Selenium	Calc WAC ICP/MS	0.0050	mg/kg	N	<0.0050	0.1	0.5	7.0
Sulphate	Calc (W)	5	mg/kg	N	49	1000.0	20000.0	50000.0
Total Dissolved Solids	Calc	1000	mg/kg	N	<1000	4000.0	60000.0	100000.0
Zinc	Calc WAC ICP/MS	0.020	mg/kg	N	0.043	4.0	50.0	200.0

Following the recommendation from the Environment Agency (England and Wales)*, the leachate preparation in this report has been carried out to BS EN 12457-2 : One Stage batch test at a liquid to solid ratio of 10 l/kg. This is also compliant with Schedule 10 of the Environmental Permitting Regulations 2010.

Note : This is the minimum amount of testing which is required.

Further testing may be required if :

- evidence of immediately leachable parameters becomes available.
- evidence to indicate that the sample could be classified as hazardous under H1-H14 of the Waste(England and Wales) Regulations 2011(as amended) becomes available.

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*** Waste Sampling and Testing for Disposal at Landfill, EBPRI 11507B, Environment Agency (England and Wales) March 2013**

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https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427077/LIT_10121.pdf

Landfill WAC analysis (specifically leaching test results) should not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Waste Acceptance Criteria

Customer Sample Reference : TP08
Our Sample Reference : 773858 019
Project Site : Harras Moor, Whitehaven
Customer Reference : C7728
Test Portion Mass (g) : 175
Top Depth : 0.4
Empty Dish Weight : 0
Wet Sample in Dish Weight : 100
Sample in Dish @ 105C : 84.3
Date Sampled : 02-OCT-2018
Matrix Class : Clay

Soil					Result	Inert Waste Landfill	Stable non reactive	Hazardous Waste Landfill
Determinand	Technique	LOD	Units	Symbol				
Total Organic Carbon	OX/IR	0.1	%	N	1.1	3.0	5.0	6.0
Loss on Ignition	Grav	0.1	%	N	4.6			10.0
BTEX (Sum)	Calc	0.040	mg/kg	U	<0.040	6.0		
PCB EC7 (Sum)	Calc	0.007	mg/kg	M	<0.007	1.0		
Total Petroleum Hydrocarbons C10-C40 (Sum)	Calc	1	mg/kg	N	(13) 2	500.0		
PAH (Sum)	Calc	1.6	mg/kg	N	<1.6	100.0		
pH	Probe			M	5.8		> 6.0	
Acid Neutralising Capacity (pH 4)	Titration	2	Mol/kg	N	<2			
Acid Neutralising Capacity (pH 7)	Titration	2	Mol/kg	N	<2			

Data for BS EN 12457-2 (10:1)					Result	Inert Waste Landfill	Stable non reactive	Hazardous Waste Landfill
Determinand	Technique	LOD	Units	Symbol				
Antimony	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.06	0.7	5.0
Arsenic	Calc WAC ICP/MS	0.0020	mg/kg	N	0.0026	0.5	2.0	25.0
Barium	Calc WAC ICP/MS	0.010	mg/kg	N	0.12	20.0	100.0	300.0
Cadmium	Calc WAC ICP/MS	0.00020	mg/kg	N	<0.00020	0.04	1.0	5.0
Chloride	Calc (W)	10	mg/kg	N	<10	800.0	15000.0	25000.0
Chromium	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.5	10.0	70.0
Copper	Calc WAC ICP/MS	0.0050	mg/kg	N	0.014	2.0	50.0	100.0
Dissolved Organic Carbon	Calc	10	mg/kg	N	41	500.0	800.0	1000.0
Fluoride	Calc (W)	0.50	mg/kg	N	0.62	10.0	150.0	500.0
Lead	Calc WAC ICP/MS	0.0030	mg/kg	N	<0.0030	0.5	10.0	50.0
Mercury	Calc WAC ICP/MS	0.00050	mg/kg	N	<0.00050	0.01	0.2	2.0
Molybdenum	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.5	10.0	30.0
Nickel	Calc WAC ICP/MS	0.010	mg/kg	N	<0.010	0.4	10.0	40.0
Phenols (Total-Mono)	Calc	1.0	mg/kg	N	<1.0	1.0		
Selenium	Calc WAC ICP/MS	0.0050	mg/kg	N	<0.0050	0.1	0.5	7.0
Sulphate	Calc (W)	5	mg/kg	N	51	1000.0	20000.0	50000.0
Total Dissolved Solids	Calc	1000	mg/kg	N	<1000	4000.0	60000.0	100000.0
Zinc	Calc WAC ICP/MS	0.020	mg/kg	N	0.029	4.0	50.0	200.0

Following the recommendation from the Environment Agency (England and Wales)*, the leachate preparation in this report has been carried out to BS EN 12457-2 : One Stage batch test at a liquid to solid ratio of 10 l/kg. This is also compliant with Schedule 10 of the Environmental Permitting Regulations 2010.

Note : This is the minimum amount of testing which is required.

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Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
MCERTS Preparation

				Concept Reference	773858 001	773858 002	773858 005	773858 006	773858 007
				Customer Sample Reference	TP02	TP05	TP08	TP03	TP03
				Test Sample	AR	AR	AR	AR	AR
				Top Depth	0.2	0.5	0.1	0.1	0.9
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Clay	Clay
Determinand	Method	LOD	Units	Symbol					
Moisture @105C	Grav (1 Dec) (105 C)	0.1	%	N	27	19	33	28	18

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
MCERTS Preparation

				Concept Reference	773858 008	773858 009	773858 010	773858 011	773858 012
				Customer Sample Reference	TP04	TP04	TP01	TP10	TP09
				Test Sample	AR	AR	AR	AR	AR
				Top Depth	0.2	0.5	0.1	0.1	0.6
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol					
Moisture @105C	Grav (1 Dec) (105 C)	0.1	%	N	31	20	35	27	17

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
MCERTS Preparation

				Concept Reference	773858 013	773858 014	773858 018	773858 019
				Customer Sample Reference	TP09	TP07	TP02	TP08
				Test Sample	AR	AR	AR	AR
				Top Depth	0.1	0.2	0.6	0.4
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Topsoil	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol				
Moisture @105C	Grav (1 Dec) (105 C)	0.1	%	N	19	35	15	16

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
MCERTS Preparation

				Concept Reference	773858 001	773858 002	773858 005	773858 006	773858 007
				Customer Sample Reference	TP02	TP05	TP08	TP03	TP03
				Test Sample	M40	M40	M40	M40	M40
				Top Depth	0.2	0.5	0.1	0.1	0.9
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Clay	Clay
Determinand	Method	LOD	Units	Symbol					
Retained on 10mm sieve	Grav	0.1	%	N	<0.1	<0.1	<0.1	<0.1	<0.1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
MCERTS Preparation

				Concept Reference	773858 008	773858 009	773858 010	773858 011	773858 012
				Customer Sample Reference	TP04	TP04	TP01	TP10	TP09
				Test Sample	M40	M40	M40	M40	M40
				Top Depth	0.2	0.5	0.1	0.1	0.6
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol					
Retained on 10mm sieve	Grav	0.1	%	N	<0.1	<0.1	<0.1	<0.1	<0.1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
MCERTS Preparation

				Concept Reference	773858 013	773858 014	773858 018	773858 019
				Customer Sample Reference	TP09	TP07	TP02	TP08
				Test Sample	M40	M40	M40	M40
				Top Depth	0.1	0.2	0.6	0.4
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Topsoil	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol				
Retained on 10mm sieve	Grav	0.1	%	N	<0.1	<0.1	<0.1	<0.1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
BTEX

				Concept Reference	773858 002	773858 018	773858 019
				Customer Sample Reference	TP05	TP02	TP08
				Test Sample	M105	M105	M105
				Top Depth	0.5	0.6	0.4
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Clay	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol			
Benzene	GC/MS (Head Space)(MCERTS)	10	µg/kg	M	[13] <10	[13] <10	[13] <10
Toluene	GC/MS (Head Space)(MCERTS)	10	µg/kg	M	19	<10	<10
EthylBenzene	GC/MS (Head Space)(MCERTS)	10	µg/kg	M	<10	<10	<10
Meta/Para-Xylene	GC/MS (Head Space)(MCERTS)	10	µg/kg	M	<10	<10	<10
Ortho-Xylene	GC/MS (Head Space)(MCERTS)	10	µg/kg	M	<10	<10	<10

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
PCB EC7

				Concept Reference	773858 002	773858 018	773858 019
				Customer Sample Reference	TP05	TP02	TP08
				Test Sample	AR	AR	AR
				Top Depth	0.5	0.6	0.4
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Clay	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol			
Polychlorinated biphenyl BZ#101	GC/MS (SIR)	1	µg/kg	M	<1	<1	<1
Polychlorinated biphenyl BZ#118	GC/MS (SIR)	1	µg/kg	M	<1	<1	<1
Polychlorinated biphenyl BZ#138	GC/MS (SIR)	1	µg/kg	M	<1	<1	<1
Polychlorinated biphenyl BZ#153	GC/MS (SIR)	1	µg/kg	M	<1	<1	<1
Polychlorinated biphenyl BZ#180	GC/MS (SIR)	1	µg/kg	M	<1	<1	<1
Polychlorinated biphenyl BZ#28	GC/MS (SIR)	1	µg/kg	M	<1	<1	<1
Polychlorinated biphenyl BZ#52	GC/MS (SIR)	1	µg/kg	M	<1	<1	<1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Total and Speciated USEPA16 PAH

				Concept Reference	773858 002	773858 018	773858 019
				Customer Sample Reference	TP05	TP02	TP08
				Test Sample	M105	M105	M105
				Top Depth	0.5	0.6	0.4
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Clay	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol			
Naphthalene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Acenaphthylene	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	<0.1
Acenaphthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Fluorene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Phenanthrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Anthracene	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	<0.1
Fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Benzo(a)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Chrysene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Benzo(b/k)Fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Benzo(a)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Indeno(123-cd)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Dibenzo(ah)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Benzo(ghi)Perylene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1
Polyaromatic Hydrocarbons (Total)	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	<0.1
Coronene	GC/MS	0.1	mg/kg	N	<0.1	<0.1	<0.1
Phenol	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Total Petroleum Hydrocarbons

				Concept Reference	773858 002	773858 018	773858 019
				Customer Sample Reference	TP05	TP02	TP08
				Test Sample	M105	M105	M105
				Top Depth	0.5	0.6	0.4
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Clay	Sandy Soil	Clay
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Total Petroleum Hydrocarbons	GC/FID	1	mg/kg	M	(13) 4	(13) 3	(13) 2
Total Petroleum Hydrocarbons (C35-C40)	GC/FID	1	mg/kg	N	(13) <1	(13) <1	(13) <1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

				Concept Reference	773858 001	773858 002	773858 005	773858 006	773858 007
				Customer Sample Reference	TP02	TP05	TP08	TP03	TP03
				Test Sample	A40	A40	A40	A40	A40
				Top Depth	0.2	0.5	0.1	0.1	0.9
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Clay	Clay
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
pH	Probe			M	5.9	6.0	5.0	5.8	5.5
(Water Soluble) Sulphate expressed as SO4	2:1 Extraction/ICP/OES (TRL 447 T1)	0.05	g/l	M	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphate (Total)	ICP/OES (HCl extract)	0.01	%	M	0.06	0.03	0.05	0.07	0.02
Soil Organic Matter	Calc TOC/0.58	0.1	%	N	7.4	2.7	5.6	8.2	2.2
Total Organic Carbon	OX/IR	0.1	%	N	4.3	1.5	3.2	4.7	1.3

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

				Concept Reference	773858 008	773858 009	773858 010	773858 011	773858 012
				Customer Sample Reference	TP04	TP04	TP01	TP10	TP09
				Test Sample	A40	A40	A40	A40	A40
				Top Depth	0.2	0.5	0.1	0.1	0.6
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Sandy Soil	Clay
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
pH	Probe			M	5.8	4.7	5.4	6.1	7.9
(Water Soluble) Sulphate expressed as SO4	2:1 Extraction/ICP/OES (TRL 447 T1)	0.05	g/l	M	<0.05	<0.05	<0.05	<0.05	0.06
Sulphate (Total)	ICP/OES (HCl extract)	0.01	%	M	0.06	0.04	0.08	0.06	0.05
Soil Organic Matter	Calc TOC/0.58	0.1	%	N	5.9	1.5	8.1	6.7	3.7
Total Organic Carbon	OX/IR	0.1	%	N	3.4	0.8	4.7	3.9	2.1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

Concept Reference	773858 013	773858 014
Customer Sample Reference	TP09	TP07
Test Sample	A40	A40
Top Depth	0.1	0.2
Date Sampled	02-OCT-2018	02-OCT-2018
Matrix Class	Topsoil	Topsoil

Determinand	Method	LOD	Units	Symbol		
pH	Probe			M	7.9	6.3
(Water Soluble) Sulphate expressed as SO4	2:1 Extraction/ICP/OES (TRL 447 T1)	0.05	g/l	M	<0.05	<0.05
Sulphate (Total)	ICP/OES (HCl extract)	0.01	%	M	0.05	0.07
Soil Organic Matter	Calc TOC/0.58	0.1	%	N	1.6	14
Total Organic Carbon	OX/IR	0.1	%	N	0.9	8.3

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

Concept Reference					773858 001	773858 002	773858 005	773858 006	773858 007
Customer Sample Reference					TP02	TP05	TP08	TP03	TP03
Test Sample					AR	AR	AR	AR	AR
Top Depth					0.2	0.5	0.1	0.1	0.9
Date Sampled					02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
Matrix Class					Topsoil	Clay	Topsoil	Clay	Clay
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Phenols (Total-Mono)	Colorimetry (CF)	1	mg/kg	M	<1	<1	<1	<1	<1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

Concept Reference					773858 008	773858 009	773858 010	773858 011	773858 012
Customer Sample Reference					TP04	TP04	TP01	TP10	TP09
Test Sample					AR	AR	AR	AR	AR
Top Depth					0.2	0.5	0.1	0.1	0.6
Date Sampled					02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
Matrix Class					Topsoil	Clay	Topsoil	Sandy Soil	Clay
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Phenols (Total-Mono)	Colorimetry (CF)	1	mg/kg	M	<1	<1	<1	<1	<1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

Concept Reference					773858 013	773858 014
Customer Sample Reference					TP09	TP07
Test Sample					AR	AR
Top Depth					0.1	0.2
Date Sampled					02-OCT-2018	02-OCT-2018
Matrix Class					Topsoil	Topsoil
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Phenols (Total-Mono)	Colorimetry (CF)	1	mg/kg	M	<1	<1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

				Concept Reference	773858 001	773858 002	773858 005	773858 006	773858 007
				Customer Sample Reference	TP02	TP05	TP08	TP03	TP03
				Test Sample	M105	M105	M105	M105	M105
				Top Depth	0.2	0.5	0.1	0.1	0.9
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Clay	Clay
Determinand	Method	LOD	Units	Symbol					
Acenaphthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	0.2	<0.1	<0.1	<0.1	<0.1
Benzo(a)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	0.2	<0.1	<0.1	<0.1	<0.1
Benzo(b)fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	0.2	<0.1	<0.1	<0.1	<0.1
Benzo(k)fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	0.2	<0.1	<0.1	<0.1	<0.1
Benzo(ghi)Perylene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	GC/MS (MCERTS)	0.1	mg/kg	M	0.2	<0.1	<0.1	<0.1	<0.1
Dibenzo(ah)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	0.5	<0.1	<0.1	<0.1	<0.1
Fluorene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(123-cd)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	<0.1
Naphthalene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	GC/MS (MCERTS)	0.1	mg/kg	M	0.3	<0.1	<0.1	<0.1	<0.1
Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	0.4	<0.1	<0.1	<0.1	<0.1
Polyaromatic Hydrocarbons (Total)	GC/MS (MCERTS)	0.1	mg/kg	U	2.2	<0.1	<0.1	<0.1	<0.1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

				Concept Reference	773858 008	773858 009	773858 010	773858 011	773858 012
				Customer Sample Reference	TP04	TP04	TP01	TP10	TP09
				Test Sample	M105	M105	M105	M105	M105
				Top Depth	0.2	0.5	0.1	0.1	0.6
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol					
Acenaphthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	0.1
Acenaphthylene	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	<0.1	<0.1	0.5
Benzo(a)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	0.2	<0.1	1.2
Benzo(a)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	0.8
Benzo(b)fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	0.8
Benzo(k)fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	0.2	<0.1	0.9
Benzo(ghi)Perylene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	0.4
Chrysene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	0.2	<0.1	1.3
Dibenzo(ah)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	0.2
Fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	0.4	0.2	1.9
Fluorene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	0.2
Indeno(123-cd)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	0.4
Naphthalene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	<0.1	<0.1	1.8
Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1	0.3	0.1	1.6
Polyaromatic Hydrocarbons (Total)	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1	1.2	0.3	12

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

Concept Reference	773858 013	773858 014
Customer Sample Reference	TP09	TP07
Test Sample	M105	M105
Top Depth	0.1	0.2
Date Sampled	02-OCT-2018	02-OCT-2018
Matrix Class	Topsoil	Topsoil

Determinand	Method	LOD	Units	Symbol		
Acenaphthene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1
Acenaphthylene	GC/MS (MCERTS)	0.1	mg/kg	U	<0.1	<0.1
Anthracene	GC/MS (MCERTS)	0.1	mg/kg	U	0.2	<0.1
Benzo(a)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	1.1	0.2
Benzo(a)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	0.8	0.2
Benzo(b)fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	0.8	0.2
Benzo(k)fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	0.9	0.2
Benzo(ghi)Perylene	GC/MS (MCERTS)	0.1	mg/kg	M	0.4	<0.1
Chrysene	GC/MS (MCERTS)	0.1	mg/kg	M	1.1	0.2
Dibenzo(ah)Anthracene	GC/MS (MCERTS)	0.1	mg/kg	M	0.2	<0.1
Fluoranthene	GC/MS (MCERTS)	0.1	mg/kg	M	1.7	0.4
Fluorene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1
Indeno(123-cd)Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	0.4	<0.1
Naphthalene	GC/MS (MCERTS)	0.1	mg/kg	M	<0.1	<0.1
Phenanthrene	GC/MS (MCERTS)	0.1	mg/kg	M	1.0	0.3
Pyrene	GC/MS (MCERTS)	0.1	mg/kg	M	1.5	0.3
Polyaromatic Hydrocarbons (Total)	GC/MS (MCERTS)	0.1	mg/kg	U	10	1.9

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

Concept Reference	773858 001	773858 002	773858 005	773858 006	773858 007
Customer Sample Reference	TP02	TP05	TP08	TP03	TP03
Test Sample	M40	M40	M40	M40	M40
Top Depth	0.2	0.5	0.1	0.1	0.9
Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
Matrix Class	Topsoil	Clay	Topsoil	Clay	Clay

Determinand	Method	LOD	Units	Symbol					
Arsenic	ICP/OES	2	mg/kg	M	17	12	16	11	9
Cadmium	ICP/OES	1	mg/kg	M	<1	<1	<1	<1	<1
Chromium	ICP/OES	1	mg/kg	M	18	18	19	18	23
Copper	ICP/OES	1	mg/kg	M	26	29	30	19	24
Lead	ICP/OES	1	mg/kg	M	48	18	39	40	15
Mercury	ICP/OES	1	mg/kg	M	<1	<1	<1	<1	<1
Nickel	ICP/OES	1	mg/kg	M	22	20	21	14	18
Selenium	ICP/OES	3	mg/kg	M	<3	<3	<3	<3	<3
Zinc	ICP/OES	1	mg/kg	M	45	32	40	52	28

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

				Concept Reference	773858 008	773858 009	773858 010	773858 011	773858 012
				Customer Sample Reference	TP04	TP04	TP01	TP10	TP09
				Test Sample	M40	M40	M40	M40	M40
				Top Depth	0.2	0.5	0.1	0.1	0.6
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Sandy Soil	Clay
Determinand	Method	LOD	Units	Symbol					
Arsenic	ICP/OES	2	mg/kg	M	16	12	16	18	13
Cadmium	ICP/OES	1	mg/kg	M	<1	<1	<1	<1	<1
Chromium	ICP/OES	1	mg/kg	M	20	23	17	20	19
Copper	ICP/OES	1	mg/kg	M	26	28	22	31	33
Lead	ICP/OES	1	mg/kg	M	39	17	46	45	28
Mercury	ICP/OES	1	mg/kg	M	<1	<1	<1	<1	<1
Nickel	ICP/OES	1	mg/kg	M	16	17	15	23	22
Selenium	ICP/OES	3	mg/kg	M	<3	<3	<3	<3	<3
Zinc	ICP/OES	1	mg/kg	M	38	30	45	44	39

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Sirius Soil Suite 1

				Concept Reference	773858 013	773858 014
				Customer Sample Reference	TP09	TP07
				Test Sample	M40	M40
				Top Depth	0.1	0.2
				Date Sampled	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Topsoil
Determinand	Method	LOD	Units	Symbol		
Arsenic	ICP/OES	2	mg/kg	M	15	24
Cadmium	ICP/OES	1	mg/kg	M	<1	<1
Chromium	ICP/OES	1	mg/kg	M	19	18
Copper	ICP/OES	1	mg/kg	M	25	29
Lead	ICP/OES	1	mg/kg	M	35	55
Mercury	ICP/OES	1	mg/kg	M	<1	<1
Nickel	ICP/OES	1	mg/kg	M	22	18
Selenium	ICP/OES	3	mg/kg	M	<3	<3
Zinc	ICP/OES	1	mg/kg	M	48	65

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Miscellaneous

				Concept Reference	773858 001	773858 002	773858 005	773858 006	773858 007	773858 008
				Customer Sample Reference	TP02	TP05	TP08	TP03	TP03	TP04
				Test Sample	A40	A40	A40	A40	A40	A40
				Top Depth	0.2	0.5	0.1	0.1	0.9	0.2
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Topsoil	Clay	Topsoil	Clay	Clay	Topsoil
Determinand	Method	LOD	Units	Symbol						
Asbestos ID	PLM			SU	Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected
pH	Probe			U	5.9	6.0	5.0	5.8	5.5	5.8
(Water Soluble) Sulphate expressed as SO4	2:1 Extraction/ICP/OES (TRL 447 T1)	0.05	g/l	M	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Miscellaneous

				Concept Reference	773858 009	773858 010	773858 011	773858 012	773858 013	773858 014
				Customer Sample Reference	TP04	TP01	TP10	TP09	TP09	TP07
				Test Sample	A40	A40	A40	A40	A40	A40
				Top Depth	0.5	0.1	0.1	0.6	0.1	0.2
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Clay	Topsoil	Sandy Soil	Clay	Topsoil	Topsoil
Determinand	**Method**	**LOD**	**Units**	**Symbol**						
Asbestos ID	PLM			SU	Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected
pH	Probe			U	4.7	5.4	6.1	7.9	7.9	6.3
(Water Soluble) Sulphate expressed as SO4	2:1 Extraction/ICP/OES (TRL 447 T1)	0.05	g/l	M	<0.05	<0.05	<0.05	0.06	<0.05	<0.05

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Soil Analysed as Soil
Miscellaneous

				Concept Reference	773858 003	773858 004	773858 015	773858 016	773858 017
				Customer Sample Reference	TP05	TP02	TP08	TP03	CPR 02
				Test Sample	AR	AR	AR	AR	AR
				Top Depth	1.2	0.5	1.5	1.5	2
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018	02-OCT-2018	01-OCT-2018
				Matrix Class					
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Calorific Value (Gross) (Moisture Free)	Bomb calorimetry (based on BS EN 15408:2011) (Moisture Free)	0.1	MJ/kg	N	0.4	0.4	<0.1	<0.1	<0.1

Concept Reference: 773858
Project Site: Harras Moor, Whitehaven
Customer Reference: C7728

Leachate to BS EN 12457-2 (10:1) Analysed as Water
Waste Acceptance Criteria

				Concept Reference	773858 002	773858 018	773858 019
				Customer Sample Reference	TP05	TP02	TP08
				Test Sample	10:1	10:1	10:1
				Top Depth	0.5	0.6	0.4
				Date Sampled	02-OCT-2018	02-OCT-2018	02-OCT-2018
				Matrix Class	Clay	Sandy Soil	Clay
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Arsenic (Dissolved)	ICP/MS (Filtered)	0.2	µg/l	U	<0.2	<0.2	0.3
Barium (Dissolved)	ICP/MS (Filtered)	1	µg/l	U	6	13	12
Molybdenum (Dissolved)	ICP/MS (Filtered)	1	µg/l	N	<1	<1	<1
Total Dissolved Solids	Grav	100	mg/l	N	<100	<100	<100
Phenols (Total-Mono)	Colorimetry	0.1	mg/l	U	<0.1	<0.1	<0.1
Dissolved Organic Carbon	OX/IR	1	mg/l	N	<1	3	4
Electrical Conductivity	Probe	10	µS/cm	N	23	21	23
Antimony (Dissolved)	ICP/MS (Filtered)	1	µg/l	U	<1	<1	<1
Cadmium (Dissolved)	ICP/MS (Filtered)	0.02	µg/l	U	<0.02	<0.02	<0.02
Chromium (Dissolved)	ICP/MS (Filtered)	1	µg/l	U	<1	<1	<1
Copper (Dissolved)	ICP/MS (Filtered)	0.5	µg/l	U	<0.5	1.4	1.4
Lead (Dissolved)	ICP/MS (Filtered)	0.3	µg/l	U	<0.3	<0.3	<0.3
Mercury (Dissolved)	ICP/MS (Filtered)	0.05	µg/l	U	<0.05	<0.05	<0.05
Nickel (Dissolved)	ICP/MS (Filtered)	1	µg/l	U	<1	1	<1
Selenium (Dissolved)	ICP/MS (Filtered)	0.5	µg/l	U	<0.5	<0.5	<0.5
Zinc (Dissolved)	ICP/MS (Filtered)	2	µg/l	U	4	4	3
Chloride	Discrete Analyser	1	mg/l	U	<1	<1	<1
Fluoride	Discrete Analyser	0.05	mg/l	U	<0.05	<0.05	0.06
Sulphate	Discrete Analyser	0.5	mg/l	U	5.6	4.9	5.1

Index to symbols used in 773858-1

Value	Description
A40	Assisted dried < 40C
10:1	Leachate to BS EN 12457-2 (10:1)
10:1 S	Data for BS EN 12457-2 (10:1)
AR	As Received
M40	Analysis conducted on sample assisted dried at no more than 40C. Results are reported on a dry weight basis.
M105	Analysis conducted on an "as received" aliquot. Results are reported on a dry weight basis where moisture content was determined by assisted drying of sample at 105C
13	Results have been blank corrected.
S	Analysis was subcontracted
M	Analysis is MCERTS accredited
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited

Notes

Asbestos was subcontracted to REC Asbestos.

LABORATORY REPORT

4043

Contract Number: PSL18/5341

Report Date: 06 November 2018

Client's Reference: C7728

Client Name: Sirius Durham
Suite 2, Russel House
Mill Road
Langley Moor
Durham
DH7 8HJ

For the attention of: Dan Gallagher

Contract Title: Harras Moor, Whitehaven

Date Received: 17/10/2018
Date Commenced: 17/10/2018
Date Completed: 5/11/2018

Notes: **Opinions and Interpretations are outside the UKAS Accreditation**

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced other than in full, without the prior written approval of the laboratory.

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SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
TP04		D	0.50		Brown mottled grey slightly gravelly sandy CLAY.
TP01		D	0.70		Brown mottled grey slightly gravelly sandy CLAY.
TP06		D	0.80		Brown very sandy GRAVEL.
TP10		D	1.30		Brown highly weathered MUDSTONE.
TP09		D	1.00		Brown slightly gravelly sandy CLAY.
TP09		D	2.00		Brown mottled grey slightly gravelly sandy CLAY.
TP07		D	0.90		Brown slightly gravelly sandy CLAY.
TP04		D	1.20		Brown very sandy very clayey GRAVEL.

SUMMARY OF SOIL CLASSIFICATION TESTS

(BS1377 : PART 2 : 1990)

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Moisture Content % Clause 3.2	Linear Shrinkage % Clause 6.5	Particle Density Mg/m^3 Clause 8.2	Liquid Limit % Clause 4.3/4	Plastic Limit % Clause 5.3	Plasticity Index % Clause 5.4	Passing .425mm %	Remarks
TP04		D	0.50		28			47	23	24	96	Intermediate plasticity CI.
TP01		D	0.70		23			43	22	21	94	Intermediate plasticity CI.
TP06		D	0.80		13				NP			
TP10		D	1.30		13			39	22	17	82	Intermediate plasticity CI.
TP09		D	1.00		24			41	21	20	95	Intermediate plasticity CI.
TP09		D	2.00		22			41	20	21	96	Intermediate plasticity CI.
TP07		D	0.90		27			47	22	25	96	Intermediate plasticity CI.
TP04		D	1.20		15			33	18	15	46	Low plasticity CL.

SYMBOLS : **NP : Non Plastic** *** : Liquid Limit and Plastic Limit Wet Sieved.**

UKAS TESTING 4043

PSL Professional Soils Laboratory

Harras Moor, Whitehaven

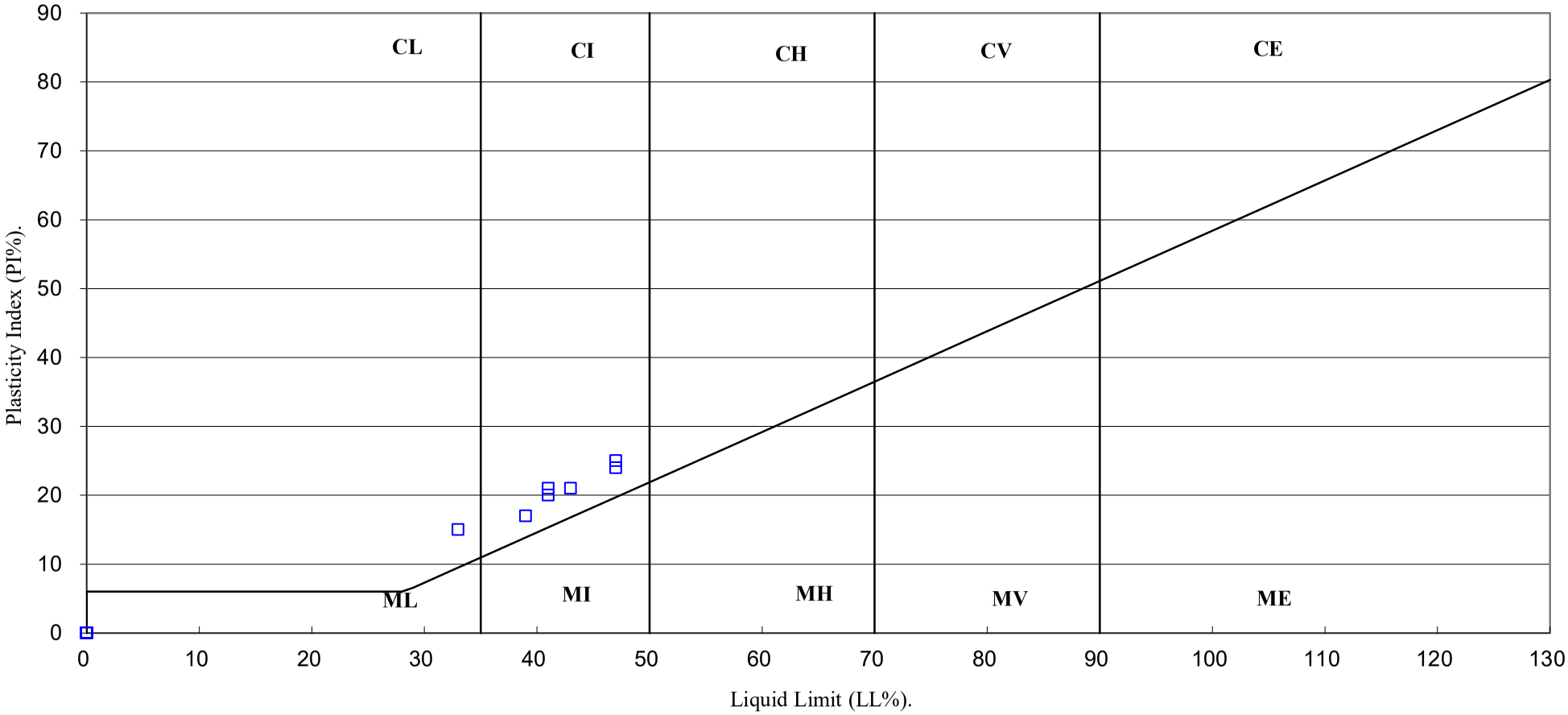
Contract No:

PSL18/5341

Client Ref:

C7728

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.



UKAS TESTING 4043	PSL Professional Soils Laboratory	Harras Moor, Whitehaven	Contract No: PSL18/5341 Client Ref: C7728

APPENDIX E

GROUND GAS AND GROUNDWATER MONITORING RESULTS

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Client: Michael Little **Job No:** C7728
Site: Harras Moor, Whitehaven **Visit No:** 1 **of** 6
Date: 16/10/2018 **Operator:** DB **Project Manager:** GA

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Qhg per borehole		WELL AND WATER DATA					Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Top of BH (mAOD)	Water level (mAOD)	Response Zone	
	Peak	Steady	Peak	Steady	Peak	**Steady**	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady										
CP01	**ND**	ND	ND	ND	17.4	**17.4**	ND	ND	ND	ND	2.4	2.4	NR	NR	ND	ND			0.0001	0.0174	DRY	4.62				
CPR02	**ND**	ND	ND	ND	14.8	**14.8**	ND	ND	ND	ND	3.7	3.7	NR	NR	ND	ND			0.0001	0.0148	20.62	20.92				
CP03	**ND**	ND	ND	ND	2.1	**2.1**	ND	ND	ND	ND	15.7	15.7	NR	NR	ND	ND			0.0001	0.0021	4.92	5.08				
R05	**ND**	ND	ND	ND	2.4	**2.4**	ND	ND	ND	ND	7.2	7.2	NR	NR	ND	ND			0.0001	0.0024	2.58	5.17				
R03	**ND**	ND	ND	ND	0.4	**0.4**	ND	ND	ND	ND	18.9	18.9	NR	NR	ND	ND			0.0001	0.0004	3.10	5.32				
R02	**5.2**	5.2	>>>>	>>>>	13.2	**13.2**	ND	ND	ND	ND	2.1	2.1	NR	NR	ND	ND			0.0052	0.0132	4.33	5.12				
PIEZO	**NR**	NR	NR	NR	NR	**NR**	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR			NR	NR	DRY	>35				Old borehole in northwest of site
Max	**5.2**	**5.2**	**ND**	**ND**	**17.4**	**17.4**	**ND**	**ND**	**ND**	**ND**	**18.9**	**18.9**	**NR**	**NR**	**ND**	**ND**	**NR**	**NR**	**0.0052**	**0.0174**	**20.62**			**NR**		
Min	**ND**	**ND**	**ND**	**ND**	**0.4**	**0.4**	**ND**	**ND**	**ND**	**ND**	**2.1**	**2.1**	**NR**	**NR**	**ND**	**ND**	**NR**	**NR**	**0.0001**	**0.0004**	**DRY**			**NR**		

ND - Not detected

NR - Not recorded

NB: Where no flow (ND) recorded, Qhg values are calculated using equiment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of Qhg.

METEOROLOGICAL AND SITE INFORMATION: (Select correct box with X or enter data, as applicable)

State of ground:		Dry		Moist	X	Wet		Snow		Frozen
Wind:		Calm		Light	X	Moderate		Strong		
Cloud cover:		None		Slight		Cloudy	X	Overcast		
Precipitation:		None	X	Slight		Moderate		Heavy		
Time monitoring performed:				Start				End		
Barometric pressure (mbar):			994	Start			994	End		
Pressure trend (Daily):				Falling		Steady	X	Rising		
Source:	weatheronline.co.uk									
Air Temperature (Deg. C):			11	Before			12	After		

INSTRUMENTATION TECHNICAL SPECIFICATIONS:

Ground gas meter: GFM436-12746
Gas Range: **CH_4** **CO_2** **O_2**
Gas Flow range:
Differential Pressure:
Date of last calibration: 01/10/2018
Date of next calibration: 05/11/2018

Ambient air check: **CH_4** ND **CO_2** ND **O_2** 19.4

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Client: Michael Little **Job No:** C7728
Site: Harras Moor, Whitehaven **Visit No:** 2 **of** 6
Date: 30/10/2018 **Operator:** DB **Project Manager:** GA

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Qhg per borehole		WELL AND WATER DATA					Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Top of BH (mAOD)	Water level (mAOD)	Response Zone	
	Peak	Steady	Peak	Steady	Peak	**Steady**	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady										
CP01	**ND**	ND	ND	ND	19.9	**20.0**	ND	ND	ND	ND	0.8	0.8	NR	NR	ND	ND		20	0.0001	0.0200	4.79	5.06				
CPR02	**ND**	ND	ND	ND	16.3	**16.3**	ND	ND	ND	ND	0.4	0.4	NR	NR	0.1	ND	0.0	0	0.0001	0.0163	20.57	21.00				
CP03	**ND**	ND	ND	ND	10.0	**9.9**	ND	ND	ND	ND	0,7	0.5	NR	NR	11.5	11.5	0.0	20	0.0115	1.1385	4.98	5.08				
R05	**ND**	ND	ND	ND	8.0	**8.1**	ND	ND	ND	ND	1.7	1.6	NR	NR	1.7	1.6	21.0	150	0.0017	0.1296	2.94	5.17				
R03	**ND**	ND	ND	ND	6.2	**6.2**	ND	ND	ND	ND	13.7	13.7	NR	NR	6.6	ND	0.0	20	0.0066	0.0062	4.36	5.32				
R02	**14.5**	14.5	>>>>	>>>>	11.9	**11.9**	ND	ND	ND	ND	0.8	0.8	NR	NR	0.1	ND	0.0	20	0.0145	0.0119	4.35	5.12				
Max	**14.5**	**14.5**	**ND**	**ND**	**19.9**	**20.0**	**ND**	**ND**	**ND**	**ND**	**13.7**	**13.7**	**NR**	**NR**	**11.5**	**11.5**	**21.0**	**150**	**0.0145**	**1.1385**	**20.57**			**NR**		
Min	**ND**	**ND**	**ND**	**ND**	**6.2**	**6.2**	**ND**	**ND**	**ND**	**ND**	**0.4**	**0.4**	**NR**	**NR**	**0.1**	**1.6**	**0.0**	**0**	**0.0001**	**0.0062**	**2.94**			**NR**		

ND - Not detected

NR - Not recorded

NB: Where no flow (ND) recorded, Qhg values are calculated using equiment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of Qhg.

METEOROLOGICAL AND SITE INFORMATION: (Select correct box with X or enter data, as applicable)

State of ground:		Dry		Moist	X	Wet		Snow		Frozen
Wind:		Calm	X	Light		Moderate		Strong		
Cloud cover:		None	X	Slight		Cloudy		Overcast		
Precipitation:	X	None		Slight		Moderate		Heavy		
Time monitoring performed:			1PM	Start			3PM	End		
Barometric pressure (mbar):			983	Start			983	End		
Pressure trend (Daily):			X	Falling		Steady		Rising		
Source:	weatheronline.co.uk									
Air Temperature (Deg. C):			16	Before			12	After		

INSTRUMENTATION TECHNICAL SPECIFICATIONS:

Ground gas meter: GFM436-12746
Gas Range: **CH_4** **CO_2** **O_2**
Gas Flow range:
Differential Pressure:
Date of last calibration: 01/10/2018
Date of next calibration: 05/11/2018

Ambient air check: **CH_4** ND **CO_2** ND **O_2** 18.8

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Client: Michael Little **Job No:** C7728
Site: Harras Moor, Whitehaven **Visit No:** 3 **of** 6
Date: 13/11/2018 **Operator:** DB **Project Manager:** GA

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Qhg per borehole		WELL AND WATER DATA					Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Top of BH (mAOD)	Water level (mAOD)	Response Zone	
	Peak	Steady	Peak	Steady	Peak	**Steady**	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady										
CP01	**NR**	NR	NR	NR	NR	**NR**	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR			NR	NR		4.62				Underwater
CPR02	**ND**	ND	ND	ND	0.7	**0.7**	ND	ND	ND	ND	20.4	20.4	NR	NR	-40.8	ND			0.0408	0.0007	20.60	21.00				
CP03	**ND**	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	20.4	20.4	NR	NR	0.9	ND	0.0	20	0.0009	0.0001	4.96	5.08				
R05	**ND**	ND	ND	ND	14.8	**14.8**	ND	ND	ND	ND	2.2	2.2	NR	NR	-9.3	ND			0.0093	0.0148	3.20	5.17				
R03	**ND**	ND	ND	ND	10.2	**10.2**	ND	ND	ND	ND	3.9	3.9	NR	NR	-2.9	ND			0.0029	0.0102	4.89	5.32				
R02	**25.9**	25.9	>>>>	>>>>	17.4	**17.4**	ND	ND	ND	ND	1.3	1.3	NR	NR	ND	ND			0.0259	0.0174	4.27	5.12				
Max	**25.9**	**25.9**	**ND**	**ND**	**17.4**	**17.4**	**ND**	**ND**	**ND**	**ND**	**20.4**	**20.4**	**NR**	**NR**	**0.9**	**ND**	**0.0**	**20**	**0.0408**	**0.0174**	**20.60**				**NR**	
Min	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**1.3**	**1.3**	**NR**	**NR**	**-40.8**	**ND**	**0.0**	**20**	**0.0009**	**0.0001**	**3.20**				**NR**	

ND - Not detected

NR - Not recorded

NB: Where no flow (ND) recorded, Qhg values are calculated using equiment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of Qhg.

METEOROLOGICAL AND SITE INFORMATION: (Select correct box with X or enter data, as applicable)

State of ground:		Dry		Moist	X	Wet		Snow		Frozen
Wind:		Calm		Light	X	Moderate		Strong		
Cloud cover:		None	X	Slight		Cloudy		Overcast		
Precipitation:	X	None		Slight		Moderate		Heavy		
Time monitoring performed:			10AM	Start			12	End		
Barometric pressure (mbar):			994	Start			994	End		
Pressure trend (Daily):				Falling		Steady	X	Rising		
Source:	weatheronline.co.uk									
Air Temperature (Deg. C):			10	Before			12	After		

INSTRUMENTATION TECHNICAL SPECIFICATIONS:

Ground gas meter: GFM436-12746
Gas Range: **CH_4** **CO_2** **O_2**
Gas Flow range:
Differential Pressure:
Date of last calibration: 05/11/2018
Date of next calibration: 03/12/2018

Ambient air check: **CH_4** ND **CO_2** ND **O_2** 20.7

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Client: Michael Little **Job No:** C7728
Site: Harras Moor, Whitehaven **Visit No:** 4 **of** 6
Date: 27/11/2018 **Operator:** DB **Project Manager:** GA

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Qhg per borehole		WELL AND WATER DATA					Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Top of BH (mAOD)	Water level (mAOD)	Response Zone	
	Peak	Steady	Peak	Steady	Peak	**Steady**	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady										
CP01	**ND**	ND	ND	ND	49.4	**49.4**	ND	ND	ND	ND	0.4	0.4	NR	NR	ND	ND			0.0001	0.0494	3.37	4.62				
CPR02	**ND**	ND	ND	ND	26.2	**26.2**	ND	ND	ND	ND	1.2	1.2	NR	NR	0.1	ND	0.0	10	0.0001	0.0262	20.46	21.00				
CP03	**ND**	ND	ND	ND	29.5	**29.5**	ND	ND	ND	ND	1.1	1.1	NR	NR	25.2	ND	0.0	39	0.0252	0.0295	5.03	5.08				
R05	**ND**	ND	ND	ND	15.5	**15.5**	ND	ND	ND	ND	0.1	0.1	NR	NR	ND	ND			0.0001	0.0155	2.95	5.17				
R03	**ND**	ND	ND	ND	12.9	**12.9**	ND	ND	ND	ND	3.4	3.4	NR	NR	ND	ND			0.0001	0.0129	5.13	5.32				
R02	**24.1**	24.1	>>>>	>>>>	14.9	**14.9**	ND	ND	ND	ND	1.1	1.1	NR	NR	ND	ND			0.0241	0.0149	4.29	5.12				
Max	**24.1**	**24.1**	**ND**	**ND**	**49.4**	**49.4**	**ND**	**ND**	**ND**	**ND**	**3.4**	**3.4**	**NR**	**NR**	**25.2**	**ND**	**0.0**	**39**	**0.0252**	**0.0494**	**20.46**			**NR**		
Min	**ND**	**ND**	**ND**	**ND**	**12.9**	**12.9**	**ND**	**ND**	**ND**	**ND**	**0.1**	**0.1**	**NR**	**NR**	**0.1**	**ND**	**0.0**	**10**	**0.0001**	**0.0129**	**2.95**			**NR**		

ND - Not detected

NR - Not recorded

NB: Where no flow (ND) recorded, Qhg values are calculated using equiment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of Qhg.

METEOROLOGICAL AND SITE INFORMATION: (Select correct box with X or enter data, as applicable)

State of ground:		Dry		Moist	X	Wet		Snow		Frozen
Wind:		Calm		Light	X	Moderate		Strong		
Cloud cover:		None	X	Slight		Cloudy		Overcast		
Precipitation:	X	None		Slight		Moderate		Heavy		
Time monitoring performed:			9AM	Start			11	End		
Barometric pressure (mbar):			987	Start			987	End		
Pressure trend (Daily):			X	Falling		Steady		Rising		
Source:	weatheronline.co.uk									
Air Temperature (Deg. C):			6	Before			6	After		

INSTRUMENTATION TECHNICAL SPECIFICATIONS:

Ground gas meter: GFM436-12746
Gas Range: **CH_4** **CO_2** **O_2**
Gas Flow range:
Differential Pressure:
Date of last calibration: 23/11/2018
Date of next calibration: 03/12/2018

Ambient air check: **CH_4** ND **CO_2** ND **O_2** 20.2

APPENDIX F

SIRIUS GENERIC ASSESSMENT CRITERIA

SIRIUS GENERIC ASSESSMENT CRITERIA

Context

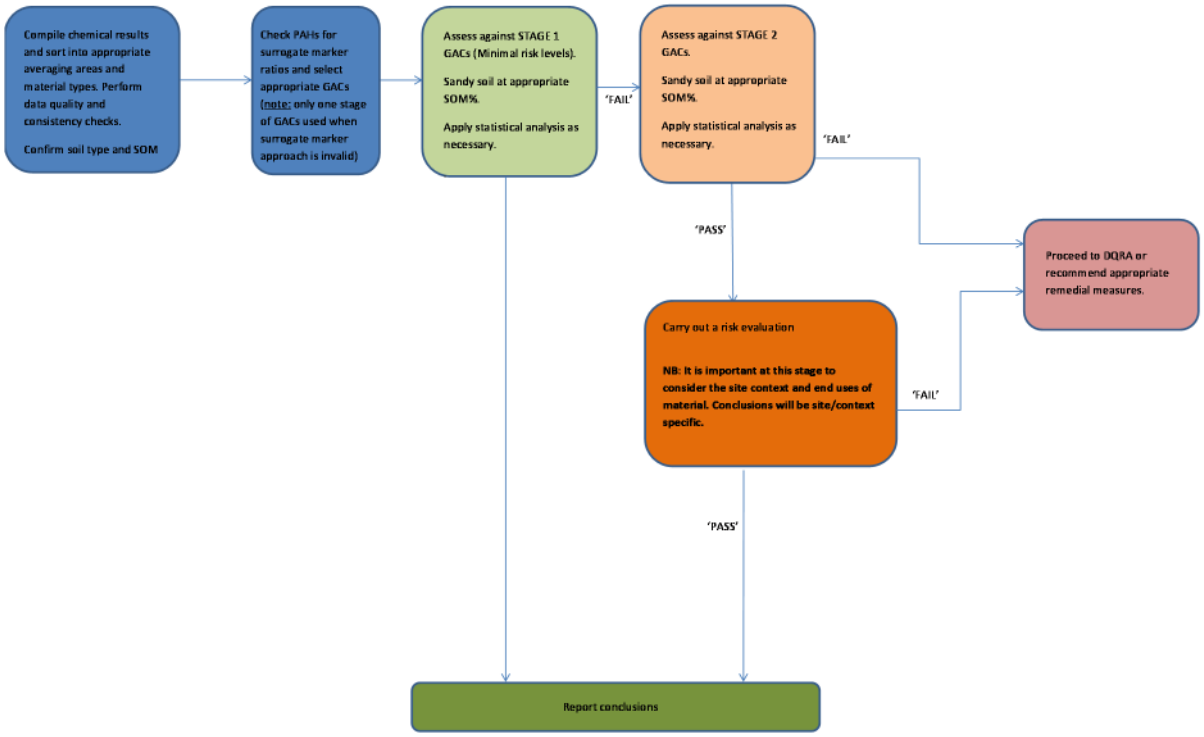
The framework for conducting site investigations, risk assessments and undertaking any necessary remedial works in the UK is provided by Environment Agency report CLR11 "Model Procedures for the Management of Contaminated Land". This presents a phased approach to risk assessment, involving: identification and qualitative assessment of potential pollutant linkages (source-pathway-receptor relationships) by means of a Conceptual Site Model; Generic Quantitative Risk Assessment (GQRA) of potentially significant pollutant links by comparing contaminant concentrations with appropriate Generic Assessment Criteria (GAC) values; and, if required, a Detailed Quantitative Risk Assessment (DQRA) based on site-specific conditions.

Assessment of Risk to Human Health

Introduction

A staged approach to GQRA has been adopted by Sirius for the evaluation of soil concentration data, as shown schematically in Figure 1.

Figure 1. GQRA Process.



The first stage of GQRA comprises assessment of the data against GAC values derived using toxicological parameter values based on "minimum risk". Any contaminants exceeding their GACs at this stage are further assessed against Stage 2 GACs, which have been derived using Low Level of Toxicological Concern (LLTC) criteria, where these are available.

With appropriate justification, a contaminant concentration that does not exceed the relevant Stage 2 GAC value may be considered to indicate that the land is "suitable for use". The appropriate use of LLTC-based criteria within the planning regime is considered reasonable by government agencies, as most recently highlighted in the letter (dated 3rd September 2014) to all local authorities from Lord de Mauley, Parliamentary Under Secretary at DEFRA.

A narrative "risk evaluation" must therefore accompany any Stage 2 assessment to justify the conclusions drawn. Where appropriate, this may provide a basis for eliminating from further consideration those contaminants whose concentrations do not exceed the applicable Stage 2 GAC value.

For the specific case of lead, the Category 4 Screening Level criteria given in CL:AIRE (2014)[1] have been adopted directly as GACs, as these are considered to be based on expert interpretation of current toxicological evidence.

In some areas, background concentrations of lead, other metals and metalloids, and/or individual PAHs may exceed their respective GACs and it may be appropriate to consider relative site and background concentration data as part of a more detailed assessment of the data.

Derivation of GACs

Except where otherwise stated, GACs have been derived by Sirius using CLEA version 1.071.

The GAC values have been derived for a sandy soil type, which will be conservative for the majority of soils (including made ground) encountered on historically contaminated sites. For organic contaminants of concern, criteria have been derived for a number of Soil Organic Matter (SOM) contents.

Genotoxic PAHs are assessed by the "Surrogate Method" using benzo(a)pyrene. Further information on this approach is given below.

Unless specifically stated, chemical properties and Health Criteria Values (HCVs) were obtained from:

- Environment Agency Science Report SC050021 series;
- Nathanail *et al*. (2009) "The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment", 2nd edition, Land Quality Press, Nottingham;
- CL:AIRE - AGS - EIC (2010) "Soil Generic Assessment Criteria for Human Health Risk Assessment". CL:AIRE, London.

GACs for arsenic, benzene, benzo(a)pyrene, cadmium and chromium (VI) have been derived using the

[1] CL:AIRE (2014) "Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination", Report SP1010, rev. 2.

Low Level of Toxicological Concern (LLTC) criteria given in CL:AIRE (2013). These criteria are considered a reasonable basis for assessment as they are still highly precautionary and definitely do not approach an intake level that could be defined as approaching Significant Possibility of Significant Harm to human health in the context of Part 2A of the Environmental Protection Act 1990. It must be further understood that the GACs derived will still incorporate a residual level of conservatism resulting from the exposure parameters used and the assumptions inherent in the model algorithms.

GACs for Genotoxic PAHs

Our approach to the assessment of genotoxic PAHs retains the use of benzo(a)pyrene as a surrogate marker. This approach for genotoxic PAHs is recommended by the HPA (2010)[2], which we consider to be the authoritative current guidance produced by a UK expert body and note that it was retained in the DEFRA Category 4 Screening Levels project (CL:AIRE, 2014).

The surrogate marker approach allows the assessment of the combined carcinogenic risk associated with all genotoxic PAHs[3] present as a mixture within soil, even though detailed toxicological information for many of the individual compounds may be lacking. The approach is based on determining the risk posed by the genotoxic PAH mixture using the concentration of benzo(a)pyrene present as an indicator.

To use the GAC for benzo(a)pyrene as a surrogate marker, a number of requirements must be met (HPA, 2010):

- Benzo(a)pyrene must be present in all soil samples containing genotoxic PAHs for which this method of assessment is being used;
- A similar profile of the genotoxic PAHs relative to benzo(a)pyrene should be present in all of the samples being assessed;
- The PAH profile of PAHs in the soil samples should be similar to that present in the pivotal toxicity study on which toxicological criterion for benzo(a)pyrene was based (Culp et al., 1998[4]). Table 1 provides the basis for defining the acceptable range.

Data indicate that contaminated soils in the UK generally meet these criteria[5] but the assessor must review their dataset before adopting this approach. If the above criteria are not met, then the surrogate marker approach must not be adopted and individual GAC or SSAC values are to be applied.

[2] HPA (2010) "Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)", version 5.

[3] The genotoxic PAHs included in the USEPA PAH 16 analysis reported by analytical labs are: benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, benzo(a)pyrene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene.

[4] Culp, S. *et al*. (1998) Carcinogenesis, 19, 117-124.

[5] Bull, S. & Collins, C. (2013) Environ. Geochem. Health, 31, 101-109.

Table 1. Profile of Genotoxic PAHs Relative to Benzo(a)pyrene that are Considered Acceptable for Application of Benzo(a)pyrene as a Surrogate Marker.

PAH	Acceptable Ratio of PAH Concentration to Benzo(a)pyrene for Application of Surrogate Marker Assessment	
	Lower Limit	Upper Limit
Benz[a]anthracene	0.12	12.43
Benzo[b]fluoranthene	0.11	10.85
Benzo[k]fluoranthene	0.04	3.72
Benzo[g,h,i]perylene	0.08	8.22
Chrysene	0.12	11.61
Dibenz[a,h]anthracene	0.01	1.38
Indeno[1,2,3-c,d]pyrene	0.07	7.27

For further information see: HPA (2010).

Soil Criteria Set for Purposes Other Than Human Health Protection

The Sirius GACs for sulphate, total organic carbon (TOC) and calorific value are set on basis of risks other than human health and their exceedance does not indicate a potential risk to future site users:

- The GAC for sulphate content is based on potential detrimental effects on buried concrete[6] and must be assessed with reference to the soil pH;
- The GAC for TOC content is provided for indicative assessment of disposal options if off-site landfill of soil were to be considered. This GAC is set at the 'Inert' waste threshold and should be considered as being applied for information purposes only;
- The GAC for calorific value is set to assist in an initial assessment of the potential fire risk posed by made ground or natural soils containing elevated concentrations of potentially combustible organic matter.

Assessment criteria more stringent than those for human health may be set for specific purposes, for example, elimination of nuisance odours or ensuring that potentially mobile free-phase organic products are not present.

Controlled Waters

The Environment Agency's "Remedial Targets Methodology" (2006) provides a framework for assessing the potential for pollution of controlled waters and for deriving remedial target concentrations in soil and groundwater.

There are no generic groundwater or surface water quality standards that are applicable to all sites. Drinking Water Standards and Environmental Quality Standards (EQS) are used by Sirius as assessment criteria where they are appropriate to the contaminant linkages under consideration. Given that these standards apply at the receptor point, this is a conservative approach for samples collected at a source or along a transport pathway.

[6] BRE (2005) "Concrete in Aggressive Ground", Special Digest No. 1; 3rd Edition.

Soil Leachability

Sirius specifies that the analytical laboratory undertakes leachate preparation by BS EN 12475-2:2002. Where specific circumstances require a different method to be used, then this will be explained and justified within the report body text.

The results of leachate analysis are compared to the relevant GAC values for controlled waters.

The Sirius Group
Stage 1 Generic Assessment Criteria for Soils

Revision: 20th August 2015

Parameter	Residential (mg/kg, unless otherwise stated)						Commercial / Industrial (mg/kg, unless otherwise stated)			Note
	With Homegrown Produce			Without Homegrown Produce						
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	
Metals/Metalloids										
Arsenic (inorganic)	37			40			630			[1]
Cadmium	11			85			190			[2]
Chromium (III)	910			4000			8600			
Chromium (VI)	6.0			6.1			33			[3]
Copper	200			7100			68000			[4]
Lead	200			310			2300			[5]
Mercury (inorganic)	40			56			1100			[6]
Nickel	130			180			980			[7]
Selenium	250			430			12000			
Vanadium	410			1200			9000			
Zinc	450			40000			750000			[4]
Other Inorganics										
pH	<5 or >9			<5 or >9			<5 or >9			
Total Sulphate	2400			2400			2400			[8]
Water-Soluble Sulphate	0.5 g/l			0.5 g/l			0.5 g/l			[8]
Free Cyanide	34			34			1400			[9]
Organics										
PAHs										
Acenaphthene	200	490	920	2000	3600	4900	75000	92000	100000	
Acenaphthylene	170	400	760	2000	3600	4900	76000	93000	100000	
Anthracene	2300	5300	9400	30000	34000	36000	520000	540000	540000	[10]
Benzo(a)anthracene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Benzo(a)pyrene	2.1	2.1	2.2	2.3	2.3	2.3	27	27	27	[11]
Benzo(b)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Benzo(k)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Benzo(g,h,i)perylene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Chrysene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Dibenzo(a,h)anthracene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Fluoranthene	280	560	820	1500	1600	1600	23000	23000	23000	
Fluorene	170	390	730	2200	3400	4000	60000	67000	70000	
Indeno(1,2,3-c,d)pyrene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Naphthalene	1.0	2.3	4.6	1.0	2.4	4.7	110	260	510	
Phenanthrene	95	220	380	1300	1400	1500	22000	22000	23000	
Pyrene	620	1200	1900	3700	3800	3800	54000	54000	54000	
BTEX and related										
Benzene	0.063	0.13	0.24	0.16	0.30	0.38	15	28	49	
Toluene	100	240	460	370	830	1100	33000	68000	110000	
Ethylbenzene	26	62	120	34	81	110	3200	7400	14000	
Xylenes (total)	28	67	130	33	78	110	3200	7700	15000	[12]
1,2,4-trimethylbenzene	0.22	0.53	1.1	0.24	0.58	1.2	39	93	170	
Iso-propylbenzene	6.6	16	32	6.8	17	33	1300	3100	6100	
Propylbenzene	21	51	100	23	57	110	3800	9100	17000	
Styrene	6.9	16	32	21	49	93	3100	6100	9500	
TPH										
Aliphatic EC 5-6	24	41	68	24	41	48	2400	4100	6900	
Aliphatic EC >6-8	53	110	210	53	110	150	5300	11000	21000	
Aliphatic EC >8-10	13	31	61	13	31	43	1300	3100	6000	
Aliphatic EC >10-12	62	150	300	62	150	220	6100	15000	28000	
Aliphatic EC >12-16	510	1200	2300	510	1200	1700	43000	72000	85000	
Aliphatic EC >16-35	41000	70000	90000	42000	70000	80000	>1E6	>1E6	>1E6	[13]
Aromatic EC >5-7	53	110	200	150	300	380	15000	28000	48000	
Aromatic EC >7-8	100	240	460	370	820	1100	33000	68000	110000	
Aromatic EC >8-10	20	48	94	22	54	75	2200	5200	9800	
Aromatic EC >10-12	63	150	290	120	290	400	11000	22000	30000	
Aromatic EC >12-16	140	320	570	1100	1900	2100	35000	37000	37000	
Aromatic EC >16-21	260	540	840	1800	1900	1900	28000	28000	28000	
Aromatic EC >21-35	1100	1500	1700	1900	1900	1900	28000	28000	28000	
Chlorinated Organics										
Chlorobenzene	0.19	0.44	0.86	0.19	0.45	0.87	31	71	140	
Dichloromethane (DCM)	0.47	0.78	1.2	1.2	1.7	2.4	250	340	470	
1,1-dichloroethane (DCA)	1.4	2.4	4.0	1.4	2.4	4.1	260	420	690	
1,2-dichloroethane (DCA)	0.0031	0.0048	0.0076	0.0035	0.0053	0.0084	0.34	0.51	0.81	
1,1-dichloroethene (DCE)	0.15	0.26	0.45	0.15	0.26	0.46	24	43	74	
cis-1,2-dichloroethene (DCE)	0.066	0.12	0.20	0.069	0.12	0.21	14	23	38	
trans-1,2-dichloroethene (DCE)	0.11	0.21	0.38	0.12	0.22	0.39	21	37	65	
Pentachlorophenol	0.21	0.52	1.0	27	30	31	400	400	400	
1,1,1,2-tetrachloroethane	0.56	1.3	2.6	0.63	1.5	2.9	59	140	270	

The Sirius Group
Stage 1 Generic Assessment Criteria for Soils

Parameter	Residential (mg/kg, unless otherwise stated)						Commercial / Industrial (mg/kg, unless otherwise stated)			Note
	With Homegrown Produce			Without Homegrown Produce						
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	
1,1,2,2-tetrachloroethane	0.98	2.1	4.0	1.6	3.4	6.3	150	310	570	
Tetrachloroethene (PCE)	0.074	0.17	0.32	0.07	0.17	0.33	10	23	45	
Tetrachloromethane (CT)	0.011	0.024	0.046	0.011	0.024	0.046	1.6	3.6	6.9	
1,1,1-trichloroethane (TCA)	3.7	7.8	15	3.8	7.9	15	370	770	1400	
1,1,2-trichloroethane (TCA)	0.39	0.85	1.6	0.51	1.1	2.0	89	180	320	
Trichloroethene (TCE)	0.0070	0.015	0.028	0.0071	0.015	0.68	1.5	2.8	44	
Trichloromethane (CF)	0.43	0.80	1.4	0.48	0.89	53	98	170	300	
Vinyl Chloride	0.00034	0.00045	0.00062	0.00037	0.00048	0.00066	0.038	0.049	0.068	
Miscellaneous Organics										
Carbon disulphide	0.066	0.13	0.25	0.066	0.13	0.25	6.7	14	25	
Di-(2-ethylhexyl)-phthalate	290	660	1100	3900	4000	4100	85000	85000	8600	
MTBE	31	55	94	39	68	120	7400	12000	19000	
Phenol	110	190	330	420	440	440	440			[14]
Methylphenols (cresols), total	78	170	330	5600	8200	9900	160000	170000	18000	[15]
2,4-dimethylphenol (m-xylenol)	18	43	82	200	430	720	15000	23000	28000	
Other Parameters										
TOC	3% w/w			3% w/w			3% w/w			[16]
Calorific Value	2 MJ/kg			2 MJ/kg			2 MJ/kg			[17]
Asbestos	Fibres present			Fibres present			Fibres present			

All concentration-based criteria are rounded to 2 significant figures.

The criteria assume a sandy soil type, which will be conservative for the great majority of soils (including made ground) encountered on historically contaminated sites.

Except where otherwise stated, criteria have been derived by Sirius using CLEA version 1.06. Parameters for the land use cases are consistent with those given in Environment Agency (2009) "Updated Technical Background to the CLEA Model", report SC050021/SR3 but updated (where relevant) for respiration rate, exposure frequency for dermal contact outdoors, soil adherence factors for children, and plant uptake concentration factors given in CL:AIRE (2014) and Nathanail et al., (2015). No correction has been made for the "Top Two" crop types in the Residential with Homegrown Produce land use and the criteria will therefore be conservative in this regard.

Health Criteria Values (HCVs) and (except where specifically noted) chemical property data were obtained from:
- Environment Agency Science Report SC050021 Series;
- Nathanail et al. (2015);
- CL:AIRE-AGS-EIC (2010).

Footnotes

[1] Based on oral GAC as this is the lower GAC and reflects a cancer risk many orders of magnitude greater than for inhalation.

[2] Determined for lifetime exposure. Plant uptake concentration factors applied were as given in CL:AIRE (2014). The GAC values are based on data for soils having a pH value in the range 6-8; caution should be applied in applying them at pH values outside this range, especially at pH values <5.

[3] Both oral and inhalation HCVs are based on local toxicological effects and therefore the lowest (oral) GAC value is adopted.

[4] For the Residential with Homegrown Produce land use, the GAC values for Cu and Zn are based on potential phytotoxic effects and have been set at the maximum allowable concentrations for sewage sludge-amended soils presented in the "Sludge (Use in Agriculture) Regulations" (SI 1263/1989); these criteria may also be applied in any land use where plants are to be grown. The equivalent GAC values for human health protection in the Residential with Homegrown Produce land use are around an order of magnitude greater.

[5] The Category 4 Screening Levels for lead defined in CL:AIRE (2013) have been adopted directly to provide an acceptable basis for initial assessment of data. Where background concentrations of lead exceed the GAC value, then site-specific evaluation will be required.

[6] The SGV for mercury is based on inorganic mercury which represents the most common form encountered within the environment. This is considered appropriate for most sites as: "…the SGV for inorganic mercury can normally be compared with chemical analysis for total mercury content because the equilibrium concentrations of elemental and methylmercury compounds are likely to be very low" (Environment Agency report SC050021/Mercury SGV). Analysis and specific assessment for elemental or methylated forms of mercury will need to be considered if historical land use or site-specific factors indicate that these forms of mercury are likely to be present.

[7] Toxicological effects by inhalation are localised, therefore the lower of the GAC values for oral and inhalation HCVs have been adopted.

[8] BRE (2005). Sulphate is not considered to pose a potential risk to human health under normal circumstances – this GAC applies to construction cases only and is set at the upper limit for DS-1 Design Sulphate Class concrete.

[9] GAC calculated for acute risk. Further information can be provided upon request.

[10] The genotoxic PAHs (benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene) are routinely assessed using benzo(a)pyrene as a surrogate (HPA (2010) "Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)", version 5). Separate information on this approach is provided.

[11] Calculated using a 'minimum risk' oral index dose derived from the application of a 10,000x safety factor to the BMD10 presented in CL:AIRE (2014) for benzo(a)pyrene as a surrogate marker and the inhalation index dose specified in CL:ARE (2014) and Nathanail *et al*. (2015). As a conservative measure, the GAC is based on combined exposure pathways to account for systemic carcinogenic effects. Further information on the derivation can be provided upon request.

[12] For screening purposes, a single GAC has been set for total xylene. This is the lowest of the values calculated for the three individual xylene isomers.

[13] "No GAC" indicates that no value has been specified for this land use as the TDSI cannot be exceeded at achievable soil concentrations.

[14] 440mg/kg is the minimum concentration that is protective for direct skin contact with phenol (See Environment Agency SR050021/Phenol SGV) and is adopted where GACs for chronic exposure are higher.

[15] For screening purposes, a single GAC has been set for total methylphenol. This is the lowest of the values calculated for the three individual methylphenol isomers.

[16] The Hazardous Waste (England and Wales) Regulations 2005. TOC content in itself does not represent a potential risk to human health. This GAC is provided for indicative assessment of disposal options, in the case that off-site landfill of soil is undertaken. This GAC is specified at the 'Inert' waste threshold and should be considered as for information purposes only.

[17] ICRCL (1986) Guidance Note 61/84, 2nd Edition, Notes on the Fire Hazards of Contaminated Land. Calorific value is not an indication of direct human health risk but may be useful in assessment of the potential fire risk posed by made ground or natural soils containing elevated concentrations of potentially combustible organic matter.

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