

CampbellReith
consulting engineers

Confidential

Kilnwood Vale
Crawley

Phase 2.4 Environmental Review and Remedial Strategy

For

Crest Strategic Projects

Project Number: 11950

June 2017

Campbell Reith Hill LLP
Friars Bridge Court
41-45 Blackfriars Road
London
SE1 8NZ

T:+44 (0)20 7340 1700
F:+44 (0)20 7340 1777
E:london@campbellreith.com
W:www.campbellreith.com

Document History and Status

Revision	Date	Purpose/Status	File Ref	Author	Check	Review
F1	June 2017	Construction	APPsmb11950-12052017-Rem_Strategy-Ph2.4-F1.doc	APP	SMB	JWC

This document has been prepared in accordance with the scope of Campbell Reith Hill LLP's (CampbellReith) appointment with its client and is subject to the terms of the appointment. It is addressed to and for the sole use and reliance of CampbellReith's client. CampbellReith accepts no liability for any use of this document other than by its client and only for the purposes, stated in the document, for which it was prepared and provided. No person other than the client may copy (in whole or in part) use or rely on the contents of this document, without the prior written permission of Campbell Reith Hill LLP. Any advice, opinions, or recommendations within this document should be read and relied upon only in the context of the document as a whole. The contents of this document are not to be construed as providing legal, business or tax advice or opinion.

© Campbell Reith Hill LLP 2017

Document Details

Last saved	29/06/2017 10:03
Path	APPsmb11950-12052017-Rem_Strategy-Ph2.4-F1.doc
Author	Antony Phin
Project Partner	James Clay
Project Number	11950
Project Name	Kilnwood Vale, Crawley

Contents

1.0 Summary 1
2.0 Introduction 2
2.1 Site Location 2
2.2 Site Layout 2
2.3 Report Objectives 3
2.4 Summary of Reports and Specifications 3
2.5 Site History and Development Proposal 6
2.6 Regulatory and Planning Status 6
3.0 2016/17 Intrusive Investigation 7
3.1 Summary of Works 7
3.2 Contamination Observations 8
3.3 Depth of Made Ground 10
4.0 Soil Contamination Assessment 11
4.1 Synopsis 11
4.2 Historical Chemical Results – Site Wide Assessment 11
4.3 Recent Chemical Results – Phase 2.4 11
4.4 Asbestos 13
4.5 Current Earthworks Strategies 14
4.6 Contamination Soil Summary 14
5.0 Controlled Waters Generic Quantitative Risk Assessment 15
5.1 Synopsis 15
5.2 Hydrogeological and Hydrological Setting 15
5.3 Proposed Drainage Works and Realignment of Bewbush Brook 16
5.4 Recent Groundwater Monitoring 16
5.5 Recent Surface Water Monitoring 18
5.6 Predicted Surface Water Concentrations in the Realigned Bewbush Brook 19
6.0 Ground Gas Assessment 23
6.1 Synopsis 23
6.2 Overview of Gas Source/s 23
6.3 Historical Gas Concentrations and Flow Rates 24
6.4 Recent Gas Monitoring of Phase 2.4 25
6.5 Total Organic Carbon (TOC) Assessment 28
6.6 Ground Gas Summary Assessment 30
6.7 Revised Ground Gas Remedial Strategy 30
6.8 Ground Gas Validation Works 31
6.9 Verification Reporting and Recommendations 34
6.10 Development and Legacy Control 34
7.0 Conclusions and Recommendations 36
7.1 Objective 36
7.2 Site History 36
7.3 Remedial Strategy 36
7.4 Soil Remediation 37
7.5 Controlled Waters Remediation 37
7.6 Ground Gas 37
7.7 General 39
Limitations 46

Appendices

Appendix A: Figures

Figure 1 – Site Location Plan
Figure 2 – Phase 2.4 Site Investigation Location Plan
Figure 3 – Phase 2.4 GSV Gas Classifications
Figure 4 – Phase 2.4 Forensic TOC Gas Classifications
Figure 5 – Phase 2.4 Bewbush Brook Realignment, Post-Earthworks Controlled Waters Conceptual Model
Figure 6 – Phase 2.4 Post-Earthworks Gas Conceptual Model
Figure 7 – Proposed Post-Earthworks Validation Monitoring Locations

Appendix B: Regulatory Correspondence

Approvals via email from Environmental Health Officer, Horsham District Council
Approvals via email from NHBC relating to environmental issues

Appendix C: Supporting Information

From Phase 2.4 GDR: Figure 2 – Phase 2.4 Proposed Phasing Plan
Figure 3 – Phase 2.4 Annotated Site Layout

Forensic TOC Calculations
Gas Monitoring Data and GSV Calculations
Calculations of predicted concentrations in Bewbush Brook
11950-BBD-CE202-P1 – Bewbush Brook Diversion Proposed layout and Existing Ground
11950-BBD-CE203-P1 – Bewbush Brook Diversion Proposed / Existing Sections

1.0 SUMMARY

PROJECT SETTING	The Kilnwood Vale site is being developed in 5 phases of which Phases 2 and 3 are partly on a former inert landfill. This report specifically considers Phase 2.4 and provides an update of the agreed Remedial Strategy referenced in the original hybrid planning permission (DC/10/1612) and updated landform contour consents (DC/13/1437 and DC/16/0108). The southern portion and parts of the northern portion of Phase 2.4 are within the former landfill where Made Ground has been proven to a maximum depth of 19m bgl at the location of a stockpile. In this area landfill material will remain (in part) beneath the completed earthworks profile. The eastern and south eastern portions of Phase 2.4 are situated directly above Weald Clay and residual landfill will not be present.
SITE INVESTIGATION	The current and historical site investigations indicate that landfill material is primarily inert waste but does contain widespread organic material, predominantly in the form of wood/timber and alluvial silts and clays. Forensic total organic carbon (fTOC) analysis has been carried out to assess the soil gas generation potential.
HUMAN HEALTH/SOIL	The chemical soils data indicate that the soils do not exceed the residential generic assessment criteria for contamination.
CONTROLLED WATERS	The critical controlled waters receptor is identified as the Bewbush Brook, which is to be realigned as part of the earthworks. Groundwater in the landfill is in partial hydraulic continuity with the brook, however, infiltration and subsequent leaching of contaminants into the groundwater will significantly decrease post-earthworks. In the groundwater, exceedances of screening values were found for metals, PAHs, total cyanide, TPH >C10-C40, ammoniacal nitrogen, sulphate and monohydric phenols. No exceedances, above detection limit, were recorded in the surface water samples collected upstream, at site or downstream. Following assessment of the predicted concentration in surface water, after realignment of the brook, it is considered that groundwater in Phases 2.4 – 2.6 does not present an unacceptable risk to controlled waters, assuming the CEMP is followed, and therefore no further remedial works are required in this regard.
GROUND GAS	In the deeper landfill area elevated methane concentrations have been detected locally above 90% v/v. Periodically and localised elevated gas flow rates (>1 l/hr) have been detected in both historical (Dec – June 2014/15) and recent (Dec - Feb 2016/17) monitoring. The gas chemistry does not conform to that of a 'standard' landfill and the recent investigation confirms that the elevated methane concentrations are likely to be due to historical generation of gas, trapped within the cohesive landfill material. Five of the sixty forensic TOC samples analysed exceeded the 4% threshold. Four of these will either be mitigated during the excavation / fill operations, and one was from material sufficiently localised and which lies at sufficient depth beneath Engineered Fill as to not pose a significant ground gas risk.
REMEDIAL STRATEGY	The remediation will comprise a process of excavation, segregation, classification/validation and reuse of site won soils, in accordance with the detailed Earthworks Specification for Phase 2.4 - 2.6 (to which reference should be made). The geotechnical treatment for the site is separately discussed in the CampbellReith Phase 2.4 Geotechnical Design Report. The risk presented by ground gas will be controlled via: the forensic TOC testing of site-won soils prior to re-use; removal of biodegradable matter from excavated soils; trial pitting across the landfill area at formation layer, including potential organic hotspots, to verify that TOC is below 4%, or is visually clear of organic materials; empirical demonstration of gas generation of site won soils via Drum Tests; surface emission surveys at the landfill formation; and, post earthworks gas monitoring. Subject to validation and final assessment it is considered that standard passive gas protection measures (suitable for Characteristic Situation 3/NHBC Amber 2) will be appropriate in landfill areas and those areas subject to backfill with Engineered Fill. If the organic load of the residual landfill soils is found to be greater than that currently assumed then further assessment will be required to determine the potential requirement for land based gas protection measures, although this is currently thought unlikely.
RECOMMENDATIONS	This Report together with the Earthworks Specification and Geotechnical Design Report should be submitted and formally agreed with the Regulatory Authorities in conjunction with the development planning conditions. Upon completion of work a Validation Report should be produced and approved.

2.0 INTRODUCTION

2.1 Site Location

2.1.1 The site lies within the Kilnwood Vale Phase 2.4-2.6 development area, which is to be developed in a number of phases as indicated on Figure 2. The Phase 2.4 site location is shown on Figures 1 and 2. The site is located approximately 3.70km to the west of Crawley town centre and just off the A264 (Crawley Road). The National Grid Reference for the centre of the site is approximately TQ236 351.

2.2 Site Layout

2.2.1 The following site features are indicated on Figure 3 from the Phase 2.4 GDR, included in Appendix C. A site walkover was undertaken by a CampbellReith representative in January 2016 and forms the basis of the following descriptions. A general description of Phase 2.4 - 2.6 is provided with items specifically relevant to Phase 2.4 highlighted.

2.2.2 It is noted that at the time of the site visit material was being moved into and around site, possibly in relation to construction undertaken on other phases. As a consequence a number of mounds and stockpiles associated with stored materials are present.

2.2.3 The Phase 2.4 site covers an area of 13.6Ha and can be separated into three areas, one to the north and another to the east and the last to the south, with each area comprising one or a number of land sale parcels. As indicated on Figure 2 from the GDR report (included in Appendix C), the northern area comprises land sale parcels 2.4A and 2.4D, the eastern area comprises land sale parcel 2.4C and the southern area comprises land sale parcels 2.4B, 2.4E, 2.4F, 2.4G and 2.4H.

2.2.4 The northern area is dominated by a gully running NE – SW. The gulley is up to 6m deep with the Bewbush Brook running along its base. The northern bank to this feature has an approximate 1 in 4 gradient, and the southern bank has a gradient of around 1 in 5. At the western end of the brook, adjacent to the western site boundary are a number of trees and dense vegetation and an attenuation pond. In the eastern end are also trees and dense vegetation and an attenuation pond. The remainder of the area is generally grassy or lightly vegetated.

2.2.5 The southern area is bisected by a notable slope running 1 in 5 (i.e. the anticipated edge of the landfill), although this is locally obscured by a recently placed stockpile of natural clay. The lower area has a gradient of around 1 in 20 to the north. It comprises bear earth and sparse vegetation and, contains a number of stockpiles, comprising processed land fill material, topsoil and a stockpile.

2.2.6 The higher area to the west of the slope centrally contains a lime treated haul road running east to west and surrounded by a number of mounds of land fill material and a number of stockpiles including topsoil, concrete, wood and unprocessed landfill material. The area is predominately muddy with numerous small ponds of water observed throughout.

2.2.7 Surrounding Area

2.2.8 Immediately to the north of Phase 2.4 – 2.6 is an ecological barrier that separates the site from a train line running east west, beyond which is ploughed farmers land.

2.2.9 Twenty to thirty metres to the east of site is Spruce Hill Brook, beyond which are a children's play area, residential houses and flats of the Bewbush neighbourhood.

2.2.10 Immediately to the south are the Phase 2.2 and 2.3 development areas which are currently under construction, beyond which is Phase 2.1 also undergoing construction. The A264 located 330m to the south, beyond which is woodland and a commercial/light industrial estate to the south-east.

2.2.11 To the west of the site is a recently constructed spine road and Hopper's Brook, beyond which is the Kilnwood Vale Phase 1 development area, which is currently under construction by Crest Nicholson.

2.3 Report Objectives

2.3.1 This Report has been produced by Campbell Reith Hill LLP (CampbellReith) on behalf of Crest Strategic Projects (the Client) to provide an environmental review and remedial strategy for Phase 2.4 of the Kilnwood Vale development considering the currently available information. It is based upon the review of historic ground investigation data combined with the review of a supplemental investigation which is presented herein.

2.3.2 The status of these works with respect to planning is summarised in section 2.5.Table 2.1 provides a summary of the contents of this report.

TABLE 2.1: Report Content Summary

Report Section	Summary of Section
2.0 Introduction	Provides a brief summary of the historical investigation reports, site history, development proposals and regulatory status
3.0 2016/17 Intrusive Investigation	Details the recent CampbellReith designed Phase 2.4 site investigation
4.0 Soil Contamination Assessment	Summarises the available soil data with respect to human health risk assessment
5.0 Controlled Waters Generic Quantitative Risk Assessment	Summarises the potential for risks to controlled water receptors based on groundwater and surface water data
6.0 Ground Gas Assessment	Details the ground gas risk assessment works and associated remedial strategy
7.0 Conclusions and Recommendations	

2.4 Summary of Reports and Specifications

2.4.1 The reports/specifications detailed in Table 2.2 have been reviewed and/or are relevant to this report. It is assumed that the reader of this report is familiar with the site and the principles of land quality assessment and if this is not the case the listed reports should be consulted for background information.

TABLE 2.2: Existing Site Specific Information

Report Title	Author	Reference, Date, Version	Internal Report Reference
Land Quality Statement	SLR	403_0404–00027, June 2010, Final	[1]
Remediation Strategy	SLR	403_0404–00027, June 2010, Final	[2]
Factual Report Phases 2 & 3	STL	J10963, 28 May 2012	[3]
Report on Earthworks Land Form and Remediation Options	URS	47063495, Rev 3, July 2013 (superseded by [12])	[4]
Factual Report Phase 1B	STL	J11372, 12 July 2013	[5]
Factual Report Phases 2 & 3	STL	J11531, 09 Jan 2014	[6]
Detailed Human Health Quantitative Risk Assessment & Remedial Target Derivation	WYG	H087540 HBR Bewbush, May 2014, Draft, Issue 1.1	[7]
Engineering Design Statement for Phase 2.1	CR	11950 20–05–15 EDS F1.doc	[8]
Earthworks Specification (Phase 2.1)	CR	AEDsmb11950–050615–Blue Area Earthworks Spec–Rev E, June 2015	[9]
Earthworks and Materials Management Strategy (Phase 2.1)	WB	J14132 Issue 08, July 2015	[10]
Phase 2.1 Environmental Review and Remedial Strategy	CR	SMBjc11950–100715–Rem_Strategy–F1, July 2015	[11]
Phases 2 and 3 Earthworks Landform and Remediation Options	CR	JWCjw11950–140116–Earthworks and Remediation Report–F1	[12]
Phase 2.2 Environmental Review and Remedial Strategy	CR	SMBjc11950–020216–Rem_Strategy_Ph2.2–F3, February 2016	[13]
Earthworks Specification, Phase 2.2	CR	AEDsmb-1195020160210–Phase2.2 Eworks Spec–Rev D, March 2016 and 11950-2017-01-03 Phase 2.2. Eworks Spec-RevE Northern Area	[14]
Gas Assessment Report, Phase 2.1	CR	SMBjc11950-260216-Ph2.1-Gas Assessment-F2, March 2016	[15]
Gas Assessment Report, Phase 2.2	CR	APP11950-020916-Ph2.2-Gas Assessment-F2, September 2016	[16]
Environmental Review, Phase 2.2	CR	SMBjc11950-020216-Rem_Strategy-Ph2.2-F3, February 2016	[17]
Geotechnical Design Report for Earthworks Development Platform, Phase 2.2	CR	AFaed-11950-280116-Kilnwood Phase 2.2. GDR-F1, January 2016	[18]
Environmental Review, Phase 2.3	CR	APPsmb11950-290716-Rem_Strategy-Ph2.3-F2, Jul 2016	[19]
Geotechnical Design Report for Earthworks Development Platform, Phase 2.3	CR	EJBejb-11950-051016-Phase 2.3 GDR F1, October 2016	[20]

Report Title	Author	Reference, Date, Version	Internal Report Reference
Earthworks Specification, Phase 2.3	CR	AEDsmb-11950-20160615-Phase 2.3. Eworks Spec-RevC, October 2016	[21]
Phase 2.4 Factual Site Investigation Report	Hydrock	Factual_Complete_Final_KWV-HYD-2.4-ZZ-RP-G-2001 P2, March 2017	[22]
Earthworks Specification, Phase 2.4-2.6	CR	Pending at time of issue	[23]
Geotechnical Design Report for Earthworks Development Platform, Phase 2.4	CR	Pending at time of issue	[24]

WYG–White Young Green; SLR–SLR Consulting; STL–Severn Trent Laboratories Ltd; CR–CampbellReith; WB–Wilson Bailey

2.4.2 The WYG report [7] was based on the SLR documents and did not include the results from any subsequent works.

2.4.3 The STL factual report from 2014 [6] includes intrusive investigation data from Phase 2 of the development with coverage of Phase 2.4. The report includes gas monitoring data and some organic matter data but no other chemical results.

2.4.4 The URS report [4] presents the rationale and supporting information to the proposed land form remodelling (as consented: DC/13/1437) which has since been superseded by details presented in [12]. The remediation options proposed by URS do not differ from those of the earlier SLR strategy [2].

2.4.5 The STL factual report from 2013 [5] includes intrusive investigation data from Phase 1 only and therefore is not directly relevant to this report.

2.4.6 The STL factual report from 2012 [3] includes intrusive investigation data from Phase 1, the recycling centre (to the west of Phase 2) and Phase 2 (trial pits only). Chemical analysis was limited to Phase 1 and the recycling centre.

2.4.7 The SLR LQS [1] includes data from several intrusive investigations, including: 2004 which covered the majority of the whole site (Phase 1, recycling centre and Phase 2 (including Phase 2.4), and included chemical analysis as well as ground gas monitoring; 2007 – focussed mainly on providing additional leachate and ground gas data to enable surrender of the Waste Management License for the site; 2008 and 2009 – both designed primarily to enable further assessment of the gas risk. The results for these investigations are contained in the LQS [1].

2.4.8 The SLR Remediation Strategy [2] provides general remedial requirements for controlled waters and the human health aspects relating to the soils but concentrates on providing additional assessment of the potential risk posed by ground gas together with associated remedial measures. These measures have been modified by CampbellReith to accommodate a different geotechnical methodology for the proposed development. The CampbellReith reports [8 & 9] and [11–21] refer to Phases 2.1–2.3 and provide site-specific information.

2.4.9 The Hydrock factual site investigation report from 2016/17 [22] is restricted to Phase 2.4 only and includes soil, groundwater, surface water and ground gas data. This was designed and specified by CampbellReith as a Supplemental Investigation to inform the design of the

earthworks operation and both the geotechnical and remedial strategy. This is hereafter called the 2016/17 site investigation.

2.4.10 The data assessment of the 2016/17 investigation and the associated remedial strategy is restricted to Phase 2.4; however, this report includes a short summary of the wider Phase 2 and 3 areas in order to contextualise the recent findings. Given the common elements of the conceptual models for Phases 2.1 - 2.4 the assessment principals for the Phase 2.1 - 2.3 strategies also apply to the strategy for Phase 2.4. It is noted that additional review and assessment work will be required for subsequent phases of development.

2.5 Site History and Development Proposal

2.5.1 A site description, and desk study information relating to the site is detailed in the associated GDR and references therein [18].

2.5.2 In summary, the Kilnwood Vale development area comprises an area of predominantly unused ground, much of which was formerly an inert landfill operation. The 'landfill' area accepted inert wastes for disposal as a land raise operation from the early 1970s, until its closure in May 2006. The Phase 2.4 area is on an area of older (>20 years) landfill, apart from the south western portion which overlaps more recent landfill.

2.5.3 Development proposals for the site currently comprise low rise housing and associated roads and infrastructure.

2.5.4 The site conceptual site model, incorporating the anticipated gas regime post-earthworks, is shown in Figure 6.

2.6 Regulatory and Planning Status

2.6.1 The Remediation Strategy for the site (Kilnwood Vale, Remediation Strategy, SLR Ref: 403-0404-00027, June 2010) for Phases 1 to 5 was consented under a hybrid application (DC/10/1612).

2.6.2 Part B of the original consent has been superseded by supplemental consents for revised landform contours, particularly for Phase 2 and part of Phase 3 relating to the landfill areas. These consents comprise DC/13/1437 (now superseded) and DC/16/0108 (current at time of writing). A discussion of the revised landform is presented in CampbellReith's Earthworks Landform and Remediation Options.

2.6.3 Detailed design remedial strategies have been produced by CampbellReith for Phase 2.1 [8] and Phase 2.2 [13]. These have been approved by the environmental health officer (EHO) for Horsham District Council and the NHBC. The works for Phase 2.1 have now been completed and approval of the validation reports, including that associated with gas assessment [15] has been received from the EHO and NHBC. Copies of these approvals are provided in Appendix B.

3.0 2016/17 INTRUSIVE INVESTIGATION

3.1 Summary of Works

3.1.1 A ground investigation was undertaken between November 2016 and January 2017. A copy of the report, referenced Hydrock, Phase 2.4, Kilnwood Vale, Bewbush, Crawley, dated March 2017, Report Reference KWV-HYD-2.4-ZZ-RP-G-2001 P2, is presented in the Appendices of the Phase 2.4 GDR Report.

3.1.2 The environmental scope of the investigation comprised chemical contamination analysis of soils samples together with forensic total organic carbon (fTOC) concentrations to inform the gas potential of the soils.

3.1.3 The investigation comprised the following:

- 33 No. boreholes to depths of 18m bgl;
- 37 No. trial pits to a maximum depth of 4.8m bgl;
- 5 No. trial trenches to a maximum depth of 4.5m bgl, and
- 29 No. Cone Penetration Tests (CPT) to a maximum depth of 16.1m bgl.

3.1.4 The standpipes installed are summarised in Table 3.1. These were all screened in the landfill material. Three groundwater and ground gas monitoring visits were undertaken between December 2016 and January 2017. Where ground gas and/or groundwater monitoring data is available, this is indicated on the table.

TABLE 3.1: Standpipe Summary for 2016/17 Investigation

Exploratory Hole	Response Zone (m bgl)	Monitoring Data	
		ground gas	groundwater
BH901	2.00 – 4.00	x	
BH903	10.00 – 13.00	x	x
BH907	3.00 – 5.00	x	x
BH909	8.00 – 10.00	x	x
BH910	3.00 – 5.00	x	
	14.00 – 15.00		x
BH911	6.00 – 8.00	x	x
BH912	3.50 – 5.20	x	
	7.00 – 7.50		x
BH913A	1.00 – 2.50	x	x
BH915	6.00 – 8.00	x	x
BH917	0.50 – 2.00	x	
	3.80 – 4.80		x
BH921A	5.00 – 7.00	x	
	10.00-11.00		x
BH927	3.00-5.00	x	
	12.00-14.00		x

Exploratory Hole	Response Zone (m bgl)	Monitoring Data	
		ground gas	groundwater
BH927A	8.00-11.00		x
BH941	3.00-5.00	x	x
BH951	2.00-4.00	x	x
BH977	3.00-5.00	x	x
BH985	2.00-5.00	x	x
BH991	3.00-5.00	x	x

3.2 Contamination Observations

3.2.1 The observations relating to the olfactory and visual evidence of potential contamination from the intrusive investigation are summarised in Table 3.2. These include observations relating to evidence of organic matter. Note that these are based on volumetric percentage and will therefore be greater than the organic content by weight..

TABLE 3.2: Summary Evidence of Degradable Materials

Hole	Depth Made Ground (m bgl)	Depth of Observation (m bgl)	Observations (quoted from exploratory hole logs)
BH901	13.0	2.5-3.0	contains cobbles of wood.
BH902	13.6	10.5-13.6	occasional wood fragments.
BH903	13.4	4.0-8.5	occasional wood fragments. <5% organic matter.
BH904	11.5	4.0-8.0	some wood fragments. <5% organic matter.
BH905	9.7	4.0-6.0	contains cobbles of wood. <5% organic matter.
BH907	6.0	0.0-6.0	<5% organic matter. At 5.5m: pockets of black organic material (<40mmx60mm).
BH913A	13.5	0.7-2.4	gravel sized wood fragments. <5% organic matter.
BH915	17.5	14.5-16.0	rare wood fragments. <5% organic matter.
BH916	17.3	11.5-13.0	abundant wood fragments. <5% organic matter.
		15.8-17.3	abundant wood fragments. <15% organic matter.
BH918B	12.4	2.8-3.8	rare pockets of black organic matter (<5%)
		5.0-10.5	
		10.5-12.4	pockets of black organic matter (<10%) and occasional blackened wood fragments (50mmx10mmx10mm)
BH927	16	13-14.5	gravel containing wood fragments. <5% organic matter.
BH932	8.3	0.0-8.3	gravel containing wood fragments. <5% organic matter.
BH968	7.1	0.0-7.1	pockets of dark grey organic clay <5% organic matter.
BH985	4.5	1.7-4.5	rare wood fragments. <5% organic matter.
BH991	5.5	1.5-5.5	frequent wood fragments from 1.7 - 2.0m. <20% organic matter.
TP903	>1.5	0.2-0.7	hydrocarbon odour
TP904	>4.5	0.0-1.9	abundant rootlets. <5% organic matter.
		1.9-4.5	gravel containing wood fragments. <5% organic matter.
TP905	>4.5	0.0-1.6	abundant rootlets. <5% organic matter.
		1.6-2.9	occasional wood fragments. <5% organic matter.
TP906	>4.5	0.0-0.6	abundant rootlets and roots
		2.7-4.5	occasional wood fragments. <5% organic matter.

Hole	Depth Made Ground (m bgl)	Depth of Observation (m bgl)	Observations (quoted from exploratory hole logs)
TP907	>4.5	0.8-1.7	rare wood. <5% organic matter.
		3.5-4.5	rare wood. <5% organic matter.
TP908	>4.5	0.3-2.0	rare wood. <5% organic matter.
		3.0-4.5	gravel containing wood fragments. <5% organic matter.
TP909	>4.7	0.8-1.5	rare wood. <5% organic matter.
TP910	>4.5	0.6-1.7	Gravel containing wood fragments and plastic bags. Occasional pockets of black amorphous and fibrous peat and strong organic odour. <5% organic matter.
TP915	>4.5	0.6-1.7	occasional wood fragments. <5% organic matter.
TP916	>4.5	0.9-4.5	gravel containing wood fragments. <5% organic matter.
TP919	>4.1	0.0-1.6	gravel containing wood fragments. <5% organic matter.
		1.6-1.9	gravel containing wood fragments. Strong organic odour.
TP923	>4.8	0.0-3.0	gravel containing wood fragments. <5% organic matter.
TP924	>4.5	0.4-4.5	rare wood. <5% organic matter.
TP925	>4.5	0.6-2.8	rare wood fragments. Occasional pockets of black organic matter. <5% organic matter.
		3.2-4.5	wood fragments. <5% organic matter.
TP926	>4.5	1.8-2.9	gravel containing wood fragments and refuse. <5% organic matter.
TP927	>4.5	0.8-1.9	gravel containing wood fragments and plastic bags. Occasional pockets of black amorphous and fibrous peat and strong organic odour. <10% organic matter.
		1.9-2.8	gravel containing wood fragments and refuse. <10% organic matter.
TP968	>4.5	1.0-4.5	gravel containing wood fragments. <5% organic matter.
TP975	>4.5	0.35-4.5	gravel containing wood fragments. <5% organic matter.
TP977	>4.5	1.7-4.5	rare wood fragments. <5% organic matter.
TP979	>4.5	1.7-4.5	occasional pockets of black soft fibrous peat (slight odour) with some wood. <5% organic matter.
TP981	>4.5	1.6-3.5	gravel containing wood fragments. <5% organic matter.
TP991	>4.5	1.2-4.1	gravel containing wood fragments. <5% organic matter.
TT901a	2.9	0.3-2.9	rare pockets of organic matter. gravel containing wood fragments. <5% organic matter.
TT901b	3.8	0.0-0.7	fine to coarse pockets of organic matter (<10%)
		0.7-3.8	rare pockets of organic matter. gravel containing wood fragments. <5% organic matter.
TT902	2.2	0.0-0.8	Occasional soft dark grey fibrous peat material, decomposed wood (moderate organic odour, 5-<10% organic matter)
TT902a	4.2	0.0-0.8	Occasional soft dark grey fibrous peat material, decomposed wood (moderate organic odour, 5-<10% organic matter)
		0.8-3.3	gravel containing wood fragments. <5% organic matter.
TT902b	>4.5	0.0-0.6	Occasional soft dark grey fibrous peat material, decomposed wood (moderate organic odour, 5-<10% organic matter)
		0.9-4.5	gravel containing wood fragments. <5% organic matter.
TT903a	4.1	1.7-4.1	gravel containing wood fragments. <5-10% organic matter.
TT908a	3.3	0.0-0.8	wood fragments
		0.8-1.8	Occasional pockets (30-50mm) of black fibrous peat. Slight organic odour, 5-<10% organic plant matter.
TT908b	>4.5	1.5-4.5	Occasional pockets (30-50mm) of black fibrous peat. Slight organic odour, 5-<10% organic plant matter.

All percentages relate to observations provided in the field, as detailed in the logs. Where Made Ground thickness is given this was found to be overlying Weald Clay.

3.3 Depth of Made Ground

3.3.1 The depth of Made Ground relative to existing ground level is illustrated on Figure 3.

3.3.2 Outside of the former landfill (i.e. the bulk of the eastern part of the site and the eastern third of the southern site area), the depth of Made Ground was generally in the region 1 to 2m , locally increasing to 3-4m. With respect to the parts of the site within the former landfill the following was noted:

- within the northern area the depth of Made Ground was highly variable. Typically depths varied from around 7 to 10m in the west, reducing to 4 to 2m in the centre and around 4 to 6m in the east. In part this variation is explained by the topography associated with the gully present in this part of the site.
- within the southern area of phase 2.4, the depth of Made Ground is generally between 12m and 13m bgl, increasing to 16 - 19m bgl in the west where there are some topographic highs (stockpiles that have recently been placed in this area).

4.0 SOIL CONTAMINATION ASSESSMENT

4.1 Synopsis

4.1.1 The intrusive investigation completed in 2016/17 across Phase 2.4 has confirmed the previous investigation findings from the wider site area that indicate that the soil chemical concentrations do not present a significant risk to future users of the development.

4.2 Historical Chemical Results – Site Wide Assessment

An assessment of the soils across the whole site is provided in Section 4.0 of the Phase 2.1 Remedial Strategy report [11] and this should be referred to for further detail. In summary, only a very small proportion of samples were identified that exceeded screening generic criteria for a residential development with private gardens. Table 7 from SLR's interpretative report [1] summarised the elevated concentrations of metals and speciated PAH soil data from the former landfilled area which includes the Phase 2.4 area. This table has been summarised below as Table 4.1 to include lead (as an indicator for metals contamination) and benzo(a)pyrene (as an indicator of PAH contamination) that exceeded Category 4 Screening level (C4SL) for a residential with plant uptake end use.

TABLE 4.1: Summary of SLR Soil Assessment for Former Landfilled Area (Phase 2)

Contaminant	Number of Samples	Maximum value mg/kg	Mean mg/kg	Screening Criteria Value mg/kg
Lead	68	234	57	200
Benzo(a)pyrene	27	5.70	1.59	5.0

4.2.1 The table demonstrates that the exceedances were nominal and the mean values were below the respective screening values. The concentrations are therefore a low risk to the future residential end users.

4.2.2 From the SLR and historical STL assessments (including the STL/CampbellReith Phase 2.1 and 2.2 investigations) 161 samples were analysed from 130 locations for asbestos (as summarised in [11]). Of these, only five were positively identified by laboratory analysis as containing asbestos and only two site observations of asbestos were made during the investigations.

4.3 Recent Chemical Results – Phase 2.4

4.3.1 From the STL/CampbellReith 2016/17 investigation, 61 samples of Made Ground were scheduled for a general contamination suite comprising metals, speciated PAHs, banded petroleum hydrocarbons, cyanide, and phenol. In addition, 131 samples were scheduled for asbestos. The results are summarised in Table 4.2.

TABLE 4.2: Summary of Made Ground Chemical Analysis

Contaminant	Units	Exceeding	Max	95th percentile	Tier 2 Screen
Inorganics					
Arsenic	mg/kg	0/ 61	22	8.8	37
Cadmium	mg/kg	0/ 61	0.8	0.28	11
Chromium	mg/kg	0/ 61	47	28.7	910
Copper	mg/kg	0/ 61	280	47.1	2400
Zinc	mg/kg	0/ 61	170	83.5	3700
Selenium	mg/kg	0/ 61	1.7	1.0	250
Lead	mg/kg	2/ 61	**220**	50.1*	200[A]
Inorganic Mercury	mg/kg	0/ 61	0.5	0.3	40
Nickel	mg/kg	0/ 61	45	21.6	130
Total cyanide	mg/kg	0/ 61	1.0	1.0	18.6[B]
Asbestos	presence	15/ 131	**Detected**		
Polynuclear Aromatic Hydrocarbons (PAHs)					
Anthracene	mg/kg	0/ 61	9.7	0.76	2400
Pyrene	mg/kg	0/ 61	36	3.3	620
Benzo(ghi)perylene	mg/kg	0/ 61	6.9	0.8	320
Indeno(1,2,3–cd)pyrene	mg/kg	0/ 61	6.4	0.7	27
Benzo(b)fluoranthene	mg/kg	6/ 61	**18**	1.9	2.6
Fluoranthene	mg/kg	0/ 61	42	4.0	280
Benzo(k)fluoranthene	mg/kg	0/ 61	9	1.1	77
Acenaphthylene	mg/kg	0/ 61	0.48	0.1	170
Chrysene	mg/kg	0/ 61	14	1.5	15
Benzo(a)pyrene	mg/kg	6/ 61	**14**	1.6	5.0[A]
Dibenzo(ah)anthracene	mg/kg	6/ 61	**1.9**	0.1*	0.24
Benzo(a)anthracene	mg/kg	2/ 61	**15**	1.8	7.2
Acenaphthene	mg/kg	0/ 61	2.1	0.3	210
Phenanthrene	mg/kg	0/ 61	36	2.8	95
Fluorene	mg/kg	0/ 61	2.9	0.30	170
Naphthalene	mg/kg	0/ 61	0.45	0.09	2.3
Petroleum Hydrocarbons					
Aromatics >EC5-EC7	mg/kg	0/ 2	0.1	NC	70
Aromatics >EC7-EC8	mg/kg	0/ 2	0.1	NC	130
Aromatics >EC8-EC10	mg/kg	0/ 2	0.1	NC	34
Aromatics >EC10-EC12	mg/kg	0/ 2	3.4	NC	74
Aromatics >EC12-EC16	mg/kg	0/ 2	18	NC	140
Aromatics >EC16-EC21	mg/kg	0/ 2	98	NC	260
Aromatics >EC21-EC35	mg/kg	0/ 2	370	NC	1100
Aromatics >EC35-EC44	mg/kg	0/ 2	630	NC	1100
Aliphatics >EC5-EC6	mg/kg	0/ 2	0.1	NC	42
Aliphatics >EC6-EC8	mg/kg	0/ 2	0.1	NC	100
Aliphatics >EC8-EC10	mg/kg	0/ 2	0.1	NC	27
Aliphatics >EC10-EC12	mg/kg	0/ 2	2.8	NC	130
Aliphatics >EC12-EC16	mg/kg	0/ 2	21	NC	1100
Aliphatics >EC16-EC21	mg/kg	0/ 2	51	NC	65000
Aliphatics >EC21-EC35	mg/kg	0/ 2	240	NC	65000
Aliphatics >EC35-EC44	mg/kg	0/ 2	260	NC	65000
EPH/TPH >C6-10	mg/kg	0/ 61	0.1	0.1	27
TPH >C6-40	mg/kg	38/ 61	**1200**	**206**	27
Other Organics					
Methyl tert-butyl ether	mg/kg	0/ 2	0.001	NC	49 B
Benzene	mg/kg	0/ 2	0.001	NC	0.087

Contaminant	Units	Exceeding	Max	95th percentile	Tier 2 Screen
Toluene	mg/kg	0/ 2	0.001	NC	130
Ethylbenzene	mg/kg	0/ 2	0.001	NC	47
o - Xylene	mg/kg	0/ 2	0.001	NC	60
m,p xylenes	mg/kg	0/ 2	0.001	NC	60
Phenol (Monohydric)	mg/kg	0/ 12	1	1	80

[A]Category 4 Screening Level. [B]SGV/GAC based on CLEA UK Beta Version at 1%. *Outliers identified using the maximum value test and values omitted from 95th percentile. NC – not calculated. Unless otherwise labelled, the values are Tier 2 Screening Values based on a residential with plant uptake end use S4UL** at 1% SOM.

** *Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL 3036. All rights reserved.*

4.3.2 Minor exceedances of the S4ULs were recorded for several PAHs, including benzo(a)pyrene and dibenzo(a,h)anthracene in approximately 10% of the samples. The C4SL for lead was also exceeded in 2 of the 61 samples. However, the 95th percentile concentrations were below the screening values.

4.3.3 The S4UL for Total Petroleum Hydrocarbon (TPH) >C6-C40 was exceeded for 38 of 61 samples and the 95th percentile also exceeded. The two highest results were analysed for TPH CWG with aromatic / aliphatic hydrocarbon split, which indicated the source to be of heavier end aliphatics and aromatics. The individual carbon bandings were not found to exceed the respective S4ULs and therefore there is not considered to be significant.

4.3.4 Outliers were detected in the dataset for dibenzo(a,h)anthracene and lead, and are listed in the Table 4.3. These are all nominal exceedances and when considered in the aggregate with the other results they represent a low risk in terms of the proposed development.

TABLE 4.3: List of Contaminant Outliers

Contaminant	Hole Ref	Depth (m bgl)	Concentration (mg/kg)	Tier 2 Screen (mg/kg)	Strata
Dibenzo(ah)anthracene	TP919	1	1.9	0.24	Made Ground
	BH940	0.25	0.54		
	TP922	1	0.44		
	BH903	1	0.3		
	TP914B	1	0.3		
	BH911	1	0.29		
	TP991	0.2	0.24		
Lead	BH985	1	220	200	
	TP967	2.2	210		

4.4 Asbestos

4.4.1 Asbestos analysis by polarised light microscopy was carried out for all the 131 environmental and geotechnical samples submitted. Asbestos was identified in 15 samples, 2 of which contained chrysotile as insulation board, 10 contained loose fibres of chrysotile and 3 contained loose fibres of amosite. No asbestos was noted in the logs.

4.4.2 From the results to date it does not appear that asbestos is widespread or requires specific remediation provisions beyond that currently specified. However, the occasional presence of localised occurrence of asbestos containing material should be presumed in view of the heterogeneous nature of the landfilled soils. A contingency plan is therefore required in case of

uncontrolled release of asbestos as a result of the earthworks. Reference to CAR-SOIL™ produced by JIWG and published by CL:AIRE is required in this regard which provides an overview of the associated requirements[1]. The Health and Safety Risk Assessments for work should include consideration of asbestos in soil and it is noted that this has been included in the associated Designers Risk Assessment prepared by CampbellReith.

4.5 Current Earthworks Strategies

4.5.1 A detailed and site specific specification was produced for Phase 2.3 to control soils excavation, validation testing, classification and backfill and, pending the issue of the Earthworks Specification for Phases 2.4 – 2.6, is to be adopted for Phase 2.4.

4.5.2 In summary, samples of soil proposed for re-use will be tested at the frequency of 1 per 2500m^3 and compared against C4SLs, where available, and S4ULs for a residential with plant uptake end use. The use of C4SLs is considered appropriate given that these represent a 'low' level of risk[2].

4.6 Contamination Soil Summary

4.6.1 The chemical results for soils indicate minimal risk to future users. Excavated Made Ground soils can be reused both beneath and as part of the proposed select fill capping layers subject to chemical validation and geotechnical suitability.

4.6.2 For the upper 2m of Engineered Fill validation will be carried out against limiting values comprising C4SLs and, where unavailable, S4ULs.

4.6.3 With respect to asbestos, the limiting values have been based on the 'as low as reasonably possible' (ALARP) principle: in the upper 2m of Engineered Fill the limiting value is <0.001% w/w. Beneath 2m of finished earthworks level it will be visual absence and <0.1% w/w.

4.6.4 The re-use of site soils will be carefully controlled to prevent risk to future users and surface water receptors and to optimise soils reuse in successive phases of work. A Materials Management Plan (MMP)[3] has been produced by CampbellReith in accordance with the CL:AIRE Code of Practice[4] to demonstrate that soil is re-used in accordance with the Waste Framework Directive 2008.

[1] CL:AIRE – JIWG CAR-SOIL™ Control of Asbestos Regulations 2012
[2] DEFRA SP1010 Development of Category 4 Screening Levels Report (Revision 2), September 2014
[3] Ref: 2017-04 05 JWC11950-MMP_Ph2.1-2.6 R01, April 2017
[4] CL:AIRE The Definition of Waste: Development Industry Code of Practice, Version 2, March 2011

5.0 CONTROLLED WATERS GENERIC QUANTITATIVE RISK ASSESSMENT

5.1 Synopsis

5.1.1 Across the wider Phase 2 and 3 areas, elevated concentrations were detected by SLR [3 and 1] in the perched groundwater associated with the Made Ground above the Weald Clay. However, they concluded [2] that these concentrations had no significant impact on the water quality of Hoppers Brook (running north–south along the western Phase 2 boundary) or Bewbush Brook (running west–east) along the northern Phase 2.4 boundary.

5.1.2 Samples were taken from six boreholes and three surface water monitoring points on the Bewbush Brook over 14-15 December 2016. The perched groundwater samples provided general site coverage. Sampling points on Bewbush Brook upstream, on site and downstream of the north of Phase 2.4, targeted the impact from perched groundwater originating in Phase 2.4, on the surface water. No hydrocarbon odour or staining was noted during monitoring and the analytical results [22] corroborate the conclusions from the SLR reports [1 – 3] that the perched groundwater is not a significant risk to surface water quality.

5.2 Hydrogeological and Hydrological Setting

5.2.1 Previous investigations showed discontinuous groundwater at various depths across the site, predominantly within the landfill material between 0.40m and 8.50m bgl. Recent groundwater monitoring (December 2016 – January 2017) indicates a continuous groundwater body within the landfill, perched above the Weald Clay.

5.2.2 The Weald Clay itself is classed as a non-aquifer by the Environment Agency, and there are no groundwater abstraction wells within one kilometre of the site. The underlying Upper Chalk Principal Aquifer was not encountered in any of the exploratory locations and is therefore not considered to be in hydraulic continuity with the perched groundwater. As such, there are no sensitive groundwater receptors.

5.2.3 Three watercourses cross, or flow adjacent to, the former Holmbush Landfill site: Bewbush Brook, and its tributaries Hopper's Brook and Spruce Hill Brook. Since the creation of the landfill the resultant perched groundwater and surface water run-off has drained to these watercourses. Spruce Hill Brook lies to the east of Phase 2.4 south area and Hopper's Brook to the north-west. Both flow northwards into Bewbush Brook. The locations of the streams are shown in Figure 3 of the Phase 2.4 GDR [24], a copy of which is provided in Appendix C.

5.2.4 Prior to 1974, Bewbush Pond was present in the north east of Phase 2, with levels artificially controlled by a sluice gate associated with a disused mill. The pond was backfilled sometime between 1963 and 1974. The Bewbush Brook was channelled in the Weald Clay and the landfill created directly adjacent to the banks. The brook drains from west to east and topographical surveying from May 2015 shows it at an elevation of 74.60m AOD in the west, falling to 71.30m AOD in the east. Bewbush Brook flows into Ifield Brook and Ifield Mill pond off-site to the north east. The Ifield Brook catchment was classified as 'good' chemical quality and 'moderate' ecological quality in the 2015 EA assessment under the Water Framework Directive.

5.2.5 Monitoring demonstrates that groundwater level in the main body of the landfill (to the south of the brook) is above the level of the surface water and it reduces down approaching the brook, as shown in Figure 5. As such, it can be assumed that the landfill drains into the brook.

5.3 Proposed Drainage Works and Realignment of Bewbush Brook

5.3.1 The course of Bewbush Brook is to be re-aligned, which will require a combination of cut in some areas and fill in others, depending on local topography. The realignment is shown in CR drawings 11950-BBD-CE202-P1 and 11950-BBD-CE203-P1, contained in Appendix C.

5.3.2 In the SLR Remediation Strategy [2] it was assumed that any realignment would comprise clay lining of the channel which would have the benefit of preventing potential pollution of the surface water by landfill leachate. Although SLR confirmed that monitoring indicated no adverse impact to surface waters for landfill leachate they did identify three sources of potential contamination:

i) elevated concentrations of metals and PAH compounds in localised areas of waste which could leach and migrate to the surface water;

ii) general migration of groundwater from the landfill, including surface water run-off, to the brook; and

iii) migration of localised hydrocarbon contamination that may be associated with the former recycling area in Phase 2.3.

5.3.3 The main potential impact to surface waters is the new channel where it is cut into landfill material in the northern portion of Phase 2.4.

5.3.4 The current proposals for Phase 2.4 include provision of a minimum of 2m of Engineered Fill, which will have a low permeability, above residual landfill material to inhibit downward migration of water.There is therefore limited potential for vertical leachate migration and therefore a reduction in groundwater flow from the site.

5.3.5 In addition, as part of the development, surface water, i.e. rainwater, will be collected by surface drains that discharge into two attenuation ponds to be installed on the eastern and western margins of the site adjacent to Bewbush Brook. These will drain into Bewbush Brook.

5.3.6 The infiltration rate to residual landfill, post-earthworks, is therefore anticipated to be much lower than at present.

5.4 Recent Groundwater Monitoring

5.4.1 The observations made during monitoring are summarised in Table 5.1 and the results of the perched groundwater sampling are summarised in Table 5.2. Since the purpose of this assessment is to show whether the landfill as a whole is, or is potentially, impacting Bewbush Brook, the results incorporate five samples from Phase 2.5 and seven samples from Phase 2.6 site investigations, in order to create a representative picture of the groundwater at the site. No groundwater observations are available for Phase 2.6 at time of writing.

5.4.2 Since the critical receptor is identified to be the Bewbush Brook, freshwater Environmental Quality Standards (EQS), where available, have been used for the Tier 2 screening values.

5.4.3 **TABLE 5.1: Summary of Water Monitoring Observations**

Borehole	Response Zone (m bgl)	Water Temperature (°C)	Dissolved Oxygen (%)	Spec. Conductivity (µS/cm)	pH	Redox potential (mV)
Phase 2.4: 14 – 15 December 2016						
BH910	14.0 – 15.0	10.8	7.7	4413	7.0	-89
BH912	7.0 – 5.0	10.8	8.2	2011	7.1	-77
BH917	3.8 – 4.8	10.8	10.9	2181	7.3	-43
BH921A	10.0 – 11.0	11.4	9.6	1477	8.6	-100
BH927	12.0 – 14.0	12.0	5.3	1159	8.1	-32
BH927A	8.0 – 11.0	11.4	16.3	3063	7.7	-108
Upstream – SW3	-	7.3	62.8	582	7.2	-39
Stream (onsite) – SW2	-	7.3	56.0	581	7.2	-27
Downstream – SW1	-	7.3	57.1	581	7.2	-33
Phase 2.5: 16 – 17 January 2017						
BH935	8 – 10	10.9	14.3	2909	7.4	-158
BH937	10.0 – 11.5	11.7	16.9	3252	8.8	-89
BH943	10.5 – 11.5	10.6	29.5	1364	7.5	-71
BH945	4.0 – 7.0	6.3	18.0	662	9.6	-235
BH953	11.0 – 12.5	6.4	21.5	747	10.3	-261

TABLE 5.2: Summary of Groundwater Analysis (December 2016 – January 2017)

Contaminant	Units	Exceeding*	Max	Mean	Tier 2 Screen
Inorganics					
Ammoniacal Nitrogen as N	ug/l	13/ 13	**150000**	**13833**	300[f,b]
Arsenic	ug/l	1/ 18	**63**	10	50[a]
Boron	ug/l	0/ 18	750	309	2000[c]
Cadmium	ug/l	0/ 18	0.06	0.02	0.25[a]
Total Chromium	ug/l	0/ 18	1.0	0.5	4.7[a]
Hexavalent Chromium	ug/l	0/ 18	<5	5	3.4[a]
Copper	ug/l	1/ 18	**300**	25	35[e]
Lead	ug/l	2/ 18	**74**	10	10.9[e]
Inorganic Mercury	ug/l	9/ 18	**0.6**	**0.1**	0.07[a]
Total Cyanide	ug/l	4/ 18	**82**	**14**	1.0[a]
Cyanide Free	ug/l	0/ 18	<10	10	1.0[a]
Selenium	ug/l	7/ 18	**75**	**14**	10[g]
Nickel	ug/l	2/ 18	**190**	23	20.6[e]
Zinc	ug/l	1/ 18	**24**	7	12.9[a]
Sulphate as SO_4	ug/l	5/ 18	**13,500,00**	307,444	400,000[d]
Polynuclear Aromatic hydrocarbons (PAHs)					
Anthracene	ug/l	9/ 18	**1.79**	**0.21**	0.1[a]
Benzo (ghi) perylene	ug/l	0/ 18	<0.01	0.01	0.002[a]
Benzo (a) pyrene	ug/l	0/ 18	<0.01	0.01	0.05[a]
Benzo (b) fluoranthene	ug/l	0/ 18	<0.01	0.01	0.03[a]
Benzo (k) fluoranthene	ug/l	0/ 18	<0.01	0.01	0.03[a]
Fluoranthene	ug/l	8/ 18	**2.04**	**0.26**	0.1[a]
Indeno (1,2,3 - cd) pyrene	ug/l	0/ 18	<0.01	0.01	0.002[a]
Naphthalene	ug/l	3/ 18	**25.9**	**3.20**	2.0[a]

Contaminant	Units	Exceeding*	Max	Mean	Tier 2 Screen
Miscellaneous					
Phenol (Monohydric)	ug/l	3/ 10	**570**	**63**	7.7[a]
BOD + ATU (5 day)	mg/l	- / 13	160	21	-
COD	mg/l	- / 13	4200	382	-
Total Organic Carbon	mg/l	- / 13	765	83	-
TPH >C10-40	ug/l	1/ 18	**160**	27	90[a]**

*Does not include where limit of detection exceeds screening value; ** - screening value for TPH>C20-C30 taken in a conservative assumption; a – Water Framework Directive 2015; b – value is for ammonia in groundwater (as N); c – Water Supply (Water Quality) Regulations 2000; d – Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances; e – site-specific predicted no effect concentration (The site-specific bioavailability of lead and nickel were assessed using the M-BAT (Metals Bio-availability Assessment Tool)[5]: taking average (n = 3) surface water pH of 7.8, total organic carbon (TOC) of 9.1mg/l, and conservative assumption of low alkalinity of 2mg/l (as $CaCO_3$), the predicted no effect concentrations were calculated and used as screening values.); f - River Basins Districts Typology (England and Wales), 2010; g - WHO drinking water standard

5.4.1 Exceedances were recorded for PAHs, TPH>C10-C40, metals, phenol (monohydric), total cyanide and ammoniacal nitrogen.

5.4.2 To assess whether the elevated contaminant concentrations detected in groundwater are impacting surface water quality, the pathway between the two was investigated via surface water sampling.

5.5 Recent Surface Water Monitoring

5.5.1 Analysis of surface water samples allows for further assessment of the impact that the minimally elevated concentrations of PAHs, sulphate, metals and monohydric phenols, and high ammoniacal nitrogen concentrations may have on the Bewbush Brook. Samples upstream, at the site and downstream of the site were sampled and the analytical results have been compared with screening values and are summarised in Table 5.3.

TABLE 5.3: Summary of Surface Water Analysis (15 December 2016)

Contaminant	Units	Exceeding*	Upstream (SW3)	Site (SW2)	Downstream (SW1)	Tier 2 Screen
Ammoniacal Nitrogen as N	ug/l	0/ 3	100	86	70	300[f,b]
Arsenic	ug/l	0/ 3	1.5	1.0	0.6	50[a]
Boron	ug/l	0/ 3	41	35	36	2000[c]
Cadmium	ug/l	0/ 3	0.02	<0.02	<0.02	0.25[a]
Chromium	ug/l	0/ 3	0.2	0.2	0.3	4.7[a]
Hexavalent Chromium	ug/l	0/ 3	<5.0	<5.0	<5.0	3.4[a]
Copper	ug/l	0/ 3	7.9	7.3	6.5	1[d]
Lead	ug/l	0/ 3	0.2	0.2	<0.2	10.9[e]
Inorganic Mercury	ug/l	0/ 3	<0.05	<0.05	<0.05	0.07[a]
Total Cyanide	ug/l	0/ 3	<10	<10	<10	1[a]
Cyanide Free	ug/l	0/ 3	<10	<10	<10	1[a]
Selenium	ug/l	0/ 3	<0.6	3.0	1.8	10[g]
Nickel	ug/l	0/ 3	5.5	6.4	4.9	20.6[e]
Zinc	ug/l	0/ 3	3.8	3.2	4.3	12.9[a]
Sulphate as SO_4	ug/l	0/ 3	104,000	95,900	101,000	400,000[d]
Anthracene	ug/l	0/ 3	<0.01	<0.01	<0.01	0.1[a]
Benzo (ghi) perylene	ug/l	0/ 3	<0.01	<0.01	<0.01	0.002[a]
Benzo (a) pyrene	ug/l	0/ 3	<0.01	<0.01	<0.01	0.05[a]

[5] http://www.wfduk.org/tagged/bioavailability-assessment-tool - *contains UKTAG information © UKTAG and database right*

Contaminant	Units	Exceeding*	Upstream (SW3)	Site (SW2)	Downstream (SW1)	Tier 2 Screen
Benzo (b) fluoranthene	ug/l	0/ 3	<0.01	<0.01	<0.01	0.03[a]
Benzo (k) fluoranthene	ug/l	0/ 3	<0.01	<0.01	<0.01	0.03[a]
Fluoranthene	ug/l	0/ 3	<0.01	<0.01	<0.01	0.1[a]
Indeno (1,2,3 - cd) pyrene	ug/l	0/ 3	<0.01	<0.01	<0.01	0.002[a]
Naphthalene	ug/l	0/ 3	<0.01	<0.01	<0.01	2[a]
Phenol (Monohydric)	ug/l	0/ 3	<10	<10	<10	7.7[a]
BOD + ATU (5 day)	ug/l	-	2.7	<1.0	<1.0	-
COD	ug/l	-	23	23	29	-
Total Organic Carbon	ug/l	-	8.71	9.98	8.68	-
TPH >C10-40	ug/l	0/ 3	<10	<10	<10	90[a]**

*Does not include where limit of detection exceeds screening value; ** - screening value for TPH>C20-C30 taken in a conservative assumption; a – Water Framework Directive 2015; b – value is for ammonia in groundwater (as N); c – Water Supply (Water Quality) Regulations 2000; d – Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances; e – site-specific predicted no effect concentration; f - River Basins Districts Typology (England and Wales), 2010; g - WHO drinking water standard

5.5.2 No exceedances above detection limits were recorded in surface waters. There was no increase in concentrations in surface water at site or downstream, for those contaminants that exceeded EQS in groundwater. These results support those of SLR [1 – 3] which indicates that the landfill is not having a significant effect on the water quality of the surface waters. However, the proposed development will include realignment of the brook, part of which will be formed in residual landfill. As such, there is potential for a greater input of landfill leachate (via groundwater) into the brook and so this requires further assessment.

5.6 Predicted Surface Water Concentrations in the Realigned Bewbush Brook

5.6.1 The surface water monitoring indicates that under current conditions, the risk to the surface water from contaminants in groundwater is low. However, the concentration of contaminants in surface water post-earthworks has been predicted in order to increase confidence in this assessment. The calculations take into account the principles of the remedial targets methodology[6].

5.6.2 Taking the contaminants in groundwater that exceed screening values (summarised in Table 5.2), the equations presented below are used to calculate their flux in groundwater. This flux is added to background flux in surface water. Therefore, only dilution in the surface water is taken into account. There are several mitigating factors which could affect the actual contaminant transport and this flux calculation is presented only to increase confidence in the previous assessment and it should not be taken as a description of risk in and of itself.

a) Groundwater Flow (m^3/s) $Q_{gw} = i \cdot K \cdot x \cdot y$

where i – hydraulic gradient (m/m), K = hydraulic conductivity (m/s), x and y = plume width and height (m)

b) Stream Flow (m^3/s) $Q_{Brook} = V \cdot a \cdot b$

where V = stream water velocity (m/s), a and b = width of channel and depth of water (m)

[6] https://www.gov.uk/government/publications/remedial-targets-worksheet-v22a-user-manual - accessed 08/05/17

c) Total Flux (g/s) = $(Q_{gw} . C_{gw}) + (Q_{Brook} . C_{Brook})$

where C_{gw} = mean contaminant concentration in groundwater (µg/l), C_{Brook} = background contaminant concentration in Brook (µg/l)

d) Predicted concentration in Brook (µg/l) = (Total Flux . Q_{Brook}) / 1000

where 1000 is to convert m^3 to l.

5.6.3 Considering the logs and proposed levels of the realigned brook, the groundwater in the landfill will be in partial hydraulic conductivity with the realigned brook. This is the case in the western half of the site (where the brook will be moved to the south into the existing landfill area), up until the brook enters a short culverted section in the centre. Upon exiting the culvert, the realigned brook will mostly be founded in Engineered Fill and/or Weald Clay as it follows the existing channel, and therefore hydraulic continuity with groundwater will be limited.

5.6.4 There is a 350m section of the brook where the pathway between groundwater in the landfill and the surface water may be made more direct following realignment. To ascertain whether the contaminant concentrations in groundwater that exceeded EQS would pose a significant risk to surface water quality, the effect of dilution has been considered.

The flows in the Bewbush Brook and groundwater have been estimated based on site-specific parameters, where available. The water level in the Bewbush Brook is considered to be low, when taking the previous four months of river monitoring at a nearby downstream gauging station on the Ifield Brook into account[7]. This therefore provides a conservative value in the estimate of flow in the brook, and therefore of dilution. The input parameters are summarised in Table 5.2.

TABLE 5.2: Parameters for Estimates of Surface Water and Groundwater Flows

Parameter	Unit	Value	Source
Bewbush Brook			
width, a	m	0.24	On site measurement – 09/05/17
depth, b	m	0.15	
velocity, V	m/s	0.01	conservatively low in-lieu of a site-derived value
flow, $Q_{brook} = V . a . b$	m^3/sec	$3.6x10^{-4}$	
Groundwater			
hydraulic gradient, i	m/m	0.029	obtained from groundwater monitoring (December 2016 – January 2017)
hydraulic conductivity, K	m/s	$2.0x10^{-7}$	considering fill material at the site is mostly cohesive, this is a conservative value, for a fine grained sand (Domenico and Schwartz, Physical and Chemical Hydrogeology, Wiley, 1990
plume width, x	m	350	Measured from plan of realigned brook that would be in contact with residual landfill
plume height, y	m	7	maximum depth of residual landfill, beneath Engineered Fill, adjacent to realigned Brook
flow, $Q_{gw} = i . K . x . y$	m^3/sec	$1.0x10^{-5}$	

[7] https://www.riverlevels.uk/ifield-brook-rusper-ifield – accessed 08/05/2017

5.6.5 Of the contaminants that exceeded screening values in groundwater, surface water concentrations were calculated that take dilution in surface water and background contaminant concentrations (from chemical analysis of upstream surface water sample, SW3) into account. Two estimates of surface water concentration are given: at the current level in the brook following a very dry period (0.15m), and at a level that is considered more representative of typical conditions (0.5m). The calculations are shown in Appendix C and the estimated surface water concentrations are compared against screening values in Table 5.3.

TABLE 5.3: Estimated Surface Water Concentrations

Contaminant	Units	Estimated concentration in surface water		Measured Concentration in brook at Site	Tier 2 Screen
		0.15m level in brook	0.5m level in brook		
Ammoniacal Nitrogen as N	ug/l	**646**	146	86	300[f,b]
Arsenic	ug/l	1.8	1.5	1.04	50[a]
Copper	ug/l	9.0	8.0	7.3	35[e]
Lead	ug/l	0.49	0.22	0.2	10.9[e]
Inorganic Mercury	ug/l	0.03	0.03	<0.05	0.07[a]
Selenium	ug/l	0.73	0.34	3	10[g]
Total Cyanide	ug/l	**5.6**	**5.0**	<10	1[a]
Anthracene	ug/l	0.01	0.01	<0.01	0.1[a]
Fluoranthene	ug/l	0.02	0.01	<0.01	0.1[a]
Naphthalene	ug/l	0.15	0.02	<0.01	2[a]
Sulphate as SO_4	ug/l	112,294	104,691	95,900	400,000[d]
Phenol (Monohydric)	ug/l	7.5	5.2	<10	7.7[a]
TPH >C10-40	ug/l	6.2	5.1	<10	90[a,**]

*Does not include where limit of detection exceeds screening value; ** - screening value for TPH>C20-C30 taken in a conservative assumption; a – Water Framework Directive 2015; b – value is for ammonia in groundwater (as N); c – Water Supply (Water Quality) Regulations 2000; d – Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances; e – site-specific predicted no effect; f - River Basins Districts Typology (England and Wales), 2010; g - WHO drinking water standard

5.6.6 The estimated concentrations of ammoniacal nitrogen and total cyanide are predicted to exceed EQS under present conditions. It should be noted that the level in the brook was measured after an extremely dry April (9.8mm rainfall in the south east and central south England[8]), and when river levels downstream at the Ifield brook are close to the annual low values. Considering this, the actual flux of phenol (monohydric), total cyanide and ammoniacal nitrogen downstream is low.

5.6.7 When taking a water level of 0.5m in the brook, ammoniacal nitrogen is not predicted to exceed EQS, but total cyanide still exceeds. It is noted that the EQS relates to free cyanide, rather than total cyanide, and free cyanide has not been detected either in the groundwater or surface water. However, the detection limit for both free and total cyanide of <10 ug/l is higher than the EQS of 1 ug/l and therefore a value of half the limit of detection was adopted in the calculations, which is likely to be conservative. A review of the site history and soil results does not indicate any source of cyanide and it is very unlikely that free cyanide is present. As such, cyanide is not considered to be a risk to Bewbush Brook.

[8] http://www.metoffice.gov.uk/climate/uk/summaries/2017/april/regional-values - accessed 08/05/2017

5.6.8 As noted previously, the infiltration rate to residual landfill, post-earthworks, will significantly decrease as a result of the earthworks design and proposed surface water drainage and therefore the production of leachate will decrease.

5.6.9 In summary, the assessment carried out indicates that following the proposed redevelopment works the leachate concentrations associated with the groundwater in the landfill will not significantly increase in flux to the Bewbush Brook. As such, the realignment of the brook will not require clay lining from a controlled waters risk assessment perspective.

5.6.10 During the Phase 2.4 earthworks, monitoring of the water courses will be addressed under the existing Construction and Environmental Management Plan (CEMP).

5.6.11 Tailored method statements/specifications will be required to demonstrate that the earthworks account for potential contamination of surface waters. They will also be required for the future phases to prevent pollution of surface waters during the proposed realignment works of Bewbush Brook. All such documentation will require discussions with and approval from the Environment Agency.

6.0 GROUND GAS ASSESSMENT

6.1 Synopsis

6.1.1 Historical gas monitoring across the wider site area, including Phase 2.4, demonstrated the presence of elevated ground gas (methane and carbon dioxide) concentrations, particularly methane, associated with the former landfill. Recent investigation of Phase 2.4 has confirmed these concentrations and similar periodic flow rates above detection limit at certain locations.

6.1.2 Elevated gas screening values (GSV) and forensic TOC concentrations of soils have been identified from the Hydrock/CampbellReith 2016/17 investigation. However, the potential ground gas risk can be mitigated via installation of standard gas protection measures – in this case, a gas protection membrane, ventilated sub-floor void and appropriate verification of installation – provided the earthworks are carefully managed and field conditions are not significantly different to those assumed from the investigation.

6.1.3 An earthworks strategy has been developed in conjunction with the geotechnical remedial design. This will excavate Made Ground from the landfill and limit the re-use of soils to those with an acceptable ground gas generation potential in the upper 2m of replaced fill. The strategy includes additional assessment to confirm the current data and if this is done then it will enable residential development to proceed on the provision that standard passive gas protection measures are included in the construction in areas of residual landfill. Alternatively, if the validation monitoring assessment indicates the potential for higher emission rates across the site than currently assumed, the requirement for land-based protection measures, such as in-ground vent wells, would need to be considered.

6.1.4 This section provides a summary of the historical and recent investigations with respect to ground gas. It compares the gas regime CIRIA/NHBC Characteristic Situation classifications produced by standard borehole gas monitoring (gas concentrations and flow rates) and the forensic TOC soil analysis method. It also details the analytical methods that have been used to assess, and will be used to control, the organic concentration of the soils and provides details of the remedial strategy and validation process.

6.2 Overview of Gas Source/s

6.2.1 SLR [1] assessed the gas chemistry of the wider site area and noted that the gas concentrations are significantly different to that of a 'standard' landfill which are generally of the order of 64% methane and 34% carbon dioxide v/v. As detailed below in Tables 6.1 to 6.3, the methane concentrations at Kilnwood were detected up to 97% v/v with carbon dioxide concentrations between 0.2 and 26% v/v, the majority below 10%. It is assumed that this is due to dissolution of carbon dioxide in groundwater, and the anaerobic conditions that must be present at site - due in part to the capping layer of clay across much of the landfill - which leads to methanogenesis[9] following sequential consumption of other terminal electron acceptors.

6.2.2 The cause of the elevated methane and carbon dioxide concentrations therefore appears to be due partly to the degradation of organic material in the landfill. Soils with high organic matter content, whether Alluvium or soils containing timber, have been covered by cohesive clays and are largely within a clay soil matrix in the Made Ground. In portions of the wider site, the landfill

[9] Ground Gas Handbook, S. Wilson, G. Card and S. Haines, 2009

included a capping layer of clay up to 2m thick and this was confirmed by earthworks in Phase 2.1 when a clay layer was uncovered at depth overlaying a hot spot of organic soil with timber. The result, as detailed in the SLR LQS [1], has been the generation of ground gases that have been trapped and therefore built up under pressure. It is likely that gas generation is at a low rate and gas is subsequently trapped in the soil pore spaces, which is then released when the monitoring wells are constructed. It should be noted that due to the relatively recent (c. 10 years ago at time of writing) deposition of waste – including wood – active gas generation may be occurring to some extent in the southern part of Phase 2.4.

6.2.3 This hypothesis was supported by the biological oxygen demand (BOD) and chemical oxygen demand (COD) carried out on leachate samples post-closure of the landfill, by SLR [2]. Twenty eight samples were collected and the ratios of BOD:COD were generally below 0.1 and all were below 0.2. The ratios obtained from three samples in Phase 2.4 were also all below 0.1. Ratios above 0.4 generally indicate a potential for increased gas generation[6], although it is noted that ratios are likely to follow a cycle of increase and decrease which repeats as the stages of decomposition progress. The relatively low ratios do however support the hypothesis that gas generation is low and elevated gas concentrations are trapped in soil pore spaces (which may have ruptured to form a soil pipe network) and/or more granular waste.

6.2.4 The effectiveness of the clay capping layer across the historical landfill of Phases 2 and 3 was proven by SLR [1] following flux box monitoring and a survey with a flame ionisation detector (FID) which showed only very low methane concentrations at the surface of the landfill. The highest FID reading was 16.6ppm and the majority were below 1.7ppm.

6.3 Historical Gas Concentrations and Flow Rates

6.3.1 Previous ground gas monitoring carried out by STL over December 2014 to June 2015 included five locations within the Phase 2.4 boundary – four in the southern area, and one in the north. The gas flow rate and concentrations of ground gas (methane and carbon dioxide) and the gas screening values (GSV) – the product of the gas concentration and flow rate – are presented in Table 6.1. The associated gas risk according to CIRIA CS and NHBC traffic light (NHBC) classifications is also shown – these have been amended to account for the elevated methane concentrations and associated flow rates, as per industry guidance[10], but excluding more detailed assessment which is the purpose of this report

TABLE 6.1: Previous Phase 2.4 Ground Gas Monitoring Data (December 2014 – June 2015)

Hole	Number Visits	Peak flow rate (l/hr)	Steady state CH_4 (%)	Steady State CO_2 (%)	GSV (l/hr)	CS/NHBC
BH130	1	0.3	0.1	4.4	0.01	CS1
BH131	4	108*	88	4.5	3.3	CS3
BH132	4	0.6	13	5.4	0.08	CS2 / Amber 1
BH207	4	0.8	36	6.5	0.3	CS2 / Amber 1
BH322	4	4	70	1.1	2.8	CS3

*The flow rate of 108l/hr was an initial reading; however, no steady state was recorded. The next highest flow rate on a subsequent monitoring round (3.7l/hr) was used in calculating the GSV; Limit of detection = 0.1% v/v

6.3.2 The monitoring showed that in the southern portion of Phase 2.4, and in the area of the former landfill, two of the locations were classified as NHBC Red and CS4.

[10] CIRIA C665 Assessing risks posed by hazardous ground gas to buildings

6.4 Recent Gas Monitoring of Phase 2.4

Ground gas monitoring of Phase 2.4 was carried out as part of the Hydrock/CampbellReith 2016/2017 investigation. Nineteen of the boreholes were provided with gas monitoring installations, details of which are provided in Table 3.1, and three to five gas monitoring visits were carried out. The atmospheric pressure was noted from a Met Office weather observation station Charlwood, approximately 5km north of the site. Table 6.2 summarises the atmospheric pressure on the day of sampling, relative to the preceding 24 hours.

TABLE 6.2: Phase 2.4 Methane Concentration Data (December 2016–February 2017)

Date	Atmospheric pressure (hPa)	Trend
20/12/2016	1021	falling
21/12/2016	1019	steady
16/01/2017	1027	rising
17/01/2017	1036	rising
23/01/2017	1026	steady
24/01/2017	1026	steady
24/02/2017	1017	rising

6.4.1 The monitoring data are summarised in Tables 6.3 and 6.4. Carbon dioxide concentrations were lower than the respective methane concentrations and therefore methane was used to derive gas screening values (GSV).

TABLE 6.3: Phase 2.4 Methane and Carbon Dioxide Concentration Data (December 2016–February 2017)

Hole	Number Visits	CH_4		CO_2	
		Max %	Steady state %	Max %	Steady state %
BH901	3	89	89	0.2	0.1
BH903	3	84	85	6	6
BH907	3	0.7	0.1	0.1	0.1
BH909	3	33	25	2	2
BH910	5	45	46	11	12
BH911	5	52	42	3	2
BH912	5	92	92	7	6
BH913A	3	91	95	8	8
BH915	3	85	73	0.5	0.4
BH917	3	0.6	0.2	0.2	0.2
BH918	3	72	72	0.6	3
BH921A	3	90	65	3	3
BH927	3	28	20	3	2
BH941	3	30	41	1	3
BH951	3	23	13	1	0.7
BH977	3	86	86	4	4
BH985	3	34	34	3	3

Hole	Number Visits	CH_4		CO_2	
		Max %	Steady state %	Max %	Steady state %
BH991	3	12	12	2	2
BH999	3	9.3	9.3	3	3

Limit of detection = 0.1% v/v

TABLE 6.4: Phase 2.4 Flow rates (December 2016–February 2017)

Hole	Number Visits	Max (l/hr)	Min (l/hr)	Mean (l/hr)	Standard Deviation
BH901	3	0.1	0.1	0.1	0.0
BH903	3	0.1	0.1	0.1	0.0
BH907	3	0.1	0.1	0.1	0.0
BH909	3	0.1	0.1	0.1	0.0
BH910	5	0.1	0.1	0.1	0.0
BH911	5	0.1	-4.2	-0.9	1.9
BH912	5	4.4	0.1	0.9	2.0
BH913A	3	0.1	0.1	0.1	0.0
BH915	3	0.1	0.1	0.1	0.0
BH917	3	0.1	0.1	0.1	0.0
BH918	3	0.1	0.1	0.1	0.0
BH921A	3	0.1	0.1	0.1	0.0
BH927	3	0.1	0.1	0.1	0.0
BH941	3	0.1	0.1	0.1	0.0
BH951	3	0.1	0.1	0.1	0.0
BH977	3	0.1	0.1	0.1	0.0
BH985	3	0.1	0.1	0.1	0.0
BH991	3	0.1	0.1	0.1	0.0
BH999	3	0.1	0.1	0.1	0.0

Limit of detection = 0.1l/hr

6.4.2 As detailed in Table 6.4, flow rates were detected at two of the nineteen locations, one of which was negative. Water was encountered at both of the locations where the flow rate was detected, and the negative flow rate coincided with a falling groundwater surface at that location (groundwater level on 21/12/2016 at 2.5m bgl and 3.2m bgl on 16/01/2017).

6.4.3 The GSV and associated CIRIA CS and NHBC traffic light (NHBC) classifications have been awarded for each location, and these are summarised in Table 6.5. The classifications take account of elevated methane concentrations in accordance with CIRIA C665.

TABLE 6.5: Gas Assessment Classifications Phase 2.4 (December 2016–February 2017)

Hole	Number Visits	Flow rate (l/hr)	Steady state CH_4 (%)	GSV (l/hr)	CS/NHBC
BH901	3	0.1	89	0.09	CS3 / Amber 2
BH903	3	0.1	85	0.08	CS3 / Amber 2
BH907	3	0.1	0.1	<0.01	CS1 / Green
BH909	3	0.1	25	0.03	CS3 / Amber 2

Hole	Number Visits	Flow rate (l/hr)	Steady state CH_4 (%)	GSV (l/hr)	CS/NHBC
BH910	5	0.1	46	1.24	CS3 / Amber 2
BH911	5	-4.2	42	0.04	CS3 / Amber 2
BH912	5	4.4	92	3.89	CS4 / Red
BH913A	3	0.1	95	0.09	CS3 / Amber 2
BH915	3	0.1	73	0.08	CS3 / Amber 2
BH917	3	0.1	0.2	<0.01	CS1 / Green
BH918	3	0.1	72	0.07	CS3 / Amber 2
BH921A	3	0.1	65	0.09	CS3 / Amber 2
BH927	3	0.1	20	0.03	CS3 / Amber 2
BH941	3	0.1	41	0.04	CS3 / Amber 2
BH951	3	0.1	13	0.02	CS3 / Amber 2
BH977	3	0.1	86	0.09	CS3 / Amber 2
BH985	3	0.1	34	0.03	CS3 / Amber 2
BH991	3	0.1	12	0.01	CS2 / Amber 1
BH999	3	0.1	9	0.01	CS2 / Amber 1

GSV–Gas Screening Value; CS–CIRIA Characteristic Situation; NHBC–NHBC Traffic Light Classification (Yellow = 'Amber 1', Orange = 'Amber 2'); limit of detection = 0.1l/hr; All GSVs are based on methane concentrations. The CS and NHBC ratings have been increased from their GSV based classifications, where appropriate, in accordance with CIRIA C665.

6.4.4 Where there was an exceedance by a GSV of the threshold for CS4, and NHBC red traffic light, or the flow rate was negative, these locations were visited again, with the gas tap left open for a longer period of time – 40 to 50 minutes – between initial and steady state readings. The results of this additional monitoring are reported in Table 6.6.

TABLE 6.6: Gas Assessment Classifications Phase 2.4 – Additional Monitoring (24 February 2017)

Hole	Time	Flow rate (l/hr)	CH_4 (%)	GSV (l/hr)	CS/NHBC
BH910	12:50	0.1	30	0.03	CS3 / Amber 2
	13:30	0.1	18	0.02	CS3 / Amber 2
BH911	14:00	0.1	41	0.04	CS3 / Amber 2
	14:50	0.1	42	0.04	CS3 / Amber 2
BH912	14:20	0.1	92	0.09	CS3 / Amber 2
	15:10	0.1	89	0.09	CS3 / Amber 2

limit of detection = 0.1l/hr

6.4.5 The additional round showed that for BH912, where the CS4 / Red threshold was previously exceeded, flow rate was not recorded above detection limit. The negative flow rate at BH911 was also not encountered. Despite efforts to avoid screening gas monitoring wells beneath the water table, the presence of groundwater in these boreholes may have given rise to the periodically elevated flow rates.

6.4.6 It is noted that NHBC guidance on gas classification of low rising housing stipulates that where methane concentrations exceed 20% v/v, as is the case at a significant number of the boreholes across Phase 2.4, then consideration should be given to increasing the classification to Red. This is not considered applicable, due to the low flow rates and indications that the

volumes of methane are low and if the volume of ground gas being actively generated at the site is low, then high concentrations are not necessarily a significant risk. However, assessment and control of organic load of the soils is required to support this assumption since it is the potential for gas generation, and the subsequent emission rate, that are the driving factors when considering gas risk, and therefore the remedial and associated validation works are based on controlling the organic load of the soils via forensic TOC assessment. The adequate level of gas protection required (as associated with the Characteristic Situation) is determined by a given forensic TOC concentration, as detailed below.

6.5 Total Organic Carbon (TOC) Assessment

6.5.1 CL:AIRE research bulletin 17 on ground gas assessment (CL:AIRE RB17)[11] and Annex E of BS8485[12] detail the use of organic carbon assessment to assess gas risk. The use of this method in RB17 is as a preliminary screening exercise for classifying sites with respect to gas risk and therefore has a number of restrictions associated with its use. However, it can be used in a 'lines of evidence' approach to indicate the potential for gas generation from a given soil. The forensic total organic carbon (fTOC) is calculated based on the TOC of *all the Made Ground components*, including fill materials (timber, textiles etc.) in accordance with the method described in CL:AIRE RB17. This method has been used for Phases 2.1 - 2.3.

6.5.2 According to estimates of emission rates, for Made Ground that has been in place for less than 20 years and has an fTOC content less than or equal to 4% weight, standard gas protection measures are adequate. This value was derived from gas generation modelling and based on a maximum ground emission rate of 3.5l/hr since this is the upper threshold for CS3 (Table 8.5, CIRIA C665). As the boundary of Phase 2.4 is predominantly within the area of the older landfill (>20 years), an alternative fTOC content of 6% can be applied that would also be estimated to result in a maximum ground emission rate of 3.5l/hr, reflective of the slower degradation rate of the older organic material. However, the 4% fTOC limiting value has been conservatively retained.

6.5.3 The soil TOC data (on soil fines fraction only) for the historical site investigations before CampbellReith's involvement has been reviewed, to give an indication of organic load. The STL investigation carried out in 2013 across the Phase 2 and 3 site and reported in 2014 [6] included analysis of 41 soil samples for organic matter (which can be converted to TOC concentrations by a simple conversion factor). The investigation covered Phase 2 and all but one sample (6.96%) returned TOC concentrations below 4%. As noted above, these are likely to be under-estimates of the actual TOC concentrations of the materials as a whole.

6.5.4 Consequently, sampling and analysis for fTOC was undertaken as part of the Phase 2.4 2016/2017 investigation. Samples were scheduled in order to provide representative concentrations of decayable materials in the soils across Phase 2.4 and, therefore, although some samples were scheduled based on log observations of organic materials others were scheduled where no evidence of organic materials was encountered. In total, sixty samples were analysed for forensic TOC determination. The results provided in the Hydrock Factual report [22] refer only to the weights and proportions of the relative fractions of the soils and the TOC concentration of the soil fraction. These results do not provide the fTOC concentration for each sample and therefore a separate results page is provided that shows the fTOC

[11] CL:AIRE Research Bulletin 17 – A Pragmatic Approach to Ground Gas Risk Assessment, November 2012.
[12] BS8485: 2015, Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

concentrations, as calculated by CampbellReith (Appendix C). The percentage degradable organic carbon of the various organic soil components (e.g. 43% of the wood component is degradable organic carbon) have been taken from literature, as detailed in the CL:AIRE RB17 guidance, and corrected for moisture content.

6.5.5 The forensic TOC results range between 0.27% and 10.8%, with 8% of samples >4%. The CIRIA Characteristic Situations and NHBC traffic light classifications that would be associated with fTOC > 4%, as defined in CL:AIRE RB17, are given in Table 6.7 and all fTOC are shown in Figure 4.

TABLE 6.7: Log Description of Decayable Material with Forensic TOC and Associated CS / Traffic Light

Hole	Depth of fTOC sample (m bgl)	fTOC (%)	Wood TOC %	Log description of decayable material	Depth of observation (m bgl)	Corresponding gas monitoring CS/NHBC classification
BH913A	4.5 – 5.5	**5.5**	4.7	-	-	CS3 / Amber 2
BH914A	4.5 – 5.5	**4.7**	3.8	Wood fragments up to 120x40x30mm	4.5	-
BH927	13.0 – 13.5	**10.8**	10.4	Wood up to 130x70x30mm. <5% organic matter	13.0 - 14.5	CS3 / Amber 2
BH903	5.5	**5.2**	4.1	Occasional wood fragments. <5% organic matter	4.0 – 8.5	CS3 / Amber 2
BH991	1.7 – 2.0	**6.8**	5.2	Frequent wood	1.7 - 2.0	CS2 / Amber 1

6.5.6 Five bulk soil samples from the 2016/17 investigation returned fTOC concentrations greater than 4%. The proportion of wood and the organic content of the soil fines fraction (<10mm) were found to be the main causes of the elevated TOC concentrations (see Appendix C). The other degradable constituents (paper, card, vegetable matter, etc.) were not present in significant quantities.

6.5.7 Where fTOC was greater than 4%, the GSV for the corresponding installation (where available) indicated that standard gas protection measures would be sufficient which perhaps indicates that although the soil sampled has a potential for an elevated emission rate there is insufficient material to generate significant volumes of gas.

6.5.8 It is not unexpected that the different methods of classification produce different results as the apparent disparity between the gas characterisations and those based on forensic TOCs is due to the difference in what each of the classifications is based on:

- the CIRIA CS and NHBC traffic light gas data classifications are based on a simple calculation involving gas concentration and flow rate, producing an emission rate which is assumed to be present directly beneath the building. This then informs the degree of gas protection required. Gas concentrations and flow rate measurements in boreholes are significantly affected by below ground conditions such that artificially elevated

classifications can be produced, e.g. due to release of gases trapped in soil pore space, artificial gas migration pathways created by borehole installations and presence of groundwater; and,

- the forensic TOC classifications derive from emission rates that are calculated based on degradable organic carbon concentrations of the different soil fractions (i.e. wood, textiles etc.).

6.6 Ground Gas Summary Assessment

6.6.1 Although landfilling across the wider site area was supposed to comprise inert materials, it is known that organic materials are present, predominantly in the form of timber and reworked natural materials such as peat and alluvial silts and clays. Borehole monitoring undertaken between 2008 and the present day has shown significantly elevated ground gas concentrations, particularly methane, with periodically elevated flow rates at certain locations (in particular BH911 and BH912, and historically BH131 and BH132 – all in the southern portion of Phase 2.4) However, when considering the flow rate over time, only periodic, as opposed to consistently high, flow rates have been encountered.

6.6.2 It is thought that the elevated concentrations are due to gases which have been produced historically and trapped by overlying cohesive soils, rather than an active gassing regime. This is supported by the high ratios of methane to carbon dioxide, which are not indicative of an active landfill and by the BOD and COD leachate determinations by SLR, and subsequently during the 2016/17 investigation.

6.6.3 Five elevated forensic TOC concentrations (i.e. >4%) have been identified from the 2016/17 investigation, however, four of these are at depths (1.7 – 5.5m bgl) that will be excavated as part of the cut/fill operations. The fTOC exceedance at 13.0 - 13.5m bgl will not be excavated; however, the log indicates the layer of decayable materials present within the soil is limited to between 13.0m and 14.5m bgl. As such, there is limited potential for significant gas production. It would be prudent to target this area during the validation monitoring during and post-earthworks.

6.6.4 Overall, the ground gas risk can be mitigated via installation of standard gas protection measures, provided the earthworks are carefully managed to ensure that only soils with a forensic TOC concentration <4% are used in the Engineered Fill.

6.6.5 On-going assessment and validation will be required during the earthworks in case the volume of organic rich soils is greater than that currently assumed since if this were the case then land-based gas protection measures may be required. The works required are based on the same strategy used in both Phases 2.1 - 2.3 and are detailed in Section 6.7.

6.6.6 A detailed earthworks specification is being produced [23] to ensure the proposed remedial strategy is carried out appropriately. This will provide for soils to be adequately characterised and monitored to provide sufficient confidence that the potential emission rates are limited to those that can be mitigated by standard gas protection measures.

6.7 Revised Ground Gas Remedial Strategy

6.7.1 The remedial strategy is based on:

- detailed examination and validation of the soils that will be moved as part of the cut and fill operation;

- trial pitting across the landfill areas of the site to confirm forensic TOC concentrations and emission potential of the in-situ soils; and
- surface emission monitoring of remaining landfill soils and placed Engineered Fill.

6.7.2 The strategy follows that established for Phases 2.1 - 2.3 and it has been formalised in the Earthworks Specifications for Phase 2.4 -2.6 [23] with each aspect discussed below. It is noted that as part of the contractual obligations the earthworks are being implemented on the basis of these specifications.

6.7.3 To achieve the proposed levels and accommodate geotechnical measures to control settlement in the landfill portion of the site, it is currently proposed that the following measures will be undertaken:

- in areas of net cut, current ground levels will be reduced to earthworks finish levels, with a 2.00m over-dig to accommodate the low permeability layer of Engineered Fill (that will be tested for permeability). Alternatively, a 1.50m over-dig will be undertaken followed by rolling dynamic compaction ;
- in areas of net fill there will be a 1.00m dig below current ground levels that will then be backfilled up to the earthworks finish level; or
- in areas of cut, where the base of the Made Ground is within 4.50m of the existing ground level, or areas of fill where the base of the Made Ground is within 3.50m of the proposed level, treatment by excavation and re-compaction is required.

6.7.4 For simplicity, these areas will be termed:

- 'surcharge area' (residual landfill soils will remain); and,
- 'Engineered Fill area' (where Made Ground <4.5m will be excavated to natural Weald Clay. Includes the eastern and southeastern areas where levels will be raised above current ground levels.)

6.7.5 Given the existing and proposed levels there will be a net fill of materials in Phase 2.4.

6.8 Ground Gas Validation Works

Watching Brief and Soil Sampling

6.8.1 A watching brief and sorting operation will be implemented throughout the earthworks to disqualify Unacceptable Materials (as defined in the SHW, including as Class U1A and U1B material) including perishable/biodegradable material and/or soils that exceed the Forensic TOC content limit of 4%.

6.8.2 Drawing 11950-2.4A-H-CE423-P1 'Phase 2.4 Instrumentation and Monitoring Plan', included in Appendix C, shows the locations of the following validation locations.

Drum Tests

6.8.3 During the earthworks, soils will be selected for forensic TOC analysis (detailed below) and for Drum Tests. Drum Tests are intended to empirically monitor the gas generation of fill material left in-situ and soils that have been classified as suitable for reuse. They are intended, in part, to enable the amount of post placement borehole monitoring to be decreased in these areas as they allow monitoring of the soils to be undertaken in tandem with the earthworks (rather than awaiting their completion).

6.8.4 Samples of soils to be re-used on Phase 2.4 are to be taken at a frequency of one per 2,500m^3. Drum tests will also be undertaken for the soils excavated as part of the validation trial pit exercise (detailed below) at the rate of one per pit. For surplus soils that are to be reused elsewhere across Phase 2 the testing frequency will be agreed in due course and included in the appropriate Earthworks Specifications relevant to the phase in question.

6.8.5 The Earthworks Specification provides full details of the method but in summary, soils are placed in air tight containers (the 'Drums') with addition of site-derived groundwater. Gas monitoring, together with measurement of other parameters, is then undertaken at regular intervals. The results will enable calculation of the ground gas emission rate of the soils to confirm those predicted from the forensic TOC tests.

Trial Pitting

6.8.6 Trial pits will be excavated to a maximum 4m below excavation formation level on a 50m grid, across the area which will retain landfilled materials (surcharge area). In total, 25 trial pits will be excavated and the proposed locations are shown in Figure 6. Additional trial pits may be required for geotechnical assessment purposes and these will be observed and sampled if appropriate. Composite samples of representative soils will be taken from each trial pit for forensic TOC and Drum Test analysis and where any material of highly organic nature are found they will be appraised and, if necessary, removed.

Forensic TOC Analysis and Assessment

6.8.7 The forensic TOC compliance testing will work to a 90th percentile compliance standard, rather than an average or absolute maximum standard. One sample will be collected per 500m^3 of soil proposed for reuse across Phase 2.4. Samples will also be undertaken for the soils excavated as part of the validation trial pit exercise at the rate of one per pit.

6.8.8 The percentile standard approach focuses on regulating the overall performance of the materials to be re-used on site, accepting that a limited number of sample exceedances are to be expected due to variability of the backfilled materials and sample heterogeneity. This approach is used extensively in the wastewater sector (e.g. effluent discharge consents) and other waste sectors to control processes within prescribed limits, whilst making allowance for occasional exceedances due to inherent sample heterogeneity or process variability. This regime is recognised by the Environment Agency as providing appropriate environmental protection and accommodating a small proportion of soils with elevated TOC concentrations will only result in a very small change to the potential gas generation rate. Any such accommodation will be justified with appropriate assessment using the procedure given in CL:AIRE RB17 and the EA's report on landfill gas management[13]. Similarly, any such assessment will demonstrate that the incidents of elevated TOC should not make any significant difference to the Gas Screening Values for the site, or to the proposed level of gas protection to be provided.

Surface Monitoring

6.8.9 In order to provide assurance that gas generation rates are acceptable and in accordance with those predicted, monitoring of ground gases will be undertaken by a surface emissions survey and flux chamber tests following completion of the excavation and levelling works.

6.8.10 For the surcharge area the surface emissions survey will be carried out across a 5m grid (i.e. on a series of traverse lines spaced at 5m centres) on completion of the reduced level dig and prior

[13] Environment Agency - Guidance on the management of landfill gas, 2004

to import of the Engineered Fill. For the remainder of the site there will be no remaining Made Ground and only nominal depths /areas of Engineered Fill and therefore there is no significant gas risk to the future users; however, a surface emissions survey will be carried out on the final finished formation level (i.e. surface of the placed Engineered Fill or surface of natural clay – depending on location) across a 25m grid (i.e. on a series of traverse lines spaced at 25m centres) to provide empirical evidence of the lack of risk.

6.8.11 The measurements will be taken at 10mm above ground level with a laser diode methane detector with a detection threshold of 1 ppm. Readings shall be taken every 3 seconds and shall be time stamped with the time and GPS location. The results will be reported as a table of results alongside a contour plot of the emissions recorded. The wind speed/direction, temperature, atmospheric pressure and rainfall on the site at the time of the survey will also be recorded.

6.8.12 Flux chamber tests will be undertaken at five locations, on the same formation levels as the surface emissions survey detailed above. These are shown on Figure 6. The methodology and reporting of results will be in accordance with the guidance in the Environment Agency LFGTN 07, Guidance on monitoring landfill gas surface emissions.

6.8.13 The surface emission tests and the flux chamber tests may be repeated across the surcharge area on completion of the Engineered Fill (prior to installation of the surcharge) if there is any concern over gas concentrations following the previous assessments.

Validation Gas Monitoring

6.8.14 The proposed remedial works, as detailed above, should control ground gas related risks such that the residual gas risk in the areas of residual landfill and Engineered Fill atop Weald Clay can be sufficiently mitigated by standard gas protection measures. Although the works previously described should control ground gas related risks, a reassurance measure provision was required for the previous phases comprising the installation and monitoring of boreholes. The intent was to eventually remove the need for traditional gas monitoring once a definite trend was established from previous phases. It is considered that the works undertaken across the previous phases have proven that gas monitoring is not required for validation. This will require liaison with, and prior approval by, the regulatory authorities (EHO and NHBC). If approval cannot be obtained then the works detailed below should be undertaken:

- four boreholes should be installed on completion of the finished levels in the surcharge area and one borehole on completion of the finished levels in the re-engineered landfill area.

6.8.15 If required, the installations will be carried out via Dynamic Continuous Sampler (DCS) at the five locations indicated on Figure 6.

6.8.16 For the surcharge area where there is Engineered Fill above, and unclassified fill beneath, two installations will be required per location in order to separately monitor the Engineered Fill and the unclassified fill. The response zones shall be isolated into one material only. The shallow well shall be 1m deep overall with a 0.5m response zone located in the Engineered Fill. The deeper well shall be sealed with bentonite from the surface all the way to the base of the Engineered Fill. The response zone will extend 3m into the underlying fill material or to the base of the Made Ground whichever is the shallower.

6.8.17 For the south eastern and eastern parts of the site, the boreholes will be installed in areas of placed Engineered Fill and two holes will be required where the depth of fill is greater than 2.5m. Response zones will be located 0.5-1.0m bgl and 2m from the base of the Engineered Fill. If the fill is less than 2.5m deep then the response zone will be located from 0.5m to the base of the fill.

6.8.18 Monitoring for flammable gases via Flame Ionisation Detector (FID) will be carried out, together with measurement of soil temperature, at 1m intervals during formation of each borehole.

6.8.19 For those holes that are located in the surcharge area ground gas monitoring will be undertaken weekly for one month and then fortnightly for a maximum period of two months[14]. For the boreholes in the re-engineered landfill area monitoring will be carried out weekly for three weeks.

6.9 Verification Reporting and Recommendations

6.9.1 On completion of the gas monitoring and associated assessments, a Verification Report will be prepared and the gas classification for development affirmed.

6.9.2 All the records detailed in this Strategy will be collated and summarised. With respect to ground gas the results will be interpreted and expressed in terms of the Characteristic Situation and the NHBC traffic light system.

6.9.3 Given the division of the site between the southern and northern landfilled areas and the eastern area which will comprise Engineered Fill atop Weald Clay, there will be a delineation of gas classification zones and, therefore, difference in the requirement for gas protection measures. Appropriate assessment and supporting information will be provided. The report will provide general recommendations regarding the likely scope of gas protection measures that will be required for both areas.

6.9.4 In the surcharge area, where fill materials will remain at depth and in areas where Engineered Fill is to be placed, gas protection measures to buildings should be presumed based on CS3/Amber 2. In all other areas, where Made Ground is absent or will be completely removed, there is no potential for ground gas to be present at concentrations which could pose a risk to future users and therefore gas protection measures are not required.

6.9.5 The report will indicate if/where there have been any incidents which could imply that CS3/Amber2 protection measures are not sufficient for specific areas in which case it will be necessary to carry out further assessment, consider supplementary gas protection measures and possibly the design of land based gas protection measures. For example, the forensic TOC results and drum test monitoring from the trial pits will be used to confirm whether or not standard gas protection measures are suitable or whether additional land based protection measures are required. Similarly, if results are obtained for areas of Engineered Fill (and no residual landfill materials at depth) that suggest a lower gas risk is applicable (e.g. CS2/Amber 1 or CS1/Green) then further assessment would be appropriate to demonstrate this.

6.10 Development and Legacy Control

6.10.1 It is recognised that the development of the site will occur in a phased manner with the involvement of several parties, considering a wide range of engineering and construction issues. In order to simply explain the approach and constraints of the current engineering philosophy in

[14] The duration should be confirmed by the regulatory authorities (EHO and NHBC).

a holistic sense, a separate Engineering Design Statement [8] has been produced. This is intended to be a non–technical summary of the earthworks treatment for the dual purpose of regulatory discussions and illustration of onward development constraints for subsequent house builders (and their designers).

6.10.2 A separate Geotechnical Design Report [18] is in preparation associated with the geotechnical treatment.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Objective

7.1.1 A review has been carried out of the historical investigation reports for Phase 2 and 3 with particular reference to Phase 2.4. In addition, a supplemental investigation has been completed for Phase 2.4 in order to inform the geotechnical design and the remedial strategy that has been employed across Phases 2.1 and 2.2, on which the current planning agreement is based.

7.2 Site History

7.2.1 In summary, the Kilnwood Vale development area comprises an area of predominantly unused ground, much of which was formerly an inert landfill operation. The 'landfill' area accepted inert wastes for disposal as a land raise operation from the early 1970s, until its closure in May 2006. The Phase 2.4 area is on an area of older (>20 years) landfill, apart from the south western portion which overlaps in part more recent landfill. Although the site was only licensed to accept inert construction waste, some organic materials have been locally confirmed, predominantly in the form of wood/timber and alluvial silts and clays.

7.2.2 The southern portion and parts of the northern portion of Phase 2.4 are within the former landfill where Made Ground has been proven to a maximum depth of 18m bgl. In this area landfill material will remain (in part) beneath the completed earthworks profile. The eastern and south eastern portions of Phase 2.4 are situated directly above Weald Clay and untreated Made Ground will not be present.

7.3 Remedial Strategy

7.3.1 Following a review of the available data the revised remedial strategy is outlined below. It is separately detailed in the CampbellReith Earthworks Specification that will be issued for construction. Agreement of these revised proposals is required from the regulatory authorities with respect to Phase 2.4.

7.3.2 Phase 2.4 is being re-engineered such that a proportion of Made Ground (landfill material) is being excavated across the site, where present, and replaced in a controlled manner (based on the CampbellReith Phase 2.4 – 2.6 Earthworks Specification [23]). Unacceptable materials – as defined in the specification – including organic material such as timber, will be removed from the excavated materials to make them suitable for re-use as Engineered Fill. The eastern and south eastern areas of the site are on natural ground, where Engineered Fill will be placed on top to make up to formation level.

7.3.3 To achieve the proposed levels and accommodate geotechnical measures to control settlement in the landfill portion of the site, it is currently proposed that the following measures will be undertaken:

- in areas of net cut, current ground levels will be reduced to earthworks finish levels, with a 2.00m over-dig to accommodate the low permeability layer of Engineered Fill (that will be tested for permeability). Alternatively, a 1.50m over-dig will be undertaken followed by rolling dynamic compaction;
- in areas of net fill there will be a 1.00m dig below current ground levels that will then be backfilled up to the earthworks finish level; or

- in areas of cut, where the base of the Made Ground is within 4.50m of the existing ground level, or areas of fill where the base of the Made Ground is within 3.50m of the proposed level, treatment by excavation and recompaction is required.

7.3.4 Given the existing and proposed levels there will be a net fill of materials in Phase 2.4.

7.4 Soil Remediation

7.4.1 The analytical results do not indicate any significant soil contamination and therefore formal soil remediation is not needed. The Earthworks Specification includes Limiting Values for the upper 2m of the Engineered Fill based on C4SLs and S4ULs for a residential with plant uptake end use. Below this depth Limiting Values are stated for asbestos in soils only. The Limiting Values will be applied as part of the broader process of excavation, material inspections / classification for use or rejection based upon the Earthworks Specification. It is noted that an additional 0.5m clean soil will also be placed as part of the final development works. All site works should consider the potential for risk for contamination and asbestos and appropriate method statements are required.

7.5 Controlled Waters Remediation

7.5.1 Although elevated groundwater concentrations have been detected during historical and recent investigations, the risk to surface water receptors from the Phase 2.4 works is considered to be low and specific remedial works in this regard are not required.

7.5.2 This is based on a risk assessment of the pathway between the contaminant concentrations in groundwater and the predicted and measured concentrations in the Bewbush Brook.

7.5.3 There is no need for a clay lining in the proposed realignment of the Bewbush Brook, from a controlled waters risk perspective.

7.5.4 Monitoring of the water courses will be addressed under the existing Construction and Environmental Management Plan (CEMP). Method statements/specifications will be required to demonstrate that the earthworks take consideration of the potential for groundwater and/or surface water contamination.

7.6 Ground Gas

7.6.1 Gas monitoring undertaken across Phase 2.4 between December 2016 and February 2017 has shown significantly elevated ground gas concentrations (particularly methane) and generally low flow rates. However, periodic and localised high flow rates were recorded across the site historically, and during the most recent phase of investigation. The high ratio of methane to carbon dioxide indicates that gas production is not currently occurring and that the concentrations are indicative of gas that has been historically generated and trapped by overlying cohesive soils.

7.6.2 The remedial strategy designed by CampbellReith and used in Phases 2.1 - 2.3, is based on the control of organic load of the soils reused in the developments. The organic load threshold concentration has been set at 4% forensic TOC and this enables prediction and control of the emission rate of the soil which in turn enables the use of standard gas protection measures in accordance with CS3/Amber 2.

7.6.3 Elevated forensic TOC concentrations have been detected in the Hydrock/CampbellReith 2016/17 investigation with approximately 8% of the sixty samples exceeding the 4% threshold

concentration analysed across Phase 2.4. However, the Made Ground from which the samples which exceeded were taken will be excavated and reengineered as part of the earthworks. One exceedance at 13.0m bgl in the centre of the site, is deemed to be sufficiently localised as to not present a significant ground gas risk.

7.6.4 The Earthworks Specification [23] contains a significant amount of validation works during and post-earthworks to control gas risk. These are based on the assessment detailed in this report but are informed by the works carried out for Phases 2.1 and 2.2, where the identified risks were very similar. They comprise:

- control of the proportion of organic material that will be re-deposited such that the likely emission rate potential can be controlled by standard gas protection measures. CIRIA Characteristic Situation 3 / NHBC Amber 2 design provisions have been presumed. Materials with a forensic TOC of >4% will be disqualified from reuse and close inspection will be made to remove other Unacceptable Material classes (which includes biodegradable matter).
- empirical demonstration of the gas generation of classified and reworked soils. Drum Tests will be carried on representative samples of classified soils and the associated gas generation will be monitored during works.
- surface emission surveys of ground gases following completion of the general earthworks platform to the underside of the Engineered Fill and/or surface of the areas that will be filled using laser diode monitoring techniques and flux chamber tests.
- validation of residual landfill soils, via trial pits, at the maximum extent of excavation and, if necessary, removal. This will be on a 50 x 50m grid system across the surcharge area in order to inspect the Made Ground soils that will be left in place. Samples will be taken for forensic TOC assessment and drum tests.

7.6.5 It is considered that the implementation of the works detailed above in Phases 2.1 and 2.2 has proven that traditional post earthworks gas monitoring is not required as part of the validation exercise. However, prior to regulatory approval a contingency has been made for supplemental gas monitoring. This will be omitted subject to discussion with the regulatory authorities (EHO and NHBC). If the discussions indicate that the works are required then the following provision should be made:

- provision of four new gas monitoring installations across affected areas of the site as part of the validation exercise. It is assumed that monitoring will be required for 3 months in the surcharge areas. In the area that will be fully excavated and then filled to level, it is not considered that monitoring is required given the control measures that are in place (forensic TOC analysis etc.); however, provision will be made for 3 no. monitoring visits subject to regulatory approval.

7.6.6 Based on the available data and the proposed validation works CS3/Amber 2 gas protection provisions will be appropriate for the surcharge area. However, this is subject to confirmation of the current gas emission assessment based on the validation works. In the event that results and/or assessment indicates that CS3/Amber 2 protection measures are not sufficient for specific areas then additional protection measures may be required such as land based gas protection measures.

7.6.7 For the portions of the site where Made Ground <4.5m will be removed and levels made up with Engineered Fill then provision should be made for CS3/Amber 2 gas protection measures although it is recommended that the validation data are assessed on completion of the earthworks since they may indicate that the gas protection measures can be downgraded. For those western areas of the site which will be excavated down to natural Weald Clay and will not be subject to backfill, gas protection should not be required.

7.6.8 On completion of the works, a Verification Report will be issued. This will include an assessment of the Characteristic Situation/s (CS) across the site using the collated data.

7.7 General

7.7.1 A Materials Management Plan (MMP) has been produced for the site (Phases 2.1 – 2.6) (2017-04-05 JWC11950-MMP_Ph2.1-2.6 R01, May 2017) to demonstrate that soil is re-used in accordance with waste guidance.

7.7.2 At the time of writing, an Earthworks Specification [23] is being produced to ensure that the soils are assessed, screened and appropriately classified as part of the excavation works such that they can be categorised for future re-use in subsequent phases of the development. The general provisions of the remedial strategy will be presented in this specification [23].

7.7.3 Additional review and assessment work will be required for subsequent phases of development.

ENVIRONMENTAL RISK ASSESSMENT SUPPORTING INFORMATION

Soil Screening Values

The Environment Agency has published non statutory technical guidance for Regulators and their advisors to assess the chronic risk posed to human health from land contamination, known as the Contaminated Land Exposure Assessment (CLEA) Framework.

The CLEA Framework documents and associated risk assessment model are subject to ongoing technical review. In July 2008 guidance documents CLR7 to 10, which previously underpinned the CLEA Framework, were withdrawn. In January 2009 the Environment Agency published CLEA V1.04 risk assessment software and associated guidance documents[15] as a replacement to the previous CLEA UK Beta Version and documents CLR 7 to 10. Further revisions were made in September 2009 to CLEA V1.05 and October 2009 to CLEA 1.06 risk assessment software.

Soil Guideline Values (SGVs) were produced by Defra/EA and Generic Assessment Criteria (GACs) were produced by CampbellReith and others. These were based on the CLEA model and supporting guidance (SR2 and SR3) and where based on a minimal/tolerable level of risk.

In December 2014 DEFRA released final versions of the C4SLs (Category 4 Screening Levels) for 6 No. contaminants (As, benzene, BaP, Cd, Cr VI and Pb) together with a Policy Companion Document and an Erratum. These represent contaminant soil concentrations which present an acceptable (Low) level of risk, within the context of Part 2A, i.e. they are representative of Category 4 sites. In the Contaminated Land Statutory Guidance (April 2012), sites under Part 2A assessments are categorised 1 - 4, with Category 1 being definitely Part 2A and Category 4 definitely not Part 2A ('where there is no risk or the level of risk posed is low').

The C4SLs were produced using the CLEA model and follow the general approach of SR3, although, changes were made to exposure parameters and to the toxicological basis of the assessments. The C4SLs are based on a low level of toxicological concern (LLTC) and are, by definition, less conservative than Health Criteria Values (HCVs) which are the basis for assessments defined in SR2 and used in the generation of SGVs and GACs. They are, therefore, indicative of a low level of risk.

Since their release, DEFRA have confirmed that C4SLs can be used in the planning regime and DCLG (Department for Communities and Local Government) amended Planning Practice Guidance (PPG) on Land Affected by Contamination (12 June 2014)[16] which stated that C4SLs provide a simple test for deciding when land is suitable for use and definitely not contaminated land'. On 03 September 2014 the Secretary for the Environment, Lord de Mauley, issued a letter (attached) to all Local Authorities which references DCLG's PPG and confirms that C4SLs could be used in planning and provide a simple test for establishing when sites are suitable for use.

LQM/CIEH issued S4ULs in December 2014 for 89 contaminants (metals, BTEX, banded TPH, speciated PAH, chlorinated solvents, phenols, chlorophenols, chlorobenzenes, pesticides and a number of miscellaneous others). The S4ULs have generally adopted the revisions to the exposure modelling that were developed in the production of the C4SLs. Critically, however, they are based on HCVs to produce concentrations which are indicative of a minimal/tolerable level of risk.

S4ULs are therefore used as the preliminary stage of soil assessments since they are indicative of minimal/tolerable level of risk. If these are exceeded then the C4SLs are used (if available) to determine if the risk could be described as low.

Where CLEA compliant S4ULs or C4SLs are not available reference is made to Generic Assessment Criteria (GAC) derived using the CLEA UK model (beta version). These are currently used for cyanide. Where referred to, the non-compliant standing of these values is considered.

---

[15] Environment Agency Report Ref: SC050021/SR2 - *Human Health Toxicological Assessment of Contaminants in Soil.* January 2009.
Environment Agency Report Ref: SC050021/SR3 – *Updated background to the CLEA model.* January 2009.

[16] http://planningguidance.planningportal.gov.uk/blog/guidance/land-affected-by-contamination/land-affected-by-contamination-guidance/

Selection of Appropriate [Tier 2] Soil Screening Values

The CLEA model is based upon defined exposure scenarios and six generic land uses have been established for the C4SLs and S4ULs. These set out a discrete set of circumstances where exposure may occur, including a source, the pathways, and the exposed population.

The three generic land use scenarios used in the development of SGVs are:

- **commercial / Industrial;**
- **allotments; and,**
- **residential with plant uptake,**
- **residential without plant uptake,**
- **public open space (residential)**
- **public open space (parks)**

It is noted that the CLEA screening values are generic and not always applicable. Where the CLEA conceptual model is not appropriate it will be necessary to develop site specific Detailed Quantitative Risk Assessment screening values as a further stage of assessment.

It is noted that the CLEA model does not consider risks from contaminated waters beneath the site to human health and the model also assumes that no free product is present. Should such conditions exist at the subject site the requirement for application of an alternative risk assessment model should be assessed. Alternatively, construction workers are potentially exposed to acute risk and therefore require separate consideration.

Statistical Analysis of Soil Analytical Results

Statistical analysis of soil based analytical results has been undertaken in accordance with CL:AIRE Guidance on Comparing Soil Contamination Data with a Critical Concentration (May 2008). The use of the Mean Value Test and Maximum Value Test is still considered appropriate for site assessments. Although the guidance advocates use of the one - sample t test, this is a variation of the mean value test and establishes the confidence level at which the assessor can determine whether a particular screening level has / has not been succeeded. The mean value test used herein is set at the 95th percentile confidence limit in order to be risk conservative.

The Maximum Value Test is a statistical tool that is used to identify outlier values from a numerical distribution of results for a given determinant. These outlier values can be excluded and considered separately, and the remaining values are then used to calculate upper bound 95th percentile values ($95^{\%ile}$) (Mean Value Test) for comparison with the screening values.

The results are reviewed prior to any statistical analysis in order to determine if zoning of the soils is apparent and hence whether the site requires to be divided into averaging areas. Additional tables are presented where appropriate to reflect distinct ground characteristics relevant to the conceptual model.

Water Screening Values

This assessment considers potential risks to controlled waters (groundwater and surface waters) in relation to risks from any historical contamination. The most stringent test is that defined for Contaminated Land under Part 2A of the Environmental Protection Act, 1990. However, it should be recognised that a wider evaluation of risk is considered within the planning regime and CLR 11.

The Environment Agency has a wider policy agenda for the protection of controlled waters that will impinge upon judgements in relation to land contamination issues. This includes those for the Water Framework Directive and Groundwater Directive and wider legislation for both groundwater, surface water and associated elements (such as fisheries)[17].

The results of water analysis have been compared to screening values selected to assess the potential risk to the identified controlled water receptors in the Conceptual Model. The specific standards utilised for this purpose are considered in the assessment table footnotes and typically comprise: Environmental Quality Standards for the protection of aquatic life; Surface Water Standards; EC, UK and WHO Drinking Water Standards; or Background water quality (where no applicable standard exists).

The initial assessment considers the sensitivity of the receptor in the selection of the screening value. Advice for this purpose has been obtained principally from Environment Agency Technical Advice to Third Parties on Pollution of

[17] Refer to Environment Agency Publications for Groundwater Protection Policy and Practice (GP3)

Controlled Waters for Part 2A of the Environmental Protection Act 1990, No 07/02. EA, 2002. (INFO-RA2-3e), as informed by the EA's GP3.

Where a viable pollutant linkage is considered to be present and the screening criteria exceeded, a Qualitative Risk Assessment is presented with associated recommendations. Depending on the specific objectives, policy and practice of the Environment Agency, discussion of water screening values may be subsequently required.

Definitions of Consequence, Probability and Risk

The following classification has been taken from Guidance for the Safe Development of Housing on Land Affected by Contamination R&D66: 2008 Volume 1 (Environment Agency, NHBC and CIEH.

The key to the classification is that the designation of risk is based upon the consideration of both:

a) **the magnitude of the potential consequence (i.e. severity).**

[takes into account both the potential severity of the hazard and the sensitivity of the receptor]

b) **the magnitude of probability (i.e. likelihood).**
[takes into account both the presence of the hazard and receptor and the integrity of the pathway]

Classification of Consequence

Classification	Definition	Examples
Severe	Highly elevated concentrations **likely** to result in "significant harm" to human health as defined by the EPA 1990, Part 2A, if exposure occurs. Equivalent to EA **Category 1** pollution incident including persistent and/or extensive effects on water quality; leading to closure of a potable abstraction point; major impact on amenity value or major damage to agriculture or commerce. Major damage to aquatic or other ecosystems, which 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.	Significant harm to humans is defined in circular 01.2006 as death, disease*, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Major fish kill in surface water from large spillage of contaminants from site. Highly elevated concentrations of List I and II substances present in groundwater close to small potable abstraction (high sensitivity). Explosion, causing building collapse (can also equate to immediate human health risk if buildings are occupied).
Medium	Elevated concentrations which could result in "significant harm" to human health as defined by the EPA 1990, Part 2A if exposure occurs. Equivalent to **EA Category 2** pollution incident including significant effect on water quality; notification required to abstractors; reduction in amenity value or significant damage to agriculture or commerce. Significant damage to aquatic or other ecosystems, which 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 harm to humans is defined in circular 01/2006 as death, disease*, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Damage to building rendering it unsafe to occupy e.g. foundation damage resulting in instability. Ingress of contaminants through plastic potable water pipes.

Classification	Definition	Examples
	Significant damage to crops, buildings or property.	
Mild	Exposure to human health **unlikely** to lead to "significant harm". Equivalent to **EA Category 3** pollution incident including minimal or short lived effect on water quality; marginal effect on amenity value, agriculture or commerce. Minor or short lived damage to aquatic or other ecosystems, which is unlikely to result in a substantial adverse change in its functioning or harm to a species of special interest that would endanger the long-term maintenance of the population. Minor damage to crops, buildings or property.	Exposure could lead to slight short-term effects (e.g. mild skin rash). Surface spalling of concrete.
Minor	No measurable effect on humans. Equivalent to insubstantial pollution incident with no observed effect on water quality or ecosystems. Repairable effects of damage to buildings, structures and services.	The loss of plants in a landscaping scheme. Discoloration of concrete.

Classification of Probability

Classification	Definition	Examples
High likelihood	There is pollutant linkage and an event would appear very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.	*a) Elevated concentrations of toxic contaminants are present in soils in the top 0.5m in a residential garden.* *b) Ground/groundwater contamination could be present from chemical works, containing a number of USTs, having been in operation on the same site for over 50 years.*
Likely	There is pollutant linkage and all the elements are present and in the right place which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over the long-term.	*a) Elevated concentrations of toxic contaminants are present in soils at depths of 0.5-1.0m in a residential garden, or the top 0.5m in public open space.* *b) Ground/groundwater contamination could be present from an industrial site containing a UST present between 1970 and 1990. The tank is known to be single skin. There is no evidence of leakage although there are no records of integrity tests.*

Classification	Definition	Examples
Low likelihood	There is pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a long period such an event would take place, and is less likely in the shorter term.	*a) Elevated concentrations of toxic contaminants are present in soils at depths >1m in a residential garden, or 0.5-1.0m in public open space.* *b) Ground/groundwater contamination could be present on a light industrial unit constructed in the 1990s containing a UST in operation over the last 10 years – the tank is double skinned but there is no integrity testing or evidence of leakage.*
Unlikely	There is pollutant linkage but circumstances are such that it is improbable that an event would occur even in the very long-term.	*a) Elevated concentrations of toxic contaminants are present below hardstanding.* *b) Light industrial units <10 yrs old containing a double-skinned UST with annual integrity testing results available.*

Note: A pollution linkage must first be established before probability is classified. If there is no pollution linkage then there is no potential risk. If there is no pollution linkage then there is no need to apply tests for probability and consequence.

For example if there is surface contamination and a principal aquifer is present at depth, but this principal aquifer is overlain by an aquiclude of significant thickness then there is no pollution linkage and the risks to the principal aquifer are not assessed. The report should identify both the source and the receptor but state that because there is no linkage there are no potential risks.

Description of the classified risks

Very high risk
There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the site without remediation action OR there is evidence that severe harm to a designated receptor is already occurring. Realisation of that risk is likely to present a substantial liability to be site owner/or occupier. Investigation is required as a matter of urgency and remediation works likely to follow in the short-term.

High risk
Harm is likely to arise to a designated receptor from an identified hazard at the site without remediation action. Realisation of the risk is likely to present a substantial liability to the site owner/or occupier. Investigation is required as a matter of urgency to clarify the risk. Remediation works may be necessary in the short-term and are likely over the longer term.

Moderate risk
It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, and if any harm were to occur it is more likely, that the harm would be relatively mild. Further investigative work is normally required to clarify the risk and to determine the potential liability to site owner/occupier. Some remediation works may be required in the longer term.

Low risk
It is possible that harm could arise to a designated receptor from identified hazard, but it is likely at worst, that this harm if realised would normally be mild. It is unlikely that the site owner/or occupier would face substantial liabilities from such a risk. Further investigative work (which is likely to be limited) to clarify the risk may be required. Any subsequent remediation works are likely to be relatively limited.

Very low risk
It is a low possibility that harm could arise to a designated receptor, but it is likely at worst, that the harm if realised would normally be mild or minor.

No potential risk
There is no potential risk if no pollution linkage has been established.

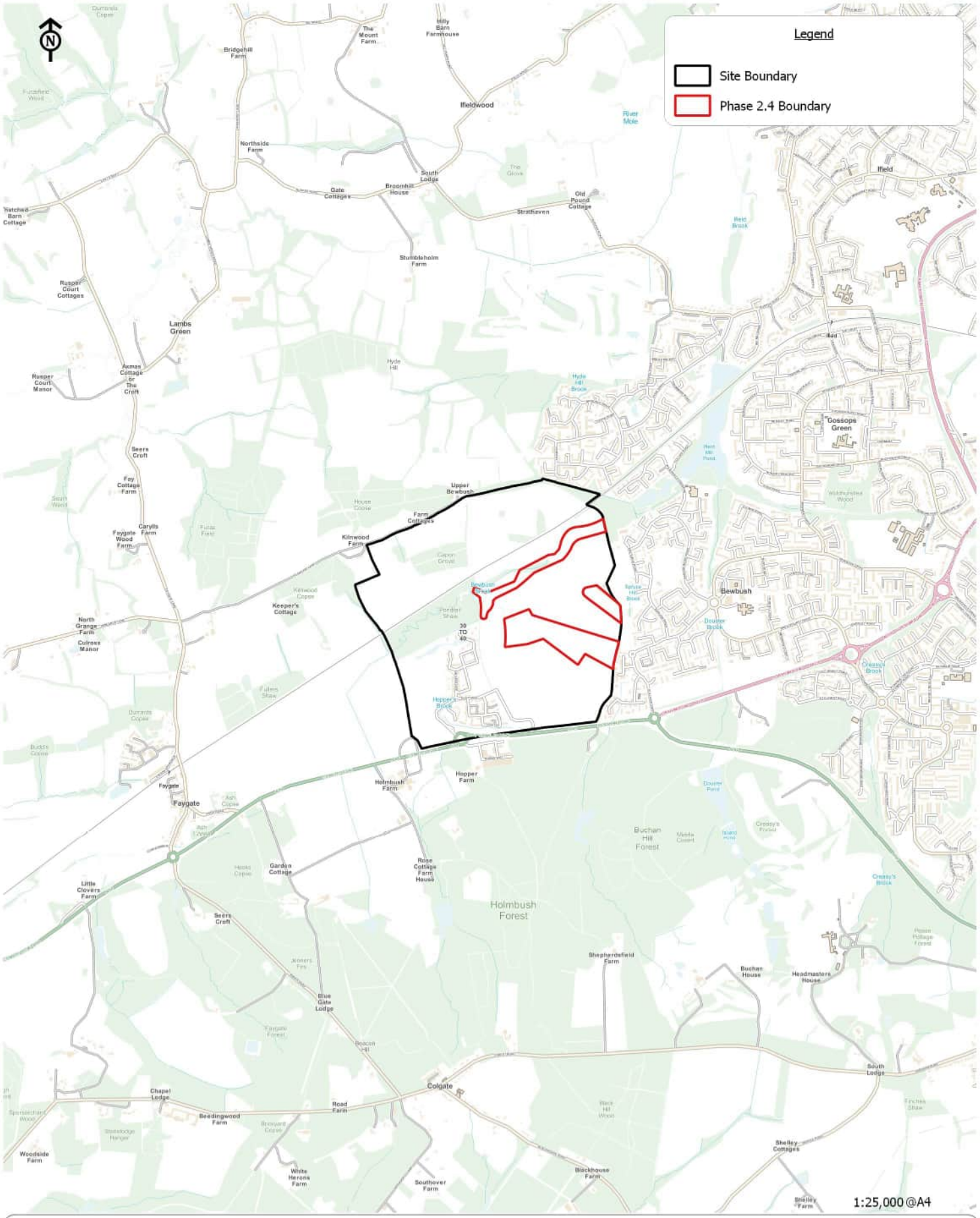
LIMITATIONS

Environmental & Geotechnical Interpretative Reports

1. This report provides available factual data for the site obtained only from the sources described in the text and related to the site on the basis of the location information provided by the client.
2. Where any data or information supplied by the client or other external source, including that from previous studies, has been used, it has been assumed that the information is correct. No responsibility can be accepted by CampbellReith for inaccuracies within this data or information. In relation to historic maps the accuracy of maps cannot be guaranteed and it should be recognized that different conditions on site may have existed between and subsequent to the various map surveys.
3. This report is limited to those aspects of historical land use and enquiries related to environmental matters reported on and no liability is accepted for any other aspects.
4. The material encountered and samples obtained during on-site investigations represent only a small proportion of the materials present on the site. There may be other conditions prevailing at the site which have not been revealed and which have therefore not been taken into account in this report. These risks can be minimised and reduced by additional investigations. If significant variations become evident, additional specialist advice should be sought to assess the implications of these few findings.
5. The generalised soil conditions described in the text are intended to convey trends in subsurface conditions. The boundaries between strata are approximate and have been developed on interpretations of the exploration locations and samples collected.
6. Water level and gas readings have been taken at times and under conditions stated on the exploration logs. It must be noted that fluctuations in the level of groundwater or gas may occur due to a variety of factors which may differ from those prevailing at the time the measurements were taken.
7. Please note that CampbellReith cannot accept any liability for observations or opinions expressed regarding the absence or presence of asbestos or on any product or waste that may contain asbestos. We recommend that an asbestos specialist, with appropriate professional indemnity insurance, is employed directly by the client in every case where asbestos may be present on the site or within the buildings or installations. Any comments made in this report with respect to asbestos, or asbestos containing materials, are only included to assist the client with the initial appraisal of the project and should not be relied upon in any way.
8. The findings and opinions expressed are relevant to those dates of the reported site work and should not be relied upon to represent conditions at substantially later dates.
9. This report is produced solely for the benefit of the client, and no liability is accepted for any reliance placed upon it by any other party unless specifically agreed in writing.

Appendix A: Figures

Figure 1 – Site Location Plan
Figure 2 – Phase 2.4 Site Investigation Location Plan
Figure 3 – Phase 2.4 GSV Gas Classifications
Figure 4 – Phase 2.4 Forensic TOC Gas Classifications
Figure 5 – Phase 2.4 Bewbush Brook Realignment, Post-Earthworks Controlled Waters Conceptual Model
Figure 6 – Phase 2.4 Post-Earthworks Gas Conceptual Model
Figure 7 – Proposed Post-Earthworks Validation Monitoring Locations



Kilnwood Vale

Client: Crest Nicholson

Figure 1:
Phase 2.4 Site Location Plan

Scale:	1:25000@A4
CampbellReith OS Copyright:	© Crown copyright. All rights reserved. Licence number 100020027
Contains Ordnance Survey data	© Crown copyright and database right 2016.
Job Number:	11950
Drawn by - Checked by:	LB - ML
Drg No - Status/Revision:	GIS125 - A
File location:	N:/11750 - 11999/11950 L - Kilnwood Vale QGIS/Project_Workspaces/Phase 2.4 - 2.6/Phase 2.4 (pdf in Outputs)
Date (Revision History):	16/02/2017 (A, First Issue, 16/02/17, LB)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

© Campbell Reith Hill LLP 2017

Legend

- Phase 2.4 Boundary
- SLR Borehole, 2002
- SLR Trial Pit, 2002
- SLR Borehole, 2004
- SLR Trial Pit, 2004
- SLR Borehole, 2008
- SLR Trial Pit, 2008
- Southern Testing Trial Pit, 2012
- Southern Testing Window Sample, 2012
- Southern Testing Borehole, 2013
- Southern Testing Trial Pit, 2013
- Wilson Bailey Partnership Trial Pit, 2015
- Wilson Bailey Partnership Trial Trench, 2015
- Southern Testing Borehole, 2015
- Southern Testing Cone Penetration Testing, 2015
- Southern Testing Trial Pit, 2015
- Southern Testing Trial Trench, 2015
- Southern Testing Borehole, 2016
- Southern Testing Cone Penetration Testing, 2016
- Southern Testing DCP, 2016
- Southern Testing Trial Pit, 2016
- Southern Testing Window Sample, 2016
- Hydrock Borehole, 2017
- Hydrock Cone Penetration Testing, 2017
- Hydrock Surface Water Sample. 2017
- Hydrock Trial Pit, 2017
- Hydrock Trial Trench, 2017
- Hydrock Window Sample, 2017

N

0 50 100 150 200 m

1:3,000@A3

Kilnwood Vale

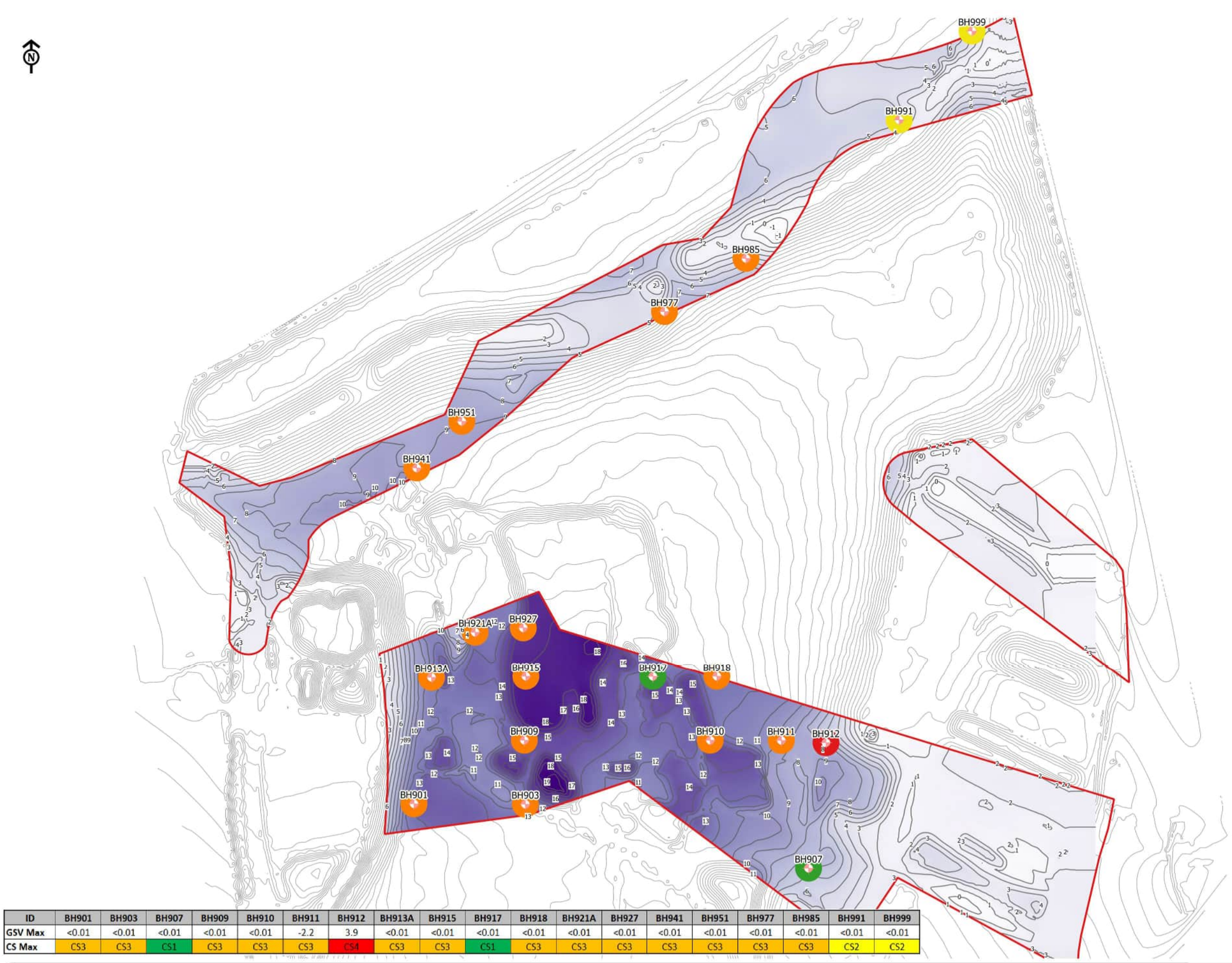
Client: Crest Nicholson

Figure: 2
Phase 2.4 Ground Investigation Locations

Scale:	1:3000@A3
CampbellReith OS Copyright:	© Crown copyright. All rights reserved. Licence number 100020027
Topo based on CampbellReith	11950GX-2D Topo survey.dwg; Boundary based on 11950-SK107
Job Number:	11950
Drawn by - Checked by:	LB - ML
Drg No - Status/Revision:	GIS124 - A
File location:	N:/11750 - 11999/11950 L - Kilnwood Vale QGIS/Project_Workspaces/Phase 2.4 - 2.6/Phase 2.4 (pdf in Outputs)
Date (Revision History):	22/02/2017 (A, First Issue, 22/02/2017, LB)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

© Campbell Reith Hill LLP 2017



Legend

Phase 2.4 Boundary

Hydrock Borehole, 2017

Depth of Made Ground, m bgl

0.00	5.00	10.00	15.00
1.00	6.00	11.00	16.00
2.00	7.00	12.00	17.00
3.00	8.00	13.00	18.00
4.00	9.00	14.00	19.00

NHBC Traffic Lights - Low Rise Housing with a Ventilated Underfloor Void. (>150mm) - Situation B

- Green
- Amber 1
- Amber 2
- Red*

* Standard residential housing not normally acceptable without further risk assessment and remedial measures.

CIRIA C665 Gas Characteristic Situation (Modified Wilson and Card Classification).

CS1 - CS6 (CS4 and above require further risk assessment and remedial measures).

Note:

The assessment and classification of risk using the Traffic Light System (NHBC) and Characteristic Situation (CS) (modified Wilson and Card methodology) is from the method described in CL:AIRE Research Bulletin 17 – A Pragmatic Approach to Ground Gas Risk Assessment, November 2012.

CS1 – Green TOC <= 1%
CS2 – Amber 1 TOC <= 1.5%
CS3 – Amber 2 TOC <= 4%
CS4 – Red TOC > 4%

ID	BH901	BH903	BH907	BH909	BH910	BH911	BH912	BH913A	BH915	BH917	BH918	BH921A	BH927	BH941	BH951	BH977	BH985	BH991	BH999
GSV Max	<0.01	<0.01	<0.01	<0.01	<0.01	-2.2	3.9	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CS Max	CS3	CS3	CS1	CS3	CS3	CS3	CS4	CS3	CS3	CS1	CS3	CS3	CS3	CS3	CS3	CS3	CS3	CS2	CS2

1:3000@A3

Kilnwood Vale

Client: Crest Nicholson

Figure 3:
Phase 2.4 Gas Monitoring Values

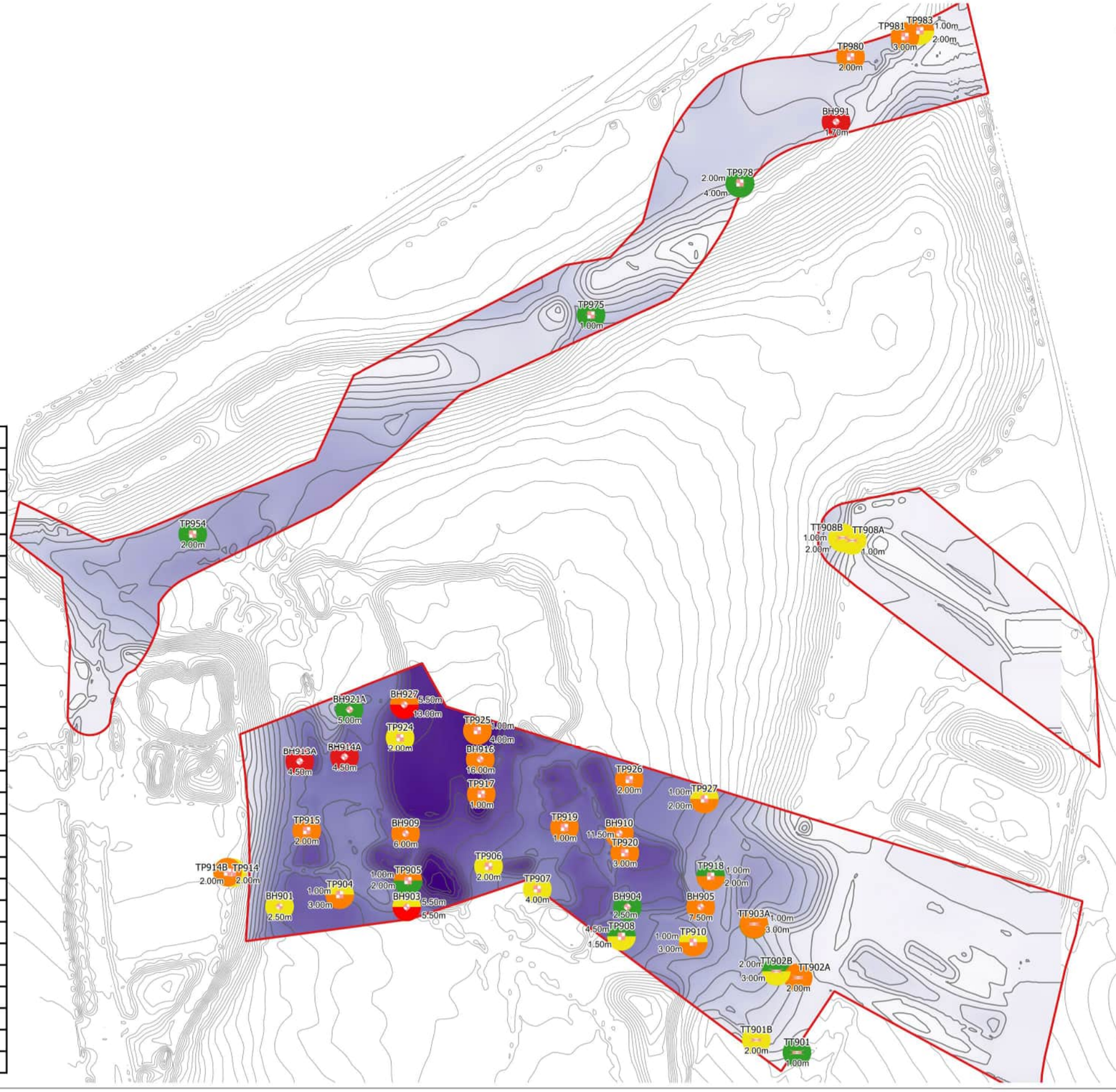
Notes:
GIS Method Details: Contour interpolated using Natural Neighbour interpolation method.

Scale: 1:3000@A3
CampbellReith OS Copyright: © Crown copyright. All rights reserved. Licence number 100020027
Topo based on CampbellReith 11950GX-2D Topo survey.dwg
Job Number: 11950
Drawn by - Checked by: LB - AP
Drg No - Status/Revision: GIS134 - A
File location: N:/11750 - 11999/11950 L - Kilnwood Vale QGIS/Project_Workspaces/Phase 2.4 - 2.6/Phase 2.4 (pdf in Outputs)
Date (Revision History): 09/03/2017 (A, First Issue, 09/03/17, LB)

© Campbell Reith Hill LLP 2017

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

ID	fTOC%	CSV	Depth
BH901	1.30	CS2	2.50m
BH903	1.35	CS2	5.50m
BH903	5.21	CS4	5.50m
BH904	0.83	CS1	2.50m
BH905	1.51	CS3	7.50m
BH909	2.29	CS3	6.00m
BH910	1.97	CS3	11.50m
BH913A	5.53	CS4	4.50m
BH914A	4.70	CS4	4.50m
BH916	2.60	CS3	16.00m
BH921A	0.96	CS1	5.00m
BH927	1.77	CS3	5.50m
BH927	10.8	CS4	13.00m
BH991	6.77	CS4	1.70m
TP901A	1.42	CS2	1.00m
TP904	2.37	CS3	3.00m
TP904	1.21	CS2	1.00m
TP905	1.98	CS3	1.00m
TP905	0.26	CS1	2.00m
TP906	1.35	CS2	2.00m
TP907	1.10	CS2	4.00m
TP908	1.07	CS2	4.50m
TP908	0.69	CS1	1.50m
TP908A	0.55	CS1	1.00m
TP910	1.17	CS2	1.00m
TP910	2.27	CS3	3.00m
TP914	1.06	CS2	2.00m
TP914B	2.32	CS3	2.00m
TP915	1.57	CS3	2.00m
TP917	1.96	CS3	1.00m
TP918	0.85	CS1	1.00m
TP918	1.68	CS3	2.00m
TP919	1.70	CS3	1.00m
TP920	2.60	CS3	3.00m
TP924	1.16	CS2	2.00m
TP925	1.62	CS3	1.00m
TP925	1.54	CS3	4.00m
TP926	2.14	CS3	2.00m
TP927	3.23	CS3	2.00m
TP927	1.47	CS2	1.00m
TP954	0.52	CS1	2.00m
TP975	0.94	CS1	1.00m
TP978	0.69	CS1	4.00m
TP978	0.96	CS1	2.00m
TP980	1.88	CS3	2.00m
TP981	1.78	CS3	3.00m
TP983	1.81	CS3	1.00m
TP983	1.13	CS2	2.00m
TT901	0.94	CS1	1.00m
TT901B	1.4	CS2	2.00m
TT902A	2.38	CS3	2.00m
TT902B	1.15	CS2	3.00m
TT902B	0.92	CS1	2.00m
TT903A	1.53	CS3	1.00m
TT903A	1.52	CS3	3.00m
TT903A	0.77	CS1	3.00m
TT903A	0.47	CS1	1.00m
TT908A	1.14	CS2	1.00m
TT908B	1.29	CS2	1.00m
TT908B	1.03	CS2	2.00m



Legend

- Phase 2.4 Boundary
- Hydrock Borehole, 2017
- Hydrock Trial Pit, 2017
- Hydrock Trial Trench, 2017

Depth of Made Ground, m bgl

0.00	5.00	10.00	15.00
1.00	6.00	11.00	16.00
2.00	7.00	12.00	17.00
3.00	8.00	13.00	18.00
4.00	9.00	14.00	19.00

NHBC Traffic Lights - Low Rise Housing with a Ventilated Underfloor Void. (>150mm) - Situation B

- Green
- Amber 1
- Amber 2
- Red*

* Standard residential housing not normally acceptable without further risk assessment and remedial measures.

CIRIA C665 Gas Characteristic Situation (Modified Wilson and Card Classification).

CS1 - CS6 (CS4 and above require further risk assessment and remedial measures).

Note:

The assessment and classification of risk using the Traffic Light System (NHBC) and Characteristic Situation (CS) (modified Wilson and Card methodology) is from the method described in CL:AIRE Research Bulletin 17 – A Pragmatic Approach to Ground Gas Risk Assessment, November 2012.

CS1 – Green TOC <= 1%
CS2 – Amber 1 TOC <= 1.5%
CS3 – Amber 2 TOC <= 4%
CS4 – Red TOC > 4%

BH900
1.5m
4.5m

Gas Characteristic Situation and NHBC Traffic Light classification for given sample depths.

The locations marked "<4%" and ">4%" have been inferred from descriptions of the Made Ground in the logs.

1:3000@A3

Kilnwood Vale

Client: Crest Nicholson

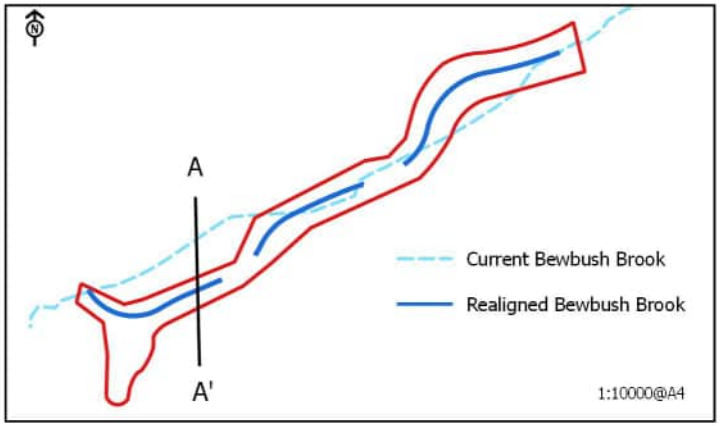
Figure 4:
Phase 2.4 Forensic TOC Gas Classification

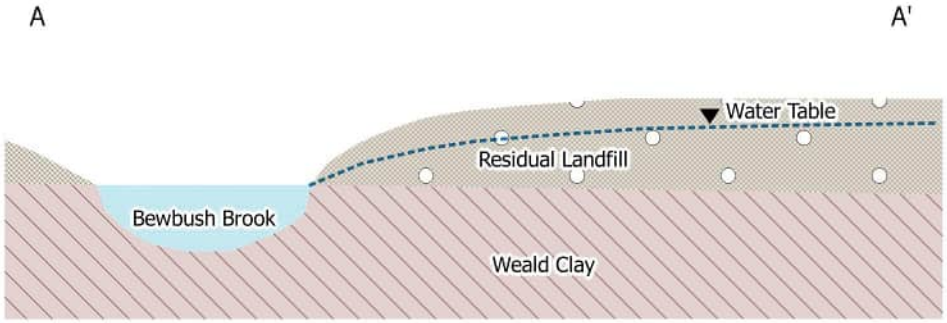
Notes:
GIS Method Details: Contour interpolated using Natural Neighbour interpolation method.

Scale: 1:3000@A3
CampbellReith OS Copyright: © Crown copyright. All rights reserved. Licence number 100020027
Topo based on CampbellReith 11950GX-2D Topo survey.dwg
Job Number: 11950
Drawn by - Checked by: LB - AP
Drg No - Status/Revision: GIS136 - A
File location: N:/11750 - 11999/11950 L - Kilnwood Vale QGIS/Project_Workspaces/Phase 2.4 - 2.6/Phase 2.4 (pdf in Outputs)
Date (Revision History): 14/03/2017 (A, First Issue, 14/03/17, LB)

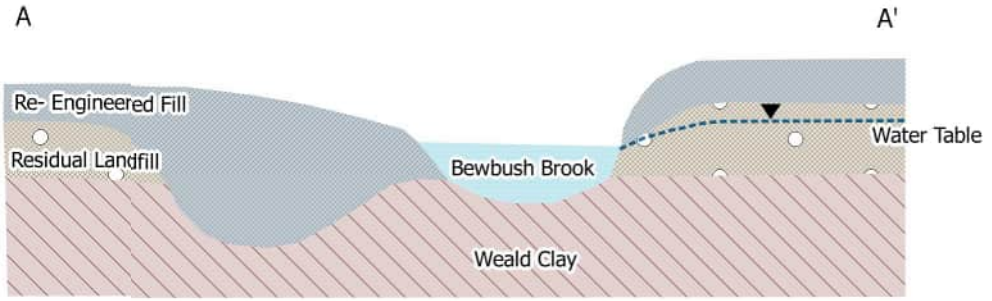
CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

© Campbell Reith Hill LLP 2016





BEFORE



AFTER

NTS

Kilnwood Vale

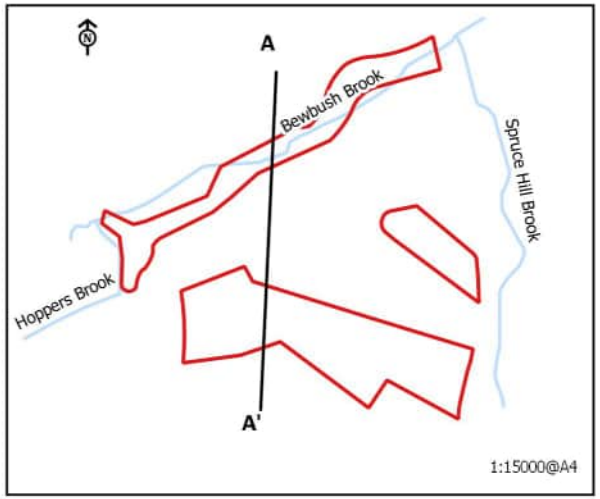
Client: Crest Nicholson

Figure 5:
Bewbush Brook Realignment Controlled Waters
Conceptual Model

Scale:	Not to Scale
CampbellReith OS Copyright:	© Crown copyright. All rights reserved. Licence number 100020027
Realligned brook based on	11950-BBO-CE202
Job Number:	11950
Drawn by - Checked by:	LB - AP
Drg No - Status/Revision:	GIS150 - A
File location:	N:\11750 - 11999\11950 L - Kilnwood Vale QGIS\Project_Workspaces\Phase 2.4 - 2.6\Phase 2.4 (pdf in Outputs)
Date (Revision History):	03/05/2017 (A, First Issue, 03/05/17, LB)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

© Campbell Reith Hill LLP 2017



Full Excavation of Made ground where <4.5m depth to Weald Clay; and placement of engineered fill

Surcharge Area:

Partial excavation of Made Ground (1-2m below finished level) and placement of engineered fill

Development Boundary

A

A'

Original Ground Level

Re- Engineered Fill on Former Landfill

Residual Landfill

Bewbush Brook

Weald Clay

NTS

Kilnwood Vale

Client: Crest Nicholson

Figure 6:
Phase 2.4 Post-Earthworks Conceptual Gas Model

Scale:	Not to Scale
CampbellReith OS Copyright:	© Crown copyright. All rights reserved. Licence number 100020027
Job Number:	11950
Drawn by - Checked by:	LB - AP
Drg No - Status/Revision:	GIS147 - A
File location:	N:\11750 - 11999\11950 L - Kilnwood Vale QGIS\Project_Workspaces\Phase 2.4 - 2.6\Phase 2.4 (pdf in Outputs)
Date (Revision History):	13/04/2017 (A, First Issue, 13/14/17, LB)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

© Campbell Reith Hill LLP 2017

ID	Easting	Northing
DCS1200	523,633.59	135,127.44
DCS1201	523,746.55	135,052.68
DCS1202	523,452.03	135,071.17
DCS1203	523,529.26	135,186.18
DTP1200	523,463.12	135,141.41
DTP1201	523,464.36	135,091.30
DTP1202	523,464.77	135,042.00
DTP1203	523,513.24	135,191.93
DTP1204	523,514.06	135,141.82
DTP1205	523,514.06	135,091.71
DTP1206	523,563.76	135,141.41
DTP1207	523,563.76	135,091.71
DTP1208	523,614.69	135,141.41
DTP1209	523,614.69	135,090.88
DTP1210	523,663.16	135,091.30
DTP1211	523,663.99	135,041.18
DTP1212	523,714.10	135,091.30
DTP1213	523,714.10	135,041.18
DTP1214	523,713.28	134,991.89
DTP1215	523,763.80	135,091.71
DTP1216	523,763.39	135,041.18
DTP1217	523,763.39	134,992.30
FCT1200	523,407.67	135,309.41
FCT1201	523,790.09	135,572.30
FCT1202	523,533.36	135,166.88
FCT1203	523,450.80	135,142.64
FCT1204	523,530.90	135,052.68
FCT1205	523,743.26	135,091.30
FCT1206	523,631.95	135,102.39



Kilnwood Vale

Client: Crest Nicholson

Figure 7:
Environmental Post-Earthworks Validation and Monitoring Locations

Scale: 1:3000@A3
CampbellReith OS Copyright: © Crown copyright. All rights reserved. Licence number 100020027
Topo based on CampbellReith 11950GX-2D Topo survey.dwg
Job Number: 11950
Drawn by - Checked by: LB - AP
Drg No - Status/Revision: GIS148 - A
File location: N:/11750 - 11999/11950 L - Kilnwood Vale QGIS/Project_Workspaces/Phase 2.4 - 2.6/Phase 2.4 (pdf in Outputs)
Date (Revision History): 18/04/2017 (A, First Issue, 18/04/17, LB)

© Campbell Reith Hill LLP 2017

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

Appendix B: Regulatory Correspondence

Approvals via email from Environmental Health Officer, Horsham District Council
Approvals via email from NHBC relating to environmental issues

[redacted]

HI Simon

Thanks for your reply.

I wanted to be clear about what would happen should unexpected circumstances be encountered and your additional comments are helpful.

Thanks also for the offer of a site visit. At the moment I am too busy fighting off alligators to drain the swamp but if things calm down in September I may well take you up on it.

I also think the topic of forensic classification would be of interest to my colleagues in the Sussex officers group. If you fancy giving a presentation later in the year let me know and I will propose it.

Regards

lee

Lee Money
Area Environmental Health Officer Only Weds,Thurs,Fri

[redacted]

HDC Logo

Horsham District Council, Parkside, Chart Way, Horsham, West Sussex RH12 1RL
Telephone: 01403 215100 (calls may be recorded) horsham.gov.uk Chief Executive - Tom Crowley

IMPORTANT NOTICE

This e-mail might contain privileged and/or confidential information. If you have received this e-mail in error, please notify the sender and delete the e-mail immediately; you may not use or pass it to anyone else. Whilst every care has been taken to check this outgoing e-mail for viruses, it is your responsibility to carry out checks upon receipt. Horsham District Council does not accept liability for any damage caused. E-mail transmission cannot guarantee to be secure or error free.

This e-mail does not create any legal relations, contractual or otherwise. Any views or opinions expressed are personal to the author and do not necessarily represent those of Horsham District Council. This Council does not accept liability for any unauthorised/unlawful statement made by an employee.

Information in this e mail may be subject to public disclosure in accordance with the law. Horsham District Council cannot guarantee that it will not provide this e mail to a third party. The Council reserves the right to monitor e-mails in accordance with the law.

If this e-mail message or any attachments are incomplete or unreadable, please telephone 01403 215100 or e-mail contact@horsham.gov.uk. Any reference to "e-mail" in this disclaimer includes any attachments.

Click here to report this email as spam.

RE: 11950 Kilnwood Vale: Geotechnical and Environmental Detailed Design for Phase 2.1; THAMES WATER / NHBC / WSCC

Simon Burr to: Money, Lee 06/08/2015 17:35

Hi Lee

Thanks for the response.

As you will gather from the Remedial Strategy, the gas issue is being dealt with by very thorough segregation and validation processes throughout the earthworks - in particular, the control of forensic TOC concentrations (we have more than 120 results to date - all are below the threshold). In addition we have built in numerous lines of evidence (surface emissions tests, flux chamber tests and drum tests) to ensure confidence in our assessment that gas can be controlled by standard gas protection measures.

As such, the Earthworks and Materials Management Plan cannot provide for scenarios which we have not and cannot predict. Although very unlikely, if results at some point suggest that the soils are suggestive of gas situations greater than CS3/Amber 3 then the first procedure would be further assessment/modelling, possible remediation, and/or if a risk is identified then land based protection measures would be installed - until we known the potential severity of the risk and the locations, we cannot predict what measures would be appropriate (beyond generic references to gas curtains etc.)

I hope this answers your query but feel free to give me a ring if you want to discuss this further. In addition, you are more than welcome to visit site to see the works progressing and get a fell for the soil we are excavating. I think you'll be pleasantly surprised by how 'clean' they are. Let me know if you are interested and we can arrange a convenient date when I, or one of my colleagues in the office, can meet you

Best Regards

Simon

Simon Burr
Associate

CampbellReith
consulting engineers

Friars Bridge Court
41 - 45 Blackfriars Road
London
SE1 8NZ

Tel +44 (0)20 7340 1700
www.campbellreith.com

"Money, Lee" Hi Simon Thanks for your message. 05/08/2015 18:01:58

[redacted]

Hi Simon

Thanks for your message.

I have reviewed both the Earthworks and Materials Management Strategy and the Remedial Strategy.

[redacted]

Hi Simon

Thanks for your message.

I have reviewed both the Earthworks and Materials Management Strategy and the Remedial Strategy. Both reports are generally satisfactory. However in the light of the comments in section 7.6.5 of the Remedial Strategy I would welcome further clarification how the on the measures incorporated within the Earthworks and Materials Management Strategy will incorporate this uncertainty.

lee

Lee Money
Area Environmental Health Officer Only Weds,Thurs,Fri

[redacted]

HDC Logo

Horsham District Council, Parkside, Chart Way, Horsham, West Sussex RH12 1RL
Telephone: 01403 215100 (calls may be recorded) horsham.gov.uk Chief Executive - Tom Crowley

IMPORTANT NOTICE

This e-mail might contain privileged and/or confidential information. If you have received this e-mail in error, please notify the sender and delete the e-mail immediately; you may not use or pass it to anyone else. Whilst every care has been taken to check this outgoing e-mail for viruses, it is your responsibility to carry out checks upon receipt. Horsham District Council does not accept liability for any damage caused. E-mail transmission cannot guarantee to be secure or error free.

This e-mail does not create any legal relations, contractual or otherwise. Any views or opinions expressed are personal to the author and do not necessarily represent those of Horsham District Council. This Council does not accept liability for any unauthorised/unlawful statement made by an employee.

Information in this e mail may be subject to public disclosure in accordance with the law. Horsham District Council cannot guarantee that it will not provide this e mail to a third party. The Council reserves the right to monitor e-mails in accordance with the law.

If this e-mail message or any attachments are incomplete or unreadable, please telephone 01403 215100 or e-mail contact@horsham.gov.uk. Any reference to "e-mail" in this disclaimer includes any attachments.

Click here to report this email as spam.

RE: 11950 Kilnwood Vale: Geotechnical and Environmental Detailed Design for Phase 2.1

[redacted] 23/09/2015 13:42

History: This message has been replied to and forwarded.

Hi Simon

Yes, I've no problem with this, and effectively assumed this to be the case in any event. I think perhaps we just didn't drill down into this level of detail in our previous discussion.

If there are areas of the site where it can be demonstrated no gas protection measures are required, then there will of course be no requirement to install them. Avoiding unnecessary remediation and cost are definitely objectives I share.

Obviously which areas this applies to will be dictated by the data etc, but I don't anticipate any difficulties reaching agreement.

If you need any further clarification/response just let me know.

Best regards

Steve Moreby
BSc MSc DipPolCon MCIWEM CWEM CEnv SiLC
Senior GeoEnvironmental Engineer
Technical Services Department
Direct tel: 01594 833731 | Mobile: 07423 467612 |
Email: smoreby@nhbc.co.uk

NHBC
Raising Standards. Protecting Homeowners

NHBC, NHBC House, Davy Avenue, Knowlhill, Milton Keynes, MK5 8FP
Tel: 0844 633 1000 | Fax 0844 633 0022 | www.nhbc.co.uk

Please consider the environment before printing this email

Major changes are being made to the Building Regulations in England (1st October 2015) and in Wales (1st January 2016). More details, including Transitional Provisions, can be found in Technical Extra 18 or click here.

[redacted]
Sent: 23 September 2015 12:54
To: Steven Moreby
Subject: RE: 11950 Kilnwood Vale: Geotechnical and Environmental Detailed Design for Phase 2.1

Steve

Re. my earlier answer phone message:

The project partner for Kilnwood has pointed out that from your email we are effectively committing to the definite requirement for gas protection for the southern area regardless of the data. If, however,

the data shows that the southern area (or at least significant proportions of) comprises natural clay over which treated clays have been placed which have no organic material (i.e. TOC of <1%) and the other lines of evidence (emissions test, etc) indicate no gassing then we would reason that there is no requirement for protection measures.

Obviously any such conclusion would need backing up with the appropriate data but if these were available then would this be something that would be acceptable to you?

I think there is perhaps a misconception that the soils being excavated are all to a greater or lesser extent those associated with the landfill and elevated methane concentrations when in fact, for Phase 2.1, the majority of soils have looked and tested 'clean', i.e. no visual or olfactory evidence of organic material and low forensic TOCs. These are the soils for which I sent photos. I appreciate your argument that excavating and mixing soils will introduce oxygen, moisture etc., but this is only relevant for soils with some organic content - such as those excavated in the northern most portion of the site, together with isolated 'hot spot' areas where soils have been uncovered which are obviously organic.

Obviously, any areas of the site that have soils with organic material will be duly protected and any proposal for areas to require no protection will be accompanied by robust data which will require full approval from yourself and Lee Money. we accept that if the data does not support this then gas protection will be needed.

If you could ring me when you've had a chance to review these comments then I can feed back to the design team.

Best Regards

Simon

Simon Burr
Associate

CampbellReith
consulting engineers

Friars Bridge Court
41 - 45 Blackfriars Road
London
SE1 8NZ

Tel +44 (0)20 7340 1700
www.campbellreith.com

[redacted]

Simon

Thank you for your response, and the follow-up phone call.

Just a final quick note to confirm my understanding of the key points of our discussions :

1 – 3 months of post remediation gas monitoring is proposed for the northern area, where undisturbed fill material remains at depth, and 2-3 rounds of monitoring is proposed (depending on initial results) for the southern area. Borehole locations as described in your Remedial Strategy.

2 – It is anticipated that the final ground gas monitoring results, in conjunction with the various other lines-of-evidence, will be sufficient to confirm the suitability of Amber 2 gas protection measures in the northern area, and either Amber 1 or Amber 2 measures (dependent upon the data) in the southern area.

3 – In the event the data, including the post-remediation gas monitoring, identifies unexpected or anomalous results, then appropriate further assessment and if necessary additional corrective action will be undertaken, subject to prior discussion with the regulatory authorities.

Unless there's any correction required to the above, nothing further is required at this stage.

I look forward to verification information in due course.

Best regards

Steve Moreby
BSc MSc DipPolCon MCIWEM CWEM CEnv SiLC
Senior GeoEnvironmental Engineer
Technical Services Department
Direct tel: 01594 833731 | Mobile: 07423 467612 |
Email: smoreby@nhbc.co.uk

Raising Standards. Protecting Homeowners

NHBC, NHBC House, Davy Avenue, Knowlhill, Milton Keynes, MK5 8FP
Tel: 0844 633 1000 | Fax 0844 633 0022 | www.nhbc.co.uk

Please consider the environment before printing this email

Major changes are being made to the Building Regulations in England (1st October 2015) and in Wales (1st January 2016). More details, including Transitional Provisions, can be found in Technical Extra 18 or click here.

From: [redacted]
Sent: 09 September 2015 11:55
To: Steven Moreby
Subject: RE: 11950 Kilnwood Vale: Geotechnical and Environmental Detailed Design for Phase 2.1; THAMES WATER / NHBC / WSCC

Hi Steve - sorry for the extended delay. My holiday followed on the back of yours and so this is the

[redacted]

Simon

Thanks for the discussions this week.

I've finished my review of the land quality and ground gas issues, and you'll be pleased to know I'm satisfied with the work that's been done and, most importantly, am satisfied with the lines of evidence presented to demonstrate the site's ability for development.

As discussed, therefore, I've made the following changes to the land quality conditions:

Cleared LQ6 site-wide (ground gas assessment/monitoring)

Cleared LQ5 site-wide (ground gas protection details)

Revised LQ3 site-wide (soils verification)
Verification report required for contamination remediation works. The report is to accord with NHBC Standards Chapter 4.1 and is to include verification of the following issues:
- Dunton/CR Remediation Verification Reporting confirms development platform soils to be free from significant contamination - confirmation of final clean top/sub soils placement in gardens/open space required (plot by plot verification is not required)

LQ4 remains unchanged site-wide (soil quality validation)
Certification of capping materials is required. Please provide chemical analysis, test results and/or supplier certification for any materials used for capping /cover systems (sub soil and/or topsoil) used in the contamination remediation works implemented on site. This is required to confirm that the material is suitable for its intended use/location on the site and does not contain contaminants that may pose a hazard.

New LQ7 currently site-wide (gas verification, to be made plot specific when plot details available)
Verification report required for contamination remediation works. The report is to accord with NHBC Standards Chapter 4.1 and is to include verification of the following issues:
- Satisfactory installation of gas protection measures to agreed criteria (Amber 1 or Amber 2), to include suitable membrane and ventilation details, as per CRH Phase 2.1 Ground Gas Assessment Report, Feb 2016
(currently set site-wide, to be restricted to relevant plots when confirmation of plot numbering available)

Hopefully this is acceptable – pleas let me know if any issues/problems.

Best regards

Steve Moreby
BSc MSc DipPolCon MCIWEM CWEM CEnv SiLC
Senior GeoEnvironmental Engineer
Technical Services Department
Direct tel: 01594 833731 | Mobile: 07423 467612 |
Email: smoreby@nhbc.co.uk

NHBC, NHBC House, Davy Avenue, Knowlhill, Milton Keynes, MK5 8FP
Tel: 0344 633 1000| Fax 01908 747255 | www.nhbc.co.uk

Please consider the environment before printing this email

Latest News

- New Building Regulations requiring Sprinklers to all new homes will be introduced in Wales from 1st January 2016. To find out more including important dates for Transitional Provisions click here.
- One decade, 100 sites, 45,000 homes – NHBC Land Quality Endorsement celebrates a decade of success in 2015. To see how NHBC can support you throughout your remediation and reclamation projects click here.

From: [redacted]
Sent: 03 March 2016 12:07
To: Steven Moreby

Subject: RE: Kilnwood 2.1 Gas Reports and NHBC response

Hi Steve

The Gas Assessment Report was issued electronically late on Friday (26) and I've been asked by the client to confirm the likely response date. They are working to the 10 day turnaround for issue of comments and I just need to check that this is OK.

Best Regards

Simon

Simon Burr
Associate

CampbellReith
consulting engineers

Friars Bridge Court
41 - 45 Blackfriars Road
London
SE1 8NZ

Tel +44 (0)20 7340 1700
www.campbellreith.com

From: [redacted]
To: [redacted]
Date: 01/02/2016 14:00
Subject: RE: Kilnwood 2.1 Gas Reports and NHBC response

Steve

That would be absolutely fine.

Thanks for your help on this.

Best Regards

Simon

Simon Burr
Associate

CampbellReith
consulting engineers

Friars Bridge Court
41 - 45 Blackfriars Road
London
SE1 8NZ

Tel +44 (0)20 7340 1700
www.campbellreith.com

From: [redacted]
To: [redacted]
Date: 01/02/2016 11:54
Subject: RE: Kilnwood 2.1 Gas Reports and NHBC response

Hi Simon

Yes that's fine, though I'll need to modify LQ3/4 a little, to include a requirement for notification of any variation from the approved generic design.

Does that sound OK ?

Steve Moreby
BSc MSc DipPolCon MCIWEM CWEM CEnv SiLC
Senior GeoEnvironmental Engineer
Technical Services Department
Direct tel: 01594 833731 | Mobile: 07423 467612 |
Email: smoreby@nhbc.co.uk

NHBC, NHBC House, Davy Avenue, Knowlhill, Milton Keynes, MK5 8FP
Tel: 0344 633 1000| Fax 01908 747255 | www.nhbc.co.uk

Please consider the environment before printing this email

Latest News

- New Building Regulations requiring Sprinklers to all new homes will be introduced in Wales from 1st January 2016. To find out more including important dates for Transitional Provisions click here.
- One decade, 100 sites, 45,000 homes – NHBC Land Quality Endorsement celebrates a decade of success in 2015. To see how NHBC can support you throughout your remediation and reclamation projects click here.

From: SimonBurr@campbellreith.com [mailto:SimonBurr@campbellreith.com]
Sent: 01 February 2016 11:47
To: Steven Moreby
Subject: RE: Kilnwood 2.1 Gas Reports and NHBC response

Hi Steve

That sounds like it might do the job since discharge of LQ5 and 6 would be sufficient for the contractual aspects. The only thing that we won't be able to provide is the detailed design construction drawing because this will need to come from the developer and won't be available. We can supply a drawing showing the generic requirements such as the void, amount of venting, minimum gas membrane specification and the verification details required. Would this be OK?

Best Regards

Simon

Simon Burr
Associate

CampbellReith
consulting engineers

Friars Bridge Court
41 - 45 Blackfriars Road
London
SE1 8NZ

Tel +44 (0)20 7340 1700
www.campbellreith.com

[redacted]

Hi Simon – just got your voicemail.

This is something that comes up from time to time, and while obviously contract terms, including the tricky to define term 'remediation', between third parties are not directly a matter for NHBC, I can confirm the following, which should hopefully be sufficient:

- At present there are four land quality conditions attached to the NHBC application: LQ3 (verification of soils/gas on a plot by plot basis), LQ4 (validation of clean soils on a plot by plot basis), LQ5 (gas protection design) and LQ6 (post-construction gas monitoring)

- At the end of current remediation (soils and gas source removal) I would expect to be able to clear LQ6 (assuming no further post-completion gas monitoring is required). This will mean no further site-wide remedial works are deemed necessary by NHBC.

- LQ5 can also be cleared on a site-wide basis at any time, upon receipt of satisfactory detailed gas protection designs/drawings.

- LQ3 and 4 will need final plot level information, based on testing of imported topsoil used in gardens and satisfactory verification of gas protection measures installed.

Hopefully this is clear, or I'm happy to discuss further if required.

Best regards

Steve Moreby
BSc MSc DipPolCon MCIWEM CWEM CEnv SiLC
Senior GeoEnvironmental Engineer
Technical Services Department
Direct tel: 01594 833731 | Mobile: 07423 467612 |
Email: smoreby@nhbc.co.uk

NHBC, NHBC House, Davy Avenue, Knowlhill, Milton Keynes, MK5 8FP
Tel: 0344 633 1000| Fax 01908 747255 | www.nhbc.co.uk

Please consider the environment before printing this email

Latest News

- New Building Regulations requiring Sprinklers to all new homes will be introduced in Wales from 1st January 2016. To find out more including important dates for Transitional Provisions click here.
- One decade, 100 sites, 45,000 homes – NHBC Land Quality Endorsement celebrates a decade of success in 2015. To see how NHBC can support you throughout your remediation and reclamation projects click here.

From: [redacted]
Sent: 27 January 2016 09:38
To: Steven Moreby
Subject: Fw: Kilnwood 2.1 Gas Reports and NHBC response

Morning Steve

Following our chat yesterday I informed the client about the conditions surrounding Plot release and he has come back with the following. Essentially, they require general approval that the remediation works have been carried out satisfactorily and and that the recommended gas protection measures are suitable.

Could you have a quick read and let me know your thoughts.

Best Regards

Simon

Simon Burr
Associate

CampbellReith
consulting engineers

Friars Bridge Court
41 - 45 Blackfriars Road
London
SE1 8NZ

Tel +44 (0)20 7340 1700
www.campbellreith.com
----- Forwarded by Simon Burr/CRH on 27/01/2016 09:34 -----

[redacted]

Date: 26/01/2016 16:58
Subject: RE: Kilnwood 2.1 Gas Reports and NHBC response

Thanks Simon,

There is a condition in the developer's contract that as part of the requirement to clear the remediation condition an approval from the NHBC is required in addition to planning condition discharge. The wording in the contract is:

(c) written confirmation addressed to the Seller from NHBC that the Remediation Works are satisfactory for its purposes to enable it to enable it to issue its NHBC Cover (as that term is defined in the Development Agreement) with a true and complete copy of such written confirmation being provided by the Buyer;

We will not be referencing specific plots in the verification report but would hope the NHBC can confirm the ground treatment to the parcel as a whole has been undertaken to their satisfaction enabling them to issue their cover notes for plots in the future subject to the follow on housebuilding works being undertaken in accordance with Building Regs and any special conditions. Can you check with Steve he is able to issue such an approval please.

Thanks

Alex Vicary BSc (Hons), MRICS
Technical Executive

Crest Strategic Projects
Crest House, Pyrcroft Road, Chertsey, KT16 9GN

[redacted]
www.crestnicholson.com

If you have received this e-mail in error please immediately notify the sender by email and delete it and any attachments from your system.

This email has been sent from CampbellReith, which is the trading name of Campbell Reith Hill LLP, a limited liability partnership registered in England and Wales. Registered number, OC300082. Registered address: Friars Bridge Court, 41-45 Blackfriars Road, London, SE1 8NZ. No employee or agent is authorised to conclude any binding agreement(s) on behalf of Campbell Reith Hill LLP with any other party by email unless it is an attachment on headed paper. Opinions, conclusions and other information in this email and any attachments which do not relate to the official business of Campbell Reith Hill LLP are neither given or endorsed by it. Please note that email traffic and content may be monitored.

As this e-mail has been transmitted over a public network the accuracy, completeness and virus status of the transmitted information is not secure and cannot be guaranteed. If verification is required please telephone the sender of the email.

This message has been scanned for malware by Websense. www.websense.com

Click here to report this email as spam.

If you have received this e-mail in error please immediately notify the sender by email and delete it and any attachments from your system.

This email has been sent from CampbellReith, which is the trading name of Campbell Reith Hill LLP, a limited liability partnership registered in England and Wales. Registered number, OC300082. Registered address: Friars Bridge Court, 41-45 Blackfriars Road, London, SE1 8NZ. No employee or agent is authorised to conclude any binding agreement(s) on behalf of Campbell Reith Hill LLP with any other party by email unless it is an attachment on headed paper. Opinions, conclusions and other information in this email and any attachments which do not relate to the official business of Campbell Reith Hill LLP are neither given or endorsed by it. Please note that email traffic and content may be monitored.

As this e-mail has been transmitted over a public network the accuracy, completeness and virus status of the transmitted information is not secure and cannot be guaranteed. If verification is required please telephone the sender of the email.

If you have received this e-mail in error please immediately notify the sender by email and delete it and any attachments from your system.

This email has been sent from CampbellReith, which is the trading name of Campbell Reith Hill LLP, a limited liability partnership registered in England and Wales. Registered number, OC300082. Registered address: Friars Bridge Court, 41-45 Blackfriars Road, London, SE1 8NZ. No employee or agent is authorised to conclude any binding agreement(s) on behalf of Campbell Reith Hill LLP with any other party by email unless it is an attachment on headed paper. Opinions, conclusions and other information in this email and any attachments which do not relate to the official business of Campbell Reith Hill LLP are neither given or endorsed by it. Please note that email traffic and content may be monitored.

As this e-mail has been transmitted over a public network the accuracy, completeness and virus status of the transmitted information is not secure and cannot be guaranteed. If verification is required please telephone the sender of the email.

If you have received this e-mail in error please immediately notify the sender by email and delete it and any attachments from your system.

This email has been sent from CampbellReith, which is the trading name of Campbell Reith Hill LLP, a limited liability partnership registered in England and Wales. Registered number, OC300082. Registered address: Friars Bridge Court, 41-45 Blackfriars Road, London, SE1 8NZ. No employee or agent is authorised to conclude any binding agreement(s) on behalf of Campbell Reith Hill LLP with any other party by email unless it is an attachment on headed paper. Opinions, conclusions and other information in this email and any attachments which do not relate to the official business of Campbell Reith Hill LLP are neither given or endorsed by it. Please note that email traffic and content may be monitored.

As this e-mail has been transmitted over a public network the accuracy, completeness and virus status of the transmitted information is not secure and cannot be guaranteed. If verification is required please telephone the sender of the email.

Kilnwood Verification Reports
Money, Lee

[redacted]

Hi Simon

I have looked over the verification reports and other documentation. I am satisfied the information submitted is sufficient to show that development can proceed safely.

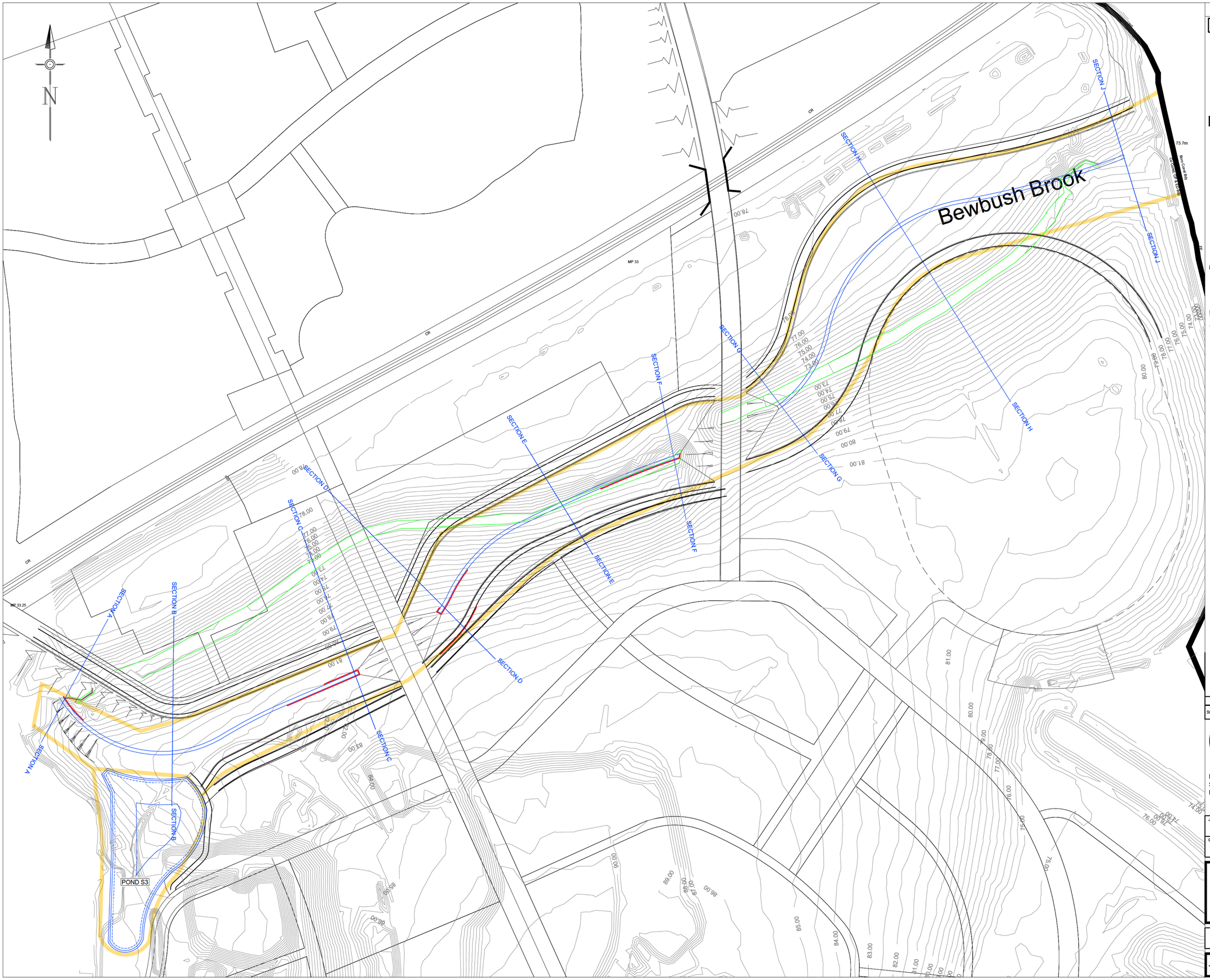
Regards

Lee Money
Area Environmental Health Officer Only Weds,Thurs,Fri

[redacted]

Appendix C: Supporting Information

Figure 3 - Annotated Site Plan
Forensic TOC Calculations
Gas Monitoring Data and GSV Calculations
Calculations of predicted concentrations in Bewbush Brook
11950-BBD-CE202-P1 – Bewbush Brook Diversion Proposed layout and Existing Ground
11950-BBD-CE203-P1 – Bewbush Brook Diversion Proposed / Existing Sections



NOTES

1 DO NOT SCALE THIS DRAWING ON PRINT OR ELECTRONICALLY. WORK FROM FIGURED DIMENSIONS ONLY.

2 No deviation from the details shown on this drawing is allowed without CampbellReith's prior permission in writing.

3 Read this drawing with all Architects, Service Engineers and CampbellReith's relevant details and drawings. **NB.** Setting-out dimensions as per the Architect's drawings take precedence.

4 All work is to be in accordance with the relevant specifications issued by CampbellReith, British Standard Codes of Practice, Statutory requirements and the Contract Documents.

5 DRAWING STATUS

P : **PRELIMINARY** - Evolving drawings for approvals,Tenders, Billings, etc.

C : **CONSTRUCTION** - Fully developed drawings issued under instruction for construction.

ONLY STATUS C DRAWINGS TO BE USED FOR CONSTRUCTION.

6 SUITABILITY CODE

WORK IN PROGRESS:

S0 - Work in progress

SHARED (NON-CONTRACTUAL):

S1 - For coordination, **S2** - For information, **S3** - For internal review and comment, **S4** - For construction approval.

DOCUMENTATION (FOR CONTRACTOR PURPOSES):

D1 - For costing, **D2** - For Tender, **D3** - For contractor design, **D4** - For manufacture / procurement.

CONSTRUCTION:

A - For construction, **B** - For construction but with comments (i.e. areas in abeyance) **C** - Comprehensive revisions required.

7 — X — Denotes Section Number.
X — Denotes Drawing Number

8. Refer to 11950-BBD-CE203 for sections.

LEGEND

RETAINING WALL

75.00 EXISTING CONTOUR

PHASE 2.4 BOUNDARY

Status/Rev	Description	Date	By
--	----------	--.--.--	---

CampbellReith
consulting engineers

LONDON 020 7340 1700 ☐ ☐ MANCHESTER 0161 819 3060
SURREY 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4345 7088
www.campbellreith.com

Job Title
KILNWOOD VALE, CRAWLEY

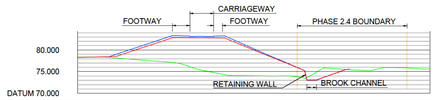
Client
CREST NICHOLSON

BEWBUSH BROOK DIVERSION PROPOSED LAYOUT AND EXISTING GROUND

drawn	date	scale @ A1	C1 checked	CR Project No.
NEJ	21.04.17	1:1000	BSF	11950

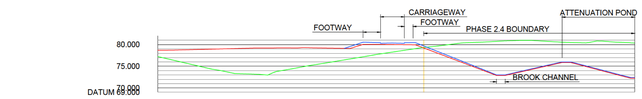
Drg No.	Suitability	Status/Revision
11950-BBD-CE202	S2	P1

© Campbell Reith Hill LLP 2015



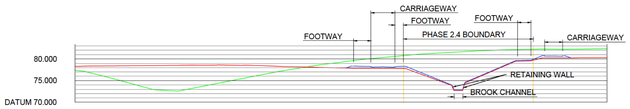
CHAINAGE	0.000	10.000	20.000	21.945	30.000	40.000	50.000	60.000	62.107	62.753	70.000	80.000	81.329
EXISTING LEVEL	78.348	78.060	77.317		75.067	74.070	73.869	75.653			75.797	75.609	75.616
PROPOSED FINISHED LEVEL				83.340	83.136	80.600	78.263	78.236	74.614	73.505			
PROPOSED BULK EARTHWORKS LEVEL	78.286	78.882	82.195		82.791	80.270	78.236		74.614		75.655		

SECTION A



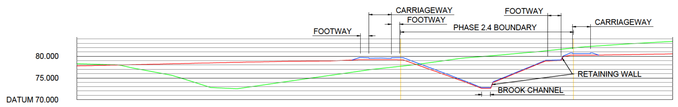
CHAINAGE	0.000	10.000	20.000	30.000	40.000	47.349	50.000	60.000	70.000	80.000	90.000	100.000	110.000
EXISTING LEVEL	77.223	74.892	73.245	74.238	75.953	77.629		79.159	80.378	80.848	80.746	80.586	80.350
PROPOSED FINISHED LEVEL						80.589	80.460	80.223	76.241	73.011	75.259	74.750	72.400
PROPOSED BULK EARTHWORKS LEVEL	78.689	78.890	79.142	79.239	79.183	80.040		79.736	75.944	72.861	75.110	74.604	72.250

SECTION B



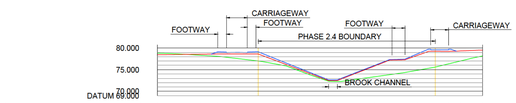
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	64.287	70.000	80.000	90.000	100.000	110.000	112.500	120.000	122.737
EXISTING LEVEL	77.400	75.114	72.782	73.798	75.750	77.598	79.065		80.237	81.146	81.694	82.113	82.255		82.316	82.376
PROPOSED FINISHED LEVEL								78.347	78.158	76.780	74.610	78.896	80.627	80.744		
PROPOSED BULK EARTHWORKS LEVEL	78.272	78.398	78.478	78.543	78.540	78.212	77.954	77.816	76.407	74.457	78.742	80.282			80.287	80.329

SECTION C



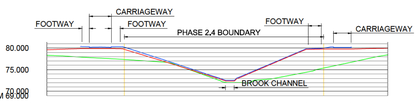
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	118.518	120.000	130.000	137.475
EXISTING LEVEL	78.269	77.944	75.978	73.089	72.946	74.397	75.804	65.277	77.189	78.319	79.651	80.604	81.439		82.381	83.011	83.415
PROPOSED FINISHED LEVEL								79.716	79.588	77.925	74.130	75.704	79.115	80.755			
PROPOSED BULK EARTHWORKS LEVEL	77.774	77.999	78.225	78.454	78.676	78.836	78.968	79.203	77.514	73.911	75.554	78.965		80.275	80.435	80.567

SECTION D



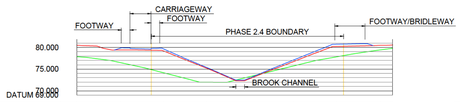
CHAINAGE	0.000	10.000	13.950	20.000	30.000	40.000	50.000	60.000	67.203	70.000	75.071
EXISTING LEVEL	78.811	78.328		77.386	75.757	72.319	73.339	74.856		77.026	78.196
PROPOSED FINISHED LEVEL			79.118	78.968	76.442	72.648	75.948	78.643	79.735		
PROPOSED BULK EARTHWORKS LEVEL	78.473	78.575		78.624	76.088	72.488	75.788	78.309		79.328	79.516

SECTION E



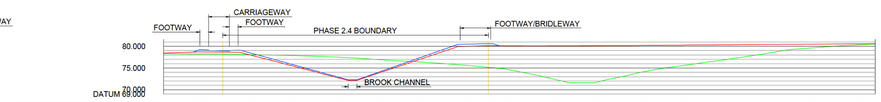
CHAINAGE	0.000	7.741	10.000	20.000	30.000	40.000	50.000	60.000	70.000	70.257	78.700
EXISTING LEVEL	78.345	77.793		77.213	76.055	72.485	72.718	74.429		76.678	78.430
PROPOSED FINISHED LEVEL			80.364	80.160	76.300	72.978	75.664	79.833	80.131	80.255	
PROPOSED BULK EARTHWORKS LEVEL	79.592	79.851		79.057	75.975	72.699	75.506	79.683		79.756	79.970

SECTION F



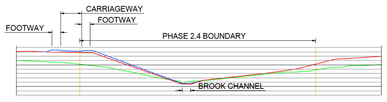
CHAINAGE	0.000	10.000	10.262	20.000	30.000	40.000	50.000	60.000	66.539	70.000	72.891
EXISTING LEVEL	77.879	76.508		74.162	71.999	73.277	75.725	77.830		79.434	79.815
PROPOSED FINISHED LEVEL			79.938	79.662	75.369	72.986	77.088	80.727	80.891		
PROPOSED BULK EARTHWORKS LEVEL	80.490	79.431		79.199	75.199	72.813	76.723	80.227		80.461	80.558

SECTION G



CHAINAGE	0.000	8.440	10.000	20.000	30.000	40.000	50.000	60.000	70.000	75.489	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	164.248
EXISTING LEVEL	78.401		78.235	78.103	77.870	77.529	76.921	76.336	75.611		74.560	72.464	71.722	73.990	75.587	76.975	78.523	79.963	80.322	80.554
PROPOSED FINISHED LEVEL		79.231	79.192	78.494	75.753	73.012	74.180	77.679	80.510	80.650										
PROPOSED BULK EARTHWORKS LEVEL	78.454		78.711	78.025	75.425	72.827	73.949	77.299	80.010		80.127	80.117	80.153	80.219	80.297	80.368	80.439	80.510	80.581	80.612

SECTION H



CHAINAGE	0.000	8.289	10.000	20.000	30.000	40.000	43.000	50.000	60.000	70.000	80.000	84.286
EXISTING LEVEL	76.014	75.561		74.555	72.599	71.198		72.062	73.151	73.964	74.814	75.068
PROPOSED FINISHED LEVEL		78.439	78.395	77.444	73.759	70.704	71.409					
PROPOSED BULK EARTHWORKS LEVEL	76.066	77.916		76.864	73.468	70.554		72.216	73.393	75.399	76.702	76.963

SECTION J

NOTES

1 DO NOT SCALE THIS DRAWING ON PRINT OR ELECTRONICALLY. WORK FROM FIGURED DIMENSIONS ONLY.

2 No deviation from the details shown on this drawing is allowed without CampbellReith's prior permission in writing.

3 Read this drawing with all Architects, Service Engineers and CampbellReith's relevant details and drawings. **NB**: Setting-out dimensions as per the Architect's drawings take precedence.

4 All work is to be in accordance with the relevant specifications issued by CampbellReith, British Standard Codes of Practice, Statutory requirements and the Contract Documents.

5 DRAWING STATUS

P - **PRELIMINARY** - Evolving drawings for approvals,Tenders, Billings, etc.

C - **CONSTRUCTION** - Fully developed drawings issued under instruction for construction.

ONLY STATUS C DRAWINGS TO BE USED FOR CONSTRUCTION.

6 SUITABILITY CODE

WORK IN PROGRESS

S0 - Work in progress

SHARED (NON-CONTRACTUAL):

S1 - For coordination, **S2** - For information, **S3** - For internal review and comment, **S4** - For construction approval.

DOCUMENTATION (FOR CONTRACTOR PURPOSES):

D1 - For costing, **D2** - For Tender, **D3** - For contractor design, **D4** - For manufacture / procurement.

CONSTRUCTION:

A - For construction, **B** - For construction but with comments (i.e. areas in abeyance) **C** - Comprehensive revisions required.

7 

8. Refer to 11950-BBD-CE202 for section locations.

Status/Rev	Description	Date	By

CampbellReith consulting engineers

LONDON 020 7340 1700 ☐ ☐ MANCHESTER 0161 819 3060
SURREY 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4345 7088
www.campbellreith.com

Job Title
KILNWOOD VALE, CRAWLEY

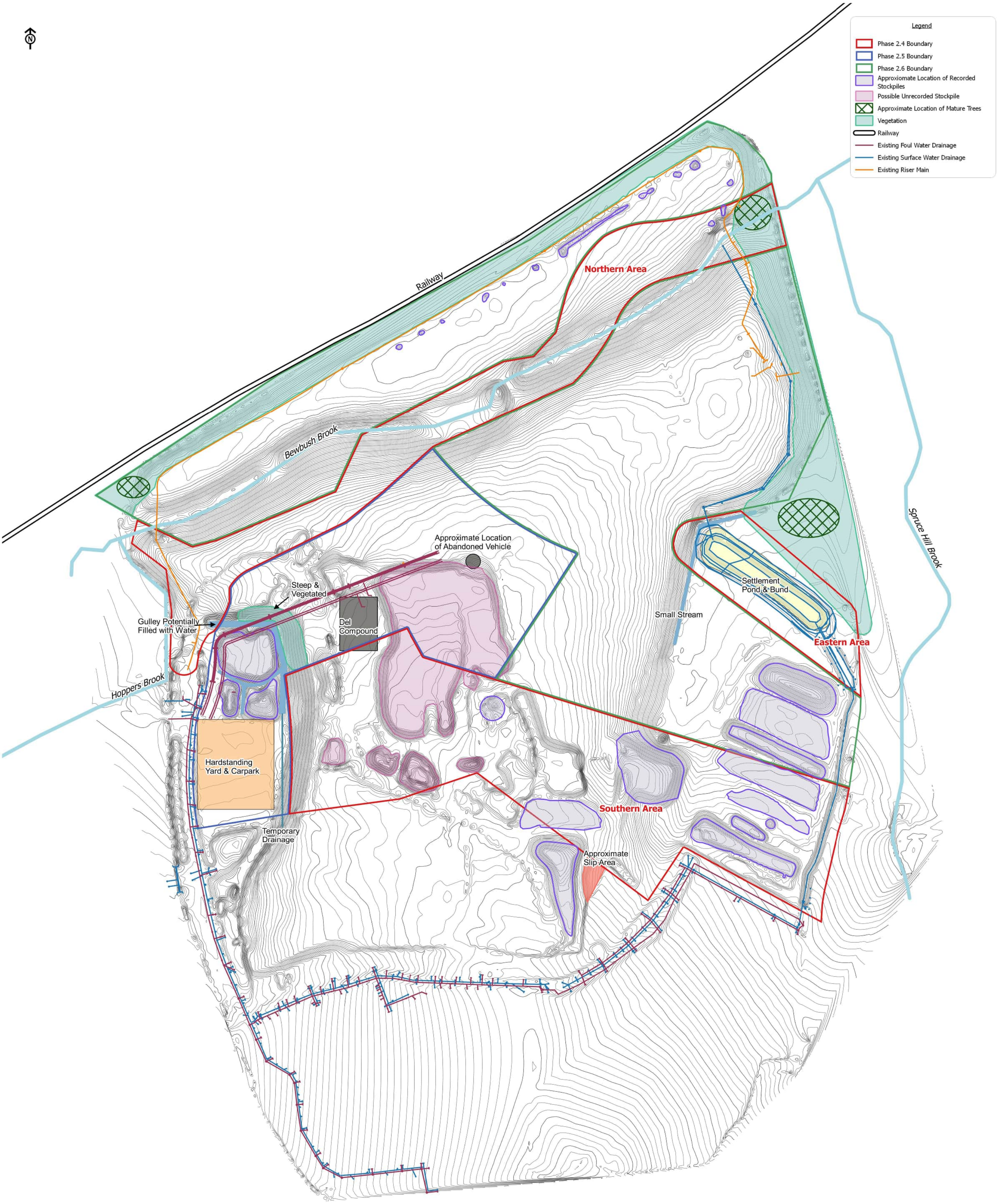
Client
CREST NICHOLSON

BEWBUSH BROOK DIVERSION PROPOSED/EXISTING SECTIONS

drawn	date	scale @ A0	C1 checked	CR Project No.
NEJ	21.04.17	1:500	BSF	11950

Drg No.	Suitability	Status/Revision
11950-BBD-CE203	S2	P1

© Campbell Reith Hill LLP 2017



1:2,500@A2

Kilnwood Vale

Client: Crest Nicholson

Figure 3:
Phase 2.4 Annotated Site Layout

Scale: 1:2500@A2
CampbellReith OS Copyright: © Crown copyright. All rights reserved. Licence number 100020027
Topo based on CampbellReith 11950GX-2D Topo survey.dwg;
Job Number: 11950
Drawn by - Checked by: LB - JB
Drg No - Status/Revision: GIS133 - A
File location: N:/11750 - 11999/11950 L - Kilnwood Vale QGIS/Project_Workspaces/Phase 2.4 - 2.6 (pdf in Outputs)
Date (Revision History): 08/03/2017 (A, First Issue, 08/03/17, LB)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

© Campbell Reith Hill LLP 2017

Legend

- Phase 2.4 Boundary
- Phase 2.5 Boundary
- Phase 2.6 Boundary
- Proposed Primary Roads
- Proposed Foul Water Drainage
- Proposed Surface Water Drainage

2.6D
Oct 2021

2.4D
Oct 2018

2.6C
July 2021

2.5B
Oct 2020

2.4A
Sept 2017

2.6B
Sept 2020

2.4C
Apr 2018

2.4E
Sept 2019

2.5A
Jun 2019

2.4G
Oct 2018

2.4F
Jul 2018

2.4B
Oct 2017

2.4H
Oct 2018

1:2,500@A2

Kilnwood Vale

Client: Crest Nicholson

Figure 2:
Phase 2.4 Proposed Phasing Plan

Scale: 1:2500@A2
CampbellReith OS Copyright: © Crown copyright. All rights reserved. Licence number 100020027
Based on CampbellReith 11950GX-2D Topo survey.dwg; Boundaries based on 11950-SK107
Job Number: 11950
Drawn by - Checked by: LB - JB
Drg No - Status/Revision: GIS131 - A
File location: N:/11750 - 11999/11950 L - Kilnwood Vale QGIS/Project_Workspaces/Phase 2.4 - 2.6/Phase 2.4 (pdf in Outputs)
Date (Revision History): 08/03/2017 (A, First Issue, 08/03/17, LB)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☒ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

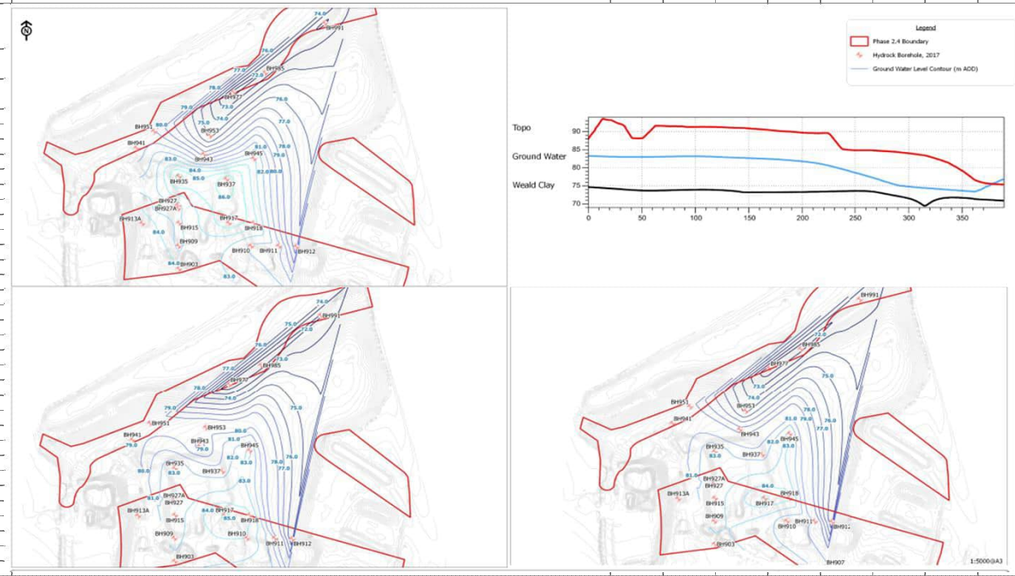
© Campbell Reith Hill LLP 2017

Date	Time	Borehole	Installation	standpipe or dual gas tap	response zone (m)	depth to water (m) or depth of hole if dry	CH4 (% v/v) initial	CH4 (% v/v) steady	atmospheric pressure (hPa)	Gas flow (l/hr)	gas flow with LOD	GSV CH4 (l/hr)	GSV CO2 (l/hr)	relative BH pressure (hPa)	CO2 (% v/v) initial	CO2 (% v/v) steady	O2 (% v/v) initial	O2 (% v/v) steady	GSV CH4 (l/hr)	GSV CO2 (l/hr)
20/12/2016	am	BH901	50mm	S	2.0-4.0	4.23	79	79.7	1009	0	0.1	0.08	0.00	0	0.1	0.1	0.9	0.4	0.08	0.00
16/01/2017	am	BH901	50mm	S	2.0-4.0	4.23	1.7	80.1	1022	0	0.1	0.08	0.00	-3.41	0.2	0.1	21	1.8	0.08	0.00
23/01/2017	am	BH901	50mm	S	2.0-4.0	3.82	88.6	88.7	1022	0	0.1	0.09	0.00	0.27	0.1	0.1	19	18	0.09	0.00
20/12/2016	am	BH903	50mm	S	10.0-13.0	3.27	80.9	81.3	1009	0	0.1	0.08	0.01	0	5.4	5.4	19.4	11.5	0.08	0.01
16/01/2017	am	BH903	50mm	S	10.0-13.0	3.81	84.4	84.5	1022	0	0.1	0.08	0.01	0.1	6.1	6.2	20.6	1.3	0.08	0.01
23/01/2017	am	BH903	50mm	S	10.0-13.0	3.78	71.9	72	1022	0	0.1	0.07	0.01	-0.12	5.8	5.9	19.3	3.8	0.07	0.01
21/12/2016	am	BH907	50mm	S	3.0-5.0	3.49	0.1	0.1	1007	0	0.1	0.00	0.00	0	0.1	0.1	21.1	20.9	0.00	0.00
16/01/2017	am	BH907	50mm	S	3.0-5.0	3.77	0.7	0.1	1022	0	0.1	0.00	0.00	0.05	0.1	0.1	21.1	21.5	0.00	0.00
23/01/2017	am	BH907	50mm	S	3.0-5.0	3.76	0.4	0.1	1022	0	0.1	0.00	0.00	0.05	0.1	0.1	21.2	21.2	0.00	0.00
20/12/2016	am	BH909	50mm	S	8.0-10.0	4.75	33	17	1009	0	0.1	0.03	0.00	0	2	2	1.9	16.5	0.03	0.00
16/01/2017	am	BH909	50mm	S	8.0-10.0	4.94	17.2	12.8	1022	0	0.1	0.02	0.00	0	0.1	0.1	21.5	18.3	0.02	0.00
23/01/2017	am	BH909	50mm	S	8.0-10.0	4.91	30.3	25.1	1022	0	0.1	0.03	0.00	0.1	1.6	1.4	19.8	15.7	0.03	0.00
21/12/2016	am	BH910	50mm	S	3.0-5.0	4.77	32.9	33.9	1009	0	0.1	0.03	0.01	0	11.2	11.8	21	1.9	0.03	0.01
21/12/2016	am	BH910	19mm	S	14.0-15.0	7.46	72.3	87.3	1009	0	0.1	0.00	0.00	0	6.8	7.9	20.2	0.6	0.00	0.00
16/01/2017	am	BH910	50mm	S	3.0-5.0	8.02	44.3	14.3	1021	0	0.1	0.04	0.01	-0.1	9	9.1	22.5	3.8	0.04	0.01
16/01/2017	am	BH910	19mm	S	14.0-15.0	5.22	90.3	90.7	1021	0.4	0.4	0.36	0.03	-0.1	8.5	8.1	13.7	1.3	0.00	0.03
23/01/2017	am	BH910	50mm	S	3.0-5.0	5.22	45.1	45.6	1021	0	0.1	0.05	0.01	-0.3	8.5	8.6	17.6	3.6	0.05	0.01
23/01/2017	am	BH910	19mm	S	14.0-15.0	8.04	88.9	47.2	1021	1.4	1.4	1.24	0.10	9.07	7.1	4.4	20.4	8	0.00	0.10
24/02/2017	12:50	BH910	50mm	S	3.0-5.0	4.52	29.5	29.5	1006	0	0.1	0.03	0.01	0	8.2	8.2	1.7	1.7	0.03	0.01
24/02/2017	13:15	BH910	19mm	S	14.0-15.0	7.37	79.4	84.5	1006	0	0.1	0.00	0.00	0	5.3	5.3	0.8	0.8	0.00	0.00
24/02/2017	13:30	BH910	50mm	S	3.0-5.0	4.52	18.2	18.2	1006	0	0.1	0.02	0.01	0	6.8	6.8	2.2	2.2	0.02	0.01
24/02/2017	13:45	BH910	19mm	S	14.0-15.0	7.37	74.9	74.9	1006	0	0.1	0.00	0.00	0	4.9	4.9	1	1	0.00	0.00
21/12/2016	am	BH911	50mm	S	6.0-8.0	2.5	39.2	19.4	1008	0	0.1	0.04	0.00	0	2.5	1.3	20.8	16	0.04	0.00
16/01/2017	am	BH911	50mm	S	6.0-8.0	3.15	52.3	23.5	1021	-4.2	-4.2	-2.20	-0.10	3.22	2.3	1.1	2.4	14.9	2.20	0.10
23/01/2017	am	BH911	50mm	S	6.0-8.0	3.15	38.5	38.5	1021	-0.1	-0.1	-0.04	0.00	14.47	1.9	1.9	18	10.9	0.04	0.00
24/02/2017	14:00	BH911	50mm	S	6.0-8.0	2.9	41	41	1006	0	0.1	0.04	0.00	0	1.9	1.9	20.8	20.8	0.04	0.00
24/02/2017	14:50	BH911	50mm	S	6.0-8.0	2.9	41.5	41.5	1006	0	0.1	0.04	0.00	0	1.6	1.9	21	21	0.04	0.00
21/12/2016	am	BH912	50mm	S	3.0-5.0	6.9	90.7	88	1009	0	0.1	0.09	0.01	0	6.5	6.4	20.8	0.9	0.09	0.01
21/12/2016	am	BH912	19mm	S	7.0-7.5	5.13	49.4	43	1009	0	0.1	0.00	0.00	0	3.8	3.2	20.5	11.1	0.00	0.00
16/01/2017	am	BH912	50mm	S	3.0-5.0	5.52	88.4	88.5	1021	4.4	4.4	3.89	0.21	-0.02	4.5	4.7	20.1	0.4	3.89	0.21
16/01/2017	am	BH912	19mm	S	7.0-7.5	7.28	1.3	92.4	1021	0	0.1	0.00	0.00	0.05	6.2	6.5	21.2	3.4	0.00	0.00
23/01/2017	am	BH912	50mm	S	3.0-5.0	5.55	92	90	1021	0	0.1	0.09	0.01	-0.05	6.2	6.2	20.8	0.5	0.09	0.01
23/01/2017	am	BH912	19mm	S	7.0-7.5	7.27	85.6	90.9	1021	0	0.1	0.00	0.00	-0.03	6	6.3	19	0.6	0.00	0.00
24/02/2017	14:20	BH912	50mm	S	3.0-5.0	5	92	92	1006	0	0.1	0.09	0.01	0	5.9	5.9	0.8	0.8	0.09	0.01
24/02/2017	14:35	BH912	19mm	S	7.0-7.5	7.27	21.2	21.2	1006	0	0.1	0.00	0.00	0	3.6	3.9	15.3	14.4	0.00	0.00
24/02/2017	15:10	BH912	50mm	S	3.0-5.0	5	89	89	1006	0	0.1	0.09	0.00	0	4.6	4.6	0.8	0.8	0.09	0.00
24/02/2017	15:25	BH912	19mm	S	7.0-7.5	7.27	20.6	20.6	1006	0	0.1	0.00	0.00	0	3.4	3.4	14.1	14.1	0.00	0.00
20/12/2016	pm	BH913A	50mm	S	1.0-2.5	2.42	91	94.7	1009	0	0.1	0.09	0.00	0	2.6	2.7	8.5	0.2	0.09	0.00
16/01/2017	am	BH913A	50mm	S	1.0-2.5	2.42	83.2	83.5	1021	0	0.1	0.08	0.01	-0.07	7.3	7.4	20.3	0.4	0.08	0.01
23/01/2017	am	BH913A	50mm	S	1.0-2.5	2.42	83.8	83.9	1021	0	0.1	0.08	0.01	-0.02	7.8	7.9	20.1	0.2	0.08	0.01
20/12/2016	pm	BH915	50mm	S	6.0-8.0	8.52	84.7	52.9	1009	0	0.1	0.08	0.00	0	0.1	0.1	15.9	7.6	0.08	0.00
16/01/2017	am	BH915	50mm	S	6.0-8.0	8.92	51.3	72.9	1022	0	0.1	0.07	0.00	0.34	0.1	0.2	21.2	4.4	0.07	0.00
23/01/2017	am	BH915	50mm	S	6.0-8.0	8.94	36.5	46.5	1021	0	0.1	0.05	0.00	0.45	0.5	0.4	20.4	10.6	0.05	0.00
21/12/2016	pm	BH917	50mm	S	0.5-2.0	1.11	0.2	0.2	1008	0	0.1	0.00	0.00	0	0.2	0.2	21.4	21.4	0.00	0.00
21/12/2016	pm	BH917	19mm	S	3.8-4.8	1.08	0	0	1008	0	0.1	0.00	0.00	0	0.2	0.3	21.1	20.8	0.00	0.00
16/01/2017	pm	BH917	50mm	S	0.5-2.0	1.77	0.6	0.1	1022	0	0.1	0.00	0.00	0.05	0.1	0.2	21.7	1.6	0.00	0.00
16/01/2017	pm	BH917	19mm	S	3.8-4.8	1.58	11.1	8.1	1022	0	0.1	0.00	0.00	0.02	0.5	0.4	21	19.5	0.00	0.00
23/01/2017	am	BH917	50mm	S	0.5-2.0	1.75	0.5	0.2	1022	0	0.1	0.00	0.00	0.03	0.2	0.1	19.7	1.4	0.00	0.00
23/01/2017	pm	BH917	19mm	S	3.8-4.8	1.57	11.1	8.1	1022	0	0.1	0.00	0.00	0.02	0.5	0.4	21	19.5	0.00	0.00
21/12/2016	am	BH918	50mm	S	2.0-6.0	1.37	71.8	71.7	1009	0	0.1	0.07	0.00	0	0.6	2.5	20.8	5.2	0.07	0.00
16/01/2017	pm	BH918	50mm	S	2.0-6.0	1.77	23	2.9	1022	0	0.1	0.02	0.00	0	0.2	1.3	21	19.7	0.02	0.00
23/01/2017	am	BH918	50mm	S	2.0-6.0	1.69	18.1	2.6	1022	0	0.1	0.02	0.00	0.6	0.1	1.1	21.2	21.2	0.02	0.00
20/12/2016	am	BH921A	50mm	S	5.0-7.0	3.35	77.8	64.7	1009	0	0.1	0.08	0.00	0	3	2.6	2.1	3.3	0.08	0.00
20/12/2016	am	BH921A	19mm	S	10.0-11.0	3.36	69.7	7.36	1009	0	0.1	0.00	0.00	0	2.8	2.2	12.1	1.5	0.00	0.00
16/01/2017	pm	BH921A	50mm	S	5.0-7.0	3.77	12.1	10.9	1021	0	0.1	0.01	0.00	-0.02	0.6	0.5	21.1	18.2	0.01	0.00
16/01/2017	pm	BH921A	19mm	S	10.0-11.0	3.86	6.3	0.8	1021	0	0.1	0.00	0.00	-0.09	0.2	0.1	21.1	21	0.00	0.00
23/01/2017	am	BH921A	50mm	S	5.0-7.0	3.78	89.7	64.8	1022	0	0.1	0.09	0.00	-1.03	2.7	2.1	19.5	4.8	0.09	0.00
23/01/2017	am	BH921A	19mm	S	10.0-11.0	3.84	8.1	1.5	1022	0	0.1	0.00	0.00	-0.07	0.4	0.2	20.5	20.5	0.00	0.00
20/12/2016	pm	BH927	50mm	S	3.0-5.0	3.68	9	4.9	1009	0	0.1	0.01	0.00	0	1.6	0.9	21.1	13.2	0.01	0.00
20/12/2016	pm	BH927	19mm	S	12.0-14.0	8.13	24.7	4	1009	0	0.1	0.00	0.00	0	2.4	0.6	17.8	20.4	0.00	0.00
16/01/2017	pm	BH927	50mm	S	3.0-5.0	4.03	28	16.1	1022	0	0.1	0.03	0.00	-4.7	2.8	1.6	20.1	11.7	0.03	0.00
16/01/2017	pm	BH927	19mm	S	12.0-14.0	8.67	29.8	7.5	1022	0	0.1	0.00	0.00	0.03	5.2	1.4	20.2	11.94	0.00	0.00
23/01/2017	pm	BH927	50mm	S	3.0-5.0	4	25.7	20.4	1022	0	0.1	0.03	0.00	0	3	2.4	20.3	8	0.03	0.00
23/01/2017	pm	BH927	19mm	S	12.0-14.0	8.61	57.9	9.2	1022	0	0.1	0.00	0.00	0.02	9.7	2	18.6	17.3	0.00	0.00
20/12/2016	pm	BH927A	19mm	S	8.0-11.0	7.79	0	0.1	1009	0	0.1	0.00	0.00	0	0.1	0.1	18.9	5.9	0.00	0.00
16/01/2017	pm	BH927A	19mm	S	8.0-11.0	8.25	1.2	1.2	1022	0	0.1	0.00	0.00	0.22	0.1	0.1	20.3	18.5	0.00	0.00
23/01/2017	pm	BH927A	19mm	S	8.0-11.0	8.25	1.6	1.5	1022	0	0.1	0.00	0.00	-0.03	0.1	0.1	20.9	17.8	0.00	0.00
20/12/2016	pm	BH941	50mm	S	3.0-5.0	2.4	30.3	30.5	1010	0	0.1	0.03	0.00	0	1.2	1.2	20.4	13.4	0.03	0.00
17/01/2017	am	BH941	50mm	S	3.0-5.0	3.56	13.4	41	1031	0	0.1	0.04	0.00	3.57	1	3.2	20.6	5.8	0.04	0.00
24/01/2017	am	BH941	50mm	S	3.0-5.0	3.19	20.6	23.3	1025	0	0.1	0.02	0.00	4.71	1.4	1.6	20.2	15.4	0.02	0.00
21/12/2016	pm	BH951	50mm	S	2.0-4.0	1.27	0.5	0.1	1009	0	0.1	0.00	0.00	0	0.3	0.1	20.2	21.3	0.00	0.00
17/01/2017	am	BH951	50mm	S	2.0-4.0	1.85	22.6	13.3	1031	0	0.1	0.02	0.00	0.05	1.1	0.7	20.6	18.21	0.02	0.00
24/01/2017	am	BH951	50mm	S	2.0-4.0	1.8	6.3	2.7	1025	0	0.1	0.01	0.00	0	0.7	0.4	20.4	19.4	0.01	0.00
21/12/2016	pm	BH977	50mm	S	3.0-5.0	4.5	72.1	76.5	1009	0	0.1	0.08	0.00	0	3.6	3.8	21	18.4	0.08	0.00
17/01/2017	am	BH977	50mm	S	3.0-5.0	4.98	83.8	84.9	1031	0	0.1	0.08	0.00	0.07	1.8	1.8	20.9	0.9	0.08	0.00
23/01/2017	pm	BH977	50mm	S	3.0-5.0	4.95	85.5	85.8	1022	0	0.1	0.09	0.00	0.31	1.7	1.7	20.1	0.4	0.09	0.00
21/12/2016	pm	BH985	50mm	S	2.0-5.0	4.85	33.1	34.3	1009	0	0.1	0.03	0.00	0	2.1	2.2	20.6	1.1	0.03	0.00
17/01/2017	am	BH985	50mm	S	2.0-5.0	4.33	33.9	33.8	1031	0	0.1	0.03	0.00	0.05	2.3	2.3	21.3	0.2	0.03	0.00
23/01/2017	pm	BH985	50mm	S	2.0-5.0	4.17	19.1	19	1022	0	0.1	0.02	0.00	0	2.6	2.6	20.6	0.6	0.02	0.00
21/12/2016	pm	BH991	50mm	S	3.0-5.0	1.93	4.7	1.5	1009	0	0.1	0.00	0.00	0	0.9	0.4	21.2	20.4	0.00	0.00
17/01/2017	am	BH991	50mm	S	3.0-5.0	1.9	12.1	12	1031	0	0.1	0.01	0.00	0.02	1.5	1.5	21.4	16.2	0.01	0.00
23/01/2017	pm	BH991	50mm	S	3.0-5.0	1.67	10.1	6.2	1022	0	0.1	0.01	0.00	0.93	0.1	0.1	21.3	21.4	0.01	0.00
24/02/2017	11:00	BH995	19mm	S	6.0-7.0	6.32	1.1	15.1	1005	0	0.1	0.00	0.00	2.2	0.1	0.1	19.4	19.4	0.00	0.00
24/02/2017	11:30	BH995	19mm	S	6.0-7.0	6.32	1.1	11	1005	0	0.1	0.00	0.00	1.5	0.1	0.1	20.1	20.1	0.00	0.00
21/12/2016	pm	BH999	50mm	S	2.0-4.0	3	9.3	9.3	1009	0	0.1	0.01	0.00	0	3.4	3.3	21.3	15.5	0.01	0.00
17/01/2017	am	BH999	50mm	S	2.0-4.0	2.65	0.1	0	1031	0	0.1	0.00	0.00	0.07	3	1	21.6	20.8	0.00	0.00
23/01/2017	pm	BH999	50mm	S	2.0-4.0	2.98	0	0	1023	0	0.1	0.00	0.00	-0.05	1.8	0.8	20.5	20.7	0.00	0.00

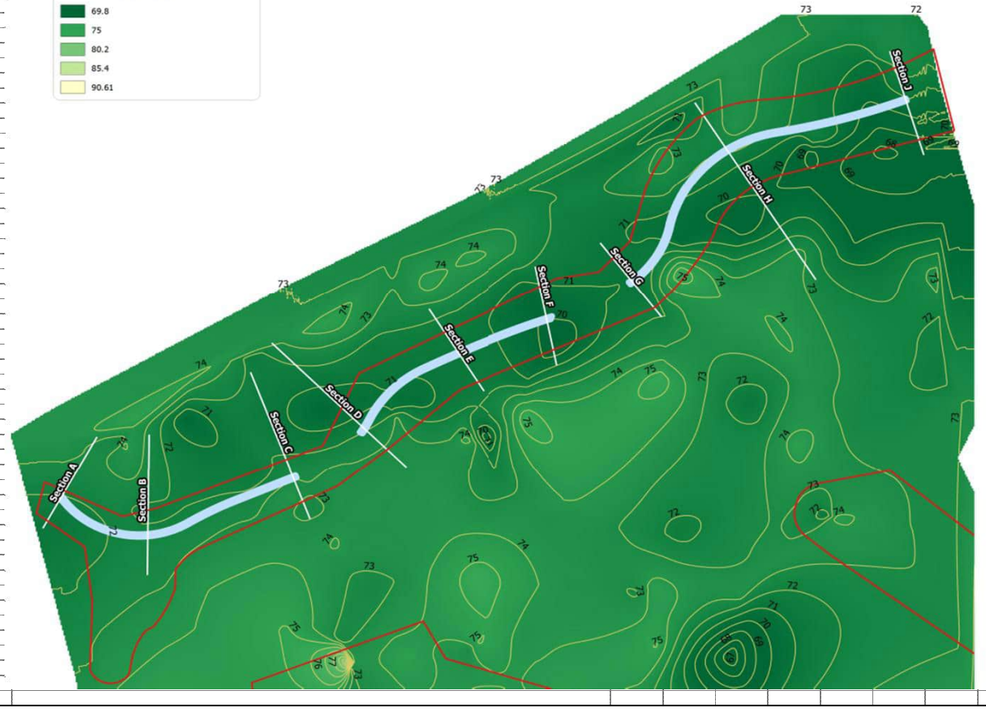
CampbellReith consulting engineers

	Groundwater flow												
	$Q_{gw} = i \cdot K \cdot x \cdot y$												
	i= hydraulic gradient = 83.5-73.5/350 = 0.029	0.029	obtained from groundwater monitoring										
	K= hydraulic conductivity = 2 E10-7 (fine grained sand = - Domenico and Schwartz, Physical and Chemical Hydrogeology, Wiley, 1990; conservative value as material in landfill mostly coehsive)	2.00E-07											
	x= plume width (m) = 350m (section of realigned Brook where base is partially in fill, before entering culverted section)	350											
	y=plume thickness(m) = average depth of residual landfil, beneath low permeability layer, adjacent to Brook= 2m	7											
	Qgw	1.42E-05	m3/s										
	River Flow												
	$Q_{river} = V \cdot (b \cdot a)$												
	V = water velocity (assuming low velocity) = 0.01m/s	0.01											
	b and a = river depth and width (assumes straight base and sides) = 0.24 x 0.15	0.036											
	b and a = river depth and width (assumes straight base and sides) = 0.24 x 0.5	0.12											
	Qriver - 0.15m level	0.00036	m3/s										
	Qriver - 0.5m level	0.00432	m3/s										
							0.15m level		0.15m level	0.15m level			
		concentration in stream (ug/l)	mean concentration in groundwater (ug/l)	concentration in stream (ug/m3)	mean concentration in groundwater (ug/m3)		flux in stream (ug/s)	flux in groundwater (ug/s)	total flux (ug/s)	predicted concentration in stream (ug/l)			
	Ammoniacal Nitrogen as N	100	13833	100000	13833000		36	197	233	646			
	Arsenic	1.45	10	1450	10000		0.522	0.1421	0.66	1.8			
	Copper	7.9	28	7900	28000		2.844	0.3979	3.24	9.0			
	Lead	0.2	7.4	200	7400		0.072	0.1052	0.18	0.49			
	Inorganic Mercury	0.025	0.2	25	200		0.009	0.0028	0.01	0.03			
	Selenium	0.3	11	300	11000		0.108	0.1563	0.26	0.73			
	Total Cyanide	5	15	5000	15000		1.8	0.2132	2.01	5.6			
	Anthracene	0.005	0.2	5	200		0.0018	0.0028	0.00	0.01			
	Fluoranthene	0.005	0.3	5	300		0.0018	0.0043	0.01	0.02			
	Naphthalene	0.005	3.7	5	3700		0.0018	0.0526	0.05	0.15			
	Sulphate as SO_4	104000	210133	104000000	210133000		37440	2986	40426	112294			
	Phenol (Monohydric)	5	62.7	5000	62700		1.8	0.8910	2.69	7.5			
	TPH >C10-40	5	30	5000	30000		1.8	0.4263	2.23	6.2			
							0.5m level		0.5m level	0.5m level			
							flux in stream (ug/s)		total flux (ug/s)	predicted concentration in stream (ug/l)	EQS		
	Ammoniacal Nitrogen as N						432		629	146	300		
	Arsenic						6.264		6.41	1.5	50		
	Copper						34.128		34.53	8.0	35		
	Lead						0.864		0.97	0.22	10.9		
	Inorganic Mercury						0.108		0.11	0.03	0.07		
	Selenium						1.296		1.45	0.34	10		
	Total Cyanide						21.6		21.81	5.0	1		
	Anthracene						0.0216		0.02	0.01	0.1		
	Fluoranthene						0.0216		0.03	0.01	0.1		
	Naphthalene						0.0216		0.07	0.02	2		
	Sulphate as SO_4						449280		452266	104691	400000		
	Phenol (Monohydric)						21.6		22.49	5.2	7.7		
	TPH >C10-40						21.6		22.03	5.1	90		
	Groundwater monitoring	response zone (m bgl)	x	y	20 - 21/12/2016		16 - 17/01/2017	23 - 24/01/2017					
	BH903	10.0-13.0	523513.93	135041.49	83.98		83.44	83.47					
	BH907	3.0-5.0	523735.77	134991.48	82		81.72	81.73					
	BH909	8.0-10.0	523513.13	135091.5	82.66		82.47	82.5					
	BH910	14.0-15.0	523658.91	135091.5	81.76		84	81.18					
	BH911	6.0-8.0	523714.49	135091.32	81.57		80.92	80.92					
	BH912	7.0-7.5	523749.39	135089.6	77.24		75.09	75.1					
	BH913A	1.0-2.5	523440.56	135140.68	84.96								
	BH915	6.0-8.0	523514.32	135141.51	82.79		82.39	82.37					
	BH917	3.8-4.8	523614.05	135141.45	85.76		85.26	85.27					
	BH918	2.0-6.0	0	0	84.6		84.2	84.28					
	BH921A	10.0-11.0	523474.61	135176.54	82.35		81.85	81.87					
	BH927	12.0-14.0	523512.3	135179.95	82.56		82.02	82.08					
	BH927A	8.0-11.0	523512.46	135173.1	82.92		82.46	82.46					
	BH941	3.0-5.0	523428.99	135305.01	80.12		78.96	79.33					
	BH951	2.0-4.0	523464.26	135341.47	80.15		79.57	79.62					
	BH977	3.0-5.0	523623.12	135427.27	71.44		70.96	70.99					
	BH985	2.0-5.0	523686.82	135468.83			71.41	71.57					
	BH991	3.0-5.0	523806.66	135577.15	71.89		71.92	72.15					
	BH999	2.0-4.0	0	0	72.65		73	72.67					
	BH935	8.0-10.0	523514.06	135243.2	86.64		83.21	83.19					
	BH937	10.0-11.5	523609.09	135237.03	86.79		81.51	81.57					
	BH943	10.5-11.5	523564.05	135291.47	78.45		78.45	78.48					
	BH945	4.0-7.0	523664.06	135282.17	83.3		83.25	83.36					
	BH953	11.0-12.5	523576.3	135332.11	74.6		79.7	74.6					
	all levels m AOD												

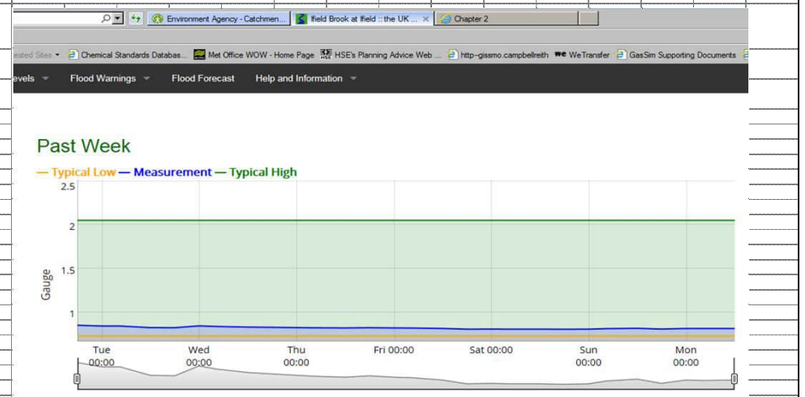
Groundwater contours based on Phase 2.4 and 2.5 groundwater monitoring in boreholes screened >5m bgl.



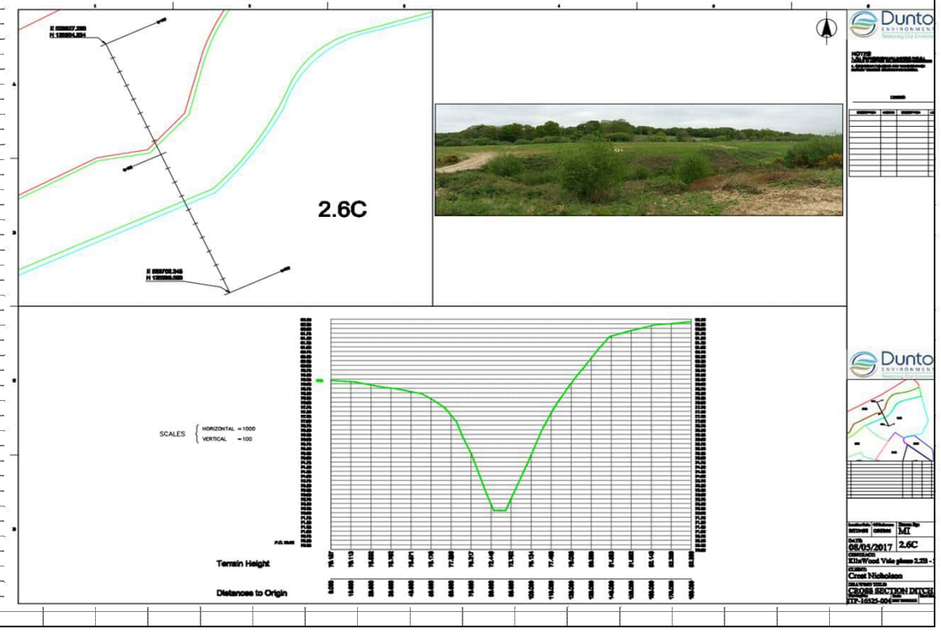
Base of Made Ground (top of Weald Clay) and the route of the realigned Brook



Ifield Brook at Ifield - River level



Topographical survey of section of the Bewbush Brook - 08/05/17



QTS Environmental Report No:16-52105	Date Sampled						
	Time Sampled						
Site Reference:Kilnwood Vale	TP / BH No	BH909	BH913A	BH914A	BH916	BH921A	BH927
Project / Job Ref:C - 07447 - C	Additional Refs						
Order No:None Supplied	Depth (m)	6.00	4.50	4.50	16.00	5.00	5.50
Reporting Date:30/11/2016	QTSE Sample No	239856	239857	239858	239859	239860	239861

Determinand	Unit	RL							
Sample Description		N / a			Brown clay	Brown clay	Brown clay		Brown clay
Moisture Content	%	0.1		17.9	25	22.9	19.6	11	21.9
Visual Non Soil Constituents - Fines 10mm	%	0.1		43.1	50.7	47.9	77.6	65.3	90.1
Visual Non Soil Constituents - Carbonaceous Material	%	0.1		34.8	2.3	6.4	4.6	0.3	1.2
Visual Non Soil Constituents - Gravel >10mm	%	0.1		5	23.7	21	11.9	0.1	5.5
Visual Non Soil Constituents - Concrete	%	0.1		14.7	10.5	12.3	2.1	32	1.6
Visual Non Soil Constituents - Brick	%	0.1		2.3	0.1	3.1	1	2.2	0.5
Visual Non Soil Constituents - Wood	%	0.1		0.1	10.9	8.8	2.7	0.1	0.1
Visual Non Soil Constituents - Vegetable Matter	%	0.1		0.1	0.1	0.1	0.1	0.1	0.2
Visual Non Soil Constituents - Textile	%	0.1		0.1	0.1	0.3	0.1	0.1	0.1
Visual Non Soil Constituents - Metal	%	0.1		0.1	0.1	0.1	0.1	0.2	0.1
Visual Non Soil Constituents - Glass	%	0.1		0.1	0.1	0.1	0.1	0.1	0.2
Visual Non Soil Constituents - Ceramics	%	0.1		0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Paper & Card	%	0.1		0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Fibrous Material	%	0.1		0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Plastic	%	0.1		0.1	1.9	0.2	0.2	0.1	0.7
Visual Non Soil Constituents - Sharps	%	0.1		0.1	0.1	0.1	0.1	0.1	0.1
Forensic TOC	%	0.1		0.9	1.2	0.9	1.4	1.2	1.7

% 10mm soil TOC	0.3879	0.6084	0.4311	1.0864	0.7836	1.5317
% carbanaceous material TOC	1.74	0.115	0.32	0.23	0.015	0.06
% wood etc TOC	0.043	4.687	3.784	1.161	0.043	0.043
% vegetable matter TOC	0.02	0.02	0.02	0.02	0.02	0.04
% textile TOC	0.024	0.024	0.072	0.024	0.024	0.024
% paper and card TOC	0.04	0.04	0.04	0.04	0.04	0.04
% fibrous material TOC	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL FORENSIC TOC %	2.2949	5.5344	4.7071	2.6014	0.9656	1.7787

Degradable Organic Carbon % (wet waste) *						
% carbanaceous material **	5	5	5	5	5	5
% wood	43	43	43	43	43	43
% vegetable matter ***	20	20	20	20	20	20
% textile	24	24	24	24	24	24
% paper and card	40	40	40	40	40	40
% fibrous material ****	40	40	40	40	40	40

* taken from 2006 IPCC Guideleines for National Greenhouse Gas Inventories, Vol 5, Ch 2, Table 2.4
** conservative value assumed for ash
*** value taken from Garden and Park waste
**** value assumed for typical TOC value for peat (Characteristics of dissolved organic matter following 20 years of peatland restoration, Holl et al 2009)
IMPORTANT: ALL VALUES LESS THAN THE LIMIT OF DETECTEION (LOD) HAVE BEEN REPLACED BY THE LOD. THE ORIGINAL DATA IS SAVED ON THE DATA SUMMARY SHEET
KEY to Totoal Forensic TOC cocentration Icons: Green = 1.0% and so CS1; Yellow = 1.5 and so CS2; Black = 4 and so CS3; Red and Red shaded cells indicate >4% and therefore CS4 and above

QTS Environmental Report No:16-52105								
Site Reference:Kilnwood Vale	BH927	TP954	TP975	TP924	TP925	TP925	TP978	BH901
Project / Job Ref:C - 07447 - C								
Order No:None Supplied	13.00	2.00	1.00	2.00	1.00	4.00	4.00	2.50
Reporting Date:30/11/2016	239862	239863	239864	240785	240786	240787	240788	240789

Determinand	Unit								
Sample Description		Brown clay	Brown clay		Brown clay	Brown clay	Grey clay	Brown clay	Grey clay
Moisture Content	%	36.2	20.2	14.6	16.2	17.6	17.6	16.2	18.1
Visual Non Soil Constituents - Fines 10mm	%	1.7	87.6	84.2	85	80.7	82.8	91.9	82
Visual Non Soil Constituents - Carbonaceous Material	%	5.9	0.1	0.4	4.6	7.3	0.8	3.1	2.4
Visual Non Soil Constituents - Gravel >10mm	%	11.4	1.8	1.3	5.7	5.7	5	3.3	3.7
Visual Non Soil Constituents - Concrete	%	47.9	10.4	4.4	2.8	3.2	7	1.2	2.3
Visual Non Soil Constituents - Brick	%	2.7	0.1	9.6	1.7	2.2	0.3	0.5	6.9
Visual Non Soil Constituents - Wood	%	24.2	0.1	0.1	0.1	0.4	0.9	0.1	1.9
Visual Non Soil Constituents - Vegetable Matter	%	0.1	0.1	0.1	0.1	0.1	0.5	0.1	0.1
Visual Non Soil Constituents - Textile	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Metal	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Glass	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Visual Non Soil Constituents - Ceramics	%	3.3	0.1	0.1	0.1	0.1	2.7	0.1	0.5
Visual Non Soil Constituents - Paper & Card	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Fibrous Material	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Plastic	%	3.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Sharps	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forensic TOC	%	1.3	0.4	0.9	0.9	1.2	1.1	0.4	0.3

% 10mm soil TOC	0.0221	0.3504	0.7578	0.765	0.9684	0.9108	0.3676	0.246
% carbanaceous material TOC	0.295	0.005	0.02	0.23	0.365	0.04	0.155	0.12
% wood etc TOC	10.406	0.043	0.043	0.043	0.172	0.387	0.043	0.817
% vegetable matter TOC	0.02	0.02	0.02	0.02	0.02	0.1	0.02	0.02
% textile TOC	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
% paper and card TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
% fibrous material TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL FORENSIC TOC %	10.8471	0.5224	0.9448	1.162	1.6294	1.5418	0.6896	1.307

Degradable Organic Carbon % (wet waste) *								
% carbanaceous material **	5	5	5	5	5	5	5	5
% wood	43	43	43	43	43	43	43	43
% vegetable matter ***	20	20	20	20	20	20	20	20
% textile	24	24	24	24	24	24	24	24
% paper and card	40	40	40	40	40	40	40	40
% fibrous material ****	40	40	40	40	40	40	40	40

* taken from 2006 IPCC Guideleines for National Greenhouse Gas Inventories,
** conservative value assumed for ash
*** value taken from Garden and Park waste
**** value assumed for typical TOC value for peat (Characteristics of dissolved
IMPORTANT: ALL VALUES LESS THAN THE LIMIT OF DETECTEION (LOD)
KEY to Totoal Forensic TOC cocentration Icons: Green = 1.0% and so CS1; Ye

QTS Environmental Report No:16-52105								
Site Reference:Kilnwood Vale	BH904	BH905	TP908	TP978	TP908	TP907	BH903	BH903
Project / Job Ref:C - 07447 - C								
Order No:None Supplied	2.50	7.50	4.50	2.00	1.50	4.00	5.50	5.50
Reporting Date:30/11/2016	240791	240792	240793	240794	240795	240796	240797	241507

Determinand	Unit								
Sample Description		Brown clay	Grey gravelly clay	Blue clay	Brown clay	Brown clay	Light grey clay	Grey clay	rown sandy grav
Moisture Content	%	15.6	20.3	20.6	18	15.2	16.6	18.6	49.9
Visual Non Soil Constituents - Fines 10mm	%	72.6	65.9	73.7	92.3	85.2	69.4	62.4	57.3
Visual Non Soil Constituents - Carbonaceous Material	%	4.6	7.2	3.4	1.1	3.7	6.8	7.6	1
Visual Non Soil Constituents - Gravel >10mm	%	8.1	12.8	6	3.6	2.7	7.4	11.1	2.6
Visual Non Soil Constituents - Concrete	%	13.3	9.3	15.6	2.1	4.2	14.9	16.3	21.1
Visual Non Soil Constituents - Brick	%	0.7	2.9	0.6	0.6	4.1	0.6	2.6	5.4
Visual Non Soil Constituents - Wood	%	0.1	0.1	0.1	0.1	0.1	0.2	0.1	9.6
Visual Non Soil Constituents - Vegetable Matter	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Textile	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Metal	%	0.1	1.2	0.1	0.1	0.1	0.1	0.1	0.3
Visual Non Soil Constituents - Glass	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Ceramics	%	0.1	0.1	0.1	0.1	0.1	0.5	0.1	1.8
Visual Non Soil Constituents - Paper & Card	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Fibrous Material	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Plastic	%	0.2	0.3	0.3	0.1	0.1	0.1	0.1	0.8
Visual Non Soil Constituents - Sharps	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forensic TOC	%	0.6	1.5	1	0.8	0.4	0.8	1.3	1.6

% 10mm soil TOC	0.4356	0.9885	0.737	0.7384	0.3408	0.5552	0.8112	0.9168
% carbanaceous material TOC	0.23	0.36	0.17	0.055	0.185	0.34	0.38	0.05
% wood etc TOC	0.043	0.043	0.043	0.043	0.043	0.086	0.043	4.128
% vegetable matter TOC	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
% textile TOC	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
% paper and card TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
% fibrous material TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL FORENSIC TOC %	0.8326	1.5155	1.074	0.9604	0.6928	1.1052	1.3582	5.2188

Degradable Organic Carbon % (wet waste) *								
% carbanaceous material **	5	5	5	5	5	5	5	5
% wood	43	43	43	43	43	43	43	43
% vegetable matter ***	20	20	20	20	20	20	20	20
% textile	24	24	24	24	24	24	24	24
% paper and card	40	40	40	40	40	40	40	40
% fibrous material ****	40	40	40	40	40	40	40	40

* taken from 2006 IPCC Guideleines for National Greenhouse Gas Inventories,
** conservative value assumed for ash
*** value taken from Garden and Park waste
**** value assumed for typical TOC value for peat (Characteristics of dissolved
IMPORTANT: ALL VALUES LESS THAN THE LIMIT OF DETECTEION (LOD)
KEY to Totoal Forensic TOC cocentration Icons: Green = 1.0% and so CS1; Ye

QTS Environmental Report No:16-52105											
Site Reference:Kilnwood Vale	TP980	TP914	TP915	TP904	TP905	TP906	BH910	TP918	TP918	TP920	TP983
Project / Job Ref:C - 07447 - C											
Order No:None Supplied	2.00	2.00	2.00	3.00	1.00	2.00	11.50	1.00	2.00	3.00	1.00
Reporting Date:30/11/2016	244101	244103	244105	244106	244107	244108	244109	244111	244112	244115	244116

Determinand	Unit											
Sample Description		Grey clay	grey sandy	amy clay w	wn gravelly	Grey clay	ght brown cl	Grey clay	Brown clay	Brown c ay	wn loamy c	brown sand
Moisture Content	%	22.5	18.3	18.6	16.2	19.6	19.7	18.5	17.3	25.1	22.1	18.2
Visual Non Soil Constituents - Fines 10mm	%	76.5	99.7	66	43.7	79.6	97.8	86	88.2	90.4	96.7	83.4
Visual Non Soil Constituents - Carbonaceous Material	%	0.7	0.1	0.1	18	6.8	0.3	3	1.5	1.4	0.1	1.2
Visual Non Soil Constituents - Gravel >10mm	%	2.5	0.2	2.9	13.6	1.5	0.2	6.1	1.1	2	0.9	0.9
Visual Non Soil Constituents - Concrete	%	20	0.1	30.4	17.9	11.4	1.3	3.2	8.6	3.8	0.1	14.2
Visual Non Soil Constituents - Brick	%	0.2	0.1	0.2	5.2	0.2	0.5	0.9	0.5	0.8	0.1	0.2
Visual Non Soil Constituents - Wood	%	0.1	0.1	0.1	1.2	0.1	0.1	0.7	0.1	0.8	0.1	0.1
Visual Non Soil Constituents - Vegetable Matter	%	0.1	0.1	0.5	0.1	0.3	0.1	0.2	0.1	0.4	2.1	0.1
Visual Non Soil Constituents - Textile	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Metal	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Glass	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Ceramics	%	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Paper & Card	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Fibrous Material	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Plastic	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
Visual Non Soil Constituents - Sharps	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forensic TOC	%	2.2	0.9	2	1.9	1.8	1.2	1.6	0.7	1.2	2.1	1.9

% 10mm soil TOC	1.683	0.8973	1.32	0.8303	1.4328	1.1736	1.376	0.6174	1.0848	2.0307	1.5846
% carbanaceous material TOC	0.035	0.01	0.01	0.90	0.34	0.02	0.15	0.08	0.07	0.01	0.06
% wood etc TOC	0.043	0.04	0.04	0.52	0.04	0.04	0.30	0.04	0.34	0.04	0.04
% vegetable matter TOC	0.02	0.02	0.10	0.02	0.06	0.02	0.04	0.02	0.08	0.42	0.02
% textile TOC	0.024	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
% paper and card TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
% fibrous material TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL FORENSIC TOC %	1.885	1.0693	1.572	2.3703	1.9798	1.3556	1.971	0.8594	1.6828	2.6027	1.8116

Degradable Organic Carbon % (wet waste) *											
% carbanaceous material **	5	5	5	5	5	5	5	5	5	5	5
% wood	43	43	43	43	43	43	43	43	43	43	43
% vegetable matter ***	20	20	20	20	20	20	20	20	20	20	20
% textile	24	24	24	24	24	24	24	24	24	24	24
% paper and card	40	40	40	40	40	40	40	40	40	40	40
% fibrous material ****	40	40	40	40	40	40	40	40	40	40	40

* taken from 2006 IPCC Guideleines for National Greenhouse Gas Inventories,
** conservative value assumed for ash
*** value taken from Garden and Park waste
**** value assumed for typical TOC value for peat (Characteristics of dissolved
IMPORTANT: ALL VALUES LESS THAN THE LIMIT OF DETECTEION (LOD)
KEY to Totoal Forensic TOC cocentration Icons: Green = 1.0% and so CS1; Ye

QTS Environmental Report No:16-52105											
Site Reference:Kilnwood Vale	TP983	TP981	BH991	TP926	TP919	TP927	TT901B	TT902B	TT903A	TT903A	TT903A
Project / Job Ref:C - 07447 - C											
Order No:None Supplied	2.00	3.00	1.70	2.00	1.00	2.00	2.00	3.00	3.00	1.00	1.00
Reporting Date:30/11/2016	244117	244118	244119	244120	244121	244122	244124	244125	244126	244127	244128

Determinand	Unit											
Sample Description		Grey clay	ght grey cla	Brown clay	Grey clay	Brown clay	Brown clay	Grey clay	Grey clay	Brown clay	Brown clay	ght brown c
Moisture Content	%	18.5	19	18.5	17.3	17.4	19.1	20.1	23.1	19.9	16.4	19.5
Visual Non Soil Constituents - Fines 10mm	%	54.6	69.5	77.7	96.4	87.8	80.8	91	94	100	95.5	99.9
Visual Non Soil Constituents - Carbonaceous Material	%	8.5	10.8	1.7	2.2	2.7	1.5	1	1.9	0.1	0.7	0.1
Visual Non Soil Constituents - Gravel >10mm	%	3.6	2.2	2.8	0.1	3	1.9	3.5	1.1	0.1	2.4	0.1
Visual Non Soil Constituents - Concrete	%	33.1	4.1	5.1	0.1	2.6	7.2	0.4	2.5	0.1	1.4	0.1
Visual Non Soil Constituents - Brick	%	0.1	12.3	0.5	0.9	3.5	1.3	0.2	0.2	0.1	0.1	0.1
Visual Non Soil Constituents - Wood	%	0.1	1	12.2	0.4	0.1	5	0.1	0.2	0.1	0.1	0.1
Visual Non Soil Constituents - Vegetable Matter	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Textile	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Metal	%	0.1	0.1	0.1	0.1	0.1	1.9	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Glass	%	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Ceramics	%	0.1	0.1	0.1	0.1	0.1	0.1	3.9	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Paper & Card	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Fibrous Material	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Plastic	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Sharps	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forensic TOC	%	1	1	1.7	1.8	1.6	1.1	1.3	0.9	0.6	1.4	0.3

% 10mm soil TOC	0.546	0.695	1.3209	1.7352	1.4048	0.8888	1.183	0.846	0.6	1.337	0.2997
% carbanaceous material TOC	0.43	0.54	0.09	0.11	0.14	0.08	0.05	0.10	0.01	0.04	0.01
% wood etc TOC	0.04	0.43	5.25	0.17	0.04	2.15	0.04	0.09	0.04	0.04	0.04
% vegetable matter TOC	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
% textile TOC	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
% paper and card TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
% fibrous material TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL FORENSIC TOC %	1.138	1.789	6.7759	2.1412	1.7068	3.2378	1.4	1.151	0.772	1.539	0.4717

Degradable Organic Carbon % (wet waste) *											
% carbanaceous material **	5	5	5	5	5	5	5	5	5	5	5
% wood	43	43	43	43	43	43	43	43	43	43	43
% vegetable matter ***	20	20	20	20	20	20	20	20	20	20	20
% textile	24	24	24	24	24	24	24	24	24	24	24
% paper and card	40	40	40	40	40	40	40	40	40	40	40
% fibrous material ****	40	40	40	40	40	40	40	40	40	40	40

* taken from 2006 IPCC Guideleines for National Greenhouse Gas Inventories,
** conservative value assumed for ash
*** value taken from Garden and Park waste
**** value assumed for typical TOC value for peat (Characteristics of dissolved
IMPORTANT: ALL VALUES LESS THAN THE LIMIT OF DETECTEION (LOD)
KEY to Totoal Forensic TOC cocentration Icons: Green = 1.0% and so CS1; Ye

QTS Environmental Report No:16-52105											
Site Reference:Kilnwood Vale	TP904	TT908B	TP917	TP914B	TP927	TP910	TP910	TP901A	TP905	TP908A	TT908A
Project / Job Ref:C - 07447 - C											
Order No:None Supplied	1.00	1.00	1.00	2.00	1.00	1.00	3.00	1.00	2.00	1.00	1.00
Reporting Date:30/11/2016	244129	244131	246979	246980	246981	246982	246983	246984	246985	246986	253419

Determinand	Unit											
Sample Description		n clay with s	Brown c ay	own sandy	own sandy	ed sandy cl	own sandy	own sandy	Brown clay	Brown clay	own sandy	ey loam w
Moisture Content	%	15.9	15.4	13.9	29.3	18.1	21.2	23	22.6	17.7	20.8	14.1
Visual Non Soil Constituents - Fines 10mm	%	89.2	93.1	76.2	81.4	96.1	46.1	97.4	91.4	94.8	95.7	96.9
Visual Non Soil Constituents - Carbonaceous Material	%	2.8	2	3.7	1.9	1.1	8.1	1.2	1.3	0.1	0.1	0.2
Visual Non Soil Constituents - Gravel >10mm	%	3.4	4.7	5.7	10.3	1.4	35.7	0.4	5.3	5	4.1	1.8
Visual Non Soil Constituents - Concrete	%	0.5	0.1	6.3	0.8	0.1	9.8	0.9	0.8	0.1	0.1	0.1
Visual Non Soil Constituents - Brick	%	2.1	0.2	2.3	0.9	1.4	0.1	0.1	0.9	0.2	0.1	0.5
Visual Non Soil Constituents - Wood	%	0.1	0.1	1.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Vegetable Matter	%	0.2	0.1	0.1	1.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Textile	%	0.1	0.1	2.9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Metal	%	1.8	0.1	0.1	2.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Glass	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Visual Non Soil Constituents - Ceramics	%	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5
Visual Non Soil Constituents - Paper & Card	%	0.1	0.1	0.1	0.9	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Fibrous Material	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Plastic	%	0.1	0.1	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Sharps	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forensic TOC	%	1	1.1	0.5	1.9	1.3	1.3	2.1	1.3	0.1	0.4	1

% 10mm soil TOC	0.892	1.0241	0.381	1.5466	1.2493	0.5993	2.0454	1.1882	0.0948	0.3828	0.969
% carbanaceous material TOC	0.14	0.10	0.19	0.10	0.06	0.41	0.06	0.07	0.01	0.01	0.01
% wood etc TOC	0.04	0.04	0.60	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
% vegetable matter TOC	0.04	0.02	0.02	0.22	0.02	0.02	0.02	0.02	0.02	0.02	0.02
% textile TOC	0.02	0.02	0.70	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
% paper and card TOC	0.04	0.04	0.04	0.36	0.04	0.04	0.04	0.04	0.04	0.04	0.04
% fibrous material TOC	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL FORENSIC TOC %	1.219	1.2911	1.964	2.3286	1.4713	1.1713	2.2724	1.4202	0.2668	0.5548	1.146

Degradable Organic Carbon % (wet waste) *											
% carbanaceous material **	5	5	5	5	5	5	5	5	5	5	5
% wood	43	43	43	43	43	43	43	43	43	43	43
% vegetable matter ***	20	20	20	20	20	20	20	20	20	20	20
% textile	24	24	24	24	24	24	24	24	24	24	24
% paper and card	40	40	40	40	40	40	40	40	40	40	40
% fibrous material ****	40	40	40	40	40	40	40	40	40	40	40

* taken from 2006 IPCC Guideleines for National Greenhouse Gas Inventories,
** conservative value assumed for ash
*** value taken from Garden and Park waste
**** value assumed for typical TOC value for peat (Characteristics of dissolved
IMPORTANT: ALL VALUES LESS THAN THE LIMIT OF DETECTEION (LOD)
KEY to Totoal Forensic TOC cocentration Icons: Green = 1.0% and so CS1; Ye

QTS Environmental Report No:16-52105					
Site Reference:Kilnwood Vale	TT908B	TT901	TT902A	TT902B	TT903A
Project / Job Ref:C - 07447 - C					
Order No:None Supplied	2.00	1.00	2.00	2.00	3.00
Reporting Date:30/11/2016	253420	253421	253422	253423	253424

Determinand	Unit					
Sample Description		yey loam w	yey loam w	yey loam w	yey loam w	yey loam w
Moisture Content	%	19.8	16.3	21.6	20.7	14.9
Visual Non Soil Constituents - Fines 10mm	%	96	96.5	83.7	95.5	97.7
Visual Non Soil Constituents - Carbonaceous Material	%	0.1	2.4	15.8	1.1	1.8
Visual Non Soil Constituents - Gravel >10mm	%	3.1	0.6	0.5	1.7	0.1
Visual Non Soil Constituents - Concrete	%	0.1	0.1	0.1	1.4	0.2
Visual Non Soil Constituents - Brick	%	0.7	0.1	0.1	0.1	0.2
Visual Non Soil Constituents - Wood	%	0.1	0.5	0.1	0.4	0.1
Visual Non Soil Constituents - Vegetable Matter	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Textile	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Metal	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Glass	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Ceramics	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Paper & Card	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Fibrous Material	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Plastic	%	0.1	0.1	0.1	0.1	0.1
Visual Non Soil Constituents - Sharps	%	0.1	0.1	0.1	0.1	0.1
Forensic TOC	%	0.9	0.5	1.7	0.6	1.3

% 10mm soil TOC	0.864	0.4825	1.4229	0.573	1.2701
% carbanaceous material TOC	0.01	0.12	0.79	0.06	0.09
% wood etc TOC	0.04	0.22	0.04	0.17	0.04
% vegetable matter TOC	0.02	0.02	0.02	0.02	0.02
% textile TOC	0.02	0.02	0.02	0.02	0.02
% paper and card TOC	0.04	0.04	0.04	0.04	0.04
% fibrous material TOC	0.04	0.04	0.04	0.04	0.04
TOTAL FORENSIC TOC %	1.036	0.9415	2.3799	0.924	1.5271

Degradable Organic Carbon % (wet waste) *					
% carbanaceous material **	5	5	5	5	5
% wood	43	43	43	43	43
% vegetable matter ***	20	20	20	20	20
% textile	24	24	24	24	24
% paper and card	40	40	40	40	40
% fibrous material ****	40	40	40	40	40

* taken from 2006 IPCC Guideleines for National Greenhouse Gas Inventories,
** conservative value assumed for ash
*** value taken from Garden and Park waste
**** value assumed for typical TOC value for peat (Characteristics of dissolved
IMPORTANT: ALL VALUES LESS THAN THE LIMIT OF DETECTEION (LOD)
KEY to Totoal Forensic TOC cocentration Icons: Green = 1.0% and so CS1; Ye

London

Friars Bridge Court
41- 45 Blackfriars Road
London, SE1 8NZ

T: +44 (0)20 7340 1700
E: london@campbellreith.com

Birmingham

Chantry House
High Street, Coleshill
Birmingham B46 3BP

T: +44 (0)1675 467 484
E: birmingham@campbellreith.com

Surrey

Raven House
29 Linkfield Lane, Redhill
Surrey RH1 1SS

T: +44 (0)1737 784 500
E: surrey@campbellreith.com

Manchester

No. 1 Marsden Street
Manchester
M2 1HW

T: +44 (0)161 819 3060
E: manchester@campbellreith.com

Bristol

Wessex House
Pixash Lane, Keynsham
Bristol BS31 1TP

T: +44 (0)117 916 1066
E: bristol@campbellreith.com

UAE

Office 705, Warsan Building
Hessa Street (East)
PO Box 28064, Dubai, UAE

T: +971 4 453 4735
E: uae@campbellreith.com

Campbell Reith Hill LLP. Registered in England & Wales. Limited Liability Partnership No OC300082
A list of Members is available at our Registered Office at: Friars Bridge Court, 41- 45 Blackfriars Road, London SE1 8NZ
VAT No 974 8892 43