

Table of likely pathways		
Receptor group	Critical receptor	Pathway
Current and proposed site users	Child	Ingestion air-borne dusts
		Ingestion of soil
		Inhalation air-borne dusts
		Inhalation of vapours
		Dermal contact with dust
		Dermal contact with soil
Construction Operatives	Adult	Ingestion air-borne dusts
		Ingestion of soil.
		Inhalation air-borne dusts
		Inhalation of vapours
		Dermal contact with dust
Proposed site users	Child	Ingestion of home grown vegetables
		Ingestion of soil attached to vegetables
Vegetation		Root uptake, deposition to shoots and foliage contact.
Controlled waters	Groundwater	Percolation of water through contaminated soils
	Surface water	Near-surface water run-off through contaminated soils

Table 8.4.4

8.5 Assessment of sources of chemical contamination

8.5.1 Introduction

8.5.1.1 Initially, potential sources of contamination are assessed using the following elements of the investigation process.

- History of the site
- Desk study information
- Site reconnaissance
- Geology
- Fieldwork

These elements will dictate a relevant soil/water testing regime to quantify possible risks of any identified contaminative sources which may harm identified receptors.

8.5.2 Source assessment – History of the site

8.5.2.1 The history of the site and its immediate surroundings based on published Ordnance Survey maps is described in Section 3.

8.5.2.2 Based on published historical maps, the area of Zone 2 to the west/southwest was occupied by railway sidings with associated engine shed, turntable, coal hopper and localised tanks between 1898 and 1974. A refuse tip was present in the area of Zone 1 to the northwest between 1966 and 1989. Additionally, a mere (large pond) was present in Zone 4 to the east of the site between 1879 and 1967.

- 8.5.2.3 The former railway land site usage associated to the railway is included in 'Industry profiles' *Railway land*; published by the department of the Environment, which provides an indication of the type of chemical contaminants likely to be used by the industry. In addition, the landfill area to the northwest is included in 'Industry profiles' *Waste recycling, treatment and disposal sites*. Clearly, the possibility of potential soil contamination from this former land use would be dependent upon the management of the potential contaminants within this former industry. Contaminants of concern are listed in table 8.5.2.6 below. At this stage we have assumed there is a risk of each of the potential contaminants impacting soils at the site, and thus there is a potential (and thus a risk) of this chemical source causing harm to site receptors.
- 8.5.2.4 Some areas of the site formed agricultural land and allotments historically, and may have been utilised for growing crops and thus likely to have been subject to the use of pesticides/herbicides. It is considered unlikely that significant concentrations of such chemicals will have been utilised in recent years in accordance with DEFRA standards for growing crops. Considering the components of pesticide, organics are unlikely to persist in the environment however metals are present in pesticides which can persist in the environment and thus could remain present in soils. Such metals include arsenic, copper, chromium, lead, zinc and vanadium. These metals form part of our suite of laboratory tests for which concentrations are measured in soil samples.
- 8.5.2.5 A small number of historical surrounding land uses (other than the landfill site to Zone 1) may also have the potential to generate sources of contamination which could impact the subject site. These would include similar land uses to those identified onsite already, in addition to works and depots. Such contaminants are similar to those already identified, thus, to save repetition, we have not specifically included as a source.
- 8.5.2.6 Clearly, the possibility of potential soil contamination from these land uses would be dependent upon the management of the potential contaminants within the business. An assessment of the likelihood of this land use impacting the site is summarised in the table below: -

Table summarising results of source assessment				
Historical/ current activity	Contaminant(s)	Source assessment	Probability of source	Testing required?
On site				
Railway land	Metals, PAHs, TPHs, acids and alkalis, asbestos	Railway land recorded in area of Zone 2.	Likely	Yes
Infilled pond	Metals, Organics, PAH, TPH, asbestos	Pond infilled to east in Zone 4.	Likely	Yes
Agricultural land and allotments	Metals	Particularly area of Zone 3 and 4.	Likely	Yes
Adjacent sites				
Hogshaw Landfill	Metals, Organics, PAH, TPH, asbestos	Former landfill to northwest in Zone 1.	Likely	Yes
Table reference 8.5.2.6				

8.5.3 Source assessment – Desk study information

8.5.3.1 Envirocheck presents a detailed database of environmental information in relation to the site including;

- Pollution incidents
- Landfill sites
- Trading activities

8.5.3.2 Based on the Envirocheck data (refer Appendix M) area of land forming Zone 1 has been subject to landfilling activities. Records indicate that it was licenced for receipt of inert, industrial and commercial waste. Furthermore, the Local Authority planning portal of High Peak Borough Council, records a refuse tip in the area of the existing recreation ground to the southwest of the site (Zone 2). The extent of the tip is not recorded. In addition to this a number of quarries were noted on historical mapping which may pose a source of contamination if infilled. Envirocheck also record an area of infilled land to the east (Zone 4), associated with the backfilling of Russia Mere. The above are likely to represent sources of contamination worthy of further consideration.

8.5.3.3 The nearest incident is recorded 189m to the south of site, associated with release of oils/diesel into Hogshaw Brook, dated in February 1998. The closest significant incident is recorded 316m to the south, associated with release of unknown organic wastes into Hogshaw Brook, dated April 1997. Given these incidents are located downstream from site, they are not likely to represent sources of contamination worthy of further consideration.

8.5.3.4 Nine active trade directory entries are recorded within 500m of the site, the closest of which is recorded 13m to the northeast, classified as Garage Services at Nunsfield Farm (Buxton 4x4). The closest inactive entry is located 5m to the northeast, associated with an Agricultural Merchants at Nunsfield Farm. The garage use may provide a source of localised contamination which could affect the subject site and is worthy of further consideration.

8.5.4 Source assessment – Site reconnaissance

8.5.4.1 A full description of the site and observed adjacent land uses is provided in Section 3 of this report. A plan summarising observations made on site during our site reconnaissance visit is presented on Drawing 02.

8.5.4.2 Localised areas of fly tipping were observed in Zone 2, and garages were present in the central and southern parts of this area, which may pose a localised source of contamination, including solvents, metals, PAHs, TPHs and asbestos.

8.5.5 Source assessment – Geology

- 8.5.5.1 The geological map of the area indicates the topography local to the site is formed in deposits of Bowland Shale Formation, Eyam Limestone Formation and Bee Low Limestone Formation. Typically, and in our experience, such deposits do not exhibit any abnormal concentrations of naturally occurring chemical contaminants.

8.5.6 Source assessment - Fieldwork observations

- 8.5.6.1 During excavation of exploratory locations within western parts of the site (Zone 2), we observed significant quantities of anthropogenic material, generally consistent with localised landfilling activities, and associated with the former railway land. Specifically, these included, slag, ash and general commercial wastes (textiles, paper etc). Similar materials were encountered locally in the eastern part of site (Zone 4), likely associated with infilling of the Mere and localised earthworks adjacent to the graveyard.
- 8.5.6.2 It should be noted that localised investigations undertaken in the Zone 1 landfill area identified significant quantities of anthropogenic material, consistent with landfilling activities. Specifically, these included potential asbestos containing materials (ACMs), significant quantities of biodegradable matter and general commercial wastes (textiles, paper etc).
- 8.5.6.3 In addition, a hydrocarbon odour was observed in Made Ground soils encountered between depths of 1.9-3.4m in trial pit TP05 (Zone 1 landfill area).
- 8.5.6.4 We obtained samples of the potentially chemically impacted soils for subsequent laboratory testing.

8.5.7 Source assessment - summary

- 8.5.7.1 Based on the paragraphs above, we have identified the following potential sources of contamination:

Table summarising results of source assessment				
Source	Origin of information	Possible contaminant	Probability of risk occurring	Likely extent of contamination
On site				
Railway Land	Desk Study and site investigations	Metals, PAHs, TPHs, acids and alkalis, asbestos	Likely	Western part of site (Zone 2)
Infilled Pond				Eastern part of site (Zone 4)
Agricultural land and allotments		Metals		Particularly area of Zones 3 and 4
Fly tipping and garages	Site reconnaissance	Solvents, metals, PAHs, TPHs and asbestos	Possible	Central and south parts of site (Zone 2)
Localised landfill type materials and TPH contamination	Fieldworks	Metals, Organics, PAH, TPH, asbestos	Likely	Zones 2, 4 and local to TP05 (TPH)
Adjacent sites				
Garage services	Site reconnaissance	Metals, PAHs, TPH, asbestos	Possible	Eastern part of site (Zone 3 and 4)
Former quarries	Desk Study		Low Likelihood	Site wide
Hogshaw Landfill/ Hogshaw Tip	Desk Study and site investigations	Metals, Organics, PAH, TPH, asbestos	Possible	Western parts of Zone 3 and northern parts of Zone 2

Table reference 8.5.7

8.6 Initial Conceptual Model

8.6.1 Based on our assessment of potential contaminative sources, identified receptors and viable pathways to receptors described in preceding paragraphs, we have produced an initial conceptual model in the form of a table which is presented in Appendix J.

8.6.2 Based on the conceptual model there are risks which exceed the low category which in our opinion are unacceptable and require either remedial action, or further investigation by laboratory testing of soil / water samples to refine the risk assessment.

8.7 Laboratory testing

8.7.1 Testing regime

8.7.1.1 Based on our source assessment (and our initial conceptual model) we have evidence to suggest that significant sources of specific contamination are potentially present onsite and on immediately adjacent sites. In order to carry out a quantitative, we have scheduled testing to measure the concentration of commonly occurring inorganic and organic contaminants, in addition to specific contaminants where necessary based on the locations of identified sources.

8.7.1.2 As outlined in paragraph 8.3.1.1, we have refined the following assessments based on development not being undertaken within Zone 1. We have presented the testing that was originally scheduled on soils taken from exploratory investigations within Zone 1 in the following table for completeness, however, such results have been omitted from subsequent interpretive analysis.

8.7.1.3 The following table summarises the chemical testing scheduled as well as a rationale for the testing: -

Table summarising scheduled testing					
Exploratory point	Depth (m)	Strata/ medium	Targeted sampling?	Scheduled testing	Rationale
TP01	0.3	Gravel	N		General site coverage
TP02	0.3	Sand	N		
TP03	0.2	Topsoil	N		
TP04	0.2	Topsoil	N		
TP05*	0.8	Made Ground - Sand	Y		Historical landfill area
TP06	0.3	Topsoil	N		General site coverage
TP10	0.8	Made Ground - Sand	Y		Former railway land
TP11	0.3	Topsoil	N		General site coverage
DTS01*	0.5	Made Ground - Clay	Y		Historical landfill area
DTS01*	0.8	Made Ground - Clay	Y		
DTS02	0.3	Topsoil	N	Suite 1	General site coverage
DTS03	0.3	Topsoil	N		
DTS04*	0.5	Made Ground - Clay	Y		Historical landfill area
DTS06	0.3	Topsoil	N		General site coverage
DTS07	0.3	Topsoil	N		
DTS09	0.3	Topsoil	N		
DTS12	0.3	Topsoil	Y		Next to agricultural supplier yard
DTS15	0.3	Topsoil	N		General site coverage
DTS18	0.3	Topsoil	N		
DTS20	0.5	Made Ground - Sand	Y		Next to garage
DTS20	0.8	Made Ground - Sand	Y		
DTS23	0.8	Made Ground - Sand	Y		General site coverage
DTS28	0.8	Clay	N		
TP05*	0.8	Made Ground - Sand	N		General site coverage
TP07	0.5	Made Ground - Gravel	Y		Potential ACM contamination
TP09	0.5	Made Ground - Gravel	N		General site coverage
TP18*	0.8	Made Ground - Sand	Y		Potential ACM material
TP18*	1.2	Made Ground - Sand	Y	Asbestos screening	
TP18*	1.4	Made Ground - Sand	Y		
TP18*	1.6	Made Ground - Sand	Y		
DTS13	0.8	Made Ground - Sand	N		General site coverage
DTS16	0.8	Made Ground - Gravel	N		
DTS20	0.8	Made Ground - Sand	Y		Potential ACM contamination
DTS21	0.5	Made Ground - Sand	N		General site coverage
DTS22	1.2	Made Ground - Sand	N		
DTS26	0.8	Made Ground - Clay	N		
DTS28	0.8	Clay	N		
DTS29	1.2	Made Ground - Sand	N		
TP03	0.5	Gravel	N		General site coverage
TP16	0.5	Made Ground - Gravel	N		
TP18*	0.5	Made Ground - Sand	N	Suite 8	
TP20	0.5	Made Ground - Sand	N		
DTS02	0.5	Sand	N		
DTS07	0.8	Clay	N		
DTS19	0.5	Made Ground - Sand	N		

DTS19	1.2	Gravel	N		
DTS21	1.8	Made Ground - Clay	N		
DTS22	1.8	Clay	N		
TP05*	2.5	Made Ground - Sand	Y	Suite 2	Hydrocarbon odour noted
TP07	0.8	Made Ground - Gravel	Y		Garages with asbestos noted
TP05*	1.2	Made Ground - Sand	Y		Historical Landfill
TP05*	1.8	Made Ground - Sand	Y		
TP08	0.8	Made Ground - Sand	Y		Potentially infilled pond
TP08	1.2	Made Ground - Sand	Y		
TP09	0.8	Clay	N		General site coverage
TP20	1.2	Made Ground - Clay	Y	Suite 17	Next to garage
DTS04*	0.8	Made Ground - Gravel	Y		Historical landfill area
DTS09	0.5	Clay	N		Next to agricultural supplier yard
DTS16	0.8	Made Ground - Gravel	N		General site coverage
DTS20	1.2	Made Ground - Sand	Y		Landfill material encountered
DTS25	0.5	Made Ground - Sand	Y		
Nuns Brook Upstream1	Surface	Water	Y		Nuns Brook immediately upstream of site
Nuns Brook Downstream1	Surface	Water	Y	Suite 17 – Water	Nuns Brook immediately downstream of site
DTS19	3.2	Water	Y		Groundwater onsite

Table 8.7.1.2

Refer to Appendix B for testing suite descriptions

*Exploratory points located within former landfill area (Zone 1), excluded from subsequent interpretative analysis.

8.7.1.4 Obviously, additional testing (quantity and types) would allow a more accurate risk assessment to be made. The results of laboratory determination of the concentrations of chemical contaminants are presented in Appendix H.

8.7.2 Criteria for assessment of test data – Human receptors

8.7.2.1 Assessment of laboratory test data has been carried out with reference to current nationally recognised documents listed in the final page of Appendix B. Due to changes in guidance on contaminated land, items 6-8 and item 10 in the document listing above have been withdrawn. In the absence of alternative guidance however we have used these documents. Where new guidance is available, this has been followed in preference to superseded guidance.

8.7.2.2 The Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) have derived Suitable for Use Levels (S4ULs) which are presented in *'The LQM/CIEH S4ULs for Human Health Risk Assessment'* (2015). S4ULs have been used as a screening tool to assess the risks posed to the health of humans from exposure to soil contamination in relation to appropriate land uses. Where published S4ULs are not available, we have adopted C4SLs (Category 4 Screening Levels) produced by DEFRA or SGVs (Soil Guideline Values) as appropriate. Where available, we have adopted the upper bound C4SL value. In the absence of any of these criteria we have adopted Soil Screening Values (SSV) derived by Soiltechnics and by Atkins (SSV^{ATK}). The CLEA model used to derive SSVs has been used with toxicology data presented by the EA, LQM/CIEH and Atkins (in that order of preference). SSVs produced by Atkins are presented on their ATRISK^{SOIL} website.

- 8.7.2.3 S4ULs, C4SLs, SGVs, SSVs and SSV^{ATK}s represent ‘intervention values’; indications to an assessor that soil concentrations above these levels might present an unacceptable risk to the health of site users. These guideline values have been produced using conceptual exposure models, which use assumptions and are applied to differing end uses of land. If the values are exceeded, it does not necessarily imply there is an actual risk to health and site-specific circumstances should be taken into account. Conversely, where a critical pathway or chemical form of the contaminant has not been evaluated, a risk may be present even if the adopted guideline value has not been exceeded.
- 8.7.2.4 For evaluation of test data in relation to polycyclic aromatic hydrocarbon (PAH), phenols and total petroleum hydrocarbon (TPH) contamination, we have compared measured concentrations with corresponding S4ULs. The S4UL fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the relevant guideline values based on SOM testing.
- 8.7.2.5 We have followed procedures outlined by the CIEH to compare measured concentrations of metals and PAH contaminants against guideline values. TPH contamination results are compared directly with the relevant guideline values. The guidance presents an approach to data analysis and includes the examination of data for potential outliers, assessment of the normality of the test data and the calculation of a 95% Upper Confidence Limit (UCL). The UCL provides an estimate of the population mean, based on test data, with a 95% confidence that the actual mean does not exceed this value. The UCL is compared to the guideline value for the site.
- 8.7.2.6 We have adopted a public open space (POS park) land use for current site users and a residential land use for proposed end users of the site.
- 8.7.3 Criteria for assessment of test data – Construction operatives**
- 8.7.3.1 In the absence of guidelines we have adopted industrial/commercial guideline values for assessment of construction operatives.
- 8.7.4 Criteria for assessment of test data – Vegetation**
- 8.7.4.1 Guidance published by Forest Research in “BPG Note 5 - Best Practice Guidance for Land Regeneration” suggests that a residential without plant uptake or industrial/commercial CLEA model should be adopted for this receptor. Specific guideline values are provided for copper and zinc at 130mg/kg and 300mg/kg respectively within BPG 5, however, this document has recently been withdrawn. As a practice we have adopted the industrial / commercial CLEA model for assessment of test data for vegetation, including those specific values outlined in BPG 5 until updated guidance is published.
- 8.7.4.2 It is difficult to quantify the phytotoxicity of a contaminant as large variations exist between plant tolerances, soil effects and synergistic/antagonistic reactions between chemicals. Due to the complexities of the effects of soil contamination on different plant species, we recommend that the test results presented in this report are passed to a landscape architect for the selection of suitable planting.

8.7.5 Criteria for assessment of test data – Controlled waters

8.7.5.1 For interpretation of test data in relation to water receptors we have directly compared measured values with the Drinking Water Standards (DWS) as presented in “*The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*”. Where DWS are not available we have adopted EQS values where applicable.

8.7.5.2 For assessment of TPH concentrations, we have adopted World Health Organisation (WHO) Drinking Water Guidelines as presented in CL:AIRE guidance “*Petroleum Hydrocarbons in Groundwater*”, 2017.

8.7.5.3 Following our receptor assessment (outlined in Section 8.3.5 above), given that Nun Brook flows through site, we have adopted EQS values in preference to UKDWS. It is acknowledged that the site is underlain by Principal Aquifers in the limestones, however given the relative position of the brook onsite, in comparison to groundwater abstractions (closest 672m southwest), we have considered the brook to be at greater risk of being adversely impacted by any contamination onsite.

8.7.6 Evaluation of test data – Human receptors

8.7.6.1 Tables summarising and analysing test data are presented in Appendix I. The following table summarises the outcome of the analyses. It should be noted that we have assessed measured concentrations in Topsoil separate to those measured in Made Ground deposits across the site, given their distinct compositional difference.

Table Summarising assessment of test data for Human receptors

Analysis tables	Receptor group	Critical receptor	CLEA model	Inorganic contaminants	Organic contaminants
1, 2, 9, 10 and 15	Current site users	Child	Public open space (park)	Refer to Section 8.7.6.2 below	Refer to Section 8.7.6.2 below
3, 4, 11, 12 and 16	Future site users	Child	Residential with plant uptake	Refer to Section 8.7.6.3 below	Refer to Section 8.7.6.3 below
5, 6, 13, 14 and 17	Construction operatives	Adult	Industrial / commercial	Refer to Section 8.7.6.4 below	Refer to Section 8.7.6.4 below

Table 8.7.6.1

8.7.6.2 Current site users

8.7.6.2.1 With reference to tables 1, 2, 9, 10 and 15 in Appendix I, analysis of chemical test data with respect to critical (child) receptors for current site uses, indicates all measured concentrations of selected contaminants and 95th percentile upper confidence limits (UCL) are below relevant adopted guideline values, with the exception of lead and dibenzo(a,h)anthracene in two samples, and benzo(a)pyrene and benzo(b)fluoranthene in one sample, all measured in Made Ground deposits (total of 10 No. samples tested).

8.7.6.2.2 Lead was measured at concentrations of 2700mg/kg (DTS20 0.5m) and 7400mg/kg (DTS23 0.8m) exceeding the C4SL (u) of 1400mg/kg. The UCL of 4482.7mg/kg for lead also exceeds the guideline value. Dibenzo(a,h)anthracene was measured at concentrations of 3.4mg/kg and 4.8mg/kg, exceeding the S4UL of 1.3mg/kg. The UCL of 3.3mg/kg for dibenzo(a,h)anthracene also exceeds the guideline value. The elevated concentrations of benzo(a)pyrene and benzo(b)fluoranthene were measured at 15mg/kg and 18mg/kg, exceeding the respective S4ULs of 12mg/kg and 15mg/kg, both located within TP10 at 0.8m depth. Such contamination was present in Zones 2 and 4.

8.7.6.2.3 Analysis indicates that concentrations of contaminants measured in all Topsoil and naturally deposited soils (17 No. samples) fall below relevant guidelines for current users.

8.7.6.3 *Future site users*

8.7.6.3.1 With reference to tables 3, 4, 11, 12 and 16 in Appendix I, analysis of chemical test data with respect to critical (child) receptors for future site uses, indicates all measured concentrations of selected contaminants and 95 percentile upper confidence limits (UCL) are below relevant adopted guideline values, with the exception of arsenic, beryllium, lead and nickel in a small number of Topsoil/natural soil samples, and arsenic, beryllium, lead, mercury, benzo(a) anthracene, benzo(a)pyrene, benzo(b)fluoranthene and dibenzo(a)anthracene in a large number of Made Ground samples.

8.7.6.3.2 Four elevated concentrations of arsenic have been measured in Topsoil/natural soils, recorded between 49mg/kg and 65mg/kg (S4UL of 37mg/kg), with five elevated concentrations of beryllium recorded ranging between 1.8mg/kg to 2.5mg/kg (S4UL of 1.7mg/kg), three elevated concentrations of lead ranging between 250mg/kg and 320mg/kg (C4SL (u) of 210mg/kg) and a single elevated concentration of nickel measured at 200mg/kg (S4UL of 180mg/kg). Such contamination was locally present in Topsoil/natural soils within Zones 3 and 4.

8.7.6.3.3 Within Made Ground samples, the following exceedances have been identified: -

- Arsenic within 9 of 10 samples, with exceedances measured at concentrations ranging between 47mg/kg and 160mg/kg. The mean value of 84.3mg/kg and UCL of 109.6mg/kg also exceed the guideline value (S4UL of 37mg/kg). Samples are located within Zones 2 and 4.
- Beryllium within 8 of 10 samples, with exceedances measured at concentrations ranging between 3.6mg/kg and 9.6mg/kg. The mean value of 5.3mg/kg and UCL of 7.2mg/kg also exceed the guideline value (S4UL of 1.4mg/kg). Samples are located within Zones 2 and 4.
- Lead within 7 of 10 samples, with exceedances measured at concentrations ranging between 420mg/kg and 7400mg/kg. The mean value of 1357.4mg/kg and UCL of 4482.7mg/kg also exceed the guideline value (C4SL(u) of 210mg/kg). Samples are located within Zones 2 and 4.

- Mercury within 1 of 10 samples, with an exceedance measured at a concentration of 1.6mg/kg (DTS23 0.8m) within Zone 2, exceeding the S4UL of 1.2mg/kg. The mean value of 1.3mg/kg also exceeds the guideline value.
- Benzo(a)anthracene within 1 of 10 samples, with an exceedance measured at a concentration of 12mg/kg, (TP10 0.8m) within Zone 2, exceeding the S4UL of 11mg/kg.
- Benzo(a)pyrene within 3 of 10 samples, with exceedances measured at concentrations ranging between 3.1mg/kg and 15mg/kg, exceeding the S4UL of 2.7mg/kg. The UCL of 9.0mg/kg also exceeds the guideline value. Samples are located within Zones 2 and 4.
- Benzo(b)fluoranthene within 3 of 10 samples, with exceedances measured at concentrations ranging between 3.6mg/kg and 18mg/kg, exceeding the S4UL of 3.3mg/kg. The UCL of 11.0mg/kg also exceeds the guideline value. Samples are located within Zones 2 and 4.
- Dibenzo(a,h)anthracene within 3 of 10 samples, with exceedances measured at concentrations ranging between 1.1mg/kg and 4.8mg/kg, exceeding the S4UL of 0.28mg/kg. The mean value of 1.0mg/kg and UCL of 3.3mg/kg also exceed the guideline value. Samples are located within Zones 2 and 4.

8.7.6.4 *Construction operatives*

8.7.6.4.1 With reference to tables 5, 6, 13, 14 and 17 in Appendix I, analysis of chemical test data with respect to construction operatives (adult receptors), indicates all measured concentrations of selected contaminants and 95 percentile upper confidence limits (UCL) are below relevant adopted guideline values, with the exception of one concentration of both lead and dibenzo(a,h)anthracene in Made Ground deposits.

8.7.6.4.2 Elevated lead was measured at a concentration of 7400mg/kg (DTS23 0.8m) exceeding the C4SL (u) of 6000mg/kg, with dibenzo(a)anthracene measured at a concentration 4.8mg/kg (TP08 1.2m), exceeding the S4UL of 3.6mg/kg. Such contamination was present in Zone 4.

8.7.6.4.3 Analysis indicates that concentrations of contaminants measured in all Topsoil and naturally deposited soils (17 No. samples) fall below relevant guidelines for construction operatives.

8.7.6.5 *Asbestos*

8.7.6.5.1 Asbestos screening was carried out in 9 samples of Made Ground and 1 sample of natural soil. Analysis indicates that asbestos is present in 3 of the 14 samples of Made Ground tested (DTS13, DTS20 and DTS22 within Zones 2 and 4), described as chrysotile fibres/clumps. Where analysed, total asbestos (%) content was recorded below 0.002% w/w with the exception for DTS13 at 0.8m depth, which recorded asbestos at 53% w/w.

8.7.6.6 VOCS & SVOCs

8.7.6.6.1 In addition to the above, with the exception of PAHs, BTEX and MTBE, a number of other Volatile and Semi Volatile Organic Compounds (VOC & SVOCs) were scheduled for testing. The majority of compounds tested for indicated measured concentrations below detectable limits, however, concentrations were measured for a select number, as follows: -

Table Summarising VOC/SVOC contamination for Human receptors

Location	Depth (m)	Compound	Concentration	Guideline*
DTS25	0.5	2-Methylnaphthalene	0.17mg/kg	N/A
DTS16	0.8	Carbazole	0.087mg/kg	N/A
		Butylbenzyl Phthalate	0.074mg/kg	N/A
TP08	1.2	2-Methylnaphthalene	0.43mg/kg	N/A
		Dibenzofuran	0.32mg/kg	N/A
		Carbazole	0.56mg/kg	N/A
		Butylbenzyl Phthalate	0.094mg/kg	N/A
		Bis(2-Ethylhexyl)Phthalate	0.31mg/kg	N/A
		Di-N-Octyl Phthalate	0.067mg/kg	N/A
		4-Nitrophenol	0.31mg/kg	N/A

Table 8.7.6.6

*Guideline values presented in from Soil Generic Assessment Criteria for Human Health Risk Assessment, January 2010, produced by CL:AIRE (including EIC and AGS).

8.7.6.6.2 Based on the above, guideline values are not currently available for the measured concentrations of VOCs/SVOCs detected. Thus, we have provided further details on these in the following paragraphs. It is noted that the CL:AIRE document as outlined in Table 8.7.6.6 above indicates that the pathway exposure contributions SVOCs are predominantly associated with inhalation of vapours and background inhalation.

8.7.6.6.3 A large number of the VOCs/SVOCs for which guidelines are not currently available are commonly used in insecticides, fungicides, herbicides, pesticides, in addition to dyes, heat transfer agents, plasticisers, lubricants and fuel additives.

8.7.6.6.4 The contaminants identified above have all been measured in Made Ground deposits at the site, largely consistent with the landfill type Made Ground deposits encountered in Zone 2 and partly Zone 4. It is therefore, most likely that such contamination is indicative of the source location where the materials were imported from prior to landfilling or re-profiling works which the site has been subject to.

8.7.6.6.5 Based on the above, such contaminants are unlikely to pose a risk to human health via pathways associated with dermal contact or ingestion. The greatest risk will be associated with vapour pathways and background inhalation, as outlined above in paragraph 8.7.6.6.2. Given the relatively insignificant concentrations measured, however, and when taken in context with the GACs that are currently available for VOC/SVOC for varying land uses, it is considered unlikely that such contaminants would pose a risk to human health via vapour pathways.

8.7.7 Evaluation of test data – Vegetation

8.7.7.1 With reference to tables 7, 8, 13, 14 and 17 in Appendix I, analysis of chemical test data with respect to vegetation indicates all measured concentrations of selected contaminants and 95 percentile upper confidence limits (UCL) are below relevant adopted guideline values, with the exception of copper, and zinc in a small number of Topsoil/natural soil samples, and copper, lead, zinc and dibenzo(a,h)anthracene in a number of Made Ground samples.

8.7.7.2 Two elevated concentrations of zinc have been measured in Topsoil/natural soils, recorded at 350mg/kg and 370mg/kg (BPG 5 value of 300mg/kg), with copper elevated in one sample, measured at a concentration of 140g/kg (BPG 5 of 130mg/kg). Such contamination was locally present in Topsoil/natural soils within Zone 3.

8.7.7.3 Within Made Ground samples, the following exceedances have been identified: -

- Copper within 9 of 10 samples, with exceedances measured at concentrations ranging between 140mg/kg and 700mg/kg. The mean value of 388.4mg/kg and UCL of 754.3mg/kg also exceed the guideline value (BPG 5 value of 130mg/kg). Samples are located within Zones 2 and 4.
- Zinc within 4 of 10 samples, with exceedances measured at concentrations ranging between 440mg/kg and 1000mg/kg. The mean value of 357.1mg/kg and UCL of 756.8mg/kg also exceed the guideline value (BPG 5 value of 300mg/kg). Samples are located within Zones 2 and 4.
- Lead within one sample (DTS23 0.8m), measured at a concentration of 7400mg/kg and exceeding the S4UL of 6000mg/kg. Sample located within Zone 2.
- Dibenzo(a,h)anthracene within one sample (TP08 1.2m), measured at a concentration of 4.8mg/kg and exceeding the S4UL of 3.6mg/kg. Sample located within Zone 4.

8.7.8 Evaluation of test data – Controlled waters

8.7.8.1 Inorganic contaminants

8.7.8.1.1 With reference to Table 18 in Appendix I, none of the measured concentrations of inorganic soluble and leachable contaminants exceed the relevant guidelines with the exception for soluble copper (EQS of 1µg/l) within a groundwater sample from DTS19 at 3.2m, measured at 1.2µg/l, and a surface water sample from Nun Brook downstream of the site, measured at 1.1µg/l. In addition, a leachable concentration of copper was measured in natural soils from DTS106 0.8m, measured at 10µg/l.

8.7.8.2 Organic contaminants (polycyclic aromatic hydrocarbons)

8.7.8.2.1 With reference to Table 18 in Appendix I, none of the measured concentrations of inorganic soluble and leachable contaminants exceed the relevant available guidelines.

8.7.8.3 *Organic contaminants (total petroleum hydrocarbons)*

8.7.8.3.1 The measured values of soluble TPH contaminants fall below the relevant guideline values, with many being below the limit of detection.

8.8 Updated conceptual model

8.8.2 Current site users

8.8.2.1 Contaminants measured in existing Topsoil deposits present in Zones 3 and to some extent Zone 4 are unlikely to present a risk of causing harm to human health.

8.8.2.2 A small number of measured concentrations of contaminants (lead, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene), within Made Ground deposits in the areas of Zones 2 and 4 exceed respective guideline values. Due to the relatively high concentrations measured, the UCL for lead and dibenzo(a,h)anthracene exceed the respective C4SL (u) and S4ULs for current users.

8.8.2.3 Providing the site is developed then the risk of harm being caused to current users from identified contamination is clearly a short-term issue and unlikely to require any remediation. If development does not proceed as planned, further consideration should be given to such risks and the requirement for remediation.

8.8.3 Future site users

8.8.3.1 Elevated localised concentrations of arsenic, beryllium, lead and nickel have been measured in a small number of Topsoil/natural soil samples within Zones 3 and 4. As these areas of the site have remained 'greenfield' over the years, and not been subject to past industrial activities which could have handled such contaminants, then we are of the opinion that contamination is likely to be naturally occurring. Typically, however, a significant proportion of compounds forming naturally occurring contaminants are not toxic to humans.

8.8.3.2 The existing guideline value for beryllium is based on research into the impact of **industrial** exposure, where the inhalation exposure route poses the most significant risk to end users. Indeed, the overwhelming majority of the existing literature strongly indicates that intake of beryllium orally through dermal contact has no ill health effects on humans and there is no evidence to suggest that naturally occurring beryllium poses a risk to end users.

- 8.8.3.3 As Zones 3 and 4 where Topsoil is present have not been subject to past industrial activities which are likely to have handled beryllium, concentrations recorded on site are likely to be naturally occurring. The average concentration of natural beryllium in the earth's crust is approximately 2 to 5mg/kg which notably exceeds the residential guideline value of 1.7mg/kg, derived by research into industrial exposure. On site, the concentrations of beryllium within soils were recorded between 1.8mg/kg to 2.5mg/kg, which reflect natural, background concentrations. On this basis, the recorded concentrations of beryllium are not considered to present a risk to end users of the site.
- 8.8.3.4 Similarly, concentrations of lead were measured between 250mg/kg and 320mg/kg, exceeding the C4SL (u) of 210mg/kg. It is noted that lead concentrations in the Derbyshire and Peak District area are frequently elevated above the national average. This is due to the presence of lead mineral veins in the underlying limestones, which were also mined/quarried and smelted historically. With reference to Envirocheck data presented in Appendix M, soil geochemistry mapping indicates background concentrations of lead of up to 200mg/kg at the site, however, it is noted that concentrations across the Peak District are typically higher. On this basis, the recorded concentrations of lead in Topsoil/natural soils across Zones 3 and partly Zone 4 are not considered to present a risk to end users of the site.
- 8.8.3.5 Similarly, the very localised elevated arsenic and nickel is likely to be associated with localised ferruginous inclusions which can be present within the limestone. This is similar to the issues experienced in Northamptonshire with arsenic, vanadium and nickel contamination, associated with the naturally deposited Northampton Sand Formation. Again, on this basis, the recorded concentrations of arsenic and nickel (the latter very marginally exceeding the S4UL) are not considered to present a risk to end users of the site.
- 8.8.3.6 Based on the assessment provided in paragraphs 8.8.3.1 to 8.8.3.5 above, we consider that Topsoil/naturally deposited soils at the site are unlikely to cause significant harm to human health and can be reused within the proposed development where necessary.
- 8.8.3.7 With reference to paragraph 8.7.6.3.3 above, a significant number of concentrations of contaminants exceed relevant guidelines for end users within Made Ground deposits across the site, largely encountered in Zone 2, and to a lesser extent in Zone 4. Notably, arsenic, beryllium and lead and a number of PAHs have been identified. Rather than naturally occurring, based on the composition of Made Ground across the areas where elevated contaminants have been measured, and based on the considerably high concentrations recorded, it is most likely to be attributed to the presence of anthropogenic material such as slag, ash and localised landfill type materials.

8.8.3.8 Based on the above, where Made Ground is present in Zones 2 and 4 such soils are likely to cause harm to the health of end users in their current condition. Proposed buildings and hardstanding will sever the pathway to such soils, however, where landscaping/gardens/POS is proposed, remedial measures will need to be implemented to render such areas fit for purpose. Typically, this could take the form of a cover system of clean Topsoil/subsoil placed in such areas. The recommended remedial measures are summarised in Section 8.9 below.

8.8.3.9 Furthermore, we have identified asbestos in 3 of 14 samples of Made Ground soils tested. Such asbestos has been identified in Made Ground soils in Zones 2 and partly Zone 4 across the site.

8.8.3.10 If Made Ground soils are not disturbed, there is likely to be a low risk of identified ACMs or free fibres causing harm to human health, including the health of current users. If such areas are developed, which they are likely to be, there remains a risk that end users are likely to come into contact with such soils and potentially disperse fibres into the air. Whilst we have not encountered asbestos in other laboratory samples tested, we cannot say for certain that ACM would not be encountered elsewhere onsite. The proposed cover system as recommended in paragraph 8.8.3.8 will serve to sever the pathway to such ACMs and reduce potential exposure.

8.8.4 Construction operatives

8.8.4.1 Analysis indicates that concentrations of contaminants measured in all Topsoil and naturally deposited soils fall below relevant guidelines for construction operatives.

8.8.4.2 Based on Section 8.7.6.4 above, a single concentration of both lead and dibenzo(a,h) anthracene have been measured above guideline values for construction operatives out of 10 Made Ground samples across the site. Based on such, providing adequate hygiene precautions are adopted at all times, we do not consider there to be a significant possibility of significant harm being caused to the health of construction operatives at the site (see Section 8.10 below). This is with the exception of risks associated with asbestos as discussed below.

8.8.4.3 If Made Ground soils are not disturbed, there is likely to be a low risk of identified ACMs causing harm to the health of construction operatives. If such areas are developed, which they are likely to be, there remains a risk that construction operatives are likely to come into contact with such soils and potentially disperse fibres into the air. Whilst we have not encountered asbestos in other laboratory samples tested, we cannot say for certain that ACM would not be encountered elsewhere onsite.

8.8.4.4 Consequently we recommend that a suitably experienced asbestos specialist is consulted to confirm the precautions that could be taken during groundworks to minimise contact/disturbance and potential release of fibres. It would also be prudent to undertake further testing of Made Ground soils across the site to determine if asbestos is present elsewhere. We would be happy to undertake such testing on further request.

8.8.5 Vegetation

8.8.5.1 Two elevated concentrations of zinc and a single elevated concentration of copper have been measured in Topsoil/natural soils, which marginally exceed the respective guideline values (see Section 8.7.7 above). Such contamination was locally present in Topsoil/natural soils within Zone 3. In our opinion, such contamination is unlikely to present a risk of causing significant harm to vegetation.

8.8.5.2 It is difficult to quantify the phytotoxicity of a contaminant as large variations exist between plant tolerances, soil effects and synergistic/antagonistic reactions between chemicals. Due to the complexities of the effects of soil contamination on different plant species, we recommend that the test results presented in this report are passed to a landscape architect for the selection of suitable planting.

8.8.5.3 With reference to paragraph 8.7.7.3 above, a significant number of concentrations of contaminants exceed relevant guidelines for vegetation within Made Ground deposits encountered in Zones 2 and 4. Notably copper, zinc, lead, dibenzo(a,h)anthracene have been identified. In our opinion, such contamination is likely to present a risk of causing significant harm to vegetation. Consequently, remedial measures will need to be implemented to render such areas fit for purpose. Typically, this could take the form of a cover system of clean Topsoil/subsoil, suitably deepened where major vegetation is likely to be present, which will provide a suitable growing medium. The recommended remedial measures are summarised in Section 8.9 below.

8.8.6 Controlled waters

8.8.6.1 With reference to 8.7.8.1, groundwater at the site local to the channel of Nun Brook exhibits very marginal elevated concentrations of soluble copper ($1.2\mu\text{g/l}$ compared to a guideline of $1.0\mu\text{g/l}$). Based on leachate testing previously undertaken within landfill type Made Ground deposits in Zone 1, such soils exhibit slightly elevated concentrations of leachable copper ($10\mu\text{g/l}$), which could be the source of copper found in groundwater adjacent to the brook.

8.8.6.2 It is also noted that concentrations of soluble contaminants in a sample from the brook taken upstream from site are all below relevant guidelines. However, a sample taken downstream of the site suggests very marginal elevated concentrations of soluble copper ($1.1\mu\text{g/l}$). The copper identified in the brook could be sourced from the marginally impacted groundwater onsite, which is likely to be providing a base flow to the brook.

8.8.6.3 Based on the above, given the marginal exceedances of soluble copper identified in groundwater and surface waters, and also based on the conservatism factored into the EQS value for copper (we have not adjusted the guideline based on hardness at the site), then we consider the risk of leachable copper previously identified within landfill material to Zone 1 adversely impacting the quality of groundwater and surface waters is low.

8.8.6.4 Having now completed analysis of laboratory testing, we can now update our conceptual model which is presented in Appendix J.

8.8.6.5 Based on the conceptual model there are risks which exceed the low category which in our opinion are unacceptable and require remedial action which is discussed below.

8.9 Remedial action

8.9.1 Based on the above we recommend the following action is taken: -

a) Provision of a capping in garden and soft landscaping areas where Made Ground is present in Zones 2 and 4, deepened in areas of major vegetation as required. Details of this remediation (in the form of a statement / specification) is provided in Section 13.

b) Adoption of adequate hygiene precautions for construction operatives.

8.9.2 In addition to the above, we recommend that a suitably experienced asbestos specialist is consulted to confirm the precautions that could be taken during groundworks to minimise contact/disturbance and potential release of asbestos fibres identified in Made Ground deposits across the site. It would also be prudent to undertake further testing of Made Ground soils across the site to determine if asbestos is present elsewhere. We would be happy to undertake such testing on further request.

8.10 Risk assessment in relation to use of infiltration systems

8.10.1 With reference to Environment Agency publication '*Groundwater protection: Policy and practice (GP3)* 2012, outside of SPZ1, the EA will support sustainable drainage systems for new discharges to ground. This is subject to an appropriate risk assessment to demonstrate that ground conditions are suitable and infiltration systems do not present an unacceptable risk of promoting mobilisation of contaminants or creating new pathways for contaminant migration.

8.10.2 The permeability of the near surface weathered Eyam Limestone, Bowland shale and Bee low Limestone Formation in combination with the site located over Secondary A (Bowland Shale) and principal aquifers (limestone deposits) suggests the site is sensitive to migration of contaminants. The site is not located within or close to a source protection zone. Providing that surface water is restricted from freely migrating through Made Ground deposits, the risk of infiltration systems promoting mobilisation of contaminants at the site is considered low. All discharges to groundwater are subject to compliance with the Water Framework Directive (2000/60/EC) and Groundwater Daughter Directive (2006/118/EC).

8.11 Risk assessment summary and recommendations

8.11.1 Based on our assessments described above, we can provide the following summary and recommendations for each identified receptor.

8.11.2 Current site users

- 8.11.2.1 Providing the site is developed then the risk of harm being caused to current users from identified contamination is clearly a short-term issue and unlikely to require any remediation. If development does not proceed as planned, further consideration should be given to such risks and the requirement for remediation.

8.11.3 End users

- 8.11.3.1 Concentrations of chemical contaminants have been measured above guideline values within Made Ground deposits across the site. In such areas, we are of the opinion that the site represents a medium to high risk of causing harm to future end users of the developed site, based on current development proposals. Providing the remedial measures as outlined in 8.9 above and Section 13 are implemented, the risk of harm being caused to the health of end users is considered to be low.
- 8.11.3.2 We also consider that Topsoil/naturally deposited soils at the site are unlikely to cause significant harm to human health and can be reused within the proposed development where necessary.

8.11.4 Construction operatives and other site investigators

- 8.11.4.1 The risk of damage to health of construction operatives and other site investigators is, in our opinion, medium to high, primarily due to the presence of asbestos in Made Ground soils. Generally, risks would be minimised by taking adequate hygiene precautions on site. Such precautions would be: -
- Wearing protective clothing particularly gloves to minimise ingestion from soil contaminated hands.
 - Avoiding dust by dampening the soils during the works.
 - Wearing masks if processing produces dust.
- 8.11.4.2 Consideration will need to be given to the presence of asbestos in Made Ground soils onsite and the additional precautions that will need to be taken during groundworks to minimise contact/disturbance and potential release of fibres.
- 8.11.4.3 Guidance on safe working practices can be obtained from the following documents
- The Health and Safety Executive Publication *“Protection of Workers and the General Public during the Development of Contaminated Land”* (HMSO) and
 - *“A Guide to Safer Working on Contaminated Sites”* (CIRIA Report 132).
- 8.11.4.4 In addition, reference should be made to the Health and Safety Executive. In all cases work shall be undertaken following the requirements of the Health and Safety at Work Act 1974 and regulations made under the Act including the COSHH regulations.

8.11.5 Controlled waters

- 8.11.5.1 Marginal elevated concentrations of leachable copper have previously been identified in landfill Made Ground soils to Zone 1, with very marginal concentrations of soluble copper identified in groundwater onsite and surface waters downstream of site. Given the marginal exceedances of soluble copper, and based on the conservatism factored into the EQS value for copper, we consider the risk of leachable copper previously identified adversely impacting the quality of groundwater and surface waters is low.

8.11.6 Vegetation

- 8.11.6.1 In our opinion, marginal contamination identified in Topsoil/natural soils across the site is unlikely to present a risk of causing significant harm to vegetation.
- 8.11.6.2 Concentrations of contaminants exceed relevant guidelines within Made Ground deposits across the site. In our opinion, such contamination is likely to present a risk of causing significant harm to vegetation. Providing the remedial measures as outlined in 8.9 above and Section 13 are implemented, the risk of harm being caused to the health of vegetation is considered to be low.

8.12 Final conceptual model

- 8.12.1 On the assumption that remedial action described above has been successfully completed, we have produced a final conceptual model which is presented in Appendix J, which shows the risks for human health have been reduced to acceptable levels and the site therefore fit for purpose.

8.13 Statement with respect to National Planning Policy Framework

- 8.13.1 Based on investigations completed to date with respect to chemical contamination, we are of the opinion the proposed development will be safe and suitable for use for the purpose for which it is intended (without the need for any remedial action) thus meeting the requirements of the National Planning Policy Framework section 178, and compliant with the Building Regulations Part C, '*Site preparation and resistance to contaminants and moisture*'.

8.14 On Site Monitoring

- 8.14.1 We have attempted to identify the potential for chemical contamination on the site, however, areas, which have not been investigated at this stage, may exhibit higher levels of contamination. If such areas are exposed at any time during construction we will be pleased to re-attend site to assess what action is required to allow the development of safely proceed.

9 Gaseous contamination

9.1	Legislative framework
9.2	General
9.3	Assessment of source of gases
9.4	Gas migration
9.5	Conceptual model
9.6	Development categorisation
9.7	Monitoring observations
9.8	Classification of site characteristic gas situation
9.9	Gas protective measures – new buildings
9.10	Flammability
9.11	Gas protective measures – construction operatives
9.12	Statement with respect to National Planning Policy Framework

9.1 Legislative framework

- 9.1.1 There is currently a complex mix of documentation relating to legislative and regulatory procedures on the issue of contamination and it is not considered a purpose of this report to discuss the detail of these regulations. Essentially, Government Policy is based on *'suitable for use approach'*, which is relevant to both the current and proposed future use of land. For current use Part IIA of the Environmental Protection Act 1990 provides the regulatory regime (see Section 8.1 above). The presence of harmful soil gases could provide a 'source' in a 'pollutant linkage' allowing the regulator (Local Authority) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented with the Environment Agency responsible for enforcement.
- 9.1.2 The Town and Country Planning (General Development Procedure) Order 1995, requires the planning authority to consult with the Environment Agency before granting planning permission for development on land within 250 metres of land which is being used for deposit of waste, (or has been at any time in the last 30 years) or has been notified to the planning authority for the purposes of that provision.
- 9.1.3 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, *'Site preparation and resistance to contaminants and moisture'* which seeks to protect the health, safety and welfare of people in and around buildings and includes requirements for protection against harm from soil gas.

9.2 General

9.2.1 The following assessment relates to the potential for, and the effects of, gases generated by biodegradable matter. A separate, but related class of problem involves migration of vapour phase of hydrocarbons, but this is addressed under organic contamination in Section 8. The potential for the development to be affected by radon gas is considered in Section 3 above. The principal ground gases are carbon dioxide (CO₂) and methane (CH₄). The following table provides a summary of the effects of these gases when mixed with air.

Significant gas concentrations in air		
Gas	Concentration by volume	Consequence
Methane	0.25%	Ventilation required in confined spaces
	5 - 15%	Potentially explosive when mixed with air
	30%	Asphyxiation
	75%	Death after 10 minutes
Carbon Dioxide	0.5%	8 hour long term exposure limit (LTEL) (HSE workplace limit)
	1.5%	15 min short term exposure limit (STEL) (HSE workplace limit)
	>3%	Breathing difficulties
	6 – 11%	Visual distortion, headaches, loss of consciousness, possible death
	>22%	Death likely to occur

Table 9.2.1

9.2.2 Following the current Building Regulations Approved Document C1, Section 2 'Resistance to Contaminants' (2004 incorporating 2010 and 2013 amendments) a risk assessment approach is required in relation to gaseous contamination based on the source-pathway-receptor conceptual model procedure. We have adopted procedures described in the following reference documents for investigation and assessments of risk of the development being affected by landfill type gases (permanent gases) and if appropriate the identification of mitigation measures.

- BS10175:2011 'Investigation of potentially contaminated sites- Code of Practice'
- BS8576:2013 'Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs)'
- BS8485:2015 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'
- CIRIA Report C665 'Assessing risks posed by hazardous ground gases to buildings' (2007)
- NHBC report No 10627-R01(04) 'Guidance on development proposals on sites where methane and carbon dioxide are present' (January 2007)
- CL:AIRE Research Bulletin RB17 'A pragmatic approach to ground gas risk assessment' (November 2012)

Whilst we have followed the guidance and recommendations of BS8576, we have used BS8485:2015 to derive recommendations for protective works where considered necessary supplemented by NHBC report No 10627-R01(04).

9.2.3 An assessment of the risk of the site being affected by ground gases is based on the following aspects:

- a) Source of the gas
- b) Investigation information
- c) Migration feasibility
- d) Sensitivity of the development and its location relative to the source

9.3 Assessment of source of gases

9.3.1 General sources

9.3.1.1 The following table summarises the common sources of ground gases and parameters affecting the generation of ground gases:

Source and control of gases	
Type	Parameters affecting the rate of gassing
Landfills	Portion of biodegradable material, rate reduces with time
Mineworkings	Flooding reduces rate of gassing
Dock silt	Portion of organic matter
Carbonate deposits	Ground / rainwater (acidic) reacts with some carbonates to produce carbon dioxide.
Made Ground	Thickness of Made Ground and proportion of degradable organic matter
Naturally deposited soils/rocks	Portion of organic matter

Table 9.3.1

The rate of decomposition in gas production is also related to atmospheric conditions, pH, temperature, and water content / infiltration.

9.3.1.2 As the site is not within a dockland environment or an area affected by mineworkings. However the site may be affected by underlying limestone deposits, landfilling activities and near surface Made Ground soils.

9.3.2 Landfill and infilled ground sources

9.3.2.1 Waste Management Paper 27 (1991) produced by the Department of the Environment 'Control of Landfill Gases' contains the recommendation to avoid building within 50m of a landfill site actively producing large quantities of landfill type gases and to carry out site investigations within a zone 250m beyond the boundary of a landfill site. No distinction is made between sites of differing ground conditions, but the paper does not advocate the site is safe beyond the 250m zone, dependant, of course, upon the type of landfill and potential for migration of landfill gases.

9.3.2.2 Envirocheck reports one landfill site adjacent to the northwest, known as Hogshaw refuse tip (known as Zone 1). Records indicate the site was licenced for receipt of domestic, inert, industrial and commercial wastes, and licence has now lapsed. Furthermore, the Local Authority planning portal of High Peak Borough Council, records a refuse tip in the area of the existing recreation ground to the southwest of the site (Zone 2). The extent of the tip and the type of wastes deposited are not recorded.

9.3.2.3 In addition, we have reviewed old Ordnance Survey maps and there is obvious evidence of quarrying in the area, the closest of which is 200m northwest. Such sites may have been restored with materials which could generate landfill gases.

9.3.2.4 In addition 12 BGS mineral sites are recorded within 1000m from site. The closest is located 219m to the northwest, which extracted common clay and shale. All mineral site were opencast type, used to extract clay, shale or limestone. We anticipate that these are related to the quarries recorded on the historical mapping. All extraction activities have ceased.

9.3.2.5 A number of infilled land and water bodies are also recorded on site and within 1000m of the site. A feature is recorded onsite, associated with the backfilling of Russia Mere, recorded on historical mapping between 1879 and 1967.

9.3.2.6 Based on the above, records suggest there are potential sources of ground gasses in the area worthy of further consideration.

9.3.3 Soil conditions

9.3.3.1 Laboratory testing indicates that the Made Ground soils beneath the site contain between 3.1% and 40% of organic matter. The majority of these values are from Topsoil which we do not consider to represent of significant gas generation source. However, 9 No. locations where these results are higher than 5% are from deeper Made Ground deposits, which contain between 8.6% to 40% of organic matter. Our observations during the intrusive investigation, (of Made Ground materials) indicated the presence of decomposing timber, textile, paper and fibrous material. Such deposits have the potential to produce elevated quantities of carbon dioxide and / or methane gas.

9.3.3.2 The site is underlain by soils and rocks which have a naturally high carbonate content. Following BS8576 figure 6, such soils are determined to represent a very low potential for generation of a source of carbon dioxide.

9.3.4 Source assessment summary

9.3.4.1 The following table summarises the possibility of a source of landfill type gases.

Source assessment summary		
Potential source origin	Viability of source	Evidence
Landfills	Likely	Desk study information Landfill adjacent to northwest part of site (Zone 1), and LA recorded tip in south-western part (Zone 2). Potentially backfilled quarries located within 500 of the site, in addition to infilled pond to east of site (Zone 4)
Mineworkings	Unlikely	Desk Study information Geological conditions not amenable
Dock silt	Unlikely	Site remote from dockland environment
Carbonate deposits	Unlikely	Bedrock consists of limestone, however the generation potential of this source is very low
Made Ground	Likely	Made Ground >3m thickness with TOC >5%
Naturally deposited soils/rocks	Unlikely	Soils exposed in exploratory excavations do not exhibit high concentrations of organic matter
Table 9.3.4		

9.3.4.2 Based on the above it there is a possibility of a source of potential landfill gases which may affect the subject site. On this basis, it is considered necessary to consider possible pathways for migration of ground gases from this potential source to the site.

9.4 Gas migration

9.4.1 Exploratory excavations encountered predominantly coarse-grained Made Ground to depths typically between 2m to 5m within Zone 2. Made Ground was also encountered locally to depths of 1.3m to >5m in Zone 4. In our opinion, these deposits are relatively permeable and would provide little resistance to both lateral and vertical migration of landfill type gases, which would migrate directly into buildings present in such areas.

9.4.2 In addition, natural granular strata in the form of weathered bedrock (sands and gravels) and limestone is present across the site, and near surface in the area of Zones 3 and 4. It is therefore considered possible that the landfill type gases identified offsite and could feasibly migrate to the ground surface of the site, as well as migrating from areas of Made Ground, including in Zone 1 to adjacent areas of the site where such deposits are not present. Notwithstanding the above, we anticipate that the presence of localised near surface cohesive deposits could minimise vertical and lateral migration of landfill gasses within the subsurface, particularly between Zones 1 towards Zones 2/3. However, we have considered a worst-case scenario at this stage.

9.5 Conceptual model

- 9.5.1 Based on the above, there is a potential source of landfill type gases, and a feasible migration pathway to the site via potentially permeable Made Ground and near surface natural strata. Our conceptual model is tabled below. On this evidence we are of the opinion that the site is at risk of being affected by ground gases (carbon dioxide / methane) sufficient to potentially cause harm to human end users of the site, construction operatives or indeed buildings. On this basis, we have installed monitoring standpipes in boreholes, and implemented a monitoring regime, generally following procedures described in BS8576:2013 to quantify the risk and, if appropriate, identify mitigation measures.

Conceptual model		
Potential source origin	Potential pathway	Receptors at risk
Landfills	Via near surface	End users
Restored mere and number of opencast quarries – source of backfill not known.	permeable soils and directly via Made Ground	Construction operatives
Made Ground onsite		Buildings
Table 9.5.1		

9.6 Development categorisation

- 9.6.1 With reference to BS8485:2015 (table 3), the proposed building type would be classified as 'Type A - Private'.

9.7 Monitoring observations

- 9.7.1 Five standpipes have been installed at the site in accordance with BS8576:2013, Section 9 (refer Drawing 08). Following BS8576:2013 (Figure 6) and CIRIA Report C665 (Tables 5.5a and 5.5b) we have provisionally assessed the site as moderate to high generation potential of source ideally requiring fortnightly readings taken over a 2 to 12 month period. We can confirm we have completed 6 No. monitoring visits over a two month period.

- 9.7.2 We have returned to site for all of the six proposed monitoring visits to obtain measurements of landfill type gases at atmospheric conditions in the range of 955mb to 996mb and temperatures in the range of 4°C to 12°C. Essentially, within Zones 2 to 4, we detected concentrations of methane in the range of 0.0% to 0.2% and concentrations of carbon dioxide measured in the range of 0.2% to 7.9%. If flows were detected during our monitoring visits then these are recorded, but where no flow is detected then we have assumed flow at the detection limit of the monitoring equipment at 0.1l/s.

- 9.7.3 Within Zone 1 we detected concentrations of methane in the range of 9.6% to 24.8% and concentrations of carbon dioxide measured in the range of 14.1% to 19.9%

- 9.7.3 Gas monitoring results are summarised in Appendix K. It should be noted that gas measurements from location DTS06 could not be undertaken on the initial visit of the 18th February 2019 due to technical issues with the analyser at the time.

9.8 Classification of site characteristic gas situation

- 9.8.1 As outlined in previous sections, we have refined the following assessments based on development not being undertaken within Zone 1. Whilst we have not discussed any requirements for gas protection within Zone 1, we have discussed the presence gases in this area affecting other areas of the site.
- 9.8.2 Significant concentrations of landfill gases have been measured at location DTS04, situated in the main landfill site in Zone 1. Concentrations of carbon dioxide range from 18.6% to 19.9%, with methane ranging from 9.6% to 24.8%. Elsewhere onsite, concentrations of carbon dioxide range from 0.2% to 7.9%, with methane ranging from 0.0% to 0.2%.
- 9.8.2 Within Zone 2, in areas where Made Ground deposits exceed depths of >2m, and such deposits consist of landfill type materials (associated with the Local Authority recorded refuse tip), concentrations of methane rarely exceed 0.2%, however, concentrations of carbon dioxide have been measured between 1.8% and 7.9% (DTS24). Based on flow rates and gas screening values, the area would be classified as characteristic gas situation CS1 and traffic light colour 'Green'. However, concentrations of carbon dioxide have been measured at and above the maximum typical value of 5% for a green classification on 4 of the 6 monitoring occasions within DTS24, measured between 5.0% and 7.9%. It is acknowledged that borehole DTS19, also located in Zone 2, suggests a Green traffic light classification based on both gas screening values and actual measured concentrations. However, the response zone in this area is formed within natural soils and not the Made Ground observed across the zone. Based on the above, we recommend that the entire area of Zone 2 is classified as characteristic gas situation CS2 and traffic light colour 'Amber 1'.
- 9.8.3 In all other areas of the site, using test data obtained to date, Zones 3 and 4 would be classified as characteristic gas situation CS1 and traffic light colour 'Green'. Concentrations of carbon dioxide have exceeded the maximum typical value of 5% for a Green classification on one occasion to date, measured at 5.2% in borehole DTS13. Given the marginal exceedance, at this stage we do not consider it reasonable to increase the classification to CS2/Amber 1 for such areas of the site. This is likely to be associated with Made Ground deposits recorded locally in Zone 4.
- 9.8.4 Given the nature of the Made Ground encountered within Zones 2 and 4, and access issues experienced to date, we would recommend that further, more intensive ground gas monitoring is undertaken to fully classify these areas, particularly in the southern part of Zone 2 and along the boundary between Zone 1 (landfill) and Zones 2 and 3 to assess the potential for localised migration between such areas.

9.9 Gas protective measures – new buildings

- 9.9.1 Based on monitoring observations to date, development categorisation (Section 9.6 above) and the site characteristic gas situation (Section 9.8 above) and with reference to Table 4 of BS8485:2015, the area of Zones 3 and 4 are unlikely to require any gas protective measures. However, as outlined in paragraph 9.8.4 above, we recommend that this is verified by completion of further, more intensive ground gas monitoring to fully classify these areas.
- 9.9.2 In the area of Zone 2, the development will require gas protective measures which would achieve a '*gas protection score*' of 3.5. Lists of protective measures which each produce a score value are produced in Tables 5, 6 and 7 of BS8485:2015.
- 9.9.3 Furthermore, with such areas of the site being classified as 'Amber 1', then following NHBC report No 10627-R01(04) table 14.2, the following 'low level' gas protection measures are required as minimum in Zone 2: -
- a) Installation of a suitable gas resistant membrane
 - b) Ventilated subfloor to facilitate a minimum of one complete volume change per 24 hours.
 - c) Gas protective measures shall be as presented in Building Research Establishment Report 414
- 9.9.4 It is important that the necessary gas protection measures are adopted to comply with the requirements of Local Authority Building Control and Environmental Protection; considering both the British Standard and NHBC guidance, whichever applies in precedence.
- 9.9.5 Again, we recommend that this is verified by completion of further, more intensive ground gas monitoring to fully classify this area of the site, particularly in the southern part of Zone 2 and along the boundary between Zone 1 (landfill) and Zones 2 and 3 to assess the potential for localised migration between such areas.

9.10 Flammability

- 9.10.1 Methane is a flammable gas. When the concentrations of methane in air (oxygen 20.9% by volume) are between the limits of 5% and 15% by volume, then an explosive mixture is formed. The lower explosive limit (LEL) of methane is 5% which is equivalent to 100% LEL. The 15% limit is known as the upper explosive limit (UEL), but concentrations above this level cannot be assumed to represent safe concentrations. The flammability of gas mixtures is affected by their composition, presence of an ignition source, temperature, pressure and nature of the surroundings. The explosive hazard of a flammable mixture arises from the speed of propagation of the flame in a confined space and the ability of the container to absorb the associated shock wave. The flammability range can vary depending upon differing circumstances, for example:

- When carbon dioxide concentrations of greater than 25% are present, methane is rendered non-flammable, and
- If the oxygen concentration is reduced, the limits of flammability are reduced. For example at 13.45% oxygen the LEL and UEL for methane are altered to 6.5% and 7% respectively, whilst at 13.25% oxygen the mixture is incapable of propagating a flame (refer CIRIA report 130)

9.10.2 From measurements taken to date, whilst air, methane and carbon dioxide mixtures are not potentially explosive (typically due to the lack of oxygen in the ground), there is always the possibility that explosive mixtures may occur following gas migration into enclosed spaces. For example, if methane is migrating locally between Zone 1 and Zones 2 and 3. For an explosion to occur, an enclosed space together with an ignition source is required. Clearly a sub-floor void could produce a confined space, and thus in order to minimise risks, the use of a positively pressurised clean air blanket to alter the gas mix, may produce the required solution. Such issues will require consideration following completion of the mitigation measures as described in Section 9.9 above.

9.11 Gas protective measures - construction operatives

9.11.1 Areas near landfill sites, or in carbonate rich deposits (such as limestone present beneath Zones 3 and 4) have the potential to generate both harmfully low oxygen levels and high carbon dioxide levels in confined spaces. The assessment for such situations may therefore require using gas monitors to warn of significant leaks of gas into confined spaces to minimise the risks associated with an oxygen-deficient atmosphere which could lead to asphyxiation, and/or a toxic atmosphere due to high levels of carbon dioxide.

9.11.2 During construction, we recommend any excavations/confined spaces are well ventilated and human entry is avoided. The Workplace Exposure Limits (WELs) for carbon dioxide are 5000 parts per million (ppm by volume), which is equivalent to 0.5%, for the 8-hour time-weighted average (TWA); and 15000 ppm (1.5%) for the 15-minute short-term exposure limit (STEL). Typically, oxygen deficiency alarms on gas detectors are set at 19% volume ratio (v/v). Normal air contains 20.9% oxygen. Therefore should human entry be necessary then we recommend excavations/confined spaces are monitored over short- and long-term exposure periods for both oxygen and carbon dioxide gases prior to entry to ensure levels are within acceptable concentrations or suitable breathing equipment adopted.

9.11.3 We recommend further reference is made to the following documents to minimise the risks to construction workers from ground gases:

- Health and Safety Executive Publication *“Protection of Workers and the General Public during the Development of Contaminated Land”* (HMSO)
- *“A Guide to Safer Working on Contaminated Sites”* (CIRIA Report 132)
- Health and Safety Executive Publication EH40/2005 *“Workplace Exposure Limits”*

9.12 Statement with respect to National Planning Policy Framework

- 9.12.1 Providing the recommendations described above are satisfactorily completed, we are of the opinion the proposed development will be safe and suitable for use for the purpose for which it is intended, thus meeting the requirements of the National Planning Policy Framework section 178, and compliant with the Building Regulations Part C, *'Site preparation and resistance to contaminants and moisture'*.

10 Effects of ground conditions on building materials

10.1	General
10.2	Concrete – sulphate attack
10.3	Concrete – chloride attack
10.4	Concrete – acid attack
10.5	Concrete – magnesium attack
10.6	Concrete – ammonium attack
10.7	Plastic pipes

10.1 General

10.1.1 Building materials are often subjected to aggressive environments which cause them to undergo chemical or physical changes. These changes may result in loss of strength or other properties that may put at risk their structure integrity or ability to perform to design requirements. Aggressive conditions include:-

-) Severe climates
-) Coastal conditions
-) Polluted atmospheres
-) Aggressive ground conditions

10.1.2 This report section only considers aggressive ground conditions in relation to buried concrete and water pipes. Ground conditions may affect other materials but have not been considered here.

10.2 Concrete - Sulphate attack

10.2.1 Hazard

10.2.1.1 Sulphate attack on concrete is characterised by expansion, leading to loss of strength, cracking, spalling and eventual disintegration. There are three principal forms of sulphate attack, as follows:-

-) Formation of gypsum through reaction of calcium hydroxide and sulphate ions.
-) Ettringite formation through reaction of tricalcium alluminate and sulphite ions.
-) Thaumasite formation as a result of reactions between calcium silicate hydrates, carbonate ions (from aggregates) and sulphate ions.

10.2.2 Assessment

10.2.2.1 The hazard of sulphide attack is addressed by reference to procedures described in Building Research Establishment (BRE) Special Digest 1: 2005 '*Concrete in Aggressive Ground*' to establish a design sulphate class (DS) and the '*aggressive Chemical Environment for Concrete*' (ACEC). These procedures have been followed during our investigation and are described in the following paragraphs.

10.2.3 Desk Study Information

10.2.3.1 The first step in the procedure is to consider specific elements of the desk study. These are tabulated below.

Summary of desk study information			
Element	Interrogation	Outcome	SD1: 2005 reference
Geology	Likelihood of soils containing pyrites	Unlikely	Box C6
Past industrial uses	Brownfield site	Yes	C2.1.2

Table 10.2.3

10.2.3.2 A brownfield site is defined in SD1: 2005 as a site, or part of a site which has been subject to industrial development, storage of chemicals (including for agricultural use) or deposition of waste, and which may contain aggressive chemicals in residual surface materials, or in ground penetrated by leachates. Where the history of the site is not known, it should be treated as brownfield until there is evidence to classify it as natural.

10.2.3.3 Based on the above it is necessary to follow the procedures described in figure C6 (*'locations on brownfield sites except where soils may contain pyrite'*) for Zones 2 and 4. For Zone 3, it is necessary to follow the procedures described in figure C4 (*'natural ground sites except where soils may contain pyrite'*).

10.2.4 Laboratory testing

10.2.4.1 The following table summarises ground conditions and laboratory testing.

Item	Soil type	Outcome
Soil		
Number of samples	Made Ground in (Zone 2)	4
	Weathered Bowland Shale Formation (Zone 2)	2
	Weathered Eyam Limestone Formation (Zones 3 and 4)	3
Characteristic w/s sulphate	Made Ground in (Zone 2)	58
	Weathered Bowland Shale Formation (Zones 2)	270
	Weathered Eyam Limestone Formation (Zones 3 and 4)	19
Characteristic pH	Made Ground in (Zone 2)	6.7
	Weathered Bowland Shale Formation (Zones 2)	7.9
	Weathered Eyam Limestone Formation (Zones 3 and 4)	6.3
Characteristic pH	Made Ground in (Zone 2)	0.27
	Weathered Bowland Shale Formation (Zones 2)	0.22
	Weathered Eyam Limestone Formation (Zones 3 and 4)	0.18
Characteristic sulphur (%)	Made Ground in (Zone 2)	0.33
	Weathered Bowland Shale Formation (Zones 2)	0.13
	Weathered Eyam Limestone Formation	0.14

	(Zones 3 and 4)	
TPS (%SO ⁴)	Made Ground in (Zone 2)	0.99
	Weathered Bowland Shale Formation (Zones 2)	0.39
	Weathered Eyam Limestone Formation (Zones 3 and 4)	0.42
OS (%SO ⁴)	Made Ground in (Zone 2)	0.88 Pyrite is probably present.
	Weathered Bowland Shale Formation (Zones 2)	0.308 Pyrite is unlikely to be present.
	Weathered Eyam Limestone Formation (Zones 3 and 4)	0.395 Pyrite is unlikely to be present.
Groundwater and leachate		
Number of samples	Made Ground in (Zone 2)	1
	Weathered Bowland Shale Formation (Zone 2)	1
	Weathered Eyam Limestone Formation (Zones 3 and 4)	1
Characteristic sulphate	Made Ground in (Zone 2)	11mg/l
	Weathered Bowland Shale Formation (Zone 2)	63mg/l
Mobility	All locations	Mobile
Surface water		
Number of samples	Nun Brook	2
Characteristic sulphate	Nun Brook – upstream 1	26 mg/l
	Nun Brook – downstream 1	33 mg/l
Table 10.2.4		

10.2.5 Disturbed ground

10.2.5.1 Results indicate that pyrite is likely to be present in Made Ground across the site. Forming foundations by, for instance, cutting a trench through naturally deposited soils or driving pre-cast concrete piles through naturally deposited soils does not, generally, create disturbed ground as defined in BRE SD 1:2005. However, any arisings resulting from replacement piling or spread footing excavations used for bulk filling on site would be classified as disturbed ground.

10.2.6 Assessment of design sulphate class (DC) and aggressive chemical environment for concrete (ACEC)

10.2.6.1 Based on the design sulphate class, characteristic value of pH and assessment of groundwater mobility, and with reference to tables C1 and C2 of SDI: 2005, the ACEC class for each soil type is presented in Table 10.2.6 below.

Summary of concrete classification				
Soil type	Disturbed ground?	Consider TPS?	DS class	ACEC class
Made Ground in (Zone 2)	Y	Y	DS-3	AC-3
Weathered Bowland Shale Formation (Zone 2)	Y	N	DS-1	AC-1
Weathered Eyam Limestone Formation (Zones 3 & 4)	Y	N	DS-1	AC-1
Groundwater/leachate samples	N/A	N	DS-1	AC-1
Surface water	N/A	N	DS-1	AC-1
Table reference 10.2.6				

10.2.6.2 Where concrete is in contact with more than one soil/groundwater source, the more onerous of design sulphate class and ACEC class should be adopted.

10.3 Concrete - Chloride attack

10.3.1 Hazards

10.3.1.1 There are a number of ways in which chlorides can react with hydrated cement compounds in concrete. These are as follows: -

-) Chlorides react with calcium hydroxide in the cement binder to form soluble calcium chloride. This reaction increases the permeability of the concrete reducing its durability.
-) Calcium and magnesium chlorides can react with calcium aluminate hydrates to form chloroaluminates which result in low to medium expansion of the concrete.
-) If concrete is subject to wetting and drying cycles caused by groundwater fluctuations, salt crystallisation can form in concrete pores. If pressure produced by crystal growth is greater than the tensile strength of the concrete, the concrete will crack and eventually disintegrate.

10.3.2 Risk assessment

10.3.2.1 Chlorides of sodium, potassium, and calcium are generally regarded as being non-aggressive towards mass concrete; indeed, brine containers used in salt mines have been known to be serviceable after 20 years service. Depending upon the type of concrete, and the cement used up to 0.4% chloride is allowed in BS8110: Part 1.

10.3.2.2 In view of the past use of the site we consider the likelihood of elevated concentrations of chlorides in the ground is not likely to occur and on this basis have not specifically measured concentrations of chlorides and, in our opinion, the risk of buried concrete being affected by chlorides is considered low.

10.4 Concrete - Acid attack

10.4.1 Hazards

10.4.1.1 Concrete being an alkaline material is vulnerable to attack by acids. Prolonged exposure of concrete structures to acidic solutions can result in complete disintegration.

10.4.2 Risk assessment

10.4.2.1 The rate of acid attack on concrete depends upon the following:-

-) The type of acid
-) The acid concentration (pH)
-) The composition of the concrete (cement/aggregate)
-) The soil permeability
-) Groundwater movement

British Standard BS8110: Part 1 classifies extreme environment as one where concrete is exposed to flowing groundwater that has a pH<4.5. The standard also warns that Portland Cement is not suitable for acidic conditions with a pH of 5.5 or lower.

10.4.2.2 The pH of the soil/groundwater was measured exceeding 5.5 and on this basis the risk of concrete being affected by acidic conditions is considered low.

10.5 Concrete - Magnesium attack

10.5.1 Hazards

10.5.1.1 Magnesium salts (excepting magnesium hydrogen carbonate) are destructive to concrete. Corrosion of concrete occurs from cation exchange reactions where calcium in the cement paste hydrates and is replaced with magnesium. The cement loses binding power and eventually the concrete disintegrates.

10.5.2 Risk assessment

10.5.2.1 In practice 'high' concentrations of magnesium will be found in the UK only in ground having industrial residues. Following BRE Special Digest 1:2005, measurement of the concentration of magnesium is recommended if sulphate concentrations in water extract or groundwater exceed 3000mg/l. Once measured the concentration of magnesium is considered further in BRE Special Digest in establishing the concrete mix to resist chemical attack.

10.5.2.2 We are not aware the site has been subject to any manufacturing processes which would have included magnesium containing compounds, and in addition sulphate concentrations did not exceed 3000mg/l, on this basis we have not measured the concentration of magnesium in soils at the site and would consider the risk of soils at the site promoting attack on concrete is considered low.

- 10.5.2.3 BS EN 206-1:2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water, with varying concentrations of magnesium for the design/specification for concrete mixes. Based on groundwater measurements made at the site to date, there is a low risk of concrete for traditional foundations being in contact with groundwater during its life, thus we have not measured the concentration of magnesium in groundwater samples. If piled foundations are utilised onsite it is likely they will come into contact with groundwater, therefore, we recommend that the concentration of magnesium is measured in such areas of the site.

10.6 Concrete - Ammonium attack

10.6.1 Hazards

- 10.6.1.1 Ammonium salts, like magnesium salts act as weak acids and attack hardened concrete paste resulting in softening and gradual decrease in strength of the concrete.

10.6.2 Risk assessment

- 10.6.2.1 UK guidance is not available on the concentration of ammonium which may affect concrete. BS EN 206-1: 2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water with varying concentrations of ammonia for the design/specification for concrete mixes.
- 10.6.2.2 Based on groundwater measurements made at the site to date, there is a low risk of traditional concrete foundations being in contact with groundwater during its life, thus we have not measured the concentration of ammonia in groundwater samples. In addition, the site has no history which provides evidence of the uses of ammonia on site, and in overall conclusion the risk of concrete being affected by ammonia is considered low. However, if piled foundations are utilised onsite it is likely they will come into contact with groundwater, therefore, we recommend that the concentration of ammonia is measured in such areas of the site.

10.7 Plastic Pipes

10.7.1 Hazards

- 10.7.1.1 Plastic pipes are predominantly manufactured from PVC and PE but other materials can be used. In general, they perform well but it is known that chemical attack and permeation of contaminants through the pipes can result from use in contaminated land. A published review on plastic pipes reports the following:-

-) Polyethylene (PE) - good resistance to solvents, acids and alkalis
-) Poly vinyl chloride (PVC) - most common form of pipe. Good general resistance to chemical attack but can be attacked by solvents such as ketones, chlorinated hydrocarbons and aromatic polypropylene (PP) - chemically resistant to acids, alkalis and organic solvents but not recommended for use with storing oxidising acids, chlorinated hydrocarbons and aromatics.

-) Poly vinylidene fluoride (PVDF) - inert to most solvents, acids and alkalis as well as chlorine, bromide and other halogens
-) Polytetrafluoroethylene (PTFE) - one of the most inert thermoplastics available. PTFE has good chemical resistance to solvents, acids and alkalis

A survey carried out by the Water Research Centre (WRc) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

10.7.2 Assessment

10.7.2.1 A survey carried out by the Water Research Centre (WRc) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

10.7.2.2 The UK Water Industry research (UKWIR) have published a document entitled '*Guidance for the selection of Water supply pipes to be used in Brownfield sites*'. The publication defines brownfield sites as

'Land or premises that have been used or developed. They may also be vacant, or derelict. However, they are not necessarily contaminated'

10.7.2.3 The subject site has not previously been developed however, it would appear that it has been used, and on this basis could potentially be considered brownfield in accordance with the UKWIR document. Following the preliminary risk assessment procedures described in the UKWIR document however, (paragraph 2.4.2) there is no evidence to indicate that chemicals have ever been used or stored on site or adjacent to the development. However, in Zones 2 and 4 significant deposits of Made Ground have been identified and based on the concentrations of chemical contaminants measured to date, is considered likely that there will be a requirement to use barrier water supply pipes in such areas. We recommend Severn Trent however is consulted on this to gain their opinion and requirements.

11 Landfill issues

11.1	Disposal of soils off site
11.2	Landfill tax
11.3	Reuse of soils – Materials Management Plans

11.1 Disposal of soils off site

- 11.1.1 Disposal of waste soils must comply with the Landfill Directive and amendments to the '*Landfill (England and Wales) Regulations*'. Essentially, this requires the 'waste producer' to classify soils for off-site disposal to an appropriately licensed landfill facility. Laboratory testing on soils from the site would be required to allow such classification in accordance with current Environment Agency waste acceptance criteria and procedures. We can carry such testing and an assessment of soil classification for disposal on further instructions.

11.2 Landfill tax

- 11.2.1 Disposal of soils to landfill sites is normally subject to landfill tax with rates varying from year to year based on government policy. Current information on rates of landfill tax can be obtained from the HM Revenue and Customs website. (www.hmrc.gov.uk)

11.3 Reuse of Soils - Materials Management Plans

- 11.3.1 Where soils are to be moved and reused onsite, or are to be imported to the site, a Waste Exemption or an Environmental Permit is required.
- 11.3.2 An alternative is the use of a Materials Management Plan (MMP) to determine where soils are and are not considered to be a waste. By following '*The Definition of Waste: Development Industry Code of Practice*' published by CL:AIRE (produced in 2008 and revised in March 2011), soils that are suitable for reuse without the need for remediation (either chemical or geotechnical) and have a certainty of use, are not considered to be waste and therefore do not fall under waste regulations. In addition, following this guidance may present an opportunity to transfer suitable material between sites, without the need for Waste Exemptions or Environmental Permits.
- 11.3.3 MMPs offering numerous benefits, including maximising the use of soils onsite, minimising soils going to landfill and reducing costs and time involved in liaising with waste regulators.
- 11.3.4 We can provide further advice on this and provide fees for producing a Materials Management Plan on further instructions.

12 Further investigations

12.1 Further investigations

12.1

At this stage we consider further investigations to be necessary once development proposals have been finalised. Remedial measures (including verification and validation) related to chemical and gaseous contamination of the site are presented in Section 13. We advise that that further investigation should include as a minimum;

- Once development proposals are confirmed, we recommend that more detailed and plot specific investigations are undertaken to validate our foundation/floor slab assessments. Further details are provided in Section 7.
- Should piled foundations be selected then we recommend a supplementary borehole investigation be carried out in such areas to explore ground conditions at depths beyond possible pile lengths and provide geotechnical parameters for the design of the piles.
- During any further investigations within Zone 2, a detailed assessment should be made of the presence of below ground obstructions associated with the historical railway infrastructure where access has not been gained to date.
- Given the access restrictions and variable nature of ground conditions encountered in Zone 4, we recommend that further plot specific intrusive investigations are undertaken to confirm the composition of soils and determine an appropriate foundation strategy.
- Similarly, we recommend that further intrusive investigations are undertaken in Zone 2 where access could not be gained and verify foundation assessments accordingly.
- Non-intrusive geophysical surveys are undertaken by a specialist across the area of Zones 3 and 4 to determine if there are any anomalies near surface which could indicate the presence of dissolution features.
- Assessment and classification for reuse of site won soils onsite, in addition to offsite disposal to landfill.
- It would also be prudent to undertake further testing of Made Ground soils across the site to determine if asbestos is present elsewhere.
- Further area specific gas monitoring is undertaken within Zone 2 particularly to the southwest where the LA recorded refuse tip is present) and Zone 4 to fully classify such locations where significant Made Ground is present and confirm that an Amber 1/CS2 classification is appropriate.
- Where piled foundations are utilised onsite, the concentrations of magnesium and ammonia should be measured in groundwater.
- Further, more intensive, on site infiltration testing should be carried to determine if such systems are viable.
- Reassessment of CBR values is undertaken following finalisation of cut and fill levels across the site.

- 12.2 We would be happy to provide fee proposals for any of the above identified items on further instruction.
- 12.3 In addition to the above, we would also recommend that a suitably experienced asbestos specialist is consulted to confirm the precautions that could be taken during groundworks to minimise contact/disturbance and potential release of fibres. Furthermore, such a specialist could provide further advices on the disposal of ACMs identified at the site.
- 12.4 We recommend that a Japanese Knotweed remedial specialist is contacted for advice and measures to deal with the significant stands of Japanese Knotweed suspected to be present around the site (in Zone 2) prior to construction and commencement any earthworks activities.