Table 16: Qualitative Risk Assessment of potential pollutant linkages for identified sources of contamination

Source	CoCs	Potential Pathways	Potential Receptors	Assessment	Likelihood of occurrence	Severity of Consequences	Action/Investigation required
Made Ground	Heavy Metals PAH's pH & Sulphate Ground Gas: Carbon Dioxide	Direct Contact Inhalation Ingestion	Human: End-users	▪ Elevated concentrations above laboratory limits of detection of Heavy Metals (Arsenic, Cadmium, Copper, Lead, Mercury, Nickel and Zinc) and PAH's (Phenanthrene, Flouranthene, Pyrene, Benzo(a)Anthracene and Chrysene) may impact site end-users through inhalation, ingestion and/or dermal contact. ▪ Low Concentrations of Ground Gas (Carbon Dioxide) have been noted during the gas monitoring visits. This presents a potential risk to human end-users. ▪ The very shallow rockhead identified during the ground investigation, the distance to the offsite sources and the presence of preferential pathways for the gas to vent should it be generated from the offsite sources would significantly reduce the risk of a complete pollutant linkage from offsite sources being present. ▪ A low Oxygen environment has been noted within the boreholes during the monitoring rounds. Trenches and sub-surface excavations should be treated as low Oxygen hazardous environments for humans. ▪ No elevated Vapours have been noted on the monitoring visits, ▪ The site is within an '*Intermediate*' Radon probability area.	Moderate	High	**Tier 1 Risk Assessment of Contaminants.** **Ground Gas Risk Assessment of elevated levels of gas encountered at the site in accordance with CIRIA 665 BS 8485:2007** **The site is present within a Radon Affected Area. New dwellings/buildings must include 'Stage 1 Radon Protection Measures' in accordance with BRE 376.**
Natural Deposits	Ground Gas Radon						
Offsite sources of Ground gas and Vapour	Ground Gas						
Made Ground	Heavy Metals PAH's pH & Sulphate Ground Gas: Carbon Dioxide Depleted Oxygen	Direct Contact Inhalation Ingestion	Humans: Construction & Maintenance workers	▪ Elevated concentrations above laboratory limits of detection of Heavy Metals (Arsenic, Cadmium, Copper, Lead, Mercury, Nickel and Zinc) and PAH's (Phenanthrene, Flouranthene, Pyrene, Benzo(a)Anthracene and Chrysene) may negatively impact construction and maintenance workers inhalation, ingestion and/or dermal contact. However, the appropriate use of Personal Protective Equipment (PPE) and safe systems of work throughout any works should mitigate these potential risks. ▪ Low Concentrations of Ground Gases (Carbon Dioxide) were noted to be present within the boreholes on site. This presents a potential risk construction and maintenance workers through inhalation. ▪ The very shallow rockhead identified during the ground investigation, the distance to the offsite sources and the presence of preferential pathways for the gas to vent should it be generated from the offsite sources would significantly reduce the risk of a complete pollutant linkage from offsite sources being present. ▪ A low Oxygen environment has been noted within the boreholes during the monitoring rounds. Trenches and sub-surface excavations should be treated as low Oxygen hazardous environments for humans. ▪ Utilities should be placed in suitable service trenches and backfilled with clean material to limit any further contact with contaminated soils during perceived future maintenance of the utilities. ▪ No elevated Vapours have been noted on the monitoring visits, ▪ The site is within an '*Intermediate*' Radon probability area.	Moderate	High	**Safe systems of work employed under Health and Safety at Work act 1974 and CDM 2015 should protect construction and maintenance workers from exposure to risk in the workplace.** **Excavations may be toxic and are low Oxygen environments; therefore adequate precautions may be required prior to entry into excavations.**
Natural Deposits	pH & Sulphate Ground Gas Depleted Oxygen						
Offsite sources of Ground gas and Vapour	Ground Gas						

Made Ground/ Fuel Tanks	Heavy Metals PAH's pH	Leaching and Migration to Local Groundwater	The Water Environment	▪ During the drilling and installation of the boreholes in the area of the Made Ground they were all noted to be dry. ▪ During the monitoring of the boreholes in the area of the Made Ground they were all noted to be dry. ▪ No elevated TPH or PID readings were recorded in the area of the Made ground. ▪ Permeability Testing was undertaken at the site this confirmed that the Superficial Deposits were principally impermeable. ▪ There are no abstractions within the vicinity of the site.	Low	Low	**No further investigation/ assessment with respect to the Water Environment is considered necessary.**
Ground Water	Heavy Metals PAH's pH	Migration to Local Surface water	The Water Environment	▪ There was no source of the Heavy Metals and PAH's on site. It is anticipated the elevations are from the adjacent offsite infilled Dam which may be allowing water to flow into WBH06 installation at base of the borehole 2.7mbgl. ▪ Permeability Testing was undertaken at the site this confirmed that the Superficial Deposits were principally impermeable i.e. Clay. ▪ There are no abstractions within the vicinity of the site.			**No further investigation/ assessment with respect to the Water Environment is considered necessary.**
Made Ground	Heavy Metals (elevated concentrations of Copper, Nickel and Zinc)	Direct contact with ground contamination	Flora	▪ The Made ground is immediately adjacent to two properties and although is identified as on site will not be within the proposed development			**No further investigation/ assessment with respect to Flora**
Made Ground	Heavy Metals PAH's pH & Sulphate	Direct contact with ground contamination	Building Fabric and Services	▪ An assessment of the chemical concentrations of the Made Ground and Natural Deposits should be undertaken at as this may create an active pollutant linkage to the water pipe work at the site. ▪ Elevated levels of Sulphate/pH within the Natural Deposits may create an active pollutant linkage to the buildings (buried concrete) at the site.	Moderate	Moderate	**UK WIR assessment.** **BRE SD 212 Brownfield Concrete Assessment.**
Natural Deposits	pH & Sulphate						
Made Ground Natural Deposits Offsite sources of Ground gas and Vapour	Ground Gas	Pooling underneath Buildings		▪ Ground Gas (Carbon Dioxide) has been detected during monitoring. This presents a risk to Buildings (and human health) as a potential exists for gas generating materials within the soils to pool underneath buildings and within service trenches and/or voids within the site. ▪ The very shallow rockhead identified during the ground investigation, the distance to the offsite sources and the presence of preferential pathways for the gas to vent should it be generated from the offsite sources would significantly reduce the risk of a complete pollutant linkage from offsite sources being present.	Low	Moderate	**Ground Gas Risk Assessment of elevated levels of gases encountered at the site in accordance with CIRIA 665 and BS 8485:2007**

11.0 Quantitative Assessment Criteria

11.1. Human Health

A range of soil assessment criteria has to be used to enable the results of the soil samples to be compared against recognised standards. The updated Environment Agency Soil Guideline Values (SGV's) have been developed taking into account the human health risks associated with certain contaminants for a range of end uses (residential with home-grown produce). In accordance with EA guidance where SGV's are not available for all of the parameters identified as potential contaminants on site other recognised, scientific and authoritative assessment criteria have been used to assess the potential for risk from such contaminants.

The hierarchy is as follows;

- Updated Environment Agency Soil Guideline Values (2009) (uSGV) (Residential)
- LQM (2009) Generic Assessment Criteria for Human Health Risk Assessment Ed.2. (uLQM) (Residential)
- Environment Agency Soil Guideline Values (SGV) (Residential with plant uptake).
- CL:AIRE (Dec 2009) The Soil Generic Assessment Criteria for Human Health Risk Assessment (CLRE) (Residential consumption of home-grown produce)

11.2. UKWIR Water Pipework Assessment

To assess the conditions of the site in relation to the suitability of the material of water pipework to be used on the site an assessment is made. UKWIR Assessment Criteria is used (presented in Tables 19 and 20).

11.3. Buried Concrete

To assess the conditions of the site in relation to the suitability of the building materials (concrete) to be used on the site an assessment is made.
Generic Assessment Criteria used is BRE Special Digest 1 Concrete in Aggressive Ground 2005 (3rd Edition).

11.4. Assessment of Volatile Organic Compounds

UK Occupational Exposure Limits for Volatile Organic Compounds are used as an initial screening figure for the risk assessment of VOC detected during the intrusive investigation.

11.5. Assessment of Ground Gas

CIRIA C665 has been utilised to assess the values for levels of ground gases measured at the site and the levels of depleted Oxygen. For the low-rise housing, NHBC Guidance on this subject has been adopted as follows (noted in Table 17):

Table 17: NHBC Traffic Light System for Ground Gas Assessment for Low Rise Housing

Traffic Light	Methane[1]		Carbon Dioxide[1]	
	Typical Max. Concentration[5] (% v/v)	Gas Screening Value[2,4,6] (Litres per hour)	Typical Max. Concentration[5] (% v/v)	Gas Screening Value[2,3,4,,5]
Green				
Amber 1	1	**0.16**	5	**0.78**
Amber 2	5	**0.63**	10	**1.56**
Red	20	**1.56**	30	**3.13**

1. The worst case gas-regime identified at the site, either Methane or Carbon Dioxide, recorded from monitoring in the worst temporal conditions, will be the decider for which the traffic light and GSV is allocated.

2. Generic GSV's are based on guidance contained within latest revision of Department of the Environment and the Welsh Office (2004) "The Building Regulations: Approved Document 'C' and used a sub-floor void of 150mm thickness.

3. The Small Room is considered to be a downstairs toilet 1.50 x 1.50 x 2.50 m, with a soil pipe passing into the sub-floor void.

4. The GSV, in litres per hour, is as defined in Wilson and Card (1999) as the bore hole flow rate multiplied by the concentration in the air stream of the particular gas being considered.

5. The Typical Maximum Concentrations can be exceeded in certain circumstances should the conceptual site model indicate it is safe to do so. This is where professional judgement will be required, based on a thorough understanding of the gas-regime identified at the site where monitoring in the worst temporal conditions has occurred.

6. The GSV thresholds should not generally be exceeded without completion of a detailed gas risk assessment taking into account site-specific conditions.

12.0 Tier I Quantitative Assessment

The Quantitative Assessment evaluates the maximum concentrations of contaminants from the investigation found to be elevated above that of laboratory limits of detection. If these are found to be elevated above the chosen generic assessment criteria, then, further assessment is undertaken.

The quantitative risk assessment is broken down into the identified receptors of concern (Section 11.0). These are informed by the Conceptual Site Model post qualitative risk assessment (Table 16). The receptors are considered to be:

- Human End Users
- Buildings and Services (buried concrete and water pipework)

The Principles of Environmental Risk Assessment are detailed in Appendix 3.

12.1. Summary of Soil Testing Results: Human Health Assessment

The Tier 1 Risk Assessment for site soils is presented in Table 18.

Table 18: Tier 1 Quantitative Risk Assessment (Soils)

Analyte	Maximum Concentration (mg/kg)	Location	Assessment Criteria (mg/kg)	Source	Pass/Fail	Further Assessment Required
Arsenic	6	TP21 (0.00mbgl)	32	EA SGV	Pass	No
Boron (water soluble)	<1	Below LOD	291	LQM ed.2	Pass	No
Cadmium	<1	Below LOD	10	EA SGV	Pass	No
Chromium	41	TP21 (1.00mbgl)	3000	LQM ed.2	Pass	No
Copper	28	TP21 (1.00mbgl)	2330	LQM ed.2	Pass	No
Lead	16	TP21 (0.00mbgl)	450	EA SGV (old)	Pass	No
Mercury	<1	Below LOD	11	EA SGV	Pass	No
Nickel	25	TP21 (1.00mbgl)	130	EA SGV	Pass	No
Selenium	<3	Below LOD	350	EA SGV	Pass	No
Zinc	75	TP21 (1.00mbgl)	3750	LQM ed.2	Pass	No
Asbestos	Not Detected				Pass	No
Petroleum Hydrocarbons						
Aliphatic C5-C6	<0.01	Below LOD	110	LQM ed.2	Pass	No
Aliphatic C8-C10	<0.01	Below LOD	110	LQM ed.2	Pass	No
Aliphatic >C10-C12	<1	Below LOD	540 (283)v	LQM ed.2	Pass	No
Aliphatic >C12-C16	<1	Below LOD	3000 (142)s	LQM ed.2	Pass	No
Aliphatic >C16-C21	<1	Below LOD	76000	LQM ed.2	Pass	No
Aliphatic >C21-C35	<1	Below LOD				
Aromatics C6-C7	<0.01	Below LOD	N/A	LQM ed.2	Pass	No
Aromatics C7-C8	<0.01	Below LOD	N/A	LQM ed.2	Pass	No
Aromatics C8-C10	<0.01	Below LOD	151	LQM ed.2	Pass	No
Aromatics >C10-C12	<1	Below LOD	346	LQM ed.2	Pass	No
Aromatics >C12-C16	<1	Below LOD	593	LQM ed.2	Pass	No
Aromatics >C16-C21	<1	Below LOD	770	LQM ed.2	Pass	No
Aromatics >C21-C35	<1	Below LOD	1230	LQM ed.2	Pass	No
Total Petroleum Hydrocarbons	<1	Below LOD	82850	LQM ed.2	Pass	No
PAH						
Naphthalene	<0.01	Below LOD	1.5	LQM ed.2	Pass	No
Acenaphthylene	<0.01	Below LOD	170	LQM ed.2	Pass	No

Acenaphthene	<0.01	Below LOD	210	LQM ed.2	**Pass**	**No**
Fluorene	<0.01	Below LOD	160	LQM ed.2	**Pass**	**No**
Phenanthrene	0.01	WBH09 (0.50mbgl)	92	LQM ed.2	**Pass**	**No**
Anthracene	<0.01	Below LOD	2300	LQM ed.2	**Pass**	**No**
Fluoranthene	0.02	WBH07 (0.50mbgl) WBH09 (0.50mbgl)	260	LQM ed.2	**Pass**	**No**
Pyrene	0.02	WBH07 (0.50mbgl) WBH09 (0.50mbgl)	560	LQM ed.2	**Pass**	**No**
Benzo (a) anthracene	0.01	WBH09 (0.50mbgl)	3.1	LQM ed.2	**Pass**	**No**
Chrysene	0.01	WBH09 (0.50mbgl)	6	LQM ed.2	**Pass**	**No**
Benzo (b) fluoranthene	0.02	WBH09 (0.50mbgl)	5.6	LQM ed.2	**Pass**	**No**
Benzo (k) fluoranthene	<0.01	Below LOD	8.5	LQM ed.2	**Pass**	**No**
Benzo (a) pyrene	0.01	WBH09 (0.50mbgl)	0.83	LQM ed.2	**Pass**	**No**
Indeno (123-cd) pyrene	<0.01	Below LOD	3.2	LQM ed.2	**Pass**	**No**
Dibenzo (ah) anthracene	<0.01	Below LOD	0.76	LQM ed.2	**Pass**	**No**
Benzo (ghi) perylene	0.01	WBH09 (0.50mbgl)	44	LQM ed.2	**Pass**	**No**
PAH (total)	0.11	WBH09 (0.50mbgl)	N/A	N/A	**Pass**	**No**

12.2. Summary of Soil Testing Results: BRE Assessment

Table 19: Tier 1 BRE Special Digest 1: Concrete Classification (Phase I)

Sulphate Level (2:1) (mg/l)	**<10**	
Sulphate Assessment Criteria	**500-1500**	
pH (lowest encountered pH)	**5.2 – 7.6**	
pH Assessment Criteria	**AC-1: > 5.5**	**AC-2: 2.5 – 5.5**
Design Classification	**AC-2z**	**DS-1**

Table 20: Tier 1 BRE Special Digest 1: Concrete Classification (Phase II)

Sulphate Level (2:1) (mg/l)	**21**	
Sulphate Assessment Criteria	**500-1500**	
pH (lowest encountered pH)	**5.2**	
pH Assessment Criteria	**AC-1: > 5.5**	**AC-2: 2.5 – 5.5**
Design Classification	**AC-2z**	**DS-1**

Based on the results presented in Tables 19 and 20 (and Appendix 4),an upgraded concrete specification is recommended for all areas to comprise **DS-1 AC-2z**.

12.3. UKWIR Assessment of Buried Water Pipes and Buried Concrete

This Section of the Report summarises the chemical results of the ground investigation and risk assesses the buildings and services against appropriate assessment criteria.

Table 219: Summary of UKWIR Testing

Group	Parameters	Units	Thresholds	Maximum Concentration	Sample Ref
1	Extended VOC suite (with TIC)	mg/kg	0.125	<0.1	All samples
1a	- BTEX + MTBE	mg/kg	0.03	<0.001	All samples
2	Extended SVOC suite (with TIC)	mg/kg	1.4	<0.1	All samples
2e	- phenols	mg/kg	0.4	<0.01	All samples
2f	- Cresols and chlorinated phenols	mg/kg	0.04	<0.01	All samples
3	Mineral Oils C11-C20	mg/kg	10	<1	All samples
4	Mineral Oils C21-C40	mg/kg	500	<1	All samples
5	Corrosive (Conductivity, Redox and pH)				
	Conductivity	µ S/cm	>400	61 min	CBR17 @ 0.90mbgl
				90 max	CBR05 @ 0.80mbgl
	Redox potential	Volt	-	23 min	CBR09 @ 0.30mbgl CBR21 @ 0.90mbgl

				25 max	CBR13 @ 1.00mbgl CBR29 @ 0.60mbgl
	pH	-	<7 or >8	5.4 min	CBR13 @ 1.00mbgl
				6.1 max	CBR21 @ 0.90mbgl
2a	Ethers	mg/kg	0.5	<0.10	All samples
2b	Nitobenzene	mg/kg	0.5	<0.10	All samples
2c	Ketone	mg/kg	<0.10	<0.10	All samples
2d	Aldehyde	mg/kg	<0.10	<0.10	All samples
6	Amines	mg/kg	<0.10	<0.10	All samples

Table 22: UKWIR Water Pipework Classification*

Parameter group		Pipe Material					
		All threshold concentrations are in mg/kg					
		PE	PVC	Barrier pipe (PE-Al-PE)	Wrapped Steel	Wrapped Ductile Iron	Copper
1	Extended VOC suite by purge & trap or head space & GC-MS with TIC	Pass	Pass	Pass	Pass	Pass	Pass
1a	+ BTEX + MTBE	Pass	Pass	Pass	Pass	Pass	Pass
2	SVOCs TIC by purge and trap or head space & GC-MS with TIC (aliphatic and aromatic C5 - C10)	Pass	Pass	Pass	Pass	Pass	Pass
2e	+ Phenols	Pass	Pass	Pass	Pass	Pass	Pass
2f	+ Cresols & chlorinated phenols	Pass	Pass	Pass	Pass	Pass	Pass
3	Mineral oil C11-C20	Pass	Pass	Pass	Pass	Pass	Pass
4	Mineral oil C21-C40	Pass	Pass	Pass	Pass	Pass	Pass
5	Corrosive (Conductivity, Redox & pH)	Pass	Pass	Pass	Corrosive if pH <7 and conductivity >400µS/cm	Corrosive if pH <5, Eh not neutral and conductivity >400µS/cm	Corrosive if pH <5 or >8 and pH positive
2a	Ethers	Pass	Pass	Pass	Pass	Pass	Pass
2b	Nitrobenzene	Pass	Pass	Pass	Pass	Pass	Pass
2c	Ketones	Pass	Pass	Pass	Pass	Pass	Pass
2d	Aldehydes	Pass	Pass	Pass	Pass	Pass	Pass
6	Amines	Pass	Pass	Pass	Pass	Pass	Pass
Pipe Selection Assessment		✓	✓	✓	✖	✓	✓
Preferred Selection		✓					

*It should be noted that the spacing of the UKWIR samples were not to the 100m interval now required by Scottish Water and further investigation along the proposed watermain will be required.

12.4. Assessment of Volatile Organic Compounds

Table 23: Tier 1 Risk Assessment for Volatile Organic Compounds

Determinant	Maximum	Assessment Criteria	Pass/Fail	Further Assessment/ Recommendations
VOC	0.0	20ppm	Pass	**No**

12.5. Assessment of Ground Gas and Vapours

Table 24: Tier 1 Risk Assessment for Ground Gases (NHBC Traffic Light Classification)

Determinant	Flow (ltr/hr)	Max (% v/v)	GSV (ltr/hr)	Assessment Criteria	NHBC (Table 30)	Further Assessment/ Recommendations
CO_2	0.4	1.7	0.0068	CIRIA C665 CS1 (<0.7)	Green	**No**
$O_{2\ (minimum)}$	0.4	16.1	-	<18%	N/A	**Yes**[2]

[2] Due to depleted levels of Oxygen being recorded at the site, safe systems of work employed under Health and Safety at Work act 1974 and CDM 2015 should protect construction and maintenance workers from exposure to risk in the workplace.

Excavations may be toxic and be low Oxygen environments; therefore adequate precautions may be required prior to entry into excavations.

In addition to the low concentrations and flowrates identified during the gas monitoring the very shallow rockhead identified during the ground investigation, the distance to the offsite sources and the presence of preferential pathways for the gas to vent should it be generated from the offsite sources would significantly reduce the risk of a complete pollutant linkage. For these reasons the risk from ground gas and vapours is not considered further.

Table 25: CIRIA C665 & BS 8485 Ground Gas Assessment based upon site GSV

Determinant	Flow (ltr/h)	Maximum (% v/v)	GSV	Assessment Criteria	C665 Situation	BS 8485 'Required Gas Protection Level'	Further Action Required
CO_2	0.4	1.7	0.0068	CIRIA C665	CS1	**0**	**No**

12.6. Residual Pollutant Linkages

1. Radon (underlying bedrock) ⇨ Inhalation ⇨ Site End Users
2. Low pH conditions ⇨ Direct Contact ⇨ Buildings/Buried Concrete

12.7. Discussion of Residual Pollutant Linkages

Pollutant Linkage 1

The site is within an '*Intermediate*' Radon probability area. New dwellings/buildings must include *'Stage 1 Radon Protection Measures'* in accordance with BRE 376.

Pollutant Linkage 2

All buried concrete at the site is to be designed to specification **DS-1 AC-2z**.

13.0 Summary of Geotechnical Testing (Phase I)

This Section discusses the findings of the in-situ and laboratory geotechnical testing results.

13.1. Summary of in-situ Geotechnical Testing

In-situ geotechnical testing was undertaken on samples of Natural Materials. The testing, summarised in Appendix 2, was designed to classify the materials present at the site and to obtain information on the engineering properties of the soils. The results are presented in the Contractor's Factual Report (Appendix 2).

- In-situ California bearing ratio (CBR) tests were undertaken at depths of 0.30m and 0.60m within trial pits CBR02, CBR04, CBR06, CBR08, CBR010, CBR12, CBR014, CBR16, CBR18, CBR20, CBR22, CBR24, CBR26, CBR28 & CBR30-51. In-situ CBR Testing at 0.60mbgl was not possible in CBR02, CBR04, CBR08, CBR20, CBR22, CBR24, CBR26, CBR28, CBR30-36, CBR38-40, CBR43-47 & CBR49-51 due to obstructions or coarse granular material. In-situ CBR results are summarised in Table 26 and Drawing 72054/9035, Appendix 1.

Table 26: Summary of In-situ CBR Test Results

In-situ CBR Test Results				
Position	**Easting**	**Northing**	**0.3 mbgl**	**0.6 mbgl**
CBR02	390196.62	793464.19	5.6	Obstruction
CBR04	390098.71	793475.58	7.6	Obstruction
CBR06	389996.03	793485.76	3.4	8.6
CBR08	389897.94	793499.71	4.3	Obstruction
CBR10	389791.54	793480.82	3.3	4.7
CBR12	389677.86	793467.08	2.8	10.7
CBR14	389558.83	793468.37	4.0	5.1
CBR16	389469.90	793504.05	2.9	9.7
CBR18	389417.50	793498.03	3.1	8.8
CBR20	389373.85	793436.64	4.3	Obstruction
CBR22	389393.37	793368.81	3.7	Obstruction
CBR24	389482.95	793345.71	3.3	Obstruction
CBR26	389575.10	793364.69	3.7	Obstruction
CBR28	389605.38	793435.40	3.6	Obstruction
CBR30	389480.90	793679.47	9.2	Obstruction
CBR31	389419.56	793602.05	8.7	Obstruction
CBR32	389512.49	793583.46	4.4	Obstruction
CBR33	389593.50	793572.04	5.2	Obstruction
CBR34	389671.03	793546.36	3.0	Obstruction
CBR35	389530.41	793526.40	3.6	Obstruction
CBR36	389611.72	793509.58	15.2	Obstruction
CBR37	389682.12	793524.67	3.7	9.6
CBR38	389441.79	793472.76	4.3	Obstruction
CBR39	389404.38	793411.82	3.4	Obstruction
CBR40	389480.64	793387.90	5.3	Obstruction
CBR41	389378.00	793334.42	3.4	3.8
CBR42	389456.85	793312.18	3.5	3.4
CBR43	389365.53	793275.27	3.4	Obstruction
CBR44	389444.79	793250.53	4.0	Obstruction
CBR45	389553.94	793389.82	3.9	Obstruction
CBR46	389678.36	793425.15	4.1	Obstruction
CBR47	389506.27	793302.03	3.7	Obstruction
CBR48	389587.98	793326.59	3.0	7.8
CBR49	389669.26	793321.79	8.1	Obstruction
CBR50	389488.99	793202.52	4.3	Obstruction
CBR51	389591.25	793195.26	4.0	Obstruction

- SPT N-value's for the Natural Deposits are summarised in Table 27.
  Testing was undertaken in the granular deposits. The SPT N-value's from the granular deposits ranged from 19 to 28 indicating that the deposits are medium-dense.
  SPT N-value's testing was undertaken in cohesive deposits. The results ranged from 0 to 16 respectively indicating the deposits ranged from very soft to Firm.
  Testing was undertaken in the weathered bedrock. The results ranged from 25 to >50.

Table 27: In-situ SPT Testing Summary

Location	Depth (mbgl)	Depth (mAOD)	SPT N-Value	Strata (ERS Engineering Logs)
Sand				
WBH04	1.00	88.46	28	Medium dense fine and medium SAND
WBH08	1.00	112.11	19	Slightly gravelly fine and medium SAND
WBH15	1.00	98.71	19	Silty slightly gravelly fine and medium SAND
Clay				
WBH05	1.00	77.69	4	Soft slightly sandy gravelly CLAY
WBH06	1.00	85.71	4	Sandy slightly gravelly CLAY
WBH06	2.00	84.71	15	Sandy slightly gravelly CLAY
WBH10	1.00	78.69	6	Sandy slightly gravelly CLAY
WBH10	2.00	77.69	4	Slightly sandy gravelly CLAY with some subangular cobbles
WBH11	1.00	80.83	8	Soft sandy slightly gravelly CLAY
WBH11	2.00	79.83	0	Soft sandy slightly gravelly CLAY
WBH11	3.00	78.83	14	Soft sandy slightly gravelly CLAY
WBH12	1.00	80.51	16	Firm sandy slightly gravelly Clay with some subangular cobbles
WBH12	2.00	79.51	3	Soft sandy slightly gravelly CLAY
WBH12	3.00	78.51	12	Firm sandy slightly gravelly CLAY
Bedrock/Weathered Granite				
WBH04	2.00	87.46	34	Slightly sandy gravelly CLAY with some angular cobbles of granite (possible weathered bedrock)
WBH05	1.60	77.09	>50	Hard Drilling possible boulder or bedrock
WBH07	1.00	111.02	25	Hard drilling probable bedrock
WBH08	2.00	111.11	45	Reddish brown weathered GRANITE (probable bedrock)
WBH09	1.50	112.02	>50	Hard drilling probable bedrock
WBH10	2.90	76.79	>50	Hard drilling possible bedrock
WBH12	3.80	77.71	>50	Hard drilling possible bedrock
WBH13	1.00	104.30	25	Pale brown weathered GRANITE
WBH13	1.40	103.90	32	Hard drilling probable bedrock
WBH14	0.85	96.54	50	Hard ground possible weathered bed rock
WBH17	0.60	92.35	50	Hard ground possible bedrock
WBH18	0.55	97.2	50	Hard ground possible weathered bed rock

Figure 1 (Appendix 1) presents a summary of the SPT vs. level graph for the underlying superficial deposits (mAOD) at the site.

- Infiltration Testing was undertaken at the site during the ground investigation. The results are summarised in Table 28. The infiltration test Results are presented in Drawing 72054/9038 (Appendix 1) and in Appendix 2.

Table 28: Infiltration Test Results

Location	Average Infiltration Rate 'f' value	Comment on Results
SA01	0.031m/hr	Low
SA02	0.003m/hr	Very Low
SA03	0.002m/hr	Very Low
SA04	0.000m/hr	None
SA05	0.000m/hr	None
SA06	0.000m/hr	None
SA07	0.000m/hr	None
SA08	0.000m/hr	None
SA09	0.105m/hr	Moderate
SA10	0.001m/hr	Very Low
SA11	0.000m/hr	None
SA12	0.002m/hr	Very Low
SA13	0.008m/hr	Very Low

Infiltration Rates across the site vary from no Infiltration to Moderate Rates. The Infiltration rates at the site are generally very low.

13.2. Summary of Laboratory Geotechnical Testing

Geotechnical laboratory testing was undertaken in accordance with BS EN 1997 on samples of natural deposits from ground investigation. The laboratory testing is summarised in Table 29. The testing was designed to classify the materials present at the site and to obtain information on the engineering properties of the soils.

The full results are presented in the Contractors' Factual Reports (Appendix 2).

Classification

- Liquid and Plastic Limits
- Particle Size Distribution (PSD)
- Moisture Content
- CBR Test
- Compaction Test (2.5kg Rammer)
- pH and SO_4

Table 29: Summary of Geotechnical Laboratory Testing Results

Geotechnical Test	Deposits	No.	Depth (m)	Results	
Liquid and Plastic Limits	Natural Cohesive Deposits with Granular Constituents (Soft and Firm CLAY)	39	1.00 – 3.00	LL: 28-%-32% PL:15%-19% PI: 10%-16%	
Particle Size Distribution	Natural Cohesive Deposits with Granular Constituents (Soft and Firm CLAY)	31	0.50 – 3.00	Cobbles/Boulders:	0% – 12%
				Gravel:	18% – 48%
				Sand:	30% – 46%
				Silt/Clay:	18% – 40%
	Natural Granular Deposits with Clay Content (Medium Dense SAND)	33	0.50 – 2.00	Cobbles/Boulders:	0% – 29%
				Gravel:	19% – 63%
				Sand:	16% – 51%
				Silt/Clay:	6% - 37%
	Natural Granular Deposits with Clay Content (Loose and Medium Dense SAND)	17	0.50 – 2.00	Cobbles/Boulders:	0% - 19%
				Gravel:	8% - 54%
				Sand:	24 – 58%
				Silt/Clay:	8% - 46%
Moisture Content	Natural Cohesive Deposits with Granular Constituents (Soft and Firm CLAY)	42	1.00 – 3.00	11% – 25%	
CBR Test (Ex Situ)	Natural Granular Deposits with Clay Content (Medium Dense SAND)	15	0.30 – 0.60	<0.1% – 4.7%	

Compaction Test (2.5kg Rammer, 3 Layers, 62 Blows per Layer)	Natural Cohesive Deposits with Granular Constituents (Soft and Firm CLAY)	9	1.00 – 2.00	Optimum moisture content	9.7% – 17.0%
				Max dry Density (Mg/m^3)	1.74 – 2.06
				Proportion <37.5mm	91% – 100%
				Proportion <20mm	83% – 100%
				Grading Zone	1 – 5
	Natural Granular Deposits with Clay Content (Medium Dense SAND)	12	0.50 – 3.00	Optimum moisture content	8.8% – 13.7%
				Max dry Density (Mg/m^3)	1.83 – 2.02
				Proportion <37.5mm	78 – 100
				Proportion <20mm	66% – 96%
				Grading Zone	2 - 5
	Natural Granular Deposits with Clay Content (Loose and Medium Dense SAND)	9	0.50 – 1.00	Optimum moisture content	6.6% – 14.1%
				Max dry Density (Mg/m^3)	1.77 – 2.13
				Proportion <37.5mm	77% – 100%
				Proportion <20mm	74% – 97%
				Grading Zone	2 – 5
pH	Natural Cohesive Deposits with Granular Constituents (Soft and Firm CLAY)	37	1.00 – 2.00	5.5 – 7.6	
	Natural Granular Deposits with Clay Content (Medium Dense SAND)	17	0.50 – 2.00	5.2 – 7.5	
	Natural Granular Deposits with Clay Content (Loose and Medium Dense SAND)	8	0.50 – 2.00	5.5 – 6.6	
SO_4	Natural Cohesive Deposits with Granular Constituents (Soft and Firm CLAY)	37	1.00 – 2.00	0.01g/l – 0.04g/l	
	Natural Granular Deposits with Clay Content (Medium Dense SAND)	17	0.50 – 2.00	0.01g/l – 0.05g/l	
	Natural Granular Deposits with Clay Content (Loose and Medium Dense SAND)	8	0.50 – 2.00	0.01g/l – 0.03g/l	

The full results of the Particle Size Distribution Tests are included in The Contractors Factual Report, presented in Appendix 2.

13.2.1. Geotechnical Laboratory Testing

- Moisture Content testing indicated that the results (which ranged between 11-25%) for the Natural Cohesive deposits were relatively consistent.

- Particle Size Distribution (PSD) analysis was undertaken on eighty-one samples of natural deposits at the site. The results concluded that the Natural Granular materials on site (Medium Dense & Loose and Medium SAND) were relatively well-graded sands and gravels with significant 'fines' content (clay and silt particles) of between 6.0 - 46.0% and Cobbles/Boulders content of 0 – 29%. The Medium Dense SAND results indicate that the deposits were predominantly 'Coarse' in nature with the Loose and Medium Dense SAND predominantly 'Medium to Fine'. The natural cohesive deposits on site (Soft and Firm CLAY) were relatively well-graded Silty Clays with a significant granular content; Gravels 18 – 48%, Sands 30 – 46% and Cobbles/Boulders content of 0 – 12%.

- Plasticity Index testing was undertaken on thirty-nine samples of the Natural Cohesive Deposits (Soft and Firm CLAY). The values indicated relatively consistent values of between 10 and 16%. Plotting the results on the '*A-Line Classification Chart*' (Appendix 1) the clays were noted to fit the parameters of '*Clays of Low Plasticity*'.

- Compaction tests using a 2.5kg hammer were undertaken on thirty of the natural deposits from throughout the site (Table 30). The maximum dry densities of the natural granular materials (Medium Dense SAND & Loose and Medium Dense SAND) were found to range between 1.77Mg/m³ and 2.03Mg/m³. The optimum moisture content

ranged between 6.6% and 14.1%. The maximum dry densities of the natural cohesive materials (Soft and Firm CLAY) were found to range between 1.74Mg/m³ and 2.06Mg/m³. The optimum moisture content ranged between 9.7% and 17.0%

Table 30: Summary of Compaction Test Results

ID	Depth (m)	Natural Moisture Content (%)	Optimum Moisture Content (%)	Maximum dry density (Mg/m³)
Soft and Firm CLAY				
TP14	2.0	11% - 25%	10.2	2.06
TP16	1.0		17.0	1.74
TP39	2.0		11.6	1.97
TP45	2.0		9.7	2.02
TP46	1.0		10.6	1.97
TP55	1.0		9.7	2.01
TP59	1.0		11.9	1.91
SA07	1.5		13.9	1.89
SA08	1.4		12.6	1.92
Medium Dense SAND				
TP03	2.0		12.3	1.95
TP04	2.0		11.4	2.00
TP22	2.0		10.5	2.01
TP34	0.8		10.1	2.01
TP38	1.0		8.8	2.02
TP43	0.5		11.6	1.93
TP44	2.0		10.8	2.01
TP49	1.0		13.7	1.83
TP51	1.0		13.7	1.83
TP62	3.0		11.9	1.97
TP64	1.0		11.0	1.98
Loose and Medium Dense SAND				
TP05	1.0		10.3	2.02
TP06	0.5		10.7	2.00
TP07	1.0		9.1	2.06
TP09	1.0		6.6	2.13
TP11	1.0		11.9	1.96
TP13	0.5		10.0	2.02
TP18	0.5		10.6	1.94
TP19	0.5		14.1	1.77
TP20	0.5		11.7	1.97

14.0 Summary of Geotechnical Testing (Phase II)

This Section discusses the findings of the in-situ and laboratory geotechnical testing results obtained from the Phase II investigation works.

14.1. Summary of Laboratory Geotechnical Testing

Geotechnical laboratory testing was undertaken in accordance with the Scots National Roads Development Guide (NRDG) and Aberdeenshire Council requirements on samples of natural deposits obtained from the phase II ground investigation. The laboratory testing is summarised in Tables 31 and 32. The testing was designed to classify the materials present at the site and to obtain information on the engineering properties of the soils, with particular respect to the design of road construction.

The full results are presented in the Fairhurst Ground Investigation Factual Report (Appendix 2).

The following laboratory tests were undertaken, with a summary of results presented in Tables 31 and 32;

- 43 no. Particle Size Distribution (PSD) tests
- 43 no. California Bearing Ratio (CBR) tests
- 43 no. Moisture Condition Value (MCV) tests
- 24 no. pH and SO_4 determinations

Table 31: Summary of Laboratory CBR Test Results

Position	Depth (mbgl)	CBR Value – Top (%)	CBR Value – Bottom (%)
TP-01	0.70	1.30	0.70
TP-02	0.40	0.82	0.76
TP-03	0.35	0.57	0.69
TP-04	0.35	1.80	1.70
TP-05	0.30	0.66	0.60
TP-06	0.40	0.24	0.26
TP-07	0.35	1.20	1.40
TP-08	0.30	24.00	28.00
TP-09	0.30	2.70	3.80
TP-10	0.45	1.70	1.90
TP-11	0.45	1.30	1.40
TP-12	0.45	0.67	0.60
TP-13	0.45	8.00	11.00
TP-14	0.45	38.00	35.00
TP-16	0.50	1.60	1.20
TP-17	0.50	1.00	1.10
TP-18	0.60	1.70	2.00
TP-19	0.50	2.50	3.80
TP-20	0.60	4.20	5.70
TP-21	0.60	2.90	3.50
TP-22	0.40	0.20	0.30
TP-23	0.60	1.40	1.10
TP-24	0.50	0.50	0.40
TP-25	0.80	0.70	0.86
TP-26	0.45	0.64	0.58
TP-27	0.45	1.10	1.30

TP-28	0.50	1.60	1.50
TP-29	0.50	2.90	2.60
TP-30	0.45	0.95	1.30
TP-31	0.40	1.20	1.40
TP-34	0.40	0.39	0.35
TP-35	0.50	0.80	0.96
TP-36	0.50	0.63	0.56
TP-37	0.50	1.00	0.86
TP-39	0.45	2.70	4.10
TP-40	0.45	1.80	1.80
TP-41	0.50	0.80	0.50
TP-42	0.50	2.30	2.90
TP-43	0.60	2.10	1.40
TP-44	0.70	21.00	26.00
TP-46	0.60	1.80	2.20
TP-47	0.70	1.80	1.80
TP-48	0.50	1.00	1.30

Table 32: Summary of Laboratory MCV Test Results

Position	Depth (mbgl)	Moisture Content (%)	Moisture Condition Value
TP-01	0.70	15.0	4.8
TP-02	0.40	16.3	5.6
TP-03	0.35	16.6	5.4
TP-04	0.35	13.7	6.4
TP-05	0.30	23.4	6.4
TP-06	0.40	30.3	3.6
TP-07	0.35	18.8	8.3
TP-08	0.30	10.9	12.2
TP-09	0.30	16.5	8.4
TP-10	0.45	19.5	7.8
TP-11	0.45	19.3	7.6
TP-12	0.45	31.5	8.4
TP-13	0.45	11.7	9.4
TP-14	0.45	10.9	12.0
TP-16	0.50	19.0	1.5
TP-17	0.50	16.0	3.0
TP-18	0.60	15.0	7.2
TP-19	0.50	14.0	9.5
TP-20	0.60	14.0	7.4
TP-21	0.60	16.0	6.2
TP-22	0.40	15.0	3.5
TP-23	0.60	17.0	3.0
TP-24	0.50	13.0	5.2
TP-25	0.80	12.6	4.2
TP-26	0.45	16.8	3.8
TP-27	0.45	23.7	5.8
TP-28	0.50	17.7	6.6
TP-29	0.50	14.7	8.4
TP-30	0.45	16.6	6.6
TP-31	0.40	16.9	8.0
TP-34	0.40	17.2	3.2
TP-35	0.50	15.9	5.6
TP-36	0.50	18.9	4.2
TP-37	0.50	16.9	6.2
TP-39	0.45	19.0	9.6
TP-40	0.45	17.1	7.4
TP-41	0.50	17.0	4.3
TP-42	0.50	13.0	6.9

TP-43	0.60	17.0	7.4
TP-44	0.70	15.0	9.0
TP-46	0.60	16.1	7.0
TP-47	0.70	14.3	6.4
TP-48	0.50	20.0	5.8

The full results of the laboratory geotechnical testing undertaken are included in the Fairhurst Factual Report, presented in Appendix 2.

14.1.1. Summary of Geotechnical Laboratory Testing

- CBR and MCV testing returned highly variable results, however on average are concluded to conform to poor/moderate materials for the formation of roads.

- Particle Size Distribution (PSD) results concluded that the Natural Granular materials on site were relatively well-graded sands and gravels with a significant *'fines'* content (clay and silt particles). The natural cohesive deposits on site were relatively well-graded Silty Clays with a significant granular content.

15.0 Engineering-Geotechnical Assessment

15.1. Engineering-Geotechnical Considerations

The following engineering/geotechnical aspects were identified at the site during the intrusive investigation works;

- Localised Made Ground Deposits
- Shallow Rockhead
- Foundations Design Requirements
- Groundwater Conditions (unsaturated groundwater)
- Anticipated low infiltration of underlying soils
- Potential Earthworks
- Road and Pavements
- Buried Concrete
- Material Disposal/Waste
- Importation of Materials
- Public Utilities
- Decommissioning of Boreholes

15.1.1. Localised Made Ground Deposits

The intrusive investigation at the site confirmed that there was a localised pocket of Made Ground in the vicinity of Phase I trial pit TP21 (0.00-0.35m). Based on the proposed development layout, the Made Ground deposit will not be in an area subject to redevelopment as it lies between two existing buildings which are to be retained.

15.1.2. Suspected Shallow Rockhead

Shallow rockhead was encountered across the northern and central sections of the site. It is considered in these areas (dependent upon finalised levels) that there may be the requirement either for excavation into rock or earthworks to modify the existing levels to allow for the installation of infrastructure.

Drawing 72054/9033, Appendix 1, shows an indicative geological cross section of these deposits encountered during the intrusive investigation. Drawing 72054/9030, Appendix 1, shows a 2D surfer plot of rockhead/obstruction level as mbgl.

15.1.3. Foundation Design Requirements

The choice of a suitable foundation solution (dependent upon the loadings and the settlement tolerances of the structure) is determined by a system where the simplest forms are considered first, and if found unsuitable then more complex and costly solutions will be considered in turn. The site has been split into a Northern and Central and Southern section with regard to the foundation solution.

North and Central Sections

The density of the Granular Deposits (Sands and Gravels) was measured by the SPT N-values. The most conservative value was 19 (principally medium-dense Sands and Gravels) providing a safe bearing value of 150kN/m² based on a 1m wide foundation. The foundation loadings for the proposed development are unknown at the time of reporting, however, it is anticipated the maximum loading requirements for typical single storey or

two storey timber kit house with nominal reinforced concrete strip and pad footings of normal proportions would not exceed the likely safe allowable bearing capacities identified for the undisturbed granular natural deposits or weathered rockhead. Settlements within the granular deposits would be expected to be effective immediately upon loading, and within normal tolerable limits (i.e. less than 25mm).

Foundations for the Northern and Central sections of the site are not considered to be complex, Drawing 72054/9040, Appendix 1.

Southern Section

The Southern Section of the site was identified to have silt/cohesive deposits present below loose Sand. Soils of this nature can be associated with low bearing resistances and excessive settlements. The loose Sand present just below the Topsoil is anticipated to have a minimum safe bearing capacity of 20kN/m² based on a 1m wide foundation. However the safe bearing capacity of the silt/cohesive deposits present below the Loose Sand is likely to be very low, at approximately 10kN/m². The safe bearing capacity was measured by the SPT N-values. The most conservative value was assumed a lumped safety factor of 3, providing a safe bearing value of 10kN/m² based on a 1m wide foundation. These bearing capacities have taken account of the very high groundwater levels encountered on site.

It is recommended that foundations be set as high as possible on the loose Sand and the site development proposals should take account of this. It is recommended that the bearing capacity of the natural materials be improved locally where necessary by compacting the loose material and incorporating a 300mm thick layer of compacted imported fill below the foundation. **It is also recommended that further investigation is undertaken in this area by a suitably qualified engineer on a plot by plot basis.**

The foundation loadings for the proposed development are unknown at the time of reporting. However, subject to the above improvement, it is anticipated the maximum loading requirements for typical single storey or two storey timber kit house will require wide strip or grillage reinforced concrete foundations in order to limit settlements to be within tolerable limits. Such foundations for the Southern Section of the site, Drawing 72054/9040, Appendix 1, are considered to be non-standard due to the ground conditions encountered.

If the final development levels are raised above current levels the increased load may induce settlement within the silt/cohesive deposits. This should be assessed by a suitably qualified engineer following finalisation of the development levels.

Water was encountered during the works and during post-intrusive monitoring works. Based on the findings and the levels recorded (Table 8), this has been taken into consideration in the foundation recommendations made above.

Following excavation, foundations should be assessed by a suitably qualified Engineer prior to the placement of concrete and should be protected from moisture or frost.

15.1.4. Groundwater Conditions

Based on the results of the intrusive investigations and post investigation groundwater monitoring, the groundwater across the site is variable. Many of the monitorable boreholes did not identify the presence of groundwater. However sporadic unsaturated groundwater has been confirmed to be present at the site in several boreholes (Table 7 and 8). Water was also present at surface in the area adjacent to the Pheppie Burn. This would indicate that the surface water drainage in the area may be insufficient to allow these areas to drain. This may present a constraint both to the final development, if it is to remain at its current level and during construction excavations/development works, however due to the volumes of water encountered; it is likely that this will be controlled during through conventional pumps. *Reference can be made to CIRIA Report C515, Groundwater Control – Design and Practice (2000).*

15.1.5. Infiltration Properties of underlying soils

It is likely that any development scenario at the site will require a sustainable urban drainage system (SUDS). The infiltration capacity of the site soils were tested at thirteen locations (Table 28). The testing indicated that rates of infiltration associated with the natural soils were overall classified as *'very low'*; however, SA09 showed 'moderate' results.

These results should be assessed by the Civil Engineer for the works for specification of the soakaways.

15.1.6. Earthworks and Excavations

As details of any potential earthworks are not known at the time of writing, a full earthworks assessment has not been undertaken. Compaction testing was undertaken on natural deposits at the site to assess their suitability for potential reuse as an engineering fill.

Based upon the site topography it is expected that some land re-profiling would be undertaken as part of the proposed development works.

Based on the results (Appendix 2 and Tables 28 and 30), the samples (typically of a moderately dense in-situ nature) would be suitable for reuse as an engineering fill at the site. However, based on the fines content encountered in the testing, the deposits may require pre-treatment prior to placement to allow them to be reused as an engineering fill. The fine grained fractions noted in some of the analysis (Table 29) may make the materials highly susceptible to softening when wet. Moving during wet conditions should be avoided and the formations should be protected to avoid the ingress of water.

Excavation within the superficial soils should present little difficulty to traditional plant, however shallow rockhead may require specialist plant if excavations are required below the rockhead level.

The silt/cohesive deposits located in the southern section of the site, Drawing 72054/9039, Appendix 1, are considered unlikely to be suitable for re-use as an engineering fill however may be suitable in non-structural areas (i.e. out with proposed foundations, load bearing slabs or access roads/pavements).

15.1.7. Roads and Pavements

The development is to incorporate additional access roads leading to new areas of development. In-situ CBR testing undertaken during the works indicated low to moderate CBR values of 0.2% to 38.0% (Tables 26 and 31). A Drawing representing the In-situ CBR test values is presented in Drawing 72054/9035 (Appendix 1). It is understood that the access roads will be adopted by Aberdeenshire Council.

15.1.8. Buried Concrete

Due to the ground conditions encountered at the site, buried concrete should be designed to DS-1, AC-2z.

15.1.9. Waste/Material Re-use

Following finalised development proposals and associated levels for the site, some site preparation activities may be required. As a result, materials which cannot be re-used as part of the works will require offsite disposal. They should be appropriately classified and managed through Waste Management Licensing (WML) Regulations.

Appropriate chemical testing (Waste Acceptance Criteria) has not been undertaken as part of this Reporting.

Topsoil

Topsoil was identified during the works. It is likely that this will be suitable for recycling but no specific testing has been undertaken to date.

Natural Deposits/Weathered Granite

Naturals Deposits can be designated as 17 05 03 (soils and stones).

If the excavated material is deemed unsuitable for re-use and is destined for off-site disposal the waste status of the material will require to be determined and Waste Acceptance Criteria Testing carried out. All wastes destined for landfill must undergo some form of treatment. This can be as simple as sorting and segregation, which occurs in the case of most excavated wastes on construction sites anyway, but the fact that this has been done needs to be recorded. Sorting and segregation of the waste requires to be carried out under a mobile plant licence and therefore it is essential to ensure that the earthworks contractor is licensed for such activity. If the intention is to treat unsuitable or contaminated excavated material to render it suitable for re-use this needs to be done under a mobile plant licence and the material that results from the treatment should conform to an appropriate recognised Fill Specification. If the resulting material does conform to such a specification it is deemed to be a product and no longer a waste and it can be re-used on site without the need for an exemption from waste management licensing.

If however the material does not conform to a recognised specification, but is to be used anyway then an exemption from waste management licensing will be required prior to emplacement taking place.

15.1.10. Public Utilities

There are utilities on the site which may require diversion and/or removal depending upon the finalised development proposal. All information is presented in Appendix 6.

15.1.11. Decommissioning of Boreholes

It is recommended that all boreholes are reinstated in accordance with SEPA Guidance on "Decommissioning Redundant Boreholes and Wells" i.e. with materials of similar permeability to the existing soils to allow the backfilled borehole to mimic the surrounding natural strata with the intention that groundwater flow and quality will be protected prior to the development being undertaken. This guidance is presented in Appendix 5.

16.0 Conclusions and Recommendations

Environmental

The exploratory investigations (Phases I and II) and subsequent laboratory testing has identified that there are no contaminants above recognised thresholds and therefore no envisaged Source-Pathway-Receptor relationships in the completed residential development from site soils.

No Gas Defence System is required for the development due to the low gas concentrations monitored and the low flow rates identified during the gas monitoring. The pathway risk from offsite sources of ground gas to the site will be prevented due to the presence of very shallow rockhead, the distance to the potential source and the presence of preferential pathways for the gas to vent should it be generated from the offsite sources i.e. roads and services. These significantly reduce the risk of a complete pollutant linkage being present. For these reasons the risk from ground gas and vapours is considered to be very small, however the site is present within a Radon Affected Area. New dwellings must include '***Stage 1 Radon Protection Measures***' in accordance with BRE 376.

A low Oxygen environment has been identified at the site. Trenches and sub-surface excavations should be treated as low Oxygen hazardous environments for humans.

Based on the existing analysis and the Desk Study identifying the site as '*Greenfield*' no upgrading of the water pipework will be required in the proposed development (**i.e. PVC** or **PE** will be acceptable) however, Scottish Water should confirm this assessment.

Geotechnical

Shallow rockhead was encountered across the northern and central sections of the site. It is considered in these areas (dependent upon finalised levels) that there may be the requirement either for excavation into rock or earthworks to modify the existing levels to allow for the installation of infrastructure.

Northern and Central Section Foundations

It is anticipated conventional nominal reinforced concrete strip and pad footings of normal proportions bearing on the undisturbed granular deposits or shallow rockhead would be the preferred foundation solution to support lightweight structures without excessive settlements.

Southern Section Foundations

It is recommended that foundations in the Southern Section of the site be set as high as possible on the loose Sand and the site development proposals should take account of this. The bearing capacity of the natural materials should be improved locally where necessary by compaction of the loose material and incorporation of a 300mm thick layer of compacted imported fill below the foundation. It is also recommended that further investigation is undertaken in this area by a suitably qualified engineer on a plot by plot basis.

If the final development levels are raised above current levels the increased load may induce settlement within the silt/cohesive deposits. This should be assessed by a suitably qualified engineer following finalisation of the development levels.

Laboratory testing of the granular deposits have indicated that the materials in the Northern and Central Sections of the site would be suitable for re-use as an engineering material with appropriate treatment. The silt/cohesive deposits located in the Southern Section of the site are considered unlikely to be suitable for re-use as an engineering fill however, they may be suitable in non-structural areas (i.e. out with proposed foundations, load bearing slabs or access roads/pavements).

Buried concrete should be designed to **AC-2z, DS-1**.

In-situ CBR testing indicates low to moderate values (0.2%- 38.0%).

Should materials require to be removed from site, they must be disposed of at an appropriately licensed facility and all associated documents should be retained in accordance with current guidance.

Groundwater was present at surface in the area adjacent to the Pheppie Burn. This would indicate that the surface water drainage in the area may be insufficient to allow these areas to drain. This may present a constraint both to the final development, if it is to remain at its current level and during construction excavations/development works.

The infiltration rates associated with the natural soils were overall classified as ‘very low’, however, SA09 in the central eastern area showed ‘moderate’ result.

It is recommended that all boreholes are reinstated in accordance with SEPA Guidance on “*Decommissioning Redundant Boreholes and Wells*” prior to the commencement of site works.

Appendix 1

Drawings

72054/9014 Site Location Plan

72054/9005 Preliminary Conceptual Site Model

72054/9027 Ground Investigation Location Plan

72054/9030 Surfer Plot of Depth to Rockhead

72054/9033 Geological Cross Sections

72054/9035 CBR Test Results

72054/9037 Updated Conceptual Site Model

72054/9038 Infiltration Test Results

72054/9039 Cohesive and Granular Superficial Deposits

72054/9040 Site Foundations

Appendix 2

Associated Reporting

Fairhurst Geo-environmental Desk Study Report: Phase 1A Development Site Issue 1 (August 2011)

ERS Factual Report - Ground Investigation at Chapelton, Aberdeenshire (Phase1A)

Fairhurst Phase II Ground Investigation Factual Report

Appendix 3

Principles of Environmental Risk Assessment