Sheriffhall South East

Report on Site Investigations

BUCCLEUCH PROPERTY

QUATTRO CONSULT

MASON EVANS

Geo-Environmental Consultants

SHERIFFHALL SOUTH, MIDLOTHIAN

REPORT ON SITE INVESTIGATIONS

DATE

September 2021

CLIENT

Buccleuch Property (Shawfair) Limited C/O Quattro Consult

www.masonevans.co.uk

Buccleuch Property (Shawfair) Limited C/O Quattro Consult

SHERIFFHALL SOUTH, MIDLOTHIAN

REPORT ON SITE INVESTIGATIONS

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EXECUTIVE SUMMARY

Client	**Buccleuch Property (Shawfair) Limited**
Site	Sheriffhall South, Midlothian
Project Objectives	• To investigate the possible presence of ground contamination associated with the historical uses of the site and any potential associated risks. • To investigate the ground conditions and provide recommendations on foundation and infrastructure design. • To provide recommendations (if any) for additional works/remediation required.
Assessment of Risks to Human Health, Plant Life & the Water Environment	The GRQA has identified no toxic contaminants at concentrations above guideline values. In addition no asbestos was identified from samples collected across the site Therefore, the risk to human health was considered to be low. Phytotoxic zinc, copper and nickel were identified at concentrations above the BS3882:2015 screening values in the made ground obtained from the central and southern site areas. Therefore, we consider the phytotoxic risk at these locations to be moderate. No phytotoxic exceedances were recorded across the remainder of the site and therefor, outwith the made ground, the general phytotoxic risk is considered to be low. Several contaminants were present above current guidelines values within the leachate and groundwater samples tested. However, modelling was undertaken and the overall risk to the Water Environment is considered to be low.
Assessment of the Built Environment	Samples analysed for pH and sulphate are generally below BRE thresholds. No UKWIR samples were collected during this investigation. It is recommended that UKWIR samples are collected and analysed, when development layouts and levels are finalised, with the recommended water supply pipe to be confirmed by Scottish Water.
Assessment of Ground Gas	Based on the results of the gas monitoring undertaken, gas preclusion measures will be required in the proposed development corresponding to *'Characteristic Situation 2'*.
Foundation Construction	Where present, an allowable bearing capacity of at least 100 kPa is estimated for the medium dense or denser, granular deposits which are conjectured to be present at depths of between approximately 0.30 m and 4.55 m below existing ground levels. The depth to a suitable foundation bearing horizon (where present) is shown on Drawing No. P20/504/SI/R/F/10. It is concluded that abnormal foundations, likely involving vibro-compaction or piling to the underlying competent strata will be required across the southern and eastern site area. The suitability of the soils for vibro-compaction would require to be confirmed by specialist contactors. If confirmed to be appropriate, vibro-compaction should be able to provide a uniform foundation layer at the site for suitably reinforced shallow foundations designed to an allowable bearing capacity of approximately 100 to 125 kPa.
Mining	Mining instability constraints are not considered to pose a risk to development.
Radon	Radon protection measures are not considered necessary within proposed development.

1.0 INTRODUCTION

1.1 Commission

1.1.1 Mason Evans (ME) were commissioned by Quattro Consult (the Client's engineer) on behalf of Buccleuch Property (Sheriffhall South) Limited (the Client) to investigate a site located to the north-east of the intersection between the B63925 (Gilmerton Road) and Melville Gate Road, Midlothian, in connection with the proposed development of the site (Drawing Nos. P20/504/SI/R/F/01 and 02). The proposed development layout comprised of commercial and retail premises with areas of soft landscaping and road infrastructure (Drawing Nos. P20/504/SI/R/F/03).

1.1.2 In November 2009, Grontmij was commissioned by Buccleuch Property (Sheriffhall South) Limited (the Client) to produce a Mining Desk Study for a development site at Sheriffhall, Midlothian which covered a larger site area than the current investigations. The purpose of the Desk Study was to review the mineral stability of the site and allow an assessment of its suitability for the proposed use. A Report entitled, "*Buccleuch Property (Sheriffhall South) Mining Desk Study Sheriffhall South"* was provided in February 2010 (Appendix 1).

1.1.3 In 2013, 6 no. intrusive rotary bores were undertaken adjacent to the site by Raeburn Drilling and Geotechnical Ltd on behalf of Grontmij. This was reported in a Geoenvironmental Desk Study & Interpretive Report.

1.1.4 In 2017, Arc Environmental were commissioned by Quattro Consult (the Client's engineer) on behalf of Buccleuch Property (Sheriffhall South) Limited (the Client) to carry out ground investigations at a site immediately adjacent to the current investigations, known as Sheriffhall South Phase 1. A Report entitled, *"Phase 2: Ground Investigation Report Buccleuch Property (Sheriffhall South) Ltd. Proposed Development (Phase 1) Sheriffhall South East Gilmerton Road Lasswade Midlothian"* was provided in June 2017 (Appendix 1).

1.1.5 This Report takes cognisance of the previous investigations undertaken at the site in combination with the recent investigations by Mason Evans for Site 1A and Site 1B (Drawing No. P20/504/SI/R/F/02).

1.2 Investigation Proposals

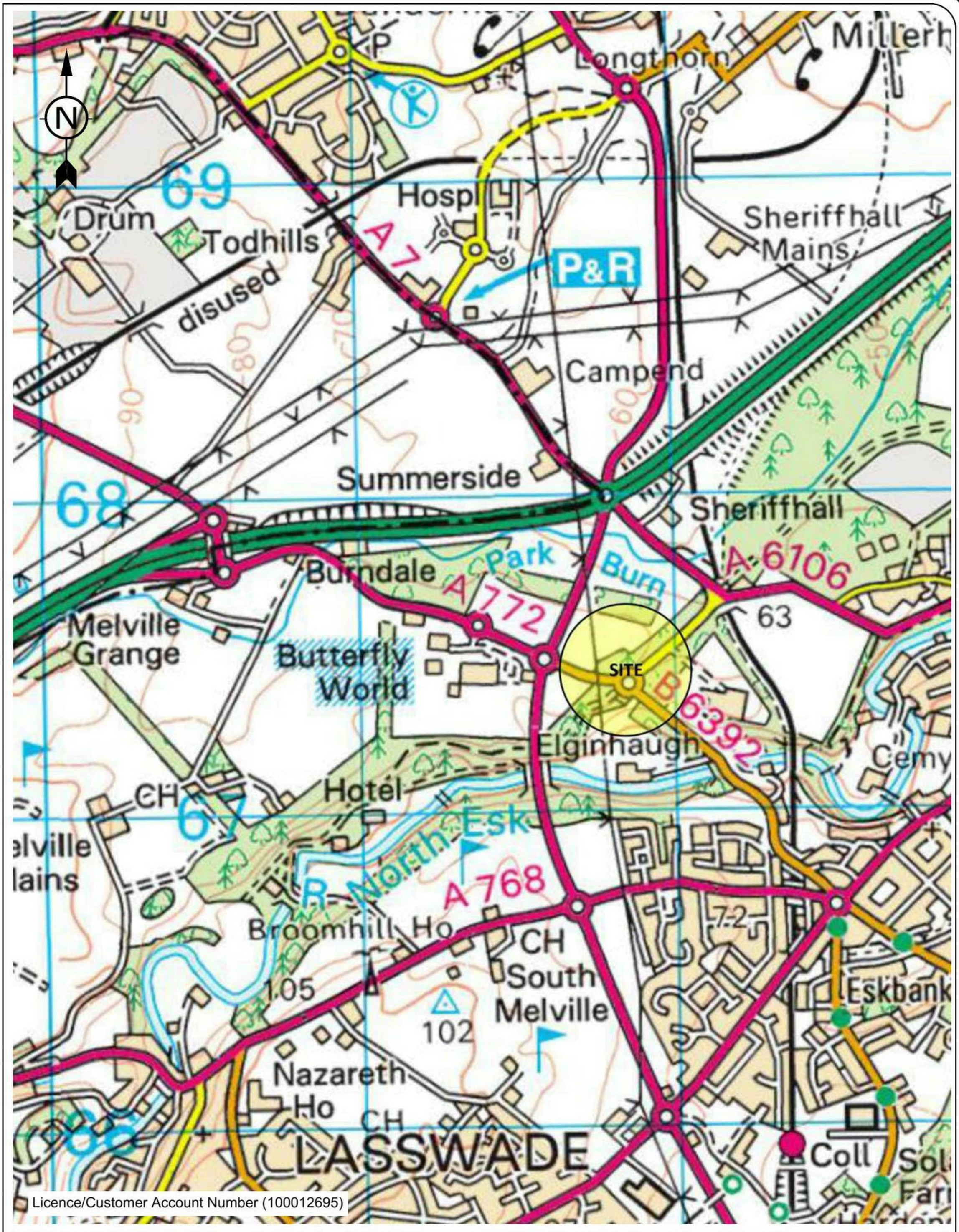
1.2.1 The investigation proposals were outlined in our correspondence to the Client, dated March 2021. The intention of the investigation was to provide further information on the following:

- Soil profile beneath proposed development areas of the site
- Chemical contamination conditions
- Gas emissions
- Geotechnical characteristics of the materials
- Foundation bearing characteristics
- Possible existence of invasive plants
- Mining Constraints

1.3 Limitations

1.3.1 Our interpretations of the ground conditions are based on the information retrieved from the exploratory pits and bores sunk at the site during the investigations. While we have carried out some interpretation of the ground conditions between the exploratory locations, it should be recognised that soil and groundwater conditions can vary from point to point. As such, ground conditions at variance with those indicated by the exploratory pits/bores may exist in areas not investigated.

1.3.2 It should be recognised that this report is prepared in accordance with current recommended practice and existing legislation. It is written in the context of a proposed commercial development. Should there be any alternative end-use, it would be prudent to consult us further to ensure the continued pertinence of the recommendations advised.



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4th FLOOR, 38 THISTLE STREET, EDINBURGH, EH2 1EN

project title: SHERIFFHALL SOUTH
MIDLOTHIAN

drawing title: SITE LOCATION PLAN

project no:	drawing no:	revision:	date:	drawn by:	approved by:	scale:
P20/504	P20/504/SI/R/F/01		11.08.21	RC	NDL	Not to Scale

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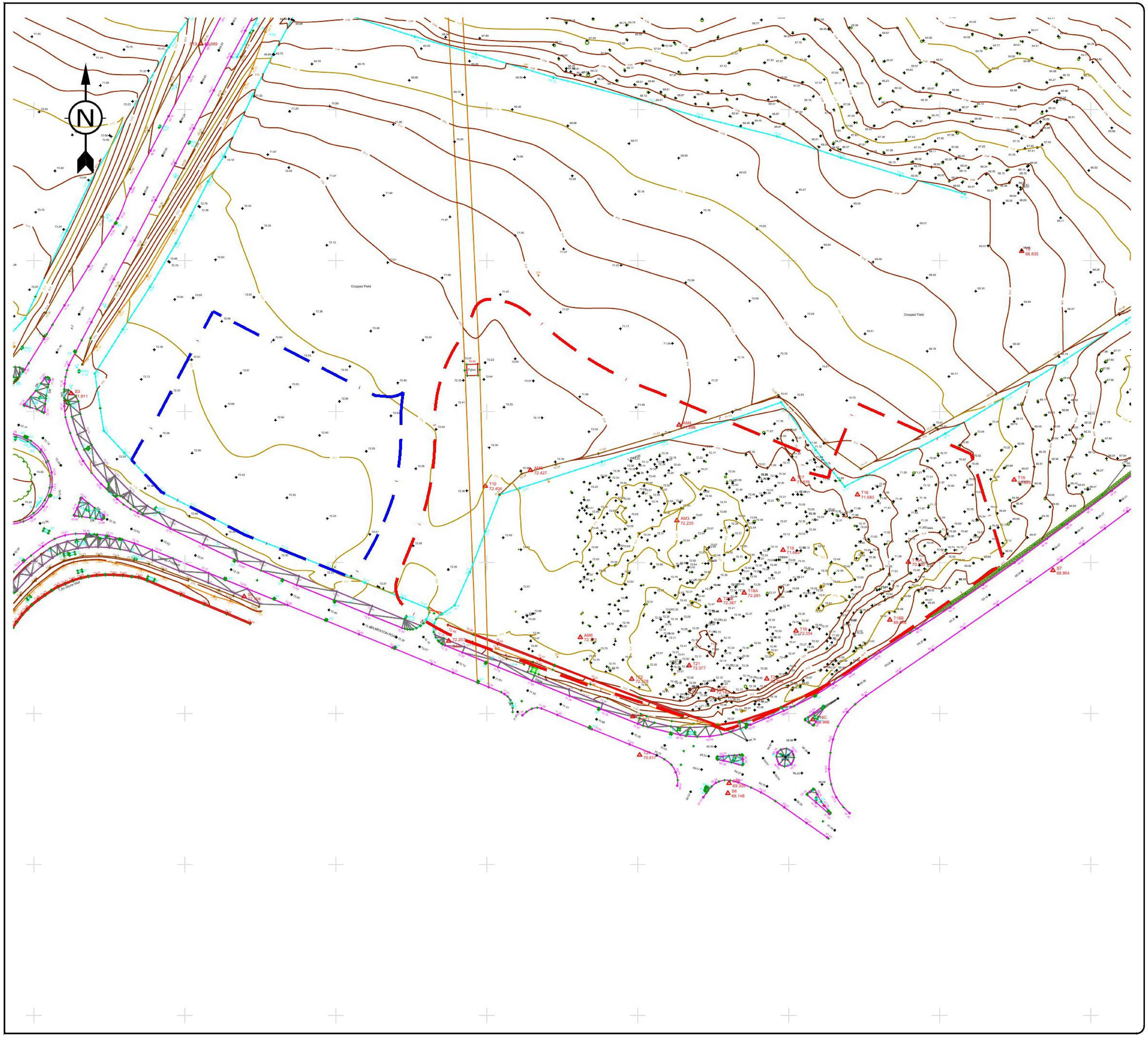

NOTES

Phase 1A site boundary (Previous Investigations)

Phase 1B site boundary (Current Investigations)

REV	DATE	DETAILS

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PROJECT TITLE

SHERIFFHALL SOUTH
MIDLOTHIAN

DRAWING TITLE

STUDY
AREA

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
RC	PJR	NDL	11.08.21	1:1250 @ A3

PROJECT No.	DRAWING No.	REVISION
P20/504	P20/504/SI/R/F/02	

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A3 border: 400 X 273

NOTES

Current Investigation Site boundary

REV	DATE	DETAILS

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PROJECT TITLE

SHERIFFHALL SOUTH
MIDLOTHIAN

DRAWING TITLE

PROPOSED DEVELOPMENT LAYOUT

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
RC	PJR	NDL	11.08.21	1:800 @ A3

PROJECT No.	DRAWING No.	REVISION
P20/504	P20/504/SI/R/F/03	

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A3 border: 400 X 273

2.0 SUMMARY OF DESK STUDY INFORMATION

2.1 The Site

2.1.1 A summary of the current site conditions as understood from the supplied survey information and site reconnaissance is included in Table 1. A site walkover was undertaken in March 2021 (included in Appendix 2), an Envirocheck report was procured (Appendix 3) and a review of selected publicly available databases was undertaken (Appendix 4). A summary of the findings of these researches are included in the table below:

TABLE 1 - Site Details and Review of Public Records

Site Name	Sheriffhall South
National Grid Ref.	331850, 667480
Site Area	Approx. 2.7 Ha
Topography	Generally flat lying, however undulating ground was noted within the current wooded area
Current Usage	At the time of the investigation the majority of the site was comprised of vacant land, with mixed woodland located along the southern site boundary and agricultural land to the centre and north. Historically, within the south of the site a Sand Pit (c. 1932 to 1938) was recorded, which appears to have been expanded and infilled as a Refuse Tip (c. 1949).
Proposed Use	The proposed development layout is comprised of a number of business units to host "small and medium enterprises" as well as areas of soft landscaping. Road infrastructure and car parking areas are also listed within the proposed development.
Surface Water Bodies	No surface water bodies were indicated within the immediate vicinity of the site. The nearest identified surface water body to the site is an unnamed river located approx. 180m south of the site. Dean Burn watercourse is recorded 203m north of the site at its closest point. River North Esk was also identified surrounding the site and is located 328m to the south at its closest point. SEPA's Water Classification Hub indicated 'River North Esk (Elginhaugh to confluence with South Esk)' (ID: 3806) to have an overall status of 'Poor' in 2018. Please see Appendix 4 for further details.
Groundwater	SEPA's Water Classification Hub indicated the shallow groundwater beneath the site area to be named 'Dalkeith' (ID: 150552). The most recent SEPA classification sheet, dated 2018, indicated this groundwater body to have an overall status of 'Poor'.
Flooding	The SEPA Flood Maps indicate that the site does not lie within an area with a risk rating for river, surface water, or coastal flooding. However, this statement is considered preliminary, and specialist flood advice should be sought for a detailed assessment of flood risks. Please see Appendix 4 for further details.
Public Register Information	There are no identified Active or Inactive Contemporary Trade Entries recorded within 250m of the proposed development site. No BGS Mineral Sites, Fuel Station Entries, Integrated Pollution Controls, Registered Waste Transfer Site, BGS Recorded Mineral Sites, Man Made Mining Cavity, Fuel Station Entries, Registered Radioactive Substances, Control of Major Accident Hazards Sites (COMAH), or Sites of Special Scientific Interest (SSSI) were recorded within 250m of the proposed development site.

TABLE 1 - Site Details and Review of Public Records (Cont)

Mining	The Coal Authority's Consultants Mining Report (Appendix 5) indicated that past underground mining has taken place beneath the site in the Lady Victoria coal seam, Monktonhall coal seam, and 3 no. unnamed coal seams at depths of between 538 and 753m, with the last recorded workings in 1982. The Lady Victoria seam is understood to dip 8.1° to the east, the Monktonhall 9.4° to the east, and the unnamed seams 21.1° and 7.9° to the east and 7.5° to the north east. The Salters Coal was also indicated to outcrop approximately 43m to the west of the site. The depths of workings provided in the Consultants Coal Mining Report may not relate directly to the site and may be inferred from workings offsite. The coal mining report has suggested that there are "probable unrecorded shallow workings" beneath the site.
Radon	The Envirocheck Report indicates that the property is in a Lower probability radon area (less than 1% of homes are estimated to be at or above the Action Level). No additional radon protective measures are necessary in the construction of new buildings.

2.2 Site History

2.2.1 Information on the site's historical land use was obtained through inspection of available Ordnance Surveys maps at 1:10,560, 1:10,000, 1:2,500, and 1:1250 scale where available, (Appendix 3) dating from 1854 to the present day. A summary of the information is presented below:

TABLE 2 - Site History

OS Map	Description
1854 (1:10,560)	The site layout was indicated to be generally as present, with the site bisected along a roughly north-east to south-west line separating mixed woodland (south and east) and agricultural land (north and west). The current roadways that border the site (B6392 and Melville Gate Road) were indicated to be present in roughly their current positions, although both were unnamed. The surrounding area was indicated to be generally undeveloped farmland and woodland. A pit may have been present approx. 500m south-west, although the map was unclear. A large-scale railway line was indicated to run approx. north-south to the east of the site area, located ~250m from the boundary at its closest point. Sheriffhall was indicated to be located approx. 400m to the north-east of the site.
1895 (1:10,560)	No significant changes on-site. An Old Shaft was indicated approx. 400m north of the site, some cuttings had occurred at Sheriffhall and in the woodland located 300-500m south and south-west of the site (adjacent to the River North Esk). Dalkeith was indicated to have expanded and at its closest was now ~750m south-east of the site area.
1907 (1:2,500)	No significant changes on-site. A pond was indicated approximately 50m to the south of the site. Reservoir (Dalkeith) Water Works were indicated approximately 250m south-west.
1908-1909 (1:10,560)	No significant changes on-site. Dalkeith town had expanded to be within 500m of the site to the south-east.
1932 (1:2,500)	A Sand Pit was indicated to have been excavated in the south of the site within the wooded area. No significant changes off-site within the immediate surrounding area.
1938 (1:10,560)	No significant changes on-site. No significant changes off-site within the immediate surrounding area.

TABLE 2 - Site History (Cont)

1948-1949 (1:2,500)	The area of the Sand Pit was now indicated as a refuse tip. Access to the Refuse Tip was indicated to be from the B6392 road to the site south-east of the site. No significant changes off-site within the immediate surrounding area.
1958 (1:10,000)	The Refuse Tip was no longer indicated to be present on-site and the south of the site was indicated to be completely wooded. Melville Nurseries were indicated in former agricultural fields to the south and west of the site. Buildings and associated infrastructure were indicated to have been constructed for the nurseries to the west only, located approximately 200m to the west of the site at the closest point. A dovecot was indicated within Sheriffhall,
1978 (1:10,000)	No significant changes on-site. The Railway to the east of the site was indicated to be "Dismantled". Dalkeith was indicated to have expended to the west.
1990 (1:2,500)	No significant changes on-site. Outline of the A7 roadway was indicated as under construction.
1993 (1:10,000)	No significant changes on-site. Melville Nurseries were indicated to have expanded south and east. Offices were indicated to have been constructed ~200m south-east of the site at closest, with associated infrastructure (entrance roadway) connecting to Melville Gate Road adjacent to the easternmost edge of the site. A7 roadway and A720 (later Edinburgh Bypass) were indicated, with the closest point of each to the site area being ~150m west and 400m north, respectively.
2021 (1:10,000)	No significant changes on-site.

2.3 Published Geological Information

Artificial and *Superficial Deposits*

2.3.1 Available geological maps indicate that the superficial deposits underlying the south of the site are comprised of glacial till deposits (Devensian), while the remainder of the site is shown to be underlain by glaciofluvial sheet deposits, typically comprised of sands and gravels (Drawing No. P20/504/SI/R/F/04). Made Ground deposits are anticipated to be found across the site south based on the on-site Sand Pit and later Refuse Tip identified in historical maps series. Historical on- and off-site boreholes suggest that superficial deposits are of variable thickness and are recorded to depths between 1.50 and 17.70m BGL (below ground level) (Appendix 7).

Solid Geology and Mining

2.3.2 Published British Geological Survey maps, presented in Drawing No P20/504/DS/R/F/04, indicate that the rock strata underlying the site are comprised wholly of Scottish Lower Coal Measures Formation (SLCMF) of Carboniferous age. The Scottish Lower Coal Measures Formation typically comprises of "*sandstone, siltstone, and mudstone in repeated cycles with seatclay or seatearth and coal at the top.*"

2.3.3 As with all areas of Coal Mining, local names are often used to name seams which may differ to those used on regional scales. For the purpose of this study, the nomenclature utilised by the Coal Authority has been used. It should be noted that local names have been used within the adjacent Grontmij Investigations. A summary of differing nomenclature for seams within the strata of interest can be found below:

Coal Seam	Correlation
Glass Coal	Whitehill Great Seam
Salters Coal	Whitehill Rough or Diamond
Nine Foot or Barrs Coal	Whitehill Splint
Cowpits Three Foot Coal	Jewel of Whitehill or Parrot Rough
Cowpits Six Foot	Whitehill Jewel
Melville Group	Melville Group

2.3.3 The Coal Authority's Consultants Mining Report (Appendix 5) indicated that past underground mining has taken place beneath the site in the Lady Victoria coal seam, Monktonhall coal seam, and 3 no. unnamed coal seams at depths of between 538 and 753m, with the last recorded workings in 1982. The Lady Victoria seam is understood to dip 8.1° to the east, the Monktonhall 9.4° to the east, and the unnamed seams 21.1° and 7.9°. to the east and 7.5° to the northeast. The Salters Coal was also indicated to outcrop approximately 43.2m to the west of the site. The depths of workings provided in the Consultants Coal Mining Report may not relate directly to the site and may be inferred from workings offsite. The coal mining report has suggested that there are "probable unrecorded shallow workings" at the site.

2.3.4 No mine entries are indicated on site or within the immediate surroundings.

2.3.5 Interpretation of the site hydrogeology requires consideration of the conditions and characteristics of the geological succession both on-site and within the vicinity of it. In this instance, the available information indicated the site to be potentially comprised of three geological units: glacial till, glaciofluvial sheet deposits, and sedimentary bedrock. Where recorded, the typical permeability of these strata are presented in Table 3 below.

TABLE 3 – Typical Material Permeability

Material	Permeability (m^2)	Hydraulic Conductivity (m/sec)
Glacial Till	$10^{-19} – 10^{-13}$	$10^{-12} – 10^{-6}$
Sedimentary Bedrock*	$10^{-17} – 10^{-9}$	$10^{-10} – 10^{-2}$

Source – Freeze and Cherry (1979); * Sedimentary rock class contains combined values for limestone, dolomite, and sandstone.

2.3.6 At the time of the study, surface run-off from the site was assumed to be low given that the site is generally surfaced in topsoil and significant vegetation. Infiltration of surface water is therefore considered to be high, however, this will be largely dependent on the clay content of the glacial till and whether it underlies the glaciofluvial sheet deposits.

2.3.7 As the superficial deposits could potentially allow infiltration, it is considered possible that a shallow groundwater table could occur within the natural soils. If the glacial till is impermeable and underlies the

glaciofluvial sheet deposits, there is the possibility of a perched water table within the sands and gravels of the sheet deposits. The potential for this, and deeper groundwater below rockhead, to interact was considered possible. Lateral migration of shallow groundwater was also considered possible.

2.3.8 It was considered possible that shallow groundwater could exist either within any made ground or natural soils. The Scottish Environmental Protection Agency (SEPA) provides guidance in document WAT-PS-10-01 'Assigning Groundwater Assessment Criteria for Pollutant Inputs' (March 2012) for assessing contamination risks to groundwater and the water environment. It was considered possible that groundwater within the superficial soils beneath the site could potentially meet the minimum criteria to be classified as a water body i.e. an abstraction could achieve 10m^3 per day. Consequently, it was considered prudent to regard groundwater as a potential sensitive receptor at this stage.

2.3.9 SEPA's Water Classification Hub indicated the shallow groundwater beneath the site area to be named 'Dalkeith' (ID: 150552). The most recent SEPA classification sheet, dated 2014, indicated this groundwater body to have an overall status of 'Poor'.

2.3.10 It should be noted that while abstractions from a deeper groundwater body are possible, we are not aware of any records to suggest that abstractions are occurring within the vicinity of the site. In addition, it is not considered that such abstractions would present a risk to the development.

2.4 Preliminary Conceptual Site Model

2.4.1 In order to fully evaluate the potential presence and impact of contamination at the site, the area must be considered in an environmental context taking account of its geology, topography and past and present land-use. Science Report SC050021/SR3, published by the Environment Agency in January 2009, supersedes the previous Contaminated Land Reports (CLR7 to CLR10 and briefing notes) series and provides standard guidance for the assessment of sites that may be contaminated. This essentially highlights the importance of developing a robust *Conceptual Site Model*. The model then forms an integral part of the contamination assessment for the proposed development site, looking at conventional source-pathway-receptor linkages.

2.4.2 Statutory guidance sets the definition of contaminated land within the context of the "suitable for use" approach. It is based on the principles of risk assessment, including the concept of a **pollutant linkage** between a **source** contaminant and a **receptor**, by means of a **pathway.** The presence of all three elements identifies a plausible pollutant linkage. An assessment of the potential sources, pathways and receptors constitutes a conceptual mode for the site. This concept is considered further below.

2.5 Receptor Characterisation

2.5.1 Potential receptors at the site are defined on the basis of the site proposal for low rise commercial units within a business park. The following receptors are considered relevant to his project:

- Humans – site end users and construction workers (outdoor),
- Humans – site end users (indoor),
- Buildings and services (including water supply pipes),
- Vegetation (landscaped areas), and
- Water Environment (groundwater and surface water).

2.6 Source Characterisation

2.6.1 The potential on-site sources of contamination identified by this desk study are:

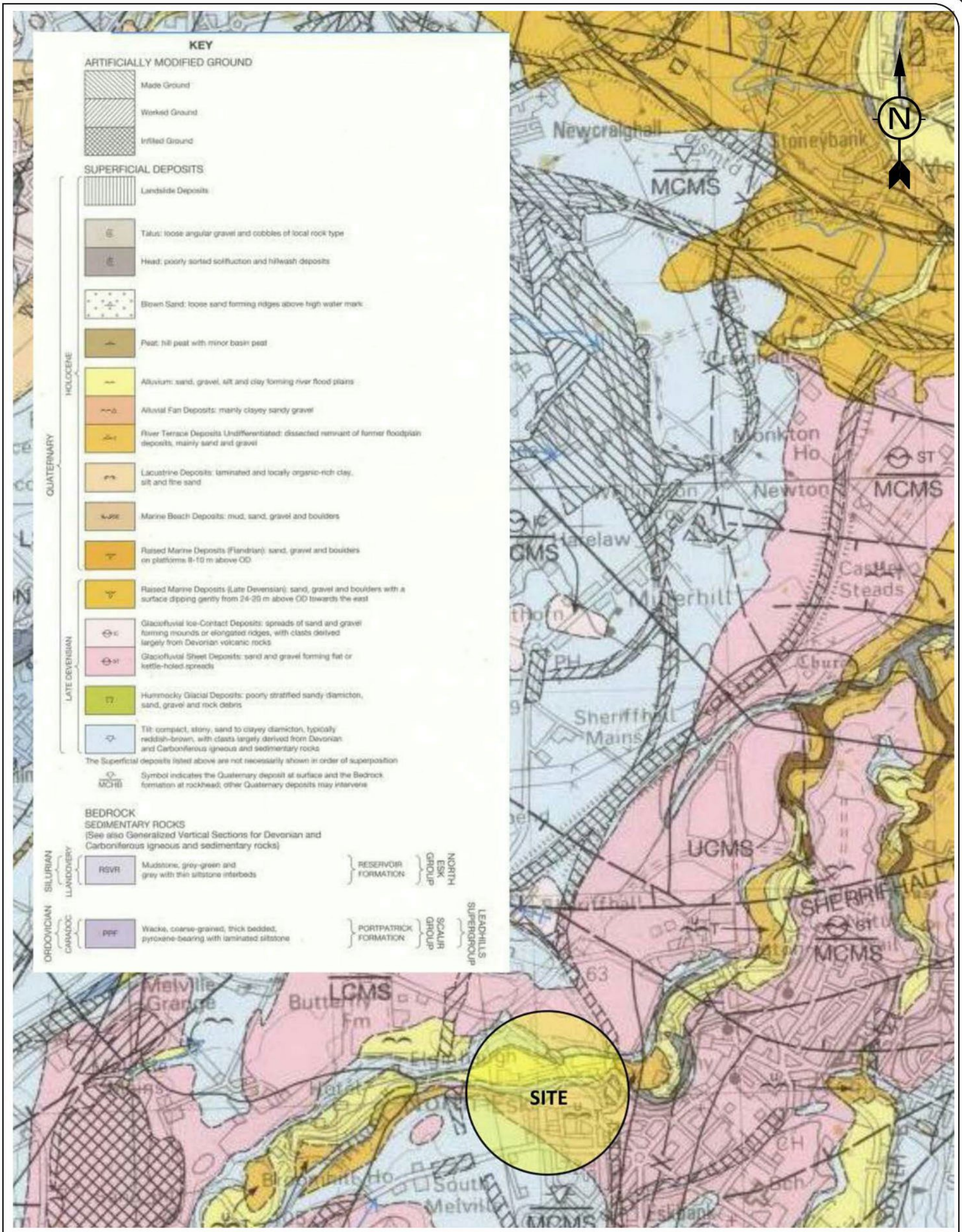
- Deposition of contaminated fill materials associated with the former refuse tip on site.
- Herbicide/Pesticide contamination from on site agricultural activities
- Generation and accumulation of ground gases from organic material within made ground or natural deposits.
- Generation and accumulation of ground gases from mineworkings.

2.6.2 The typical processes involved and associated Contaminants of Concern (COC) are discussed and summarised in Table 4 below:

TABLE 4 - Contaminants of Concern

THE SITE	Industrial Activity / Site Use	Potential Pathways	Associated Potential Contaminants
CURRENT AND PREVIOUS	• Deposition of contaminated fill materials associated with the former refuse tip on site. • Herbicide/Pesticide contamination from on site agricultural activities • Generation and accumulation of ground gasses from organic material within made ground or natural deposits. • Generation and accumulation of gasses from mineworkings.	• Deposition of waste materials, • Generation and accumulation of ground gasses, • Leaching of contaminants to groundwater, • Migration of gases and vapours, and • Spillage/leakage of fuels and chemicals.	Metals: As, Cd, Cr, Ni, Zn, Cu, Hg, Pb Organics: Fuel oils, PAH Miscellaneous: Asbestos, Cyanide Ground Gasses: CO_2, CH_4
IMMEDIATE SURROUNDING AREA	**Industrial Activity/ Site Use**	• **Potential Pathways**	**Associated Potential Contaminants**
CURRENT AND PREVIOUS	• Deposition of contaminated fill materials associated with the roadways adjacent to the site, • Spillages/leakages of fuels/oils associated with the adjacent roadways • Generation and accumulation of ground gasses from organic material within Made Ground or natural deposits off-site. • Generation and accumulation of gasses from mineworkings off site	• Deposition of waste materials, • Generation and accumulation of ground/mine gasses, • Leaching of contaminants to groundwater, • Migration of gases and vapours, and • Leakage/spillage of hydrocarbon products.	Leachates (metals, semi-metals and non-metals) Organics: Fuel oils, PAH, phenol. Ground Gasses: CO_2, CH_4

* It should be noted that the potential contaminants listed above are intended as a guide to the possible contaminant species which may be encountered in such sites, and that other contaminants could potentially be present. The species will, however, be considered in the site assessment and evolution of appropriate chemical testing regime, based upon the findings of the investigations and recommendations of the industry profiles.



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project title:	SHERIFFHALL SOUTH MIDLOTHIAN
drawing title:	EXTRACT FROM PUBLISHED GEOLOGICAL SURVEY MAP (DRIFT & SOLID)

project no:	drawing no:	revision:	date:	drawn by:	approved by:	scale:
P20/504	P20/504/SI/R/F/04		11.08.21	RC	NDL	Not to Scale

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2.7 Pathway Characterisation (Pollutant Linkages)

2.7.1 The pathways by which sensitive receptors may be exposed to potential sources of contamination, as determined by the proposed end use for the site are as follows:

1. Humans – site end users and construction workers (outdoor)

- Dermal (skin) contact with contaminated soil, fugitive dust, and the absorption of contaminants through the skin into the body,
- Inhalation of fugitive soil dust or vapour, and
- Ingestion of soil by hand to mouth activity.

2. Humans – site end users (indoor)

- Inhalation of any ground gas migrating into the buildings, and
- Inhalation of soil derived dust.

3. Buildings

- Potential soil gas generated in the ground vertically migrating and pooling within the structure, and
- Contact with aggressive or acidic soils will affect the concrete design of the foundations.

4. Services including the water supply

- Direct contact with contaminated soil or groundwater,
- Leaching of contaminants through the soil,
- Service trenches acting as preferential migration pathways for contamination, and
- Permeation of plastic water supply pipes.

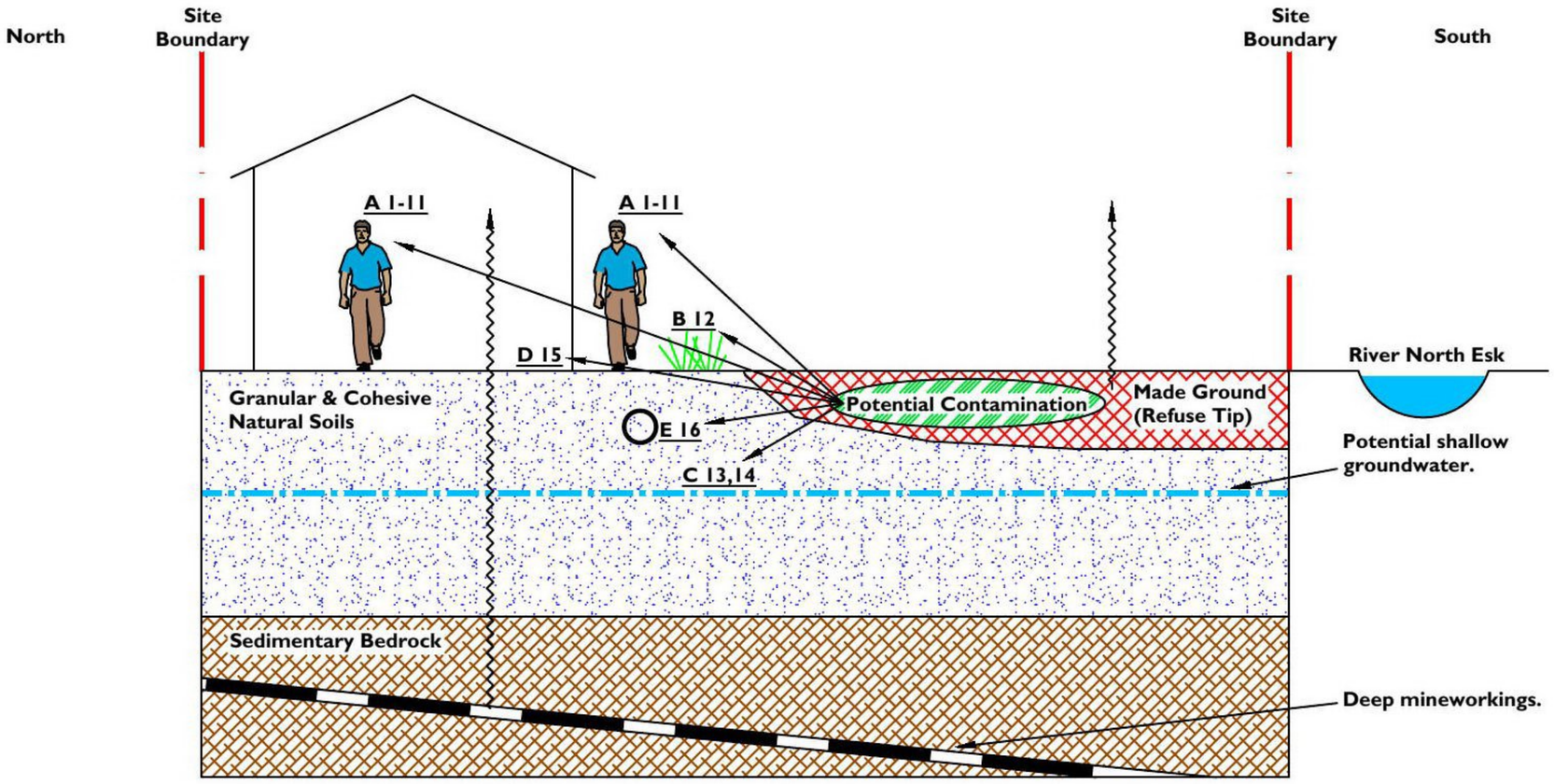
5. Vegetation (soft landscaped areas)

- Direct contact with contaminated soils and groundwater, and
- Uptake of contaminants from the soil or groundwater into vegetation.

6. Water Environment (groundwater and surface water)

- Leaching of contaminants from the soil to groundwater, and
- Contaminant migration offsite in the groundwater.

2.7.2 The potential source-receptor-pathway linkages identified for the site are illustrated within our Preliminary Conceptual Site Model (Drawing No. P20/504/SI/R/F/05) and on Tables 5A and 5B. Site investigations were required to confirm or otherwise the existence of such linkages in addition to providing further confirmation of the geological and geotechnical conditions. It should be recognised that the available documentary research suggests that the risks from any contamination are likely to be low.



Potential Source

- Deposition of contaminated fill materials associated with the former refuse tip on site.
- Herbicide/Pesticide contamination from on site agricultural activities.
- Generation and accumulation of ground gasses from organic material within made ground or natural deposits.
- Generation and accumulation of ground gasses from mineworkings.

Potential Exposure Pathways

1. Outdoor ingestion of dust.
2. Indoor ingestion of dust.
3. Consumption of homegrown vegetables.
4. Ingestion of soil attached to vegetables.
5. Skin contact with outdoor soil.
6. Skin contact with indoor dust.
7. Outdoor inhalation of dust.
8. Indoor inhalation of dust.
9. Outdoor inhalation of soil vapour.
10. Indoor inhalation of soil vapour.
11. Inhalation of ground gases.
12. Contaminant uptake by vegetation.
13. Leaching of contaminants to the groundwater.
14. Contaminant migration in the groundwater.
15. Detrimental effects on buried concrete.
16. Permeation of plastic water supply pipes.

Potential Receptors

A. Site users / construction personnel.
B. Vegetation / fauna.
C. Groundwater.
D. Buried concrete (Service and foundations)
E. Plastic water supply pipes.

NOTES

REV	DATE	DETAILS

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PROJECT TITLE

SHERIFFHALL SOUTH
MIDLOTHIAN

DRAWING TITLE

PRELIMINARY CONCEPTUAL SITE MODEL

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
RC	PJR	NDL	12.08.21	Not to Scale

PROJECT No.	DRAWING No.	REVISION
P20/504	P20/504/SI/R/F/05	

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TABLE 5A - Preliminary Qualitative Risk Assessment – On-site

Source	COCs	Pathway	Receptors (s)	Assessment	Further Investigation Required
1. Deposition of contaminated fill materials associated with the former refuse tip on site. 2. Herbicide/Pesticide contamination from on site agricultural activities 3. Generation and accumulation of ground gasses from organic material within made ground or natural deposits. 4. Generation and accumulation of gasses from mineworkings.	Metals, semi-metals and non-metals: As, Cd, Cr, Ni, Zn, Cu, Hg, Pb Organics: Hydrocarbons, PAH Anions: Cyanide, Sulphate Ground gasses: CO_2, CH_4 Asbestos	Dermal contact, ingestion, inhalation	Human – site workers Humans – end users (outdoor)	Spillage/leakage of contaminants impacting near surface soils (likely historic only). Contaminated materials may have been deposited within the site (historic Refuse Tip).	Yes
		Leaching through soil or direct migration	The water environment - groundwater	Contaminants may be leached and potentially mobilised from the soil by percolation and/or shallow groundwater movement.	Yes
		Direct contact, leaching through soil, groundwater migration	Buildings and services	Potential for aggressive chemical environments for concrete due to sulphate and acidic conditions (low likelihood, but cannot be discounted at this stage). Presence of contaminants in soil that may permeate water supply pipes.	Yes
		Gas/vapour inhalation, vertical/lateral migration	Buildings and services Humans – end users (indoor)	Contamination may include gas/vapour producing materials or compounds that could vertically migrate into overlying buildings producing a potentially asphyxiating or explosive environment.	Yes
		Direct contact, uptake	Plants	Direct contact or uptake of contamination from the soil or groundwater could adversely affect any plants grown.	Yes
		Migration in the groundwater	Groundwater	Contaminants could impact the groundwater and migrate offsite.	Yes
		Diffuse source	Surface Water	Contaminants could migrate in the groundwater and act as base flow for more distal surface water bodies.	Yes

TABLE 5B - Preliminary Qualitative Risk Assessment – Off-site

Source	COCs	Pathway	Receptors (s)	Assessment	Further Investigation Required
1. Deposition of contaminated fill materials associated with the former roadways adjacent to the site 2. Spillages/leakages of fuels/oils associated with the adjacent roadways, and 3. Generation and accumulation of ground gasses from organic material within made ground or natural deposits off site.	Metals, non-metals and semi-metals (Leachates): As, Cd, Cr, Ni, Zn, Cu, Hg, Pb Anions: Cyanide, Sulphate Ground gasses: CO_2, CH_4	Dermal contact, ingestion, inhalation	Human – site workers Humans – end users (outdoor)	Spillage/leakage of contaminants impacting near surface soils (spilt fuels and oils from the adjacent roadways). Contaminated materials may have been deposited within the near-site environs (spilt fuels and oils from the adjacent roadways).	Yes
		Leaching through soil or direct migration	The water environment - groundwater	Contaminants may be leached and potentially mobilised by shallow groundwater movement.	Yes
		Direct contact, leaching through soil, groundwater migration	Buildings and services	Potential for aggressive chemical environments for concrete due to sulphate and acidic conditions (low likelihood, but cannot be discounted at this stage). Presence of contaminants in soil that may permeate water supply pipes.	No
		Gas/vapour inhalation, vertical/lateral migration	Buildings and services Humans – end users (indoor)	Contamination may include gas/vapour producing materials or compounds that could vertically migrate into overlying buildings producing a potentially asphyxiating or explosive environment.	Yes
		Direct contact, uptake	Plants	Uptake of contamination from the soil or groundwater could adversely affect plant growth.	No
		Migration in the groundwater	Groundwater	Leachates may migrate either into the site (from the off-site source) or off-site (via an on-site source).	Yes
			Surface water	Contaminants may migrate in the groundwater and act as base flow for more distal surface water bodies, allowing contaminants to migrate significant distance in the surface watercourse.	Yes

3.0 SITE INVESTIGATIONS

3.1 Objectives

3.1.1 The investigations were designed relative to the preliminary conceptual site model and in recognition of the nature of the proposed development. The objectives of the investigation included the determination of:

a) The conjectured distribution and composition of (any) made ground and natural soils.
b) The geological context
c) The groundwater regime.
d) Chemical contamination.
e) Potential foundation solutions.
f) Mining constraints

3.1.2 The investigation was intended to provide coverage across the whole study area, facilitating the collection of sufficient chemical analyses and the installation of gas and groundwater monitoring points. In addition, the investigations were intended to allow the geotechnical characterisation of the site conditions.

3.2 Scope and Methods of Investigations

3.2.1 The scope and method of investigation to fulfil objectives (a) to (e) is summarised in Table 6 below.

TABLE 6 – Mason Evans 2021 Site Investigations Based on Objectives

Objective		Site Investigation
a)	*The conjectured distribution and composition of (any) made ground and natural soils*	11 No. trial pits (TP01 – TP11) excavated by Mason Evans 6 No. hydraulic percussive boreholes (BH01-BH06) sunk by Phoenix Drilling Ltd on behalf of Mason Evans. 4 No. rotary percussive boreholes (R01-R04) with dynamic sampling sunk by Phoenix Drilling Ltd on behalf of Mason Evans.
b)	*The geological context*	
c)	*The groundwater regime*	4 No. rotary boreholes with gas/water monitoring wells (R01 – R04) 6 No. hydraulic percussive boreholes with gas/water monitoring wells (BH01-BH04)
d)	*Chemical contamination*	<u>Soil Contamination</u> Trial pits with soil analysis i.e., 12 samples (2 No. made ground samples and 10 natural samples) recovered from TP01 – TP11 Soils boreholes with soil analysis i.e., 12 samples (6 No. made ground samples and 6 no. natural samples) recovered from BH01 – BH04 and R01 and R02.
d)	*Chemical contamination*	<u>Water Contamination</u> Trial pits with leachate analysis i.e., 12 samples (2 No. made ground samples and 10 natural samples) recovered from TP01 – TP11 Soils boreholes with leachate analysis i.e., 12 samples (6 No. made ground samples and 6 no. natural samples) recovered from BH01 – BH04 and R01 and R02.
e)	*Potential foundation solutions*	All trial pits and exploratory boreholes.
f)	*Mining Constraints*	4 No. rotary percussive boreholes (R01-R05) sunk by GBLE on behalf of Mason Evans

3.3 Summary of Ground Investigation Data

3.3.1 The scope and location of the 2021 investigation was determined by Mason Evans, The sampling was generally untargeted across the site, in order to provide coverage across the whole study area. Where access permitted, targeted sampling was undertaken within the area of the former sand pit and refuse tip. The aim was to facilitate sufficient chemical analysis, the installation of gas and groundwater monitoring points and to characterise the site conditions. The sampling was dictated by the potential contamination risks identified in the Preliminary Conceptual Site Model. Site works were implemented generally in accordance with BS10175:2011+A2:2017. Limited access was available to the south of the site.

3.3.2 The scope and location of the 2017 investigation was determined by Arc Environmental.

TABLE 7a – Mason Evans 2021 Site Investigations

Trial Pits	11 No. trial pits (TP01-TP11) excavated mechanically extended to depths of up to 3.50m and logged by an engineer from Mason Evans.
Hydraulic Percussive Boreholes	6 No. hydraulic percussive boreholes (BH01-BH06) were sunk by Phoenix Drilling on behalf of Mason Evans, to depths of up to 5.20m. Standpipe installations were installed within all the boreholes to allow for a period of gas and groundwater monitoring (BH01-BH06).
Rotary Boreholes (with dynamic sampling)	4 No. Rotary boreholes sunk by Phoenix Drilling Ltd to depths of 35.00mbgl (R01-R04). Standpipe installations were installed within all the boreholes to allow for a period of gas and groundwater monitoring (R01-R04).
Chemical Testing	24 No. samples were tested for a comprehensive range of potential contaminants and leachate analysis (including an asbestos screen and quantification, where applicable).
Geotechnical Testing	In-situ SPT tests were undertaken in all the hydraulic percussive boreholes. Samples collected from the hydraulic percussive tested for a range of geotechnical parameters.

TABLE 7c – Arc Environmental 2017 Site Investigations

Trial Pits	16 No. trial pits (TP01-TP1) excavated mechanically extended to depths of up to 3.50m
Windowless Sampling Boreholes	5 No. hydraulic percussive boreholes (BH01-BH05) were sunk by Arc Environmental, to depths of up to 5.45m. Standpipe installations were installed within 3 no. boreholes to allow for a period of gas and groundwater monitoring (BH01, BH03 and BH04).
Cable Percussive Boreholes	3 No. hydraulic percussive boreholes (CP01-CP03) were sunk by Arc Environmental to depths of up to 15.00m.
Rotary Boreholes	3 No. Rotary open hole boreholes sunk by Arc Environmental to depths of 45.00mbgl (RBH01-RBH03).
Chemical Testing	5 No. samples were tested for a comprehensive range of potential (including an asbestos screen and quantification, where applicable).
Geotechnical Testing	In-situ SPT tests were undertaken in all the percussive boreholes. Samples collected from the boreholes tested for a range of geotechnical parameters.

3.3.2 The trial pits in the 2021 investigations were intended to provide coverage of the proposed development area, in order to define the general nature of the shallow soils and allow selection of representative samples for a comprehensive suite of chemical analyses. Given the proposed end-use of the site, the purpose of the sampling and testing was to identify potential risks to site users and the Water Environment.

3.3.3 The hydraulic percussive borehole investigation was intended to provide geotechnical and hydrogeological data.

3.3.4 The rotary boreholes in the 2021 investigations were intended to identify areas of instability due to historical mineral extraction or to prove that no shallow mining was present, as well as facilitating monitoring of potential mine gas emissions.

3.3.5 The total number of sampling points from the 2021 investigations was 19 No., corresponding to a density of approximately one sampling point every 30m. This was considered appropriate given the nature of the site and the proposed residential development.

3.3.6 Representative samples of the underlying natural and made ground soils were obtained during the 2021 investigation and tested for an appropriate suite of testing associated with the potential risks from the previous site use. Samples sent for analysis were based on the conceptual model and historical activities on the site as per BS10175:2011+A2:2017. Limited access was available to the south of the site. The results of the analyses were utilised in a site-specific risk assessment in accordance with the current UK technical guidance for human health and SEPA guidance for the Water Environment.

3.3.7 All soil samples recovered for chemical analysis during the 2021 investigations were contained in sealed plastic tubs, labelled and stored onsite in cool boxes to maintain natural temperature. In addition, soil samples collected from each sample location were contained in glass amber jars to prevent chemical breakdown as a result of exposure to light and limit absorption of the contaminant to the sample container. The procedure is designed to maintain sample integrity and ensure that the chemical analysis is as representative of the site conditions as possible.

3.3.8 The scope of the chemical testing of soil samples recovered during the 2021 investigation is discussed in detail in section 6.0 of this report.

3.3.9 Properties recorded during logging of the shallow soils included the general composition, strength, material, description, colour, density, state of weathering and any other notable feature. These were generally described in accordance with the guidelines provided by the Code of Practice for Site Investigations BS5930:2015.

3.3.10 Locations of the investigative works are indicated on Drawing No. P20/504/SI/R/F/06 and records of the exploratory holes are included in Appendix 9.

3.4 Investigation Rationale – 2021 Investigations

3.4.1 The findings of our preliminary CSM indicated the potential presence of made ground deposits associated with the former refuse tip and sand pit on site, agricultural activities, as well as potential local development and possible ground/mine gases. Consequently, the sampling strategy for the investigations undertaken was largely

non-targeted across the site to determine the ground conditions throughout the site, as well as to provide geotechnical data. Where access permitted, targeted sampling was undertaken within the area of the former sand pit and refuse tip.

3.4.2 The scope and location of exploratory holes was determined by ourselves, where access permitted. The chemical analysis involved the sampling of any made ground and natural soils at regular depth intervals, to allow for an assessment of the risk to human health as well as to evaluate the risk to potential receptors including vegetation/fauna, groundwater, concrete structures/foundations and/or buried services (i.e. water supply pipes). The analytic schedule was then based on the interpreted origin of the soils and their description, which is consistent with best practice under current contaminated land guidance BS:10175:2011 *'Code of Practice for the Investigation of Contaminated Land'*. As such, we have implemented the following site practices:

- The drilling works have been undertaken by a suitably accredited sub-contractor;

- The geological succession at each trial pit location has been logged by an experienced field specialist and samples taken for laboratory analysis. A visual assessment was made of the geological character and potential contamination, if present. Soil samples have predominantly been taken at approximately 0.5 m intervals, or at a change in lithology, or where evidence of potential contamination impact was observed.

- In selecting the appropriate samples for testing, we have taken cognisance of a number of factors, including the proposed site use. Sampling rationale has been determined in accordance with R&D Technical Report P5-066/TR Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination, as indicated in the table below.

- The scope of the testing implemented considered the interpreted origin of the materials in association with their description. This is consistent with best practice under current contaminated land guidance. The chemical composition of these materials was assessed for a wide spectrum of potential contaminants, comprising a broad range of common organic and inorganic substances primarily of a toxic or phytotoxic nature, and appropriate to the past usage of the site.

- During sample collection, relevant information such as notes of field observations has been logged before transferring the samples to laboratory-prepared sample bottles of appropriate type. Care was also taken to minimise the aeration of samples during transfer to the bottles.

TABLE 8 – Sampling Strategy

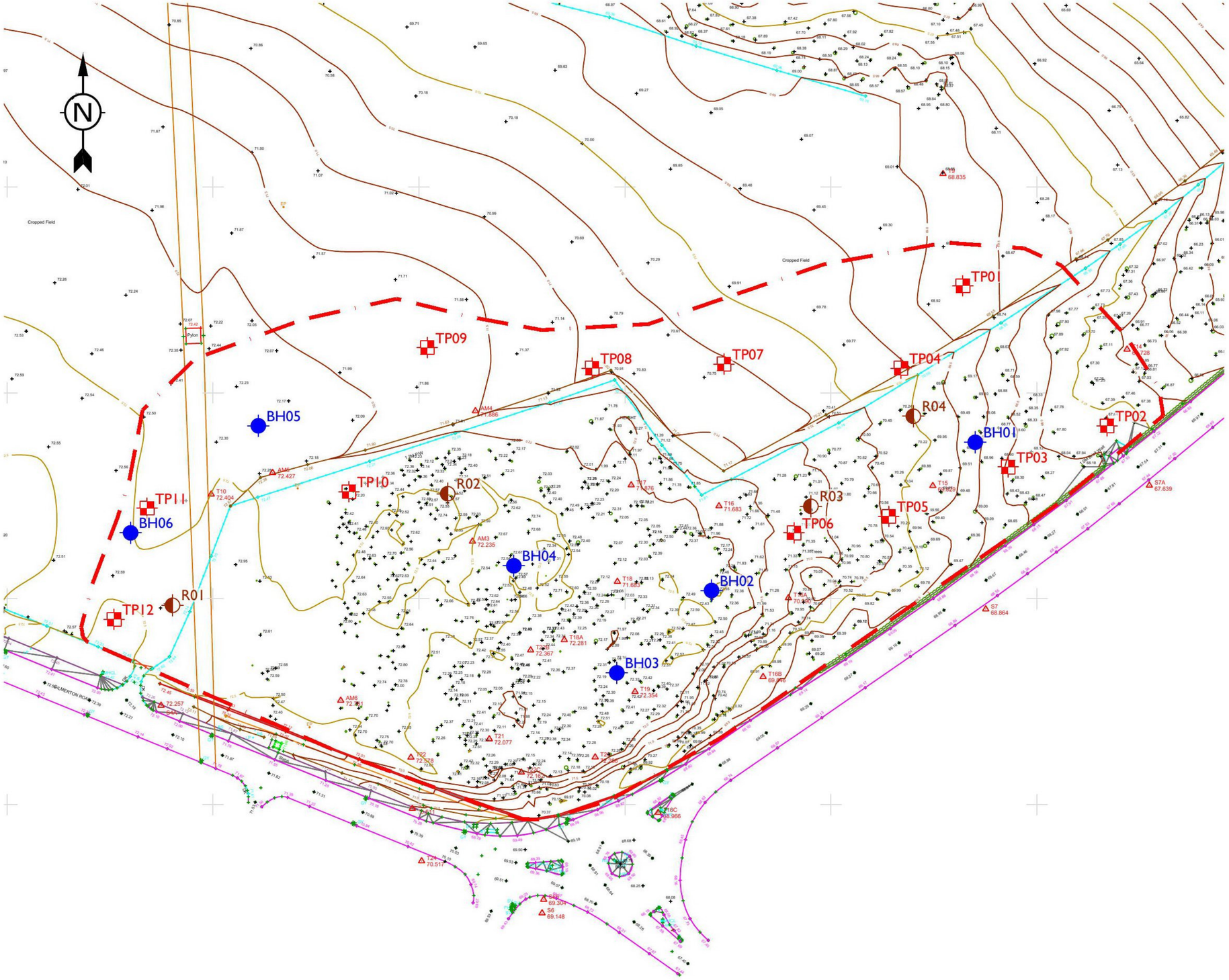
Rationale for Sampling at Different Depths	
Depth Range	**Rationale**
Ground Level – 1.0 m	To assess: • Human/ animal intake arising from ingestion and dermal contact.

	• Potential for wind entrainment leading to inhalation (of contaminated soils and dusts) or deposition onto neighbouring land. • Surface water run-off (e.g. due to flash flooding). • Uptake by shallow rooting plants (e.g. crops, ornamental and wild species). • Surface leaching to groundwater.
>1.0 m in made or natural ground	To assess: • Intake via ingestion/ inhalation/ dermal contact arising from 'abnormal' (or unpredicted) excavation (e.g. children digging dens) or for other purposes such as swimming pools, ponds, house extensions. • Uptake by deep rooting shrubs or trees. • Intake by or arising from the activities of burrowing animals. • Intake arising from construction/ maintenance of buildings and services, for example: a. Foundations (usually within 2.0 m of final formation level). b. Water supply pipes, telecommunications, gas and power (0.5 m to 1.0 m of final formation levels). c. Sewers (from 0.5 m to >1.0 m of final formation level). • To locate perched water of groundwater. • To confirm depth of made ground. • To locate possible lateral pathways for gas or vapour migration in made ground. • To establish the extent of any leaching of soluble constituents from superficial soils. • To detect 'deep' contamination (e.g. gas generating materials, leachable materials, dense solvents located above an impermeable stratum). • To obtain information on 'background' soil properties. • To locate 'natural' lateral migration pathways.

3.4.3 Samples sent for chemical analysis were selected in order to provide site wide analysis and to provide representative coverage of the site. Samples were generally collected within the first meter of soil due to the limited potential for downward migration and the low risk to human health of any contaminants found at greater depths. Please refer to Appendix 8 for a tabulated summary of the soil sampling and analysis strategy for individual exploratory hole locations.

3.5 Analytical Procedures

3.5.1 Analytical procedures adopted during the chemical analyses, carried out on behalf of the consultant, by Derwentside Environmental Testing Services (DETS), conformed to recognised practices, allowing the award of UKAS accreditation (unless indicated otherwise).



NOTES

- Site boundary
- TP01 to TP12 — Trial pits excavated by Mason Evans Partnership (April 2021)
- BH01 to BH06 — Soils boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)
- R01 to R04 — Rotary boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)

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SHERIFFHALL SOUTH
MIDLOTHIAN

DRAWING TITLE

LOCATION OF EXPLORATORY HOLES

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
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P20/504	P20/504/SI/R/F/06	

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4.0 INVESTIGATION RESULTS - 2017 and 2021 Investigations

4.1 Ground Conditions

4.1.1 The ground conditions encountered during the 2021 investigation were generally consistent with the anticipated sequence of strata indicated by the desk study information. The soils were noted to generally comprise of localised made ground overlying granular and cohesive natural deposits.

4.1.2 The results from the 2017 and 2021 investigation are summarised below:

TABLE 9 – Summary of Ground Conditions 2017 and 2021 Investigations

Soil Type	Depth Range (mbgl)
Topsoil	0.00 - 0.60
Made Ground	0.00 - 4.55
Cohesive Natural Deposits	0.30 – 26.00
Granular Natural Deposits	0.20 – 16.00
Sedimentary Bedrock	14.40 – 45.00

4.1.2 Soils Encountered

- **Topsoil** – encountered across the north of the site from the ground surface to a maximum recorded depth of 0.60mbgl. Generally described as dark brown very sandy slightly gravelly clay.

- **Made Ground Deposits** – encountered from the ground surface within the central and southern site areas extending to a maximum recorded depth of 4.55mbgl. These deposits were generally described as black, dark brown very sandy ash with gravel or light brown and orange coarse sand and gravel with frequent extraneous materials such as ash, glass, leather and porcelain. The distribution and thickness of the encountered made ground deposits is included on Drawing No. P20/504/SI/R/F/06. No made ground was recorded during the 2017 investigations.

- **Cohesive Natural Deposits** – cohesive natural soils were encountered across the site at depths of between 0.30mbgl and 14.00mbgl extending to a maximum recorded depth of 26.00mbgl. These deposits were generally described as stiff brown fine to medium slightly sandy sub-rounded gravelly boulder clay or soft light brown/grey very sandy silty CLAY

- **Granular Natural Deposits** – granular natural soils were encountered across the site at depths of between 0.20mbgl and 4.55mbgl extending to a maximum recorded depth of 16.00mbgl. These deposits were generally described as medium dense orange, brown very silty fine to medium SAND with some sub-rounded GRAVEL or medium dense very clayey orange brown SAND.

Rockhead

4.1.3 Definite rockhead was encountered within all of the rotary boreholes at depths of between 14.00mbgl and 26.00mbgl and was generally described as moderately hard sandstone.

Obstructions

4.1.4 No man-made obstructions were encountered during the exploratory works.

4.2 Groundwater

4.2.1 No shallow groundwater ingresses were encountered within any of the 2017 exploratory holes during and on completion of the works. However, within the cable percussive and windowless sampling boreholes, groundwater ingresses/seepages were noted at depths of between 2.80m and 7.50m bgl, with standing levels of between 3.50m and 4.50m within the cable percussive boreholes after 20 minutes. No final standing levels were recorded in any of the boreholes due to the natural collapse of the boreholes on completion and withdrawal of the casing.

4.2.1 Groundwater ingress was encountered in the 2021 soils bores at levels of between 67.35mAOD and 68.37mAOD.

4.2.2 Monitoring wells were installed in BH01 – BH06 during the 2021 investigations to provide a more accurate assessment of the groundwater behaviour and have been monitored on 5 No. occasions (results included in Appendix 10). The results of the groundwater level monitoring, are summarised in the table below:

TABLE 10 - Summary of Groundwater Monitoring Results 2021 Investigation

Location	BH01	BH02	BH03	BH04	BH05	BH05
Minimum Groundwater Level (mAOD)	**67.32**	**Dry**	**Dry**	**Dry**	**68.65**	**69.31**
Maximum Groundwater Level (mAOD)	**67.78**	**Dry**	**Dry**	**Dry**	**69.09**	**69.48**

4.2.3 The water depth results suggest that there may be perched and discontinuous groundwater table beneath the site, generally at levels of between 67.55mAOD and 69.39mAOD. Recharge was indicated to be slow within the boreholes where purging was attempted. We have therefore not classified this as a water body as defined by SEPA Document WAT-PS-10-01 (and supporting guidance WAT-SG-53) as it is considered unlikely to sustain 10m3 per day extraction/supply long term.

4.2.4 Monitoring wells were also installed into the rock strata initially within 4 No. of the rotary boreholes (R01 – R04) to provide a more accurate assessment of the groundwater behaviour within the rock strata and have been monitored on 5 No. occasions to date (results included in Appendix 10). Confirmatory monitoring of the rotary boreholes is continuing at the site and will be reported as an addendum to this report.

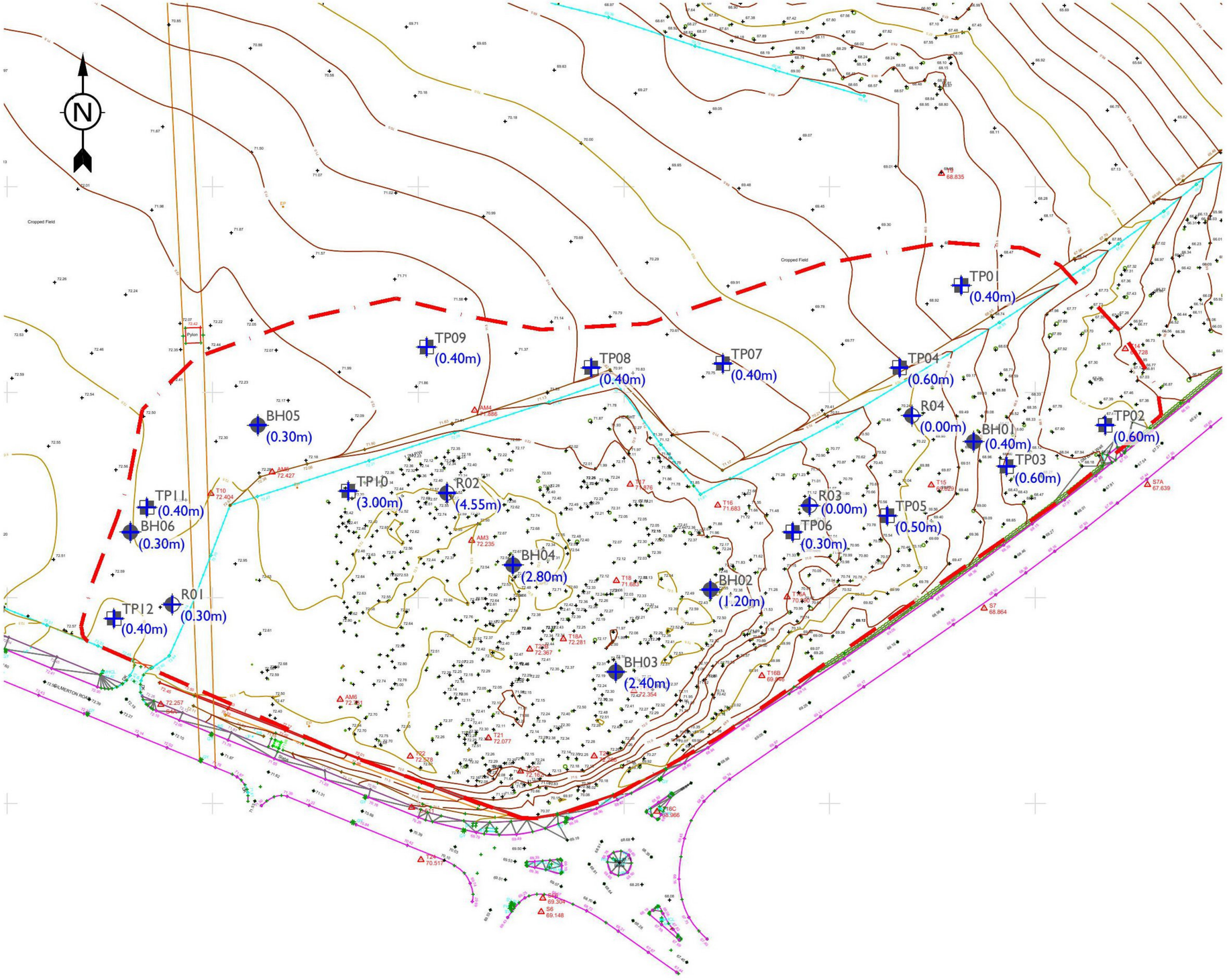
TABLE 11- Summary of Groundwater Monitoring Results within the Rock Strata To Date

Location	R01	R02	R03	R04
Minimum Groundwater Level (mAOD)	**65.48**	**54.59**	**52.21**	**65.81**
Maximum Groundwater Level (mAOD)	**66.04**	**55.73**	**53.07**	**66.01**

4.2.5 The results of the rotary borehole monitoring are similar to those encountered within the soils bores. Given the granular nature of the superficial soils there is potential for any shallow groundwater body to interact with any bedrock aquifer present.

4.3 Visual/Olfactory Evidence of Contamination

4.3.1 Visual evidence of potential contamination was encountered within the made ground strata in the form of brick, ash, glass, leather and porcelain. No olfactory evidence of contamination was noted.



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NOTES

- Site boundary
- TP01 to TP12 — Trial pits excavated by Mason Evans Partnership (April 2021)
- BH01 to BH06 — Soils boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)
- R01 to R04 — Rotary boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)
- (1.20m) — Recorded made ground thickness (m)

REV	DATE	DETAILS

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SHERIFFHALL SOUTH MIDLOTHIAN

DRAWING TITLE

RECORDED MADE GROUND THICKNESS

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5.0 CONTAMINATION RISK ASSESSMENT

5.1 Human Health and Groundwater Risk Assessment Screening Criteria

5.1.1 Consideration of analytical results against applicable, conservative risk-based screening criteria has been used to provide an assessment of risk. A tiered risk-based approach comprises:

- Preliminary Risk Assessment (e.g. establishing potential pollutant linkages);
- Generic Quantitative Risk Assessment (GQRA) (e.g. the comparison of contaminant concentrations against Soil Guideline Values (SGV) or other Generic Assessment Criteria (GAC)); and
- Detailed Quantitative Risk Assessment (DQRA) (e.g. the comparison of contaminant concentrations against site specific assessment criteria).

5.1.2 A GQRA has been carried out as part of this assessment. Soil chemical analysis data has been assessed in terms of risks to human health and vegetation while leachate data has been assessed in terms of risks to the water environment. The GACs utilised are the published Suitable 4 Use Levels (S4ULs) derived by LQM/CIEH, based on the exposure parameters, outlined in the DEFRA publication SP1010 (Category 4 Screening Levels (C4SLs) (March 2014). The S4ULs are derived in accordance with current UK legislation, and national policy using the most recent version of the CLEA software (v1.06). Normally the CLEA software utilises the default exposure pathways and land use assumptions outlined in SR3 (Environment Agency 2009b). In order to implement the revised exposure and land use assumptions introduced by DEFRA publication SP1010, a number of modifications were made to the land use and receptor databases of the CLEA model including the introduction of two additional land use scenarios: Public Open Space 'park' and Public Open Space, near residential housing. These changes are summarised in both DEFRA publication SP1010 (2014), and LQM/CIEH publication S4UL3203 (2015).

5.1.3 The derived S4ULs are based on the concept of minimal tolerable risk as described in SR2 (Environment Agency 2009a) which underpins all previous EA SGVs and other GACs. Please note that S4ULs do not incorporate any toxicological parameter changes to the CLEA base model, however recent toxicological data has been incorporated into the contaminant databases. Furthermore, S4UL GACs are considered to be equivalent to the previously published Environment agency SGVs, and previous iterations of LQM/CIEH GACs and as such are suitable for use in generic quantitative risk assessments under both planning and Part IIa regimes.

5.1.4 In this case we have utilised S4UL values appropriate to the most representative end-use i.e. **commercial.**

5.2 Statistical Analysis of Data

5.2.1 Where appropriate, chemical data for soils can be considered statistically in general accordance with the guidelines given in the Chartered Institute of Environmental Health Publication *Guidance on comparing Soil Contamination Data with a Critical Concentration* (May 2008). In this case statistical analysis has not been undertaken, as the dataset was considered to be relatively small and detailed statistical analysis was considered unnecessary.

Sample Depths

5.2.2 At the generic assessment stage, it should be assumed that all pathways contained within the generic model applied will be active. In reality, unless a contaminant is volatile (e.g. organic), exposure by direct contact will likely be mitigated by the depth of the contaminant or available surface cover. CLEA-SR3 states that 'Whether or not soil contamination at greater depth or beneath hard standing poses a risk to health depends on the importance of the contact pathways (primary injection and dermal contact_ and the likelihood that such soils may be brought to the surface through activities such as gardening and building works'. Generally, direct contact with contaminants at greater than 600 mm depth is considered unlikely to occur while direct contact with contaminants under hardstanding is highly unlikely to occur unless the ground is to be disturbed through removal of surfacing or earthworks.

5.3 Ground Gas Assessment

5.3.1 The potential presence of carbon dioxide and methane being generated at the site has been appraised in compliance with BS8576:2013 and BS 8485 (2015) & A1:2019. This document details site investigations methodologies and risk assessment procedures for assessing the results from such investigations. The risk assessment procedures are primarily based on those detailed by Wilson and Card (1999).

5.4 Building Materials Assessment

5.4.1 BRE Special Digest 1 'Concrete in Aggressive Ground' (3rd Edition, 2005) has been used to determine an appropriate concrete class for the development.

6.0 HUMAN HEALTH RISK ASSESSMENT

6.1 Contaminants In Soils

6.1.1 The results of analysis for a range of contaminants have been compared directly to their respective Generic Assessment Criteria. A summary table of all chemical results is included in Appendix 11.

TABLE 12 - Exceedance of Guideline Levels (Commercial)*

Contaminant	Effect	Measured Concentrations in Excess of SGV/GSV/SSTL (mg/kg)		Measured Exceedance Concentrations (mg/kg)		SGV/GSV/ SSV (mg/kg)	Source
		Natural	Made Ground	Natural	Made Ground		
Arsenic	Toxic	0 out of 13	0 out of 8	-	-	640	LQM/CIEH S4ULs (2015)
Boron	Toxic	0 out of 13	0 out of 8	-	-	240,000	LQM/CIEH S4ULs (2015)
Cadmium	Toxic	0 out of 13	0 out of 8	-	-	190	LQM/CIEH S4ULs (2015)
Chromium III	Toxic	0 out of 13	0 out of 8	-	-	8600	LQM/CIEH S4ULs (2015)
Chromium VI	Toxic	0 out of 13	0 out of 8	-	-	33	LQM/CIEH S4ULs (2015)
Copper	Toxic	0 out of 13	0 out of 8	-	-	68,000	LQM/CIEH S4ULs (2015)
Copper	Phytotoxic	0 out of 13	4 out of 8	-	210 - 1000	135	BS:3882 (2015)
Lead	Toxic	0 out of 13	0 out of 8	-	-	6000	C4SL (DEFRA SP1010) (2014)
Mercury (Inorganic)	Toxic	0 out of 13	0 out of 8	-	-	1100	LQM/CIEH S4ULs (2015)
Nickel	Toxic	0 out of 13	0 out of 8	-	-	980	LQM/CIEH S4ULs (2015)
Nickel	Phytotoxic	0 out of 13	6 out of 8	-	88 - 170	75	BS:3882 (2015)
Selenium	Toxic	0 out of 13	0 out of 8	-	-	12,000	LQM/CIEH S4ULs (2015)
Zinc	Toxic	0 out of 13	0 out of 8	-	-	730,000	LQM/CIEH S4ULs (2015)
Zinc	Phytotoxic	0 out of 13	7 out of 8	-	280 - 830	200	BS:3882 (2015)
Total Sulphate	Phytotoxic	0 out of 13	0 out of 8	-	-	10,000	ICRCL/SAC
Phenol	Toxic	0 out of 13	0 out of 8	-	-	1300	LQM/CIEH S4ULs (2015)
Petroleum Hydrocarbons							
Aliphatic C5-C6	Toxic	0 out of 13	0 out of 8	-	-	12,000	LQM/CIEH S4ULs (2015)
Aliphatic C6-C8	Toxic	0 out of 13	0 out of 8	-	-	40,000	LQM/CIEH S4ULs (2015)
Aliphatic C8-C10	Toxic	0 out of 13	0 out of 8	-	-	11,000	LQM/CIEH S4ULs (2015)
Aliphatic C10-C12	Toxic	0 out of 13	0 out of 8	-	-	47,000	LQM/CIEH S4ULs (2015)
Aliphatic C12-C16	Toxic	0 out of 13	0 out of 8	-	-	90,000	LQM/CIEH S4ULs (2015)
Aliphatic C16-C21	Toxic	0 out of 13	0 out of 8	-	-	1,800,000	LQM/CIEH S4ULs (2015)
Aliphatic C16-C35	Toxic	0 out of 13	0 out of 8	-	-	1,800,000	LQM/CIEH S4ULs (2015)
Aliphatic C21-C35	Toxic	0 out of 13	0 out of 8	-	-	1,800,000	LQM/CIEH S4ULs (2015)
Aromatic C5-C7	Toxic	0 out of 13	0 out of 8	-	-	86,000	LQM/CIEH S4ULs (2015)
Aromatic C7-C8	Toxic	0 out of 13	0 out of 8	-	-	180,000	LQM/CIEH S4ULs (2015)
Aromatic C8-C10	Toxic	0 out of 13	0 out of 8	-	-	17,000	LQM/CIEH S4ULs (2015)
Aromatic C10-C12	Toxic	0 out of 13	0 out of 8	-	-	34,000	LQM/CIEH S4ULs (2015)
Aromatic C12-C16	Toxic	0 out of 13	0 out of 8	-	-	38,000	LQM/CIEH S4ULs (2015)
Aromatic C16-C21	Toxic	0 out of 13	0 out of 8	-	-	28,000	LQM/CIEH S4ULs (2015)
Aromatic C21-C35	Toxic	0 out of 13	0 out of 8	-	-	28,000	LQM/CIEH S4ULs (2015)
PAHs							
Naphthalene	Toxic	0 out of 13	0 out of 8	-	-	1100	LQM/CIEH S4ULs (2015)
Acenaphthylene	Toxic	0 out of 13	0 out of 8	-	-	100,000	LQM/CIEH S4ULs (2015)
Acenaphthene	Toxic	0 out of 13	0 out of 8	-	-	100,000	LQM/CIEH S4ULs (2015)
Fluorene	Toxic	0 out of 13	0 out of 8	-	-	71,000	LQM/CIEH S4ULs (2015)
Phenanthrene	Toxic	0 out of 13	0 out of 8	-	-	23,000	LQM/CIEH S4ULs (2015)
Anthracene	Toxic	0 out of 13	0 out of 8	-	-	540,000	LQM/CIEH S4ULs (2015)
Fluoranthene	Toxic	0 out of 13	0 out of 8	-	-	23,000	LQM/CIEH S4ULs (2015)
Pyrene	Toxic	0 out of 13	0 out of 8	-	-	54,000	LQM/CIEH S4ULs (2015)
Benz(a)anthracene	Toxic	0 out of 13	0 out of 8	-	-	180	LQM/CIEH S4ULs (2015)
Chrysene	Toxic	0 out of 13	0 out of 8	-	-	350	LQM/CIEH S4ULs (2015)
Benzo(b)fluoranthene	Toxic	0 out of 13	0 out of 8	-	-	45	LQM/CIEH S4ULs (2015)
Benzo(k)fluoranthene	Toxic	0 out of 13	0 out of 8	-	-	1200	LQM/CIEH S4ULs (2015)
Benzo(a)pyrene	Toxic	0 out of 13	0 out of 8	-	-	36	LQM/CIEH S4ULs (2015)
Indeno(1,2,3-c,d)pyrene	Toxic	0 out of 13	0 out of 8	-	-	510	LQM/CIEH S4ULs (2015)
Dibenz(a,h)anthracene	Toxic	0 out of 13	0 out of 8	-	-	3.6	LQM/CIEH S4ULs (2015)
Benzo(g,h,i)perylene	Toxic	0 out of 13	0 out of 8	-	-	4000	LQM/CIEH S4ULs (2015)
Other							
Asbestos	Toxic	0 out of 13	0 out of 8	-	-	Detection	HSE

* Based on SOM of 6%. Average SOM recorded as 9.73 %
** Based on an average pH of 6.96 (6 - 7)

6.1.2 The GRQA has identified no toxic contaminants at concentrations above guideline values.

6.1.3 It should be noted that all of the results from the 2017 investigations are within the range of the results from the 2021 investigation with the exception of Chromium, with the max recorded concentration being 98mg/kg. This is also below the assessment criteria of 8600mg/kg. The results of the 2017 chemical analysis are included in Appendix 1.

6.1.3 In addition, no asbestos was recorded within any samples tested.

6.2 Pesticide/Herbicide Screen

6.2.1 A pesticide/herbicide screen was also undertaken on 3 No. samples (BH01, BH05 and TP08) obtained from the north of the site. Pesticides/herbicides were anticipated to have been used within the site due to its agricultural usage.

6.2.2 The results of the testing indicate that the values recorded are all below the limits of detection. Therefore, pesticides and herbicides are not considered to pose a significant risk to the proposed development.

7.0 WATER ENVIRONMENT RISK ASSESSMENT

7.1 Water Environment Vulnerability

7.1.1 No surface water bodies were indicated within the immediate vicinity of the site. Therefore, the nearest surface water body to the site was considered to be the River North Esk (Elginhaugh to confluence with South Esk) located approximately 330m to the south (at its closest point). SEPA's Water Classification Hub indicated the River North Esk to have an overall status of 'Poor' in 2018.

7.1.2 It was also considered that a perched and discontinuous shallow groundwater table exists beneath the site, generally at levels of between 52.21mAOD and 69.39mAOD (based on 5 No. rounds of groundwater monitoring). However, this groundwater was considered to be of low productivity due to slow recharge. As such, the groundwater table beneath the site was not considered to be a water body as defined by SEPA Document WAT-PS-10-01 (August 2014) and supporting guidance WAT-SG-53 (December 2015) as it is unlikely to sustain 10 m3 per day extraction/supply long term.

7.1.3 Based on the above information, we have taken the River North Esk as the most sensitive Water Environment receptor with regards to the subject site.

7.2 Surface Water Assessments

7.2.1 Following SEPA Position Statement WAT-PS-10-01, *'Assigning Groundwater Assessment Criteria for Pollutant Inputs'* (August 2014), the following assessment should be carried out for potential pollutant linkages to the Water Environment:

1) Assess which receptors (including surface / coastal waters, wetlands, potable water extractions, and future drinking water potential) may be affected by contamination sources.
2) For potential pollutant linkages, assess contaminant concentrations against relevant screening values at the recommended assessment point, taking into consideration mixing and upstream/upgradient concentrations, where appropriate.
3) Evaluate whether remedial measures would be either disproportionately costly, a risk to other receptors, or cause deterioration of the natural environment.

7.2.2 Leachate testing as carried out across the site to determine the risks posed, if any, by the on-site conditions (if any) to the water environment (results included in Appendix 11). Leachate testing of TPHs and PAHs was not undertaken, as by their very nature, TPHs and PAHs are very leachable and would present themselves in samples of the groundwater.

7.2.3 However, groundwater samples could not be obtained from any of the bores tested due to slow recharge rate.

7.2.4 All leachate results have been compared to the appropriate guideline values (Tables 13). Where surface water is considered a primary risk, as is the case in the instance, Environmental Quality Standards are used (EQSs) as obtained from SEPA document WAT-SG-53 (December 2020). In the absence of any SEPA published EQS we have reverted to the laboratory Limits of Detection, as recommended in SEPA position Statement WAT-PS-10.

Surface Water Assessment

7.2.5 The nearest surface water body, the River North Esk, is considered a sensitive receptor and therefore leachate results have been compared to the relevant assessment criteria as detailed above and as shown in Table 13.

TABLE 13: Analysis of Leachate Samples Compared with Environmental Quality Standards

Potential Contaminant	Environmental Quality Standard (µg/l)	Limits of Detection (µg/l)	No of Samples Above Assessment Levels	Range of Concentrations which Exceeded Relevant Guidelines mg/l
Metals				
Arsenic	50	-	0 out of 21	
Cadmium*	**<0.08**	**-**	**2 out of 21**	**0.1 – 0.26**
Chromium III	4.7	-	0 out of 21	
Copper (toxic)	**1**	**-**	**12 out of 21**	**1.1 - 18**
Lead	**1.2**	**-**	**9 out of 21**	**1.3 - 19**
Mercury (inorganic)	0.07	-	0 out of 21	
Nickel (toxic)	**4.0**	**-**	**1 out of 21**	**4.4**
Selenium**	**-**	**0.25**	**9 out of 21**	**0.44 – 1.9**
Zinc (toxic)	**11.9**	**-**	**8 out of 21**	**12 -180**
Inorganics				
Sulphate as SO4	400 (mg/l)	-	0 out of 21	-
Phenols				
Phenol	7.7	-	0 out of 21	-

* Based on an average water hardness of 19.2 mg/l

** Most conservative Limit of Detection value used as no reporting value was available in the WAT-SG-53 (2020) document.

7.2.6 Against current guideline values, the leachate testing identified exceedances of the contaminants cadmium, copper, lead, nickel, selenium and zinc.

Interpretation of Results

7.2.7 Cadmium, copper, lead, nickel, selenium and zinc were identified at concentrations which may pose a risk to the surface water environment. However, it should be noted that for the purpose of this assessment, we have utilised the leachate analysis results as groundwater samples were not available to assess surface water risk.

7.2.8 Most EQS's for metal in water are based on the amount of the contaminant that is bioavailable in the water. Consequently, to assess the risk posed by copper and zinc to the surface water environment we have utilised the UKTAG River and Lake Assessment Method Specific Pollutants (Metals) Bioavailability Assessment Tool (M-BAT) by the Water Framework Directive – United Kingdom Technical Advisory Group (WFD-UKTAG), 2014. The tool predicts the bioavailable concentration of copper, nickel and zinc (and other metals) based on site conditions including pH, calcium and dissolved organic carbon (DOC). pH and DOC were not tested for during the leachate analysis. Therefore, we been conservative in our assessment and used a DOC value of 10 mg/l and utilised the pH from the relevant soil samples tested. Utilising the M-BAT, the results indicate that the bioavailable concentrations of copper and nickel were below the respective EQS value of 1.0 ug/l and 4.0 ug/l indicating that copper and nickel are considered to pose a low risk to the surface water environment. The results also indicated that the bioavailable concentration of zinc was below the EQS value of 11.9 ug/l with the exception of BH02 at 0.50m and BH04 at 1.00m indicating that, outwith the aforementioned positions, zinc is considered to pose a low risk to the surface water environment (Appendix 12).

7.2.9 The Lead Screening Tool was utilised to predict the potential risk pose by lead to the aquatic environment (model included in Appendix 13). Again, a conservative DOC value of 10 mg/l was utilised in our assessment. The results of the model indicate that the bioavailable concentrations of lead are below the EQS value of 1.2 ug/l with the exception of BH01 and BH02. As such, outwith the aforementioned locations, lead is not considered to pose a significant risk to the surface water environment.

7.2.10 Groundwater modelling of cadmium, zinc (bioavailable), lead (bioavailable) and selenium was undertaken to assess the potential risk of these contaminant to the water environment. We utilized RD P20 RTM (V3.2) published by the Environment Agency in our assessment and a copy of the models are included in Appendix 13. Any groundwater flow was unknown but anticipated to be towards the north east. We have utilised the distance from the contamination source to the nearest surface water body (i.e. the River North Esk) along the approximate direction of groundwater flow in our assessment. We have also assumed a sandy gravel as the main constituent of the aquifer material. The model was run for each of the contaminants that were recorded to exceed EQSs or LOD's. The results of the modelling are shown in Table 14.

TABLE 14 – Results of P20 Groundwater Modelling (compliance point – River North Esk)

Contaminant	Maximum Recorded Exceedance (µg/l)	Target Value (µg/l)	Target Value Source	Final concentration (µg/l)
Selenium	1.90	0.25	LoD	0.0105
Cadmium	0.26	<0.08	WAT-SG-53 (2020)	0.00143
Zinc (Bioavailable)*	64.47	11.9	WAT-SG-53 (2020)	0.355
Lead (Bioavailable)*	1.9	1.2	WAT-SG-53 (2020)	0.066

* Bioavailable concentrations

7.2.11 Modelling to the River North Esk, the final concentration of the contaminants cadmium, zinc (bioavailable), lead (bioavailable) and selenium were recorded to be lower than the target concentrations. Therefore, these contaminants are considered to pose a low risk to the nearest surface water body i.e. the River North Esk.

7.3 Conclusions

7.3.1 As demonstrated through chemical analysis and groundwater modelling, the proposed development is not considered to pose a significant risk to the Water Environment. This is consistent with the lack of a significant contamination source and the absence of a pervasive shallow groundwater body.

8.0 GROUND GAS EMISSIONS

8.1 General

8.1.1 A ground gas assessment has been undertaken to assess risks to new buildings and their users associated with carbon dioxide and methane. Due to the presence of former mine workings, as well as the possible presence of organic material within the made ground soils (e.g. decomposed wood fragments), a ground gas assessment was undertaken to assess the risks associated with carbon dioxide and methane to new buildings and their users.

8.1.2 The assessment of risk due to ground gases has been further discussed in publications for CIRIA and BRE, which have indicated a number of 'characteristic situations' depending on the concentrations and flow rates of gas. This classification system has been further developed by Wilson and Card (1999), and Boyle and Witherington (2006) and a revised industry guidance has been provided within CIRIA Report C665 (2007) and BS 8485 (2015) & A1:2019

8.1.3 The gas monitoring data was reviewed and a risk assessment prepared in line with BS 8485 (2015) & A1:2019 whereby a scoring system is used to design suitable gas preclusion measures.

8.1.4 Combined ground gas & groundwater monitoring standpipes were installed at the locations of boreholes BH's 01, 03, & 04 during the 2017 investigation primarily to determine the ground gas regime for the site, however water levels were also observed during each visit.

8.1.5 Only 2 no. visits had been undertaken at the time of the 2017 report. These are within the range of values recorded during the 2021 investigations and the 2021 Gas Risk Assessment (below) is considered to supersede the 2017 investigations (Appendix 1).

8.2 Ground Gas – Results

8.2.1 Ground gas standpipes were installed within soils boreholes BH01-BH06, and within rotary boreholes R01-R06 and have been monitored on 5 no. occasions to date, using a portable gas meter. Confirmatory monitoring is continuing at the site and will be reported as an addendum to this report. Results and gas monitor calibration certificates are included in Appendix 10.

8.2.2 Measurements were taken over a variety of atmospheric conditions, including falling pressure conditions, with barometric pressure ranging from 993 mb to 1015 mb. Carbon dioxide concentrations ranged between 0.0% and 1.8% and methane concentrations were recorded to be 0.0% throughout the monitoring period. Oxygen concentrations ranged between 0.6% and 20.3%. Steady state flow was recorded to be 0.0l/h throughout the monitoring period with the exception of R03 where negative flow values of between 0.9l/h and 35.4l/h were recorded. The results of the gas monitoring undertaken are indicated on Drawing P20/504/SI/R/F/08.

8.3 Ground Gas – Assessment

8.3.1 Gas Screening Values have been calculated in line with CIRIA 665 and BS 8485 (2015) & A1:2019 guidance.

8.3.2 This is done by calculating a Q_{hg} for each monitoring point, for each monitoring event. Hazardous gas flow rate Q_{hg} (in lh^{-1}) is calculated using the following:

$$\mathbf{Q_{hg} = C_{hg}/100 \times q}$$

Where:

C_{hg} is the measured hazardous gas concentration (in percentage volume-by-volume)

q is the flow rate (in litres per hour) of combined gasses from the standpipe found by direct measurement.

8.3.3 Hazardous gas flow rates were calculated for each monitoring point during each event. A 'worst-case' scenario was realised on the 20th July 2021 where carbon dioxide concentration was 1.8 %vol. and a representative steady-state gas flow rate of 0.1 l/h was recorded. The resultant hazardous gas flow rate is therefore as follows:

$$\mathbf{Q_{hg} = 1.8/100 \times 0.1*}$$

$$\mathbf{Q_{hg} = 0.0018}$$

*If a gas flow rate is not detected, it should be assumed that it is at the limit of detection of the equipment used for the purpose of this calculation i.e. 0.1 l/hr

8.3.4 Based on the BS 8485 (2015) & A1:2019 guidance, the calculated worst case Qhg corresponds to a 'Characteristic Situation 1.'

8.3.5 Given that negative steady state flows were recorded in R03 throughout the monitoring period to date, it was considered prudent to calculate a theoretical worst case scenario, utilising positive flow values:

$$\mathbf{Q_{hg} = 0.6/100 \times 17.6*}$$

$$\mathbf{Q_{hg} = 0.1056}$$

8.3.6 As such, the site has been elevated to *'Characteristic Situation 2'* where gas preclusion measures are required.

TABLE 15 – Assessment of Gas Characterisation

Characteristic Situation	Hazard Potential	Gas Screening Value (GSV) (l/hr))	Additional Limiting Factors
1	Very Low	<0.07	Methane not to exceed 1% by volume and carbon dioxide not to exceed 5% by volume.
2	Low	0.07 to <0.7	Borehole air flow not to exceed 70 l/hr, otherwise increase to CS3.
3	Moderate	0.7 to <3.5	None
4	Moderate to High	3.5 to <15	None
5	High	15 to <70	None
6	Very High	>70	None

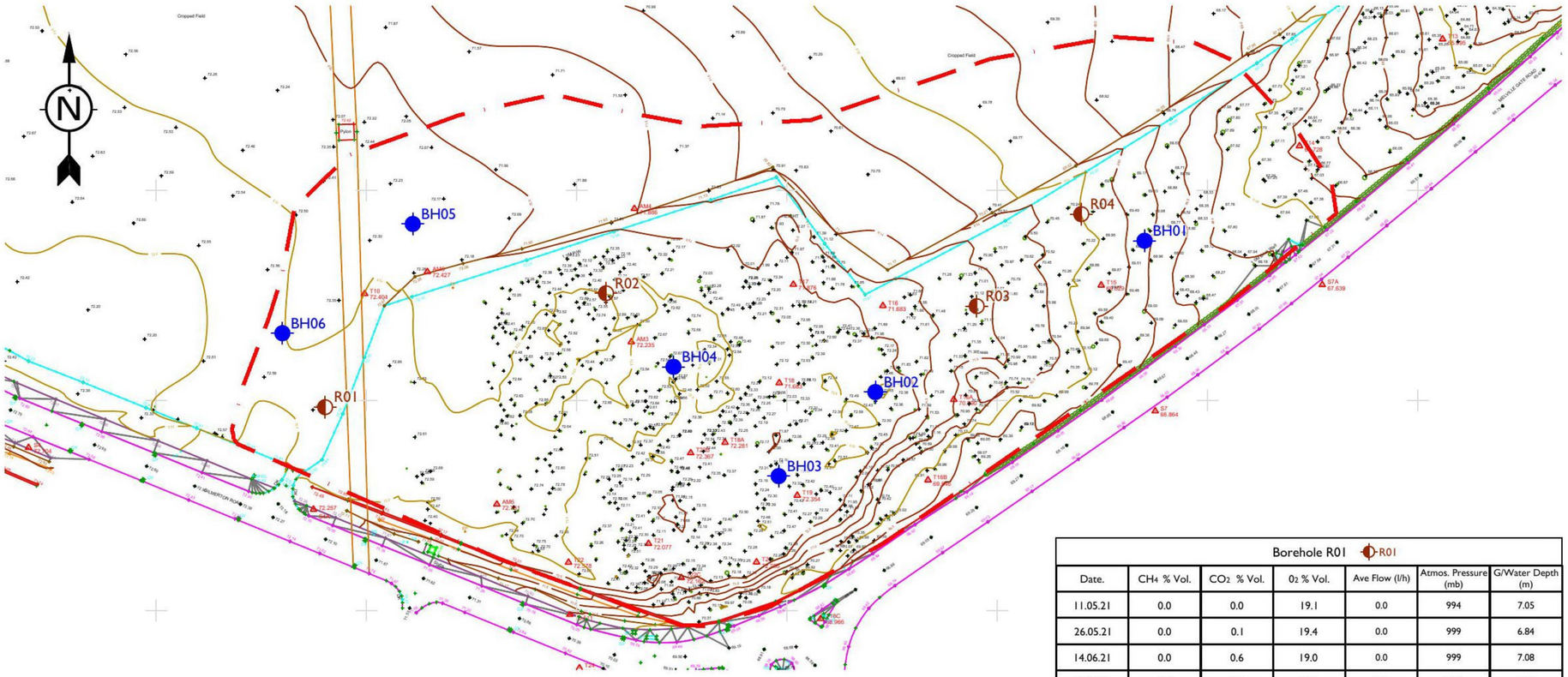
8.3.7 The construction and use of the buildings, together with the control of future structural changes to the building and its maintenance (the building's management) should be assessed, since potential risks posed by ground gases are strongly influenced by these factors. The assessment should lead to the categorisation of the building as a whole, or each different part of the building, into one of four building types: Type A, Type B, Type C or Type D.

8.3.8 New buildings should be categorized in accordance with Table 16, as outlined in BS 8485 (2015) & A1:2019. The proposed developments are considered to be Type C.

TABLE 16 – Building Types and Descriptions (BS 8485 (2015) & A1:2019)

Building Type	Description
A	Private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.
B	Private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels.
C	Commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Single occupancy of ground floor and basement areas. Small to large size rooms with active ventilation or good passive ventilation of all rooms and other internal spaces throughout ground floor and basement areas. Probably civil engineering construction. Examples include offices, some retail premises, and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).

D	Industrial style building having large volume internal space(s) that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement areas of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floor areas, warehouses. (Small rooms within these style buildings should be separately categorized as Type B or Type C).



NOTES

- Site boundary
- BH01 to BH06 — Soils boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)
- R01 to R04 — Rotary boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)

REV	DATE	DETAILS

Borehole R01 — R01

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.0	19.1	0.0	994	7.05
26.05.21	0.0	0.1	19.4	0.0	999	6.84
14.06.21	0.0	0.6	19.0	0.0	999	7.08
10.07.21	0.0	0.7	18.8	0.0	1012	6.89
20.07.21	0.0	0.6	19.1	0.0	1015	6.52
03.08.21	0.0	0.8	19.3	0.0	1006	6.37

Borehole BH01 — BH01

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.6	19.9	0.0	994	1.57
26.05.21	0.0	0.3	20.1	0.0	999	1.73
14.06.21	0.0	0.7	19.9	0.0	999	1.81
10.07.21	0.0	0.9	19.6	0.0	1012	1.84
20.07.21	0.0	1.1	19.2	0.0	1015	2.03
03.08.21	0.0	1.4	18.8	0.0	1006	2.14

Borehole BH02 — BH02

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.4	20.3	0.0	994	DRY
26.05.21	0.0	0.5	20.0	0.0	999	DRY
14.06.21	0.0	0.4	20.2	0.0	999	DRY
10.07.21	0.0	0.6	20.0	0.0	1012	DRY
20.07.21	0.0	0.8	19.7	0.0	1015	DRY
03.08.21	0.0	0.4	20.1	0.0	1006	DRY

Borehole BH03 — BH03

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.7	19.7	0.0	994	DRY
26.05.21	0.0	1.0	19.4	0.0	999	DRY
14.06.21	0.0	1.4	19.1	0.0	999	DRY
10.07.21	0.0	1.1	19.4	0.0	1012	DRY
20.07.21	0.0	1.3	19.1	0.0	1015	DRY
03.08.21	0.0	1.1	19.3	0.0	1006	DRY

Borehole BH04 — BH04

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.6	19.8	0.0	994	DRY
26.05.21	-	-	-	-	999	DRY
14.06.21	0.0	0.2	20.3	0.0	999	DRY
10.07.21	0.0	0.3	20.1	0.0	1012	DRY
20.07.21	0.0	0.4	19.9	0.0	1015	DRY
03.08.21	0.0	0.2	20.2	0.0	1006	DRY

Borehole BH05 — BH05

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.4	20.1	0.0	994	3.35
26.05.21	0.0	0.8	19.6	0.0	999	3.17
14.06.21	0.0	0.6	19.8	0.0	999	3.12
10.07.21	0.0	1.0	19.4	0.0	1012	3.02
20.07.21	0.0	1.2	19.2	0.0	1015	2.91
03.08.21	0.0	1.9	18.4	0.0	1006	2.81

Borehole BH06 — BH06

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.8	19.4	0.0	994	DAMP
26.05.21	0.0	1.2	19.0	0.0	999	3.12
14.06.21	0.0	1.4	18.7	0.0	999	3.19
10.07.21	0.0	1.6	18.4	0.0	1012	3.11
20.07.21	0.0	1.8	18.2	0.0	1015	3.02
03.08.21	0.0	1.6	18.7	0.0	1006	2.97

Borehole R02 — R02

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.0	0.6	0.0	994	17.98
26.05.21	0.0	0.2	1.1	0.0	999	17.67
14.06.21	0.0	0.1	1.2	0.0	999	17.24
10.07.21	0.0	0.2	1.4	0.0	1012	17.13
20.07.21	0.0	0.4	2.4	0.0	1015	16.84
03.08.21	0.0	0.3	5.1	0.0	1006	16.27

Borehole R03 — R03

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.0	20.5	-35.4	994	18.97
26.05.21	0.0	0.6	20.3	-17.6	999	18.42
14.06.21	0.0	0.1	20.2	-2.1	999	18.43
10.07.21	0.0	0.2	20.0	-1.1	1012	18.21
20.07.21	0.0	0.2	20.1	-0.9	1015	18.11
03.08.21	0.0	0.3	19.9	-0.1	1006	18.03

Borehole R04 — R04

Date.	CH4 % Vol.	CO2 % Vol.	O2 % Vol.	Ave Flow (l/h)	Atmos. Pressure (mb)	G/Water Depth (m)
11.05.21	0.0	0.3	17.1	0.0	994	4.04
26.05.21	0.0	0.2	18.4	0.0	999	4.19
14.06.21	0.0	0.6	17.1	0.0	999	3.99
10.07.21	0.0	0.4	17.7	0.0	1012	4.02
20.07.21	0.0	0.3	18.3	0.0	1015	4.16
03.08.21	0.0	0.2	18.7	0.0	1006	4.03

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PROJECT TITLE

SHERIFFHALL SOUTH
MIDLOTHIAN

DRAWING TITLE

GROUND GAS
EMISSIONS SURVEY

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
RC	PJR	NDL	12.08.21	1:1250 @ A3

PROJECT No.	DRAWING No.	REVISION
P20/504	P20/504/SI/R/F/08	

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8.3.9 From the identified Characteristic Situation and type of building, the minimum gas protection score should be calculated, in accordance with Table 17 below.

TABLE 17 - Gas Protection Score by Characteristic Situation and Type of Building

Characteristic Situation (CIRIA 149)	MINIMUM GAS PROTECTION SCORE (POINTS)			
	High Risk Type A Building	Type B Building	Medium Risk Type C Building	Low Risk Type D Building
1	**0**	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4	3	2.5
4	6.5	5.5	4.5	3.5
5	-	6.5	5.5	4.5
6	-	-	7.5	6.5

8.3.10 Following the determination of the minimum gas protection score, a combination of two or more of: 1) structural barrier of the floor slab; 2) ventilation measures; and 3) a gas resistant membrane should be implemented in order to achieve an adequate score. The protection measures along with relevant scores are outlined in Tables 18, 19 and 20 below.

TABLE 18 - Gas Protection Scores for the Structural Barrier

Floor and Substructure Design	Score
Precast suspended segmented subfloor (i.e. beam and block).	0
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement).	0.5
Cast in situ monolithic reinforced ground-bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations.	**1 or 1.5**
Basement floor and walls conforming to BS 8102:2009 Grade 2 Waterproofing.	2
Basement floor and walls conforming to BS 8102:2009 Grade 3 Waterproofing.	2.5

TABLE 19 - Gas Protection Scores for Ventilation Protection Measures

Protection Element / System	Score	Comments
(a) Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building)	**0.5**	**Whenever possible a pressure relief pathway (as a minimum) should be installed in all gas protection measures systems. If the layer has a low permeability and/or is not terminated in a venting trench (or similar), then the score is zero.**
(b) Passive sub floor dispersal layer: Very good performance: Good performance: Media used to provide the dispersal layer are: ▪ Clear void. ▪ Polystyrene void former blanket. ▪ Geocomposite void former blanket. ▪ No-fines gravel layer with gas drains. ▪ No-fines gravel layer.	 2.5 1.5	The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer.
(c) Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers	1.5 to 2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place. There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least "good performance".
(d) Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket.	1.5 to 2.5	This system relies on continued operation of the pumps, therefore alarm and response systems should be in place. The score assigned should be based on the efficient "coverage" of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least "good performance".
(e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park).	4	Assumes that the car park is vented to deal with car exhaust fumes, designed to Buildings Regulations 2000, Approved Document F[9].

TABLE 20 - Gas Protection Scores for the Gas Resistant Membrane

Protection Element / System	Score	Comments
Gas resistant membrane meeting all of the following criteria: ▪ **Sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m2/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method);** ▪ **Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;** ▪ **Sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab);** ▪ **Sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc);** ▪ **Capable, after installation, of providing a complete barrier to the entry of the relevant gas;** ▪ **Verified in accordance with CIRIA C735.**	**2**	**The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints.** **If a membrane is installed that does not meet all the criteria in column 1 then the score is zero.**

8.3.11 It is therefore recommended that gas protection measures comprising the following are implemented on properties. The total score of the recommended gas protection measures is therefore as follows:

TABLE 21 – Risk Assessment Summary

Gas Protection Measure	Score
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement).	0.5
Pressure relief pathway	0.5
Gas resistant membrane meeting relevant criteria	2
TOTAL SCORE	**3.0**

8.3.12 A risk assessment has classified the site as Characteristic Situation 2. Taking into account the building type (private residences) this corresponded to a required solution score of 2.5. From the above risk assessment, the gas preclusion measures recommended for the site draw a total score of 3.0, indicating a very low risk to site users from ground gas following construction.

8.4 Radon

8.4.1 The Envirocheck Report indicates that the property is in a Lower probability radon area (less than 1% of homes are estimated to be at or above the Action Level). No additional radon protective measures are necessary in the construction of new dwellings or extensions.

8.5 Conclusions

8.5.1 Based on the results of the soil gas monitoring, gas preclusion measures will be required in any buildings constructed within the proposed development area. No radon protection is required within the site.

9.0 RISKS TO CONSTRUCTED DEVELOPMENT

9.1 Sulphate Attack on Construction Materials

9.1.1 Laboratory testing was undertaken on selected soil samples recovered from the site, to determine the sulphate content and acidity and hence the concrete class required for buried concrete (results included in Appendix 11. The results of chemical tests carried out are summarised below:

TABLE 22 -Sulphate and pH Summary

Determinant	Recorded Value	SD1 DS Class	SD1 ACEC Class
pH	5.8 – 7.9	DS-1	AC-1s
Total Sulphate as SO_4 (%)*	0.207		
Sulphate as SO_4 (mg/l)	0.73 - 42		

*Concrete class was based on the mean of the highest 20% total sulphate test results as a characteristic value in accordance with guidance document BRE Special Digest (3rd Edition, 2005)

9.1.2 In accordance with BRE Special Digest 1:2005 *'Concrete in Aggressive Ground'* recommendations for concrete would be Aggressive Chemical Environment for Concrete (ACEC) Classification AC-1s with a Design Sulphate Class for the site of DS-1.

9.1.3 This is consistent with analysis undertaken in 2017 and provided in Appendix 1.

9.2 Water Supply Pipes

9.2.1 UK Water Industry Research (UKWIR) document, 'Guidance for the Selection of Water Supply Pipes to be Laid in Brownfield Sites', ref 10/WM/03/21, states that on brownfield sites, MDPE/HDPE water supply pipes could be at risk from organic contaminants including mineral oils, VOC's and SVOC's, if the pipes are laid within 15 m of recorded contamination. Additionally, UKWIR states that where metallic pipes are being considered for use, conductivity, pH and redox state of the soil should be assessed to determine if the pipes are at risk of being corroded.

9.2.2 No UKWIR samples were collected during this investigation. It is recommended that UKWIR samples are collected and analysed when development layouts and levels are finalised, with the recommended water supply pipe to be confirmed with Scottish Water. It should be noted that no significant contamination was recorded within the site boundary.

9.3 Phytotoxicity

9.3.1 Guidance on the effects of metal contamination on plant growth is provided within BS3882:2015 Specification for Topsoil and similar guidance issued by the Scottish Agricultural College (SAC). A summary of test results, versus the recommended phytotoxic screening criteria is provided below:

TABLE 23: Summary of Soil Results vs Phytotoxic Screening Criteria

Contaminant	Screening Value (mg/kg)	Conc Range (mg/kg)	Max > MAFF Screening Value
Zinc	200	16 - 830	YES
Copper	135	7.4 - 1000	YES
Nickel	75	6.5 - 170	YES

Note – screening value based on an average pH 6 – 7 (The average pH was calculated to be 6.96)

9.3.2 Phytotoxic zinc, copper and nickel was identified at concentrations above the BS3882:2015 screening values in the made ground obtained from the central and southern site areas. Therefore, we consider the phytotoxic risk at these locations to be moderate. No phytotoxic exceedances were recorded across the remainder of the site and, therefore, outwith the made ground area the general phytotoxic risk is considered to be low.

10.0 REVISED CONCEPTUAL SITE MODEL

10.1 Contamination Sources

Human Health: The GRQA has identified no toxic contaminants at concentrations above guideline values. In addition no asbestos was identified from samples collected across the site Therefore, the risk to human health was considered to be low.

Water Environment: Several contaminants were present above current guidelines values within the leachate and groundwater samples tested. However, modelling was undertaken and the overall risk to the Water Environment is considered to be low.

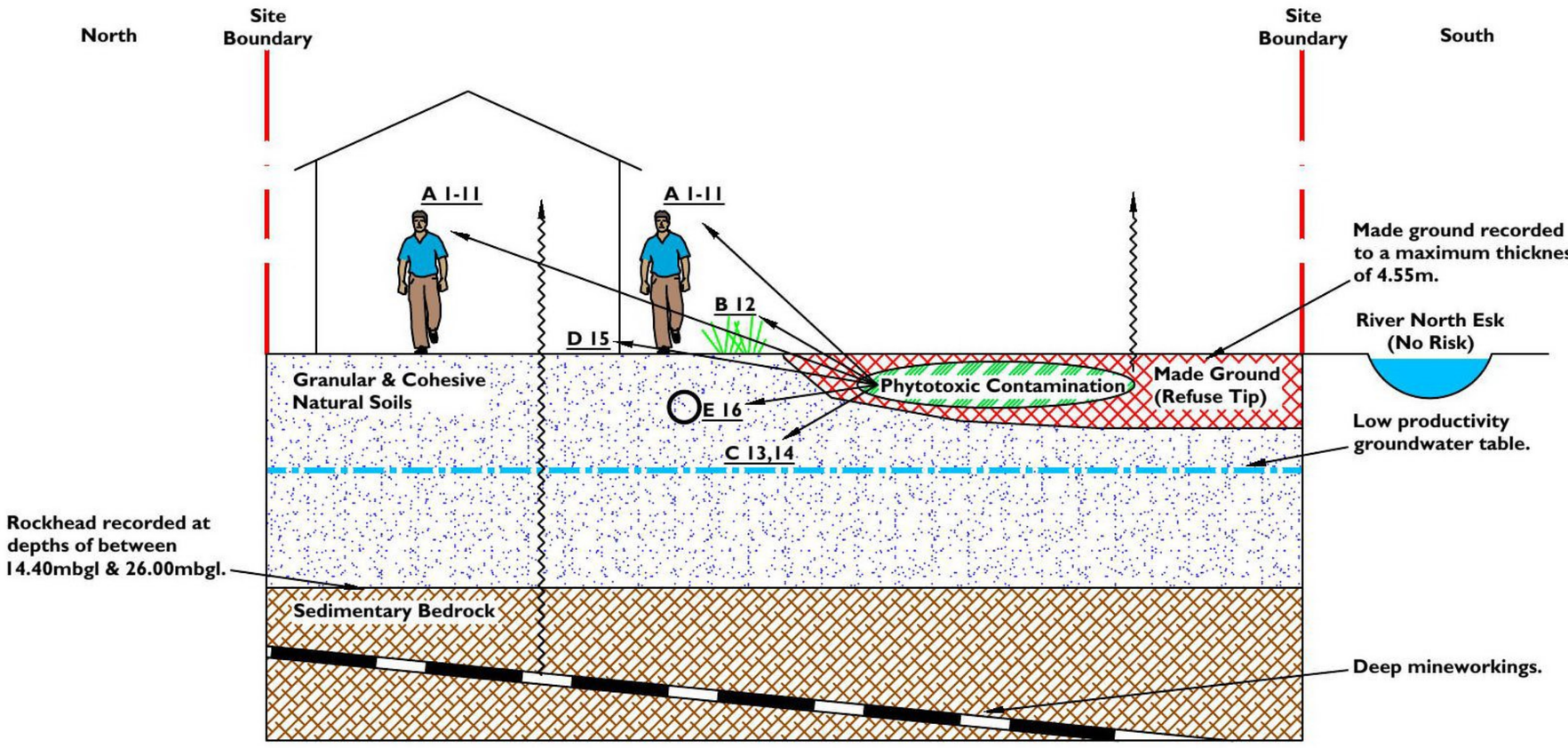
Ground Gas: Based on the results of the gas monitoring undertaken, gas preclusion measures will be required in the proposed development corresponding to *'Characteristic Situation 2'*. The Envirocheck Report indicates that the property is in a Lower probability radon area (less than 1% of homes are estimated to be at or above the Action Level). No additional radon protective measures are necessary in the construction of new buildings.

Built Environment: Samples analysed for pH and sulphate are generally below BRE thresholds.
No UKWIR samples were collected during this investigation. It is recommended that UKWIR samples are collected and analysed, when development layouts and levels are finalised, with the recommended water supply pipe to be confirmed with Scottish Water.

Plant Life: Phytotoxic zinc, copper and nickel was identified at concentrations above the BS3882:2015 screening values in the made ground obtained from the central and southern site areas. Therefore, we consider the phytotoxic risk at these locations to be moderate. No phytotoxic exceedances were recorded across the remainder of the site and in areas where made ground is absent, the general phytotoxic risk is considered to be low.

10.2 Pollutant Linkage Assessment

10.2.1 Based on the ground and groundwater contamination conditions noted at the site, viable source-pathway-receptor pollutant linkages have been identified in relation to contaminated made ground and ground gases and the conceptual site model has been revised as indicated on Drawing No. P20/504/SI/R/F/09.



Source

- Phytotoxic contamination from contaminated made ground
- Ground/Mine gases.

Exposure Pathways

1. Outdoor ingestion of dust.
2. Indoor ingestion of dust.
3. Consumption of homegrown vegetables.
4. Ingestion of soil attached to vegetables.
5. Skin contact with outdoor soil.
6. Skin contact with indoor dust.
7. Outdoor inhalation of dust.
8. Indoor inhalation of dust.
9. Outdoor inhalation of soil vapour.
10. Indoor inhalation of soil vapour.
11. Inhalation of ground gases.
12. Contaminant uptake by vegetation.
13. Leaching of contaminants to the groundwater.
14. Contaminant migration in the groundwater.
15. Detrimental effects on buried concrete.
16. Permeation of plastic water supply pipes.

Receptors

A. Site users / construction personnel.
B. Vegetation / fauna.
C. Groundwater.
D. Buried concrete (Service and foundations)
E. Plastic water supply pipes.

NOTES

REV	DATE	DETAILS

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PROJECT TITLE

SHERIFFHALL SOUTH
MIDLOTHIAN

DRAWING TITLE

REVISED CONCEPTUAL SITE MODEL

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
RC	PJR	NDL	12.08.21	Not to Scale

PROJECT No.	DRAWING No.	REVISION
P20/504	P20/504/SI/R/F/09	

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10.3 Mitigation Measures

Contamination

10.3.1 Given the presence of phytotoxic contaminants within the made ground, a capping layer of 300 mm thickness is required in all soft landscaping where the made ground is present. All capping works will require to be subject to robust validation procedures.

10.3.2 Construction personnel should be aware of the nature of the soils on the site and vigilance should be maintained for any soils at variance from those anticipated during construction works. Appropriate health and safety procedures should be adopted at the site in relation to these matters.

Groundwater

10.3.3 The shallow soils were considered to pose a low risk to the Water Environment.

Ground Gas

10.3.4 Based on the results of the soil gas monitoring undertaken, gas preclusion measures will be required in any buildings constructed within the proposed development area corresponding to *'Characteristic Situation 2'*. No radon protection is required within the site.

The Built Environment

10.3.5 No UKWIR samples were collected during this investigation. It is recommended that UKWIR samples are collected and analysed, when development layouts and levels are finalised, with the recommended water supply pipe to be confirmed with Scottish Water.

10.3.6 Concrete class DS-1, AC-1s is considered sufficient to protect buried concrete from pH and sulphate levels in the soils and groundwater.

Construction/Maintenance Workers

10.3.7 All site staff should remain vigilant to the possible risk of encountering isolated areas of unrecorded contaminated material, including the presence of asbestos. Should such materials be encountered, further testing may be required to assess the risk to health and safety of the site workers and the environment.

All works on site should be carried out in accordance with the contractors risk assessment and method statement. Procedures to be adopted at the site will be outlined in a Remediation Statement.

10.3.8 Good site working practices should be followed, including:

- Use of appropriately qualified personnel for the task;
- Use of appropriate PPE
- Provision of on-site washing facilities;
- Maintenance of a high standard of basic hygiene; and
- Implementation of a non-smoking and eating policy within the working area, with designated clean areas set aside for these activities.

10.4 Waste Management Legislation

10.4.1 Should materials be removed and disposed off-site, the developer has a statutory responsibility under the Duty of Care Regulations of the Environmental Protection Act 1990 to ensure that contaminated soil and water is disposed of off-site to a suitably licensed waste management facility in a safe and approved manner.

10.4.2 In the event that material, uncharacteristic to that which has been previously identified within the site is encountered, we would recommend that a suitably qualified engineer/scientist obtain samples of the suspect material for chemical analysis, thus determining how the material should be managed.

10.5 Contingent Liabilities

10.5.1 Assessments of the site include the determination of contingent liabilities in respect of current and future ownerships subsequent to remedial measures. These consider the impact of the environmental conditions on the study area and surrounding areas on site users, properties and also the liability of the site owners.

10.5.2 With regard to site users, considerations in relation to liability are inherent in the development of a suitable remedial strategy. In the site-specific circumstances presented by the identified conditions, the risk levels suggest minimal liability on ownership due to the environmental conditions, subsequent to development.

10.5.3 The potential for liability arising from site conditions impacting on the surrounding environment largely considers the potential for migration of pollutants beyond the site boundary normally associated with groundwater. Within this report we have concluded that there is a phytotoxic contamination source within the site. However, hydrological modelling to the nearest surface water body has shown no significant migration potential. Therefore, overall offsite migration potential is considered to be low. Consequently, the potential for liability arising from the site conditions would be considered to be low following appropriate remediation of the identified development constraints.

10.5.4 In the event that more definitive advice is required, we would recommend that the Client seeks specific advice on the liabilities incumbent on ownership from their legal advisors.

11.0 GEOTECHNICAL ASSESSMENT

11.1 General

11.1.1 Geotechnical laboratory testing was undertaken on a selection of natural and made ground soils encountered in the boreholes during the 2021 investigations (Appendix 14). In addition, visual assessment of the soils during the sinking of the boreholes was supplemented by in-situ standard penetration tests (SPT's). It should be recognised that SPT testing of cohesive soils will only provide an indicative assessment of soils strength, although testing of granular soils will provide more reliable test data. Greater reliance can be placed on visual assessment of the strength of cohesive soils in trial pits.

11.1.2 The geotechnical properties of the soils tested during the 2021 investigations at the site are indicated in the table below:

TABLE 24: 2021 Geotechnical Summary

Visual Description	Test Sample Depth Range (m)	In-situ Strength/ Density	Uncorrected N Value	Corrected N Value*
Made Ground	1.00 – 3.70	-	-	-
Granular Natural Soils	1.00 – 4.20	Very Loose to Dense	1 - 31	2 - 30
Cohesive Natural Strata	-	Very Soft to Stiff	3 – 50+	-

11.1.3 The SPT testing carried out in the boreholes generally indicated the cohesive natural deposits to be very soft to very stiff. This is consistent with the visual appraisal of these soils.

11.1.4 The SPT testing carried out in the boreholes generally indicated the granular natural deposits to be very loose to dense. This is consistent with the visual appraisal of these soils.

11.2 Particle Size Distribution Testing (PSD's)

11.2.1 The 2021 PSD testing confirmed the granular deposits to be slight gravelly silty SAND. The PSD testing also confirmed the made ground deposits to be silty/clayey SAND and GRAVEL.

11.2.2 In addition to the above, the 2017 PSD testing recorded, poorly graded clayey silty very sandy GRAVEL, slightly gravelly sandy very clayey SILT and Slightly gravelly sandy SILT.

11.3 Insitu Hand Shear Vane Tests (2017)

11.3.1 Insitu Hand Shear Vane tests were carried out using portable insitu hand vane testing equipment (upper limit 120kN/m2) during the 2017 investigations on the natural fine soil (silt and clay) deposits encountered, along the proposed drainage route and SUDS Pond location, in order to determine the undrained shear strength of these materials.

11.3.2 The results can be found on the graphic Trial Pit Record Sheets presented in Appendix 1, and are summarised in the table below

TABLE 25: 2017 Hand Shear Vane Tests

Strata	Range of Undrained Shear Strength Values (kN/m2))	Description and General Comments
Granular Natural Soils (Described as Glaciofluvial – Silt 2019)	6 - 32	The results are indicative of extremely low, very low and low strength strata.
Cohesive Natural Strata (Described as Glacial Till – Clay 2019)	58 - 120	Initially recorded as medium strength becoming high strength strata.

11.4 Insitu CBR (MEXE Cone) Tests (2017)

11.4.1 Insitu tests were carried out within the upper natural deposits encountered in TP's 01, 04 & 05 – 08, using a MEXE Cone Penetrometer. The MEXE Cone Penetrometer is a lightweight apparatus for rapidly measuring in-depth resistance to penetration. The dial indicates in terms of an Equivalent California Bearing Ratio (CBR) value. The instrument is primarily intended for finer grained soils and when used as intended measurements correlate closely with CBR values measured in-situ with conventional equipment. The results of the tests can be found adjacent to the appropriate sample level, on the graphic trial pit record sheets attached in Appendix II.

11.4.2 Based on the results it can be seen that at approximate formation level (c.0.60m bgl), a range of insitu CBR values ranging from 2.0% to 6.0% have been recorded. Consequently, when considering the use of the upper natural strata as an undisturbed subgrade, a design CBR value of 2% should be taken. It is possible that the natural superficial deposits will also improve with compaction and is it possible that higher insitu CBR values can be achieved from these materials.

11.5 Determination of Liquid and Plastic Limits (2017)

11.5.1 A representative sample of the natural clayey materials, encountered in TP15 at a shallow depth during the 2017 invstigation, was tested in order to determine the, liquid and plastic limits, so that the material might be classified. A summary of the results are presented within Appendix 1.

11.5.2 The results of the analysis indicated the clay to have a low plasticity range and a low volume change potential.

11.6 Determination of Dry Density / Moisture Content Relationship (2017)

11.6.1 Representative bulk samples of the upper natural strata collected during the 2017 investigations were combined and prepared in order to determine the Maximum Dry Density and Optimum Moisture Content (OMC) values for these materials for potential earthworks. For each combined sample, the initial moisture content has been determined and the dry density calculated for a range of moisture contents in order to establish the OMC value. The results are summarised in Appendix 1.

11.6.2 OMC values of between 13% and 15% were recorded giving maximum dry density values of 1.76Mg/m3 to 1.78Mg/m3. Assuming the compaction criteria of any future earthworks will require ≥95% maximum dry density and ≤5% air voids it can be seen that compaction moisture contents of 12.3% to 16.6% and 14.1% to 18.6% will be required. Taking into account the as received moisture content values for these materials, it can be seen that in their present condition the upper natural strata is too 'dry' to achieve the anticipated compaction specification.

11.7 Rockhead

11.7.1 Definite rockhead was encountered within all of the rotary boreholes at depths of between 14.00mbgl and 26.00mbgl and was generally described as moderately hard sandstone.

12.0 FOUNDATION RECOMMENDATIONS

12.1 Details of the Development

12.1.1 The proposed development layout comprised of commercial properties with areas of soft landscaping and road infrastructure (Drawing Nos. P20/504/SI/R/F/03).

12.2 Foundations (relative to existing site levels)

12.2.1 Made ground soils were encountered across the central and southern site areas. These deposits were encountered from the ground surface and extended to a maximum recorded depth of 4.55mbgl. The made ground deposits are not considered suitable as a foundation bearing horizon in their current condition.

12.2.2 Cohesive natural soils were encountered across the site at depths of between 0.30mbgl and 14.00mbgl extending to a maximum recorded depth of 26.00mbgl. These deposits were generally described as soft light brown/grey very sandy silty CLAY or stiff brown fine to medium slightly sandy sub-rounded gravelly boulder clay.

12.2.3 Granular natural soils were encountered across the site at depths of between 1.20mbgl and 4.55mbgl extending to a maximum recorded depth of 14.00mbgl. These deposits were generally described as medium dense orange, brown very silty fine to medium SAND with some sub-rounded GRAVEL or medium dense very clayey orange brown SAND.

12.2.4 Definite rockhead was encountered within all of the rotary boreholes at depths of between 14.00mbgl and 26.00mbgl and was generally described as moderately hard sandstone.

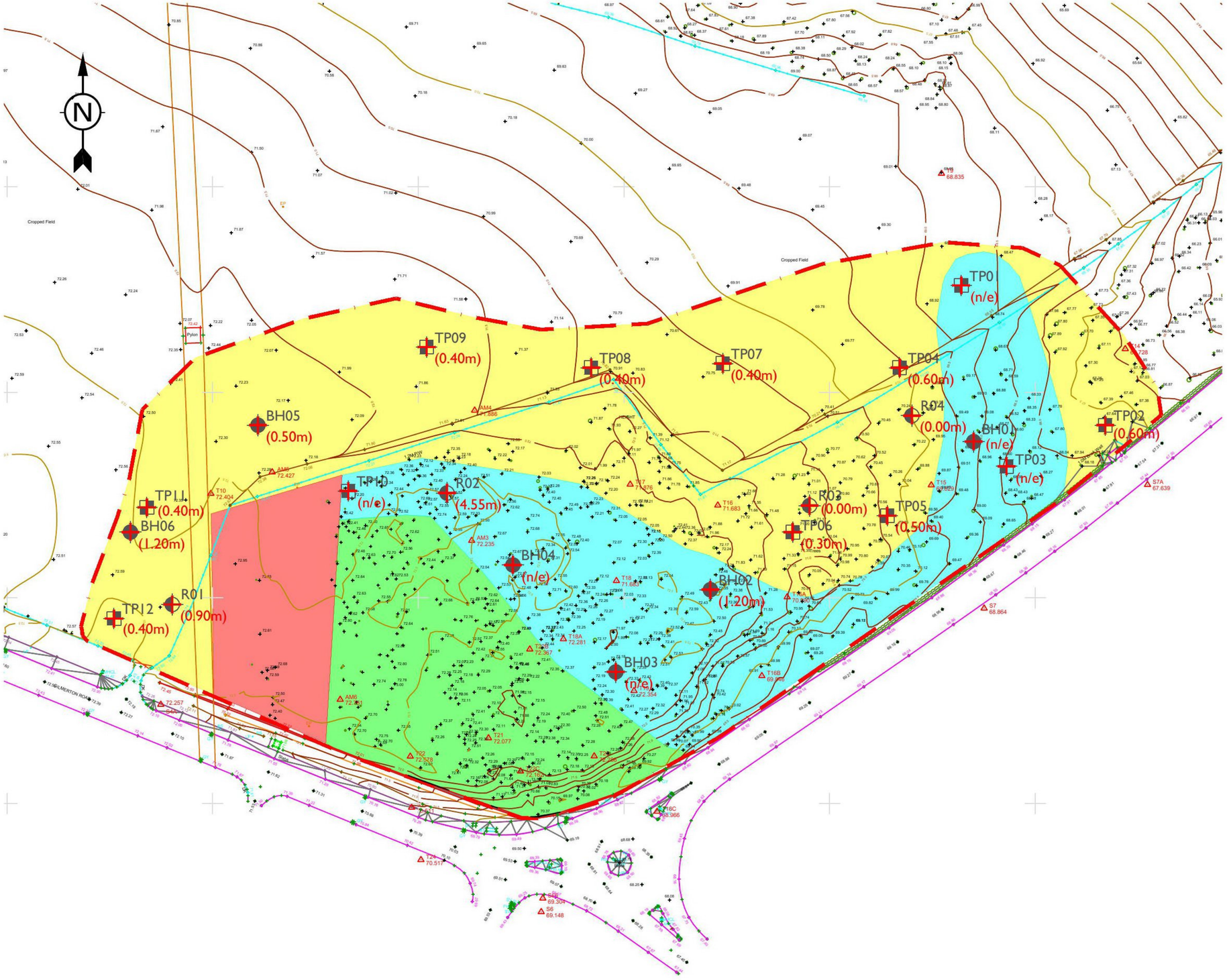
12.2.5 Where present, an allowable bearing capacity of at least 100 kPa is estimated for the medium dense or denser, granular deposits which are conjectured to be present at depths of between approximately 0.30 m and 4.55 m below existing ground levels. The depth to a suitable foundation bearing horizon (where present) is shown on Drawing No. P20/504/SI/R/F/10.

12.2.6 It is concluded that abnormal foundations, likely involving vibro-compaction or piling to the underlying competent strata will be required across the southern and eastern site area. The suitability of the soils for vibro-compaction would require to be confirmed by specialist contactors. If confirmed to be appropriate, vibro-compaction should be able to provide a uniform foundation layer at the site for suitably reinforced shallow foundations designed to an allowable bearing capacity of approximately 100 to 125 kPa.

12.3 Excavations

12.3.1 The exploratory holes indicate that the made ground and natural deposits are likely to be relatively stable in the short term in open excavations. However, all excavations below 2.0 m depth requiring manned entry should be battered well back or provided with close/continuous support.

12.3.2 If significant regrading of the site is to be undertaken, we should be consulted to ensure the continuing accuracy of our recommendations.



NOTES

	Site boundary
TP01 to TP12	Trial pits excavated by Mason Evans Partnership (April 2021)
BH01 to BH06	Soils boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)
R01 to R04	Rotary boreholes (with monitoring wells) sunk by Pheonix Drilling Ltd (April 2021)
(1.20m)	Recorded depth to a suitable foundation bearing horizon (m)
(n/e)	Not encountered
	No access due to Giant Hogweed
	No access due to dense vegetation
	Strip foundation
	Area of abnormal foundations

REV	DATE	DETAILS

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PROJECT TITLE

SHERIFFHALL SOUTH
MIDLOTHIAN

DRAWING TITLE

RECORDED DEPTH TO A SUITABLE FOUNDATION BEARING HORIZON

DRAWN BY	CHK'D BY	APP'D BY	DATE	SCALES
RC	PJR	NDL	12.08.21	1:1000 @ A3

PROJECT No.	DRAWING No.	REVISION
P20/504	P20/504/SI/R/F/10	

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13.0 IDENTIFICATION AND ASSESSMENT OF SPECIFIC COAL MINING RISKS

13.1 General

13.1.1 The Coal Authority's Consultants Coal Mining Report (Appendix 5) and geological survey indicate the presence of abandoned mine workings in the immediate site area and beneath the site at depth.

13.1.2 Published British Geological Survey maps, presented in Drawing No P20/504/DS/R/F/04, indicate that the rock strata underlying the site is comprised wholly of Scottish Lower Coal Measures Formation (SLCMF) of Carboniferous age. The Scottish Lower Coal Measures Formation typically comprises of "sandstone, siltstone, and mudstone in repeated cycles with seatclay or seatearth and coal at the top." The regional dip is to the south east at approximately 3°.

13.1.3 The Coal Authority's Consultants Mining Report (Appendix 5) indicated that past underground mining has taken place beneath the site and suggested that there are "probable unrecorded shallow workings" at the site.

13.1.4 The documentary data recorded no mine entries within the site boundary, or within 100 metres of the enquiry boundary however. A mine entry is recorded within the Grontmij Report on an adjacent site (Plot 4) (Appendix 1).

13.1.5 As old mine workings are notoriously susceptible to collapse, occasionally leading to surface subsidence, an assessment of the potential impact of old mines required consideration of various aspects of the geology and mining conditions. It was therefore considered necessary to undertake a detailed review of mining information for this area including geological maps and memoirs.

13.2 Mining Methods

13.2.1 The methods historically adopted in the area may be generally categorised as variations on two different techniques – the 'stoop and room' and 'longwall' systems of extraction. In the 'longwall' method of mining, extraction was virtually total with the seam face accessed via supported roadways. In the areas from which the seam has already been removed, the roof was generally allowed to collapse behind the face or was partially supported by spoil or 'waste' deposited within the works. While the workings would be generally closed on abandonment with the withdrawal of roof support, roads would be expected to remain open and artificially supported long after the operations had ceased.

13.2.2 A variation on the longwall method is the technique commonly used in mining today but was generally only applied to the recovery of ironstones or coals of restricted thickness in the 19th Century.

13.2.3 In the stoop and room, or pillar and stall method as it is known in England, partial excavation of the mineral was conducted, with the seam recovered from rooms and roof supported by retained stoops or pillar of the mineral.

13.2.4 Normally at least 50% of the seam would remain intact as stoops within the mine, but occasionally higher levels of extraction took place either due to favourable geological conditions, or as a result of poorer controls on the mine management and safety. Often, 'stoops' were removed on abandonment of the mine in a practice commonly known as 'stooping' or 'pillar robbing'.

13.2.5 The dimensions of the stoops and rooms varied depending on the geological conditions and seam thicknesses, but their width would normally average at about 3 to 4 times the height of the seam. Where more slender stoops were left, the additional support required for the roof would often be provided by artificial props, which would usually be timber.

13.2.6 This form of mining was prevalent through the 19th Century where seams of generally greater than 0.7 m in thickness were involved. As the operations became increasingly mechanised and more sophisticated supports introduced, the stop and room method became less widely adopted for coal mining in Scotland.

13.3 Mining Conditions

13.3.1 As discussed, the Coal Authority's Consultants Mining Report for the 1B area (2021) (Appendix 5) indicated that past underground mining has taken place beneath the site in the Lady Victoria coal seam, Monktonhall coal seam, and 3 no. unnamed coal seams at depths of between 538 and 753m, with the last recorded workings in 1982. The Lady Victoria seam is understood to dip 8.1° to the east, the Monktonhall 9.4° to the east, and the unnamed seams 21.1° and 7.9°. to the east and 7.5° to the northeast. The Salters seam was also indicated to outcrop approximately 43.2m to the west of the site. The depths of workings provided in the Consultants Coal Mining Report may not relate directly to the site and may be inferred from workings offsite. The coal mining report has suggested that there are "probable unrecorded shallow workings" at the site.

13.3.2 The Grontmij Report noted that, *'Discussions with an ex Coal Board Geologist who is known to Grontmij suggest that in the region of Dobbies (to the due south of the site) the actual position of the coal outcrops lie around 140m further west than plotted.'* The effect of this variation is indicated in the Grontmij Drawing Revised Principal Projection in Section 7, Appendix 1. No information was available as to whether the seams at shallow level under the site had been subject to unrecorded workings.'

13.3.3 One historic borehole was available within the current site boundary (NT36NW31). No shallow mining was recorded, however, a possible coal was encountered at approximately 34mbgl.

13.3.4 In 2013, 6 no. intrusive rotary bores were undertaken adjacent to the current site area by Raeburn Drilling and Geotechnical Ltd on behalf of Grontmij. This was reported in a *Geoenvironmental Desk Study & Interpretive Report.* The location of the 6 no. intrusive bores is included in Appendix 1.

13.3.5 The 6 no. mineral boreholes drilled as part of the adjacent 2013 investigation recorded solid coals across all boreholes, interpreted to be the Whitehill Great Seam (Glass Coal) (0.50m thick), the Whitehill Rough Seam (Salters Coal) (typically 1.30m thick) and the Whitehill Splint (Nine Foot/Barrs Coal) and Parrot Rough/Whitehill Jewel (Cowpits Three Foot).

13.3.6 No evidence of shallow workings was recorded in the 6 no. mineral boreholes drilled in 2013.

13.3.7 As part of the 2021 investigations, 4 No. rotary percussive probe holes were sunk within the site during the 2021 investigations to provide information on the geological and mining conditions beneath the site. The results of the boreholes confirmed the presence of limited shallow coals within the north east of the site. No evidence of shallow mineworkings was recorded. The details of our interpretation of the coal seams encountered within the boreholes are as follows:

TABLE 25– Conditions Encountered within the Rotary Boreholes (2021 Investigations)

Borehole No.	Approximate Surface Level (mAOD)	Approximate Rockhead Level (mAOD)	Depth of Borehole (m)	Remarks/Levels
R01	72.56	46.56	35.00	**No coal encountered**
R02	72.57	49.07	35.00	**No coal encountered**
R03	71.18	53.78	35.00	**COAL:** encountered at 42.08 mAOD – 40.88 mAOD (1.20 m thick); conjectured to be the Salters Coal
R04	70.00	55.6	35.00	**COAL:** encountered at 42.80 mAOD – 41.70 mAOD (1.10 m thick); conjectured to be the Salters Coal

* Surface levels are extrapolated from existing topographic information

13.3.4 A coal seam (1.10m – 1.20m thick) was encountered in R03 and R04. This has been interpreted as the Salters Coal.

13.3.5 No evidence of shallow workings was encountered within any of the rotary bores or historic bores on site and mining instability is not thought to pose a risk to development.

13.4 Mine Entries

13.4.1 The documentary data recorded no mine entries within the site boundary of area 1A or 1B, however mine entries are present within the wider local area.

13.4.2 As with any area of former mining, unrecorded mine entries may be present and vigilance should be maintained during site operations.

13.5 Site Specific Coal Mining Risk Assessment

13.5.1 We have developed a qualitative approach in risk assessment to determine the potential impact on the proposed development. It is based on three categories of 'High', 'Moderate' and 'Low' risk. These are defined as follows

a) High Risk – where records exist which indicate a significant impact requiring mitigation for development to proceed. In the case of mining subsidence, it will be determined by an expectation of seams which are known, or strongly suspected to have been mined within depths of potential influence on the surface. Where mine entries are indicated, they will be considered high risk unless information exists to suggest that these have been adequately secured. In every case where mineworkings are known or suspected, gas emissions are considered to be of 'high risk'. In each instance, investigations are advised and mitigation likely.

b) Moderate Risk – where coal seams are suspected to lie at shallow depth, but may not be worked. In the case of gas emissions, a moderate risk is considered where there is uncertainty on the existence of former mineworkings. In each instance, investigations are necessary, but mitigation may not be necessary.

c) Low Risk – where coal seams are not indicated at shallow depths or are known to be unworked. For mine entries, a low risk would be interpreted where stabilisation is known to have taken place to an adequate specification. For gas emissions, this category relates to areas known to be clear of mineworkings.

13.5.2 The geological assessments indicate that shallow mineworkings underlie the northern site area. As such, potential surface instability due to historical mining activity is possible. Table 2 has been derived from the researches, highlighting the risks relating to impact of historical coal mining activities:

Table 26: Coal Mining Risk Assessment – District Energy Centre Building

Coal Mining Impact Issue	High	Mod	Low	Comments
Underground coal mining	-	-	-	Evidence of shallow mining beneath the site was not encountered in the 2013 or 2021 site investigations.
Surface Mines (Opencast)	-	-	-	Opencast mining has taken place in the surrounding area but does not impact the current development site
Mine entries (shafts and adits)	-	-	-	The documentary data recorded no mine entries within the site boundary of area 1A or 1B, however mine entries are present within the wider local area. As with any area of former mining, unrecorded mine entries may be present and vigilance should be maintained during site operations.
Cumulative Impacts	-	-	-	**Overall risk is considered to be Low.**

13.6 Potential for Future Mineral Extraction

13.6.1 While we feel that it is highly unlikely that underground or surface mineral extraction will occur beneath or within the site in the future, we have not carried out detailed assessments of this matter during this study. However, mineral reserves exist in the locality which could be worked at some time in the future, subject to feasibility licenses and planning consent and therefore should be examined by the client's legal advisors.

14.0 ROAD CONSTRUCTION

14.1 General

14.1.1 The proposed development layout suggested road access will be from Gilmerton Road to the south west of the site.

14.2 Ground Conditions

14.2.1 No CBR testing was undertaken as part of this investigation. Once the road layout and site levels have been finalised, we would recommend that CBR testing is undertaken along the roads. Given the variability of the soils, it is considered likely that any adoptable road within the proposed development may require a full capping layer.

14.3 Chemical Contamination

14.3.1 No significant contamination constraints in relation to road or car park construction have been identified. However, appropriate health and safety measures are still advised during construction works.

14.4 Gas Emissions

14.4.1 No significant risk to road construction or maintenance personnel is envisaged due to ground gases. However, any trenches deeper than 1.2 m should be risk assessed by the contractor.

14.5 Mining and Mineral Stability

14.5.1 Based upon the results of our researches and investigations, we have concluded that the site is not affected by mine-workings within critical depths.

15.0 INVASIVE PLANT SURVEY

15.1 General

15.1.1 A survey of the site was undertaken by the specialist contractor Kleerkut Limited on the 8th of April 202 to identify the presence of any invasive plant species. It should be noted that the presence of any controlled weeds was identified by plant material/vegetation visible at the time of the inspection only, along with any plant residue such as leaf litter and dead stalks that remain from the previous growing season. A brief survey report from Kleerkut Limited is included in Appendix 15.

15.2 Results

15.2.1 The survey recorded sporadic to prolific Giant Hogweed within the boundary. Last year's dead plants, and this year's leaves are also growing among other vegetation, some shrubs and small trees. No signs of previous management were noted. Giant Hogweed is controlled in Scotland under Schedule 9 of the Wildlife Countryside (Scotland) Act 19811 as amended by the Wildlife and Natural (Scotland) Act 2001.

15.2.2 An Invasive Weeds Management Plan should be put in place to treat the Giant Hogweed. Giant Hogweed and its seeds are controlled by legislation in Scotland meaning that enforcement with 'clean up' orders can be put in place by regulatory bodies. Live vegetation and soils containing the seedbank are classified as controlled waste falling under current Waste Management Regulations. It is a highly invasive plant which spreads quickly with soil movement.

15.2.3 No other problematic, non-legislated, species were identified during the survey.

16.0 CONCLUSIONS AND RECOMMENDATIONS

16.1 General

16.1.1 In 2017, Arc Environmental were commissioned by Quattro Consult (the Client's engineer) on behalf of Buccleuch Property (Sheriffhall South) Limited (the Client) to carry out ground investigations at a site immediately adjacent to the current investigations, known as Sheriffhall South Phase 1. A Report entitled, "Phase 2: Ground Investigation Report Buccleuch Property (Sheriffhall South) Ltd. Proposed Development (Phase I) Sheriffhall South East Gilmerton Road Lasswade Midlothian" was provided in June 2017 (Appendix 1).

1.1.3 In November 2009, Grontmij was commissioned by Buccleuch Property (Sheriffhall South) Limited (the Client) to produce a Mining Desk Study for a development site at Sheriffhall, Midlothian which covered a larger site area than the current investigations. The purpose of the Desk Study is to review the mineral stability of the site and allow an assessment of its suitability for the proposed use. A Report entitled, "Buccleuch Property (Sheriffhall South) Mining Desk Study Sheriffhall South" was provided in February 2010 (Appendix 1).

16.1.1 Mason Evans have undertaken ground investigations at the site during early 2021. The works were intended to identify ground related risks that have the potential to impact on the proposed development at the site.

16.1.2 The ground conditions encountered during the investigation were generally consistent with those anticipated from published information and from previous Reports.

16.2 Contamination and Gas Emissions

16.2.1 Given the presence of phytotoxic contaminants within the made ground, a capping layer of 300mm thickness is required in all soft landscaping where the made ground is present. All capping works will require to be subject to robust validation procedures.

16.2.2 Chemical analysis and groundwater modelling indicates that the proposed development is not considered to pose a significant risk to the Water Environment.

16.2.3 Based on the results of the soil gas monitoring undertaken to date, gas preclusion measures will be required in any buildings constructed within the proposed development area corresponding to *'Characteristic Situation 2'*. In addition, no radon protection is required within the site.

16.3 The Built Environment

16.3.1 No UKWIR samples were collected during this investigation. It is recommended that UKWIR samples are collected and analysed, when development layouts and levels are finalised, with the recommended water supply pipe to be confirmed with Scottish Water.

16.3.2 Concrete class DS-1, AC-1s is considered sufficient to protect buried concrete, from pH and sulphate levels in the soils and groundwater.

16.4 Foundation Recommendations (relative to existing site levels)

16.4.1 Where present, an allowable bearing capacity of at least 100 kPa is estimated for the medium dense or denser, granular deposits which are conjectured to be present at depths of between approximately 0.30 m and 4.55 m below existing ground levels. The depth to a suitable foundation bearing horizon (where present) is shown on Drawing No. P20/504/SI/R/F/10.

16.4.2 It is concluded that abnormal foundations, likely involving vibro-compaction or piling to the underlying competent strata will be required across the southern and eastern site area. The suitability of the soils for vibro-compaction would require to be confirmed by specialist contactors. If confirmed to be appropriate, vibro-compaction should be able to provide a uniform foundation layer at the site for suitably reinforced shallow foundations designed to an allowable bearing capacity of approximately 100 to 125 kPa.

16.5 Mining

16.5.1 Mining constraints are not considered to pose a risk to development.

16.6 Consultations with Public Authorities

16.6.1 It should be noted that various local authority departments may become involved in the review of the site conditions, including the issues of contaminated land. While measures proposed are consistent with conventional practice, we would advise that before design works are advanced to any considerable stage appropriate approvals are received from Midlothian Council. We would be pleased to liaise with the Council's representatives in this regard.

16.6.2 A Remediation Method Statement will be required along with robust validation of any remedial measures.

We trust that this will meet with your current requirements. However, should you require any further information, please do not hesitate to contact us.

[redacted]

Peter Rourke

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[redacted]

Niall Lawless

Managing Director