

Earth Science Partnership

Consulting Engineers | Geologists | Environmental Scientists

Land Adjacent to 27 Heol Tabor Proposed Residential Development Preliminary Geo-Environmental and Geotechnical Report

Report Reference: ESP.8144.3844.1

This page is left intentionally blank.

Earth Science Partnership

Consulting Engineers | Geologists | Environmental Scientists

33 Cardiff Road, Taff's Well, CARDIFF, CF15 7RB ☎ 029 2081 3385
✉ enquiries@earthsciencepartnership.com www.earthsciencepartnership.com

Land Adjacent to 27 Heol Tabor Proposed Residential Development Preliminary Geo-Environmental and Geotechnical Report

Prepared for:
Mr Camps
Chapel House
Tabernacle Terrace
Cwmavon
Port Talbot
SA12 9HS

Report Reference: **ESP.8144.3844 Rev 1**

Revision	Status	Date	Written and Checked by	Approved by
0	Draft	February 2023	Mat Elcock BEng (Hons) CGeol FGS	Matt Eynon BSc (Hons) MSc CGeol EurGeol FGS RoGEP Specialist
1	Final	May 2023		
Signature:				
Notes:	1. Once issued this document is Uncontrolled, for the latest version and/or to confirm you have authorisation to use it please contact the Earth Science Partnership at enquiries@earthsciencepartnership.com or by telephone at 029 2081 3385. 2. This document has been optimised for double sided printing and therefore may produce some blank pages when printed single sided.			

Contents

1	Introduction	1
1.1	Background.....	1
1.2	Objective and Scope of Works.....	2
1.3	Report Format.....	3
1.4	Limitations of Report	4
2	Desk Study and Field Reconnaissance Visit	5
2.1	Site Location and Description.....	5
2.2	Site History.....	6
2.3	Previous Investigations and Assessments.....	8
2.4	Contact with Regulatory Bodies & Local Information Sources.....	8
2.5	Hydrology	8
2.6	Flooding	8
2.7	Geology	9
2.8	Hydrogeology.....	11
2.9	Environmental Setting.....	12
2.10	Preliminary Geotechnical Risk Register.....	14
2.11	Radon Hazard	17
3	Preliminary Geo-Environmental Risk Assessment	19
3.1	Phase One Conceptual Site Model	19
3.2	Preliminary Risk Evaluation & Plausible Pollutant Linkages.....	21
4	Exploratory Investigation	24
4.1	Investigation Points.....	24
4.2	Sampling Strategy.....	24
4.3	Evidence of Site Contamination Found During Site Works.....	25
4.4	Geotechnical Laboratory Testing	25
4.5	Geo-environmental Laboratory Testing.....	25
5	Development of the Revised Conceptual Model	27
5.1	Conceptual Ground Model - Geology	27
5.2	Conceptual Ground Model - Hydrogeology.....	27
5.3	Chronic Risks to Human Health – Generic Assessment of Risks	27
5.4	Sulphate Attack.....	31
6	Phase Two Geo-Environmental Risk Assessment	32
6.1	Discussion on Occurrence of Contamination and Distribution.....	32
6.2	Revised Risk Evaluation & Relevant Pollutant Linkages	32
7	Remedial Strategy for Contamination Risks	34

7.1	Risks to Health.....	34
7.2	Risks to Controlled Waters.....	36
7.3	Risks from Ground Gas.....	36
7.4	Risks to Property.....	37
8	Preliminary Geotechnical Comments	38
8.1	Site Preparation and Earthworks.....	38
8.2	Geotechnical Risk Register.....	39
8.3	Outline Foundation Considerations	39
9	Recommendations	40
10	References	41

Figure 1 – Investigation Point Plan

Appendix A	Risk Evaluation Methodology
Appendix B	Extracts from Historical Maps
Appendix C	Environmental Data Report
Appendix D	Borehole Records Available from the British Geological Survey (BGS)
Appendix E	Coal Authority Mining Report
Appendix F	Preliminary UXO Risk Assessment (Zetica, 2020)
Appendix G	Trial Pit Records
Appendix H	Geotechnical Laboratory Test Results
Appendix I	Geo-environmental Laboratory Test Results - Soils

General Notes
General Construction Advice

Executive Summary

Mr Camps is looking to develop the subject site for redevelopment as a residential house. ESP have undertaken a preliminary geo-environmental assessment and the key potential land quality issues identified by the assessment are summarised below:

	Potential Hazard	Anticipated Risk	Discussion
Site Setting	Current Site Status.	-	The site is currently undeveloped rough land and has had Japanese knotweed on the site.
	Identified Ground Conditions.	-	The investigation was limited due to knotweed on the site, shallow pits have shown Made Ground.
	Groundwater Conditions.	-	The site is underlain by a Secondary A Aquifer. Groundwater is anticipated within the bedrock.
	Historical Land Use.	-	Possible copper works flue on site, site never shown as developed otherwise but adjacent to residential houses.
Geo-environmental	Potential Contamination Sources	High	Historical maps suggest a flue to pass over/under the site and may have transported fumes from the copper works.
	Chronic Risks to Human Health	Moderate	Further investigation required; initial testing suggests cover system possible.
	Risks to Controlled Waters	Low	Further investigation required however given site setting and initial test results, risk is considered to be low.
	Hazardous Ground Gas	High	Basic radon protection measures will be needed. Further investigation to determine gas risk.
Geotechnical	Abandoned Mine Workings and/or Old Mine Entries	Moderate/ Low	Risk considered to be low, however, check boreholes required to confirm anticipated mining ground model.
	Weak/Compressible Ground, requiring non-traditional foundations	High	Deep made ground or possibly voids may be present on site. Further investigation required to understand ground model and outline risks.
	Shrinkage or Swelling	Low	Further testing required.
	Sulphate Attack on Buried Concrete	Low	Further testing required; initial results indicate specialist concrete not required.
	Soakaway Feasibility	-	Soakaway testing was not part of the brief.
	Other Hazards	High	e.g., slope instability, karst, running sand, asbestos in buildings etc. Only discuss if applicable.
Others	UXO	-	Preliminary UXO assessment by specialists suggests a low risk.
	Flooding	Low	Risk in environmental data report stated as low.
	Invasive Plants	High	Japanese knotweed has been noted on site and limited investigation.
	Further Investigation Required?	Yes	See Section 9.

Note: The above is intended to provide a brief summary of the conclusions of the assessment. It does not provide a definitive assessment and must not be referenced as a separate document. Refer to the main body of the report for details.

1 Introduction

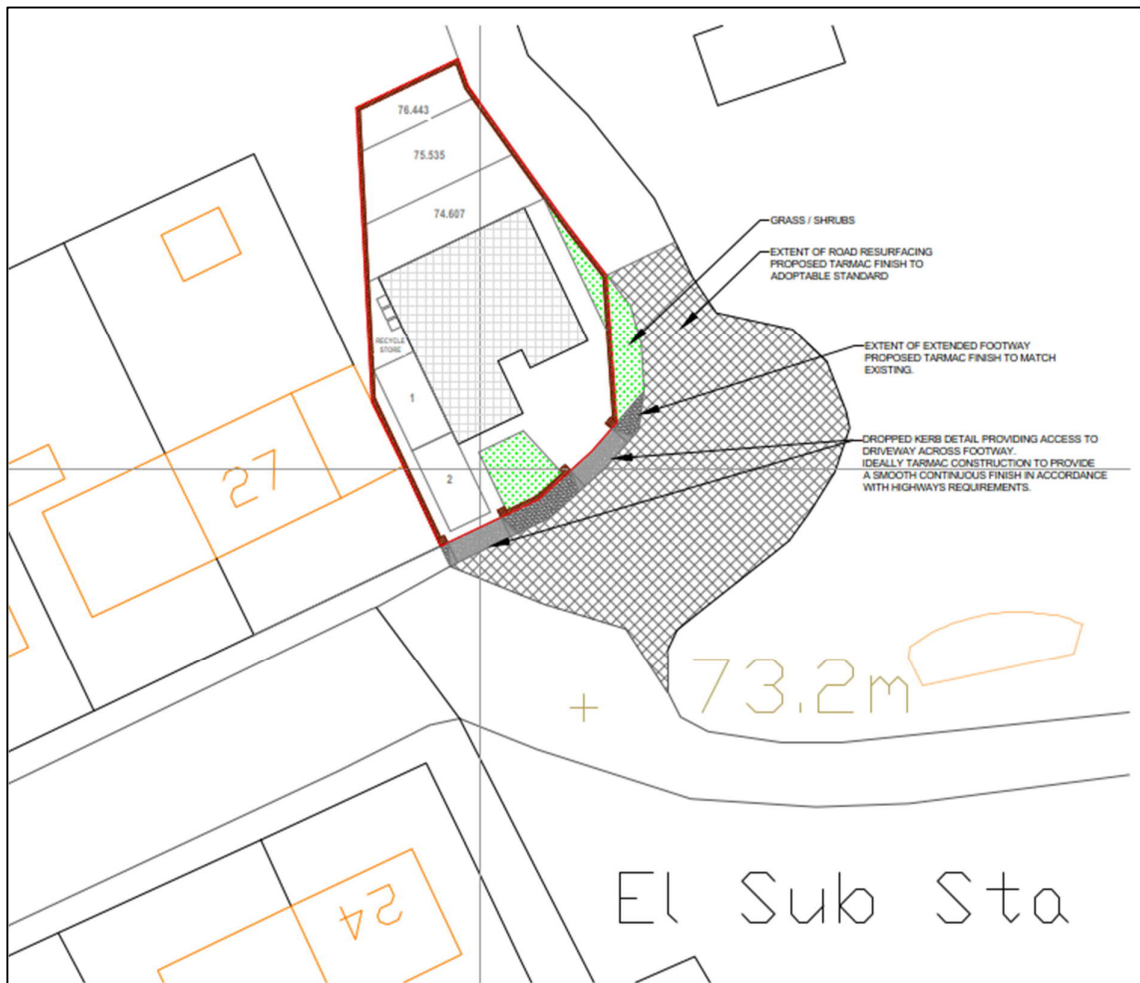
1.1 Background

Mr Camps (hereafter known as the Client) is understood to own the subject site and is proposing to construct a single residential dwelling. The Earth Science Partnership Ltd (ESP), were instructed by Tom Gronow, acting on behalf of the Client, to undertake a geo-environmental investigation and assessment to identify and evaluate potential ground hazards which could impact on the proposed development. The site location is shown on Insert 3 in Section 2.1.

The proposed development will comprise a two-storey residential dwellings with a private garden to the rear and off road parking area to the front.

We understand that, in order to construct suitable development plateau, ground levels in the north of the site will be lowered by a series of retaining walls.

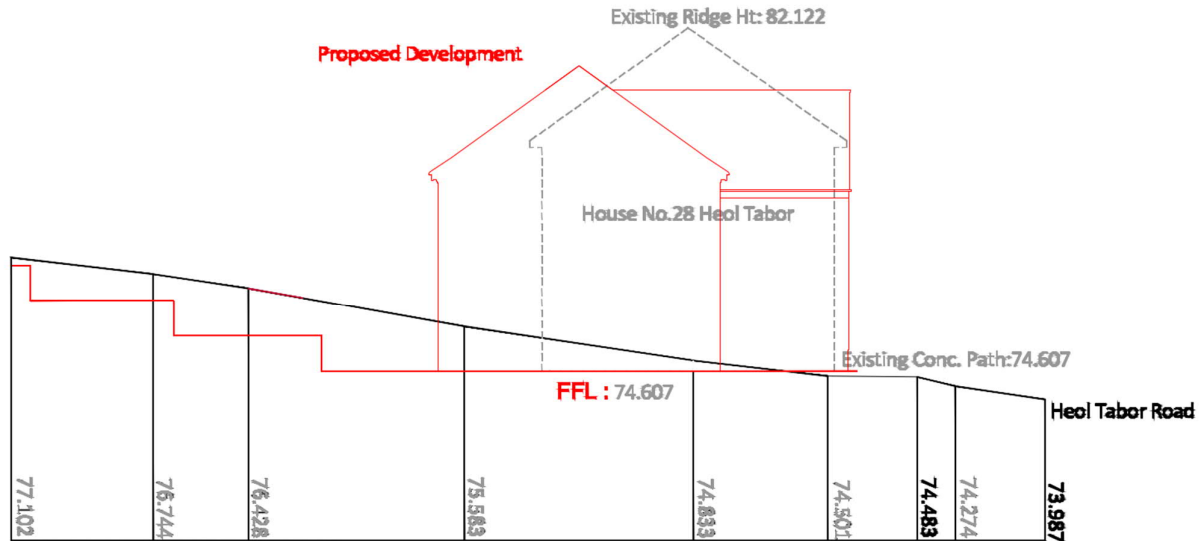
The proposed development layout is presented as Insert 1 below.



Insert 1 – Proposed Development

Based on the above, we understand that the proposed structures would be classified as Geotechnical Category 2 (BS5930:2015).

A drawing on the planning portal entitled 'Proposed Dwelling Site Block Plan' dated 28th September 2020 provides an indication of the cut and fill required at the site and is provided as Insert 2 below.



Insert 2 – Proposed Site Levels

1.2 Objective and Scope of Works

The objective of the investigation was primarily to obtain information to work toward the discharge of the land contamination conditions in the Planning Approval from the Local Planning Authority. The investigation was therefore scoped to provide this information and other comments, relating to geotechnical advice would also be provided, as allowed on the basis of the investigation carried out.

Condition 5:

No development shall commence on site until an assessment of the nature and extent of contamination affecting the application site area has been submitted to and approved in writing by the Local Planning Authority. This assessment must be carried out by or under the direction of a suitably qualified competent person in accordance with BS10175 (2011) 'Investigation of Potentially Contaminated Sites Code of Practice' and shall assess any contamination on the site, whether or not it originates on the site. The report of the findings shall include:

- (i) a desk top study to identify all previous uses at the site and potential contaminants associated with those uses and the impacts from those contaminants on land and controlled waters. The desk study shall establish a 'conceptual site model' (CSM) which identifies and assesses all identified potential source, pathway, and receptor linkages;
- (ii) an intrusive investigation to assess the extent, scale and nature of contamination which may be present, if identified as required by the desk top study;

(iii) an assessment of the potential risks to:

- human health,
- groundwater and surface waters
- adjoining land,
- property (existing or proposed) including buildings, crops, livestock, pets, woodland and service lines and pipes;- ecological systems,
- archaeological sites and ancient monuments; and
- any other receptors identified at (i) (iv) an appraisal of remedial options, and justification for the preferred remedial option(s).

This investigation and assessment have been designed in part to address the requirements of this planning condition. In addition, the desk study and investigation will outline potential geotechnical hazards at the site.

The scope of works for the investigation was designed by mutually developed with the Client by ESP within an agreed budget, and comprised a desk study review of available historical Ordnance Survey maps, environmental data, geological maps, memoirs and data, and further desk study information, a field reconnaissance visit as part of the site works, the supervision and direction of trial pits, geotechnical and geo-environmental laboratory testing, outline assessment of foundation options, risks to human health and controlled waters, and reporting.

The contract was awarded on the basis of a competitive tender quotation. The terms of reference for the assessment are as laid down in the Earth Science Partnership proposal of 18th March 2022 (ref: ESP.8144.It1.Proposal).

Upon arrival to the site in mid-2022, Japanese knotweed was identified across the site and the site works were aborted. ESP reattended site in December 2022 after we understood that Japanese knotweed had been removed. Upon arrive in December 2022, knotweed was still present on site and this precluded the use of a mechanical excavator to undertake the investigation. As such, the scope of works and assessment possible was limited and amended accordingly.

The investigation and assessment was undertaken between December 2022 and February 2023.

1.3 Report Format

This report includes the desk study and field reconnaissance reports (Section 2), and details of the investigation undertaken of Eurocode EC7 and BS5930:2015 (Section 4), along with the Preliminary Risk Assessment stage (Section 3) and Generic Quantitative Risk Assessment (Section 5) of CLR11. A preliminary evaluation of the resulting risks and any remedial measures potentially required to mitigate identified unacceptable risks from contamination and hazardous ground gas is included in Sections 6 and 7. However, it should be appreciated that this is a preliminary evaluation only, and will not generally meet the requirements of the Options Appraisal report of CLR11. The report concludes with a summary of any further surveys/ investigations/ assessments recommended (Section 9).

The assessment of the potential for hazardous substances (contamination) or conditions to exist on, at or near the site at levels or in a situation likely to warrant mitigation or consideration appropriate to the proposed end use has been undertaken using the guidance published by CIRIA (2001). This is discussed in more detail in Section 3.2.1 and in Appendix A.

This report is issued as a digital version only.

1.4 Limitations of Report

This report represents the findings of the brief relating to the proposed end use and geotechnical category of structure(s) as detailed in Section 1.1 above. The brief did not require an assessment of the implications for any other end use or structures, nor is the report a comprehensive site characterisation and should not be construed as such.

Upon arrival to the site mid 2022, Japanese knotweed was visually identified on site and the works were abandoned. We subsequently returned to the site in December 2022 after the client informed ESP that the knotweed had been removed, suspected visual evidence of recent knotweed growth was noted and a stockpile of soil including knotweed was on site. As such the proposed scope of works could not be implemented without the possibility of spreading knotweed and the investigation method was altered to hand excavated trial pits in areas of no knotweed. This therefore limited the number, depth and flexibility of the investigation and the report provides recommendations based upon the desk study and the limited investigation points where possible.

Further investigation should be carried out upon removal of the knotweed on site.

Should an alternative end use or structure be considered, the findings of the assessment should be re-examined relating to the new proposals.

Where preventative, ameliorative or remediation works are required, professional judgement will be used to make recommendations that satisfy the site-specific requirements in accordance with good practice guidance.

Consultation with regulatory authorities will be required with respect to proposed works as there may be overriding regional or policy requirements which demand additional work to be undertaken. It should be noted that both regulations and their interpretation by statutory authorities are continually changing.

This report represents the findings and opinions of experienced geo-environmental and geotechnical specialists. Earth Science Partnership does not provide legal advice and the advice of lawyers may also be required.

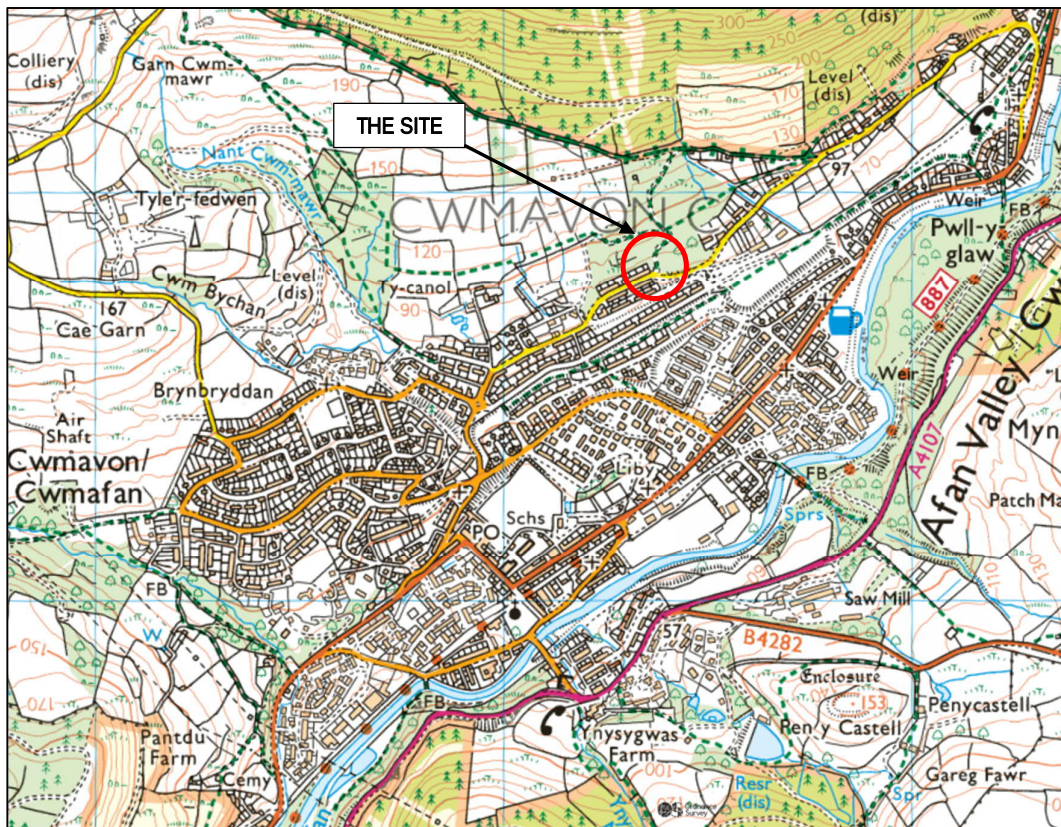
2 Desk Study and Field Reconnaissance Visit

The information presented in this section was obtained from desk-based research of sources detailed in the text, including historical maps, an environmental data report, a geological data report, information on a previous investigation at the site, and a mining report obtained from the Coal Authority. Further desk study reports/data/records are included as subsequent appendices as referenced in the text.

The site description is largely based on a field reconnaissance and site inspection visit made at the site on 8th December 2022.

2.1 Site Location and Description

The site is located at the eastern end of Heol Tabor on the northern margins of Cwmafan. The National Grid Reference of the centre of the site is (SS) 278366 192819 and the postcode is SA12 9PS. A Site Location Plan is presented as Insert 3 below.



Insert 3 - Site Location Plan from Ordnance Survey 1:25,000 scale map.
Reproduced with permission (OS License No.: AL100015788).

The site comprises an irregular shaped parcel of land that measure some 25m in length (north-south) and around 10m wide (west east) and is located on the end of a terrace, on the north and eastern side of Heol Tabor.

It is covered with scrub vegetation including Japanese knotweed.

It is bounded by:

- To the north: open scrub land
- To the east: a track and scrub land beyond
- To the south: Heol Tabor and associated houses
- To the west: terraced houses of Heol Tabor.

With the exception to the western boundary which is formed by a brick wall of No. 27 Heol Tabor, there are no other boundary features and access to the site is freely available.

At the time of the December 2022 visit, a stockpile, presumably of Japanese knotweed and soil was present near the front of the site and the site was generally devoid of mature vegetation. Possible Japanese knotweed shoots were also noted on the site.

The general topography in the area is slopes southeast towards the River Afan, and the site itself also slopes downward toward the south, thus the rear of the site is at a higher level than the front. The 'Proposed Dwelling Site Block Plan' from PLN Design on the planning portal looks to show ground levels from a topographic survey. At the front of the site, Heol Tabor is at a level of around 74mOD and the rear boundary is shown at approximately 77mOD.

2.2 Site History

2.2.1 Published Historical Maps

The site history has been assessed from a review of available historical Ordnance Survey County Series and National Grid maps. Extracts from the historical maps are presented in Appendix B and the salient features since the First Edition of the County Series maps are summarised in the table below.

Table 1: Review of Historical Maps

Date	On-Site	In Vicinity of Site
1882 – 1957	The site is shown to be within a long linear feature that is later labelled as a flue – which is possibly an underground feature. The site surface looks to be undeveloped or forms a track between rows of terraces.	The flue that possibly underlies the site generally trends north south, and ends at a chimney some 750m to the north. A row of terraced houses are noted to the west of the site, labelled as Copper Row, there are several other rows nearby, called Engine Row and Tewgoed Row. Rio Tinto Copper Works is some 100m to the south which comprises numerous large warehouse buildings, railway tracks, and smaller buildings. There are numerous coal mining buildings and old or current coal levels in the area, including a building some 100m southwest labelled Finery Slant (coal) and No.13 Pit (coal to the east. Several coal mine heaps or tips are recorded, notably several within 250m to the west. There are other signs of earthworks near roads and structures which possibly represent earthworks to form development platforms. By 1919, a Baptist Church was constructed near the eastern edge of the site, labelled as Tabor Church. At this time, much of the coal mining features are labelled as disused. The copper works looks to have become disused between 1921 and 1936.
1964 - 2022	The flue that possibly extends under the site is removed from the maps beyond 1936. No houses were constructed on the site.	The terraced houses surrounding the site, including Copper Row which bordered to the west has been demolished and Heol Tabor, generally in its current day layout, is shown. No 27 Heol Tabor is located immediately to the west. The underground flue that possibly extends under the site looks to have been removed from the mapping to the south of the site, but is still shown just beyond the northern boundary. The former copper works factory and associated infrastructure are largely removed from the maps and housing development is being constructed. The surrounding area continuous to be developed with housing until the present day.
Notes: 1. Extracts from historical maps presented in Appendix B. 2. Features may have been present on site between the dates of the individual mapping, and it should be appreciated that these cannot be identified from the map review.		

2.2.2 Other Sources

An aerial photograph, dated 2013 freely available on line (APU Online) clearly show a linear feature to the north of the site in the location of the possible underground flue. It is not possible to understand if this feature extends under/on to the subject site.

2.3 Previous Investigations and Assessments

We are not aware of any previous geotechnical or geo-environmental investigations or assessments at the site.

2.4 Contact with Regulatory Bodies & Local Information Sources

The following departments of the Local Authority (Neath Port Talbot Council) have been contacted as part of this assessment:

- Environmental Services/Health/Pollution Control
- Building Control
- Trading Standards (Petroleum Officer)

At the time of issue of this report, we have not yet received a response from the consultees. Once received, any response will be forwarded under separate cover. It should be appreciated that their responses may contain salient information on the site which could not be taken into account during the preparation of this report.

2.5 Hydrology

2.5.1 Surface Water Features

The nearest major surface water feature to the site is the River Afan which flows from north to south approximately 500m to the east. A number of streams are also present in the area, the closest of which lies some 13m to the east (see Appendix C). The site is situated on the side of a south-easterly facing slope and all surface water is anticipated to flow toward (or be culverted toward) the River Afan at the base of the valley.

2.5.2 Surface Water Abstractions

The environmental data report (Appendix C) indicates that there are no surface water abstractions within 250m of the site.

2.6 Flooding

2.6.1 Rivers and Seas

From a review of the flooding maps presented in the environmental data report and on the Natural Resources Wales (NRW) website (EA, 2023), the site is located in Flood Zone 1 and not indicated to be at risk flooding from rivers (fluvial) or seas (tidal). Flood Zone 1 is defined as an area during any given year that has less than 0.1% (1 in 1000) of flooding from rivers (fluvial) or seas (tidal).

The potential for flooding from rivers or seas has not been addressed further in this report and if required ESP are able to implement an appropriate Flood Consequences Assessment.

2.6.2 Surface Water

Surface water flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground but lies on or flows over the ground instead. This type of flooding can be difficult to predict, much more so than river or sea flooding as it is hard to forecast exactly

where or how much rain will fall in any storm. The information available depends on available records including ground levels and drainage.

From a review of information available on the Natural Resources Wales (NRW) (2023), the site is indicated to be outside areas at risk of surface water flooding and is described at Very Low Risk, defined as an area that in any given year has less than 0.1% (1 in 1000) chance of surface water flooding.

2.6.3 Groundwater

Groundwater flooding is defined as the emergence of groundwater at the ground surface away from river valleys or the rising of groundwater into man-made ground under conditions where the 'normal' range of groundwater levels and groundwater flows is exceeded and predicted risk from groundwater flooding aims to identify locations where this form of groundwater flooding could happen. It does not incorporate anomalous discharge from springs leading to groundwater flooding down the topographic slope or flooding associated with urban groundwater rebound, mine water discharge, urban drainage, or any other flooding associated with changes in the engineered environment.

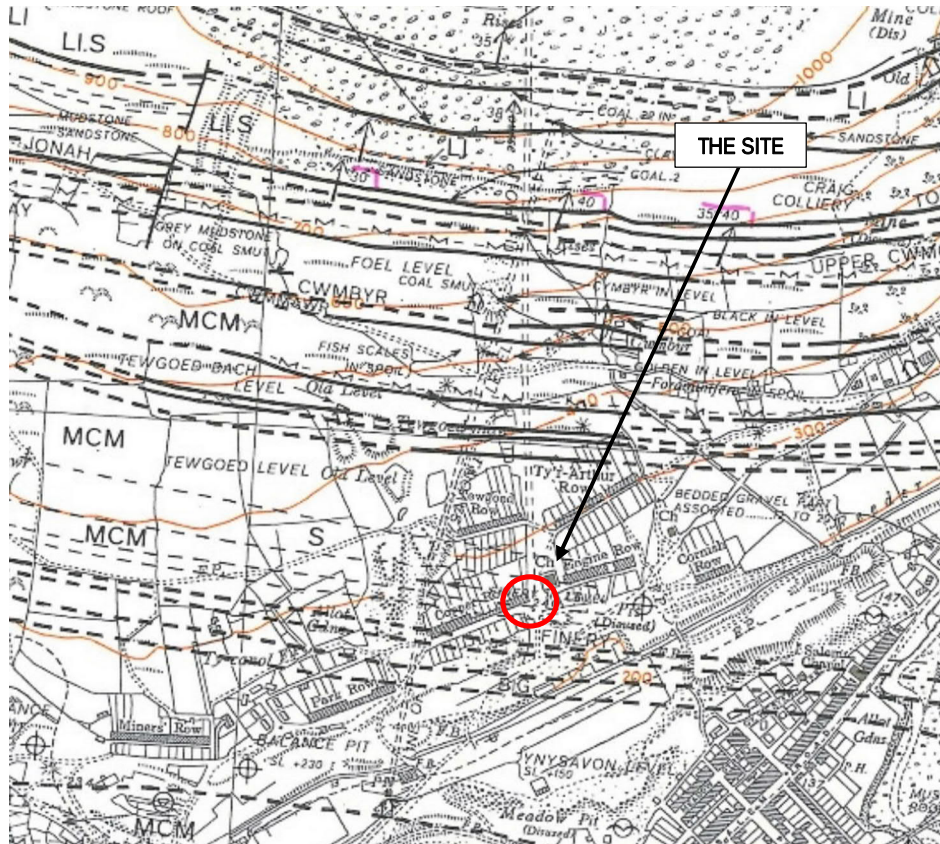
The environmental report in Appendix C indicates that the site is not at risk (negligible) from groundwater flooding.

2.7 Geology

2.7.1 Published Geology

The published 1:10,560 scale geological map for the area of the site (Sheet SS79SE) indicates the site to be underlain by bedrock of the South Wales Middle Coal Measures Formation.

Reference to the up-to-date mapping available on the website of the British Geological Survey (BGS, 2023) generally confirms the geological map.



Insert 1 - Extract from BGS Geological Map Sheet SS79SE original 1:10,560 scale.
Reproduced with permission (BGS licence number: C15/05 CSL)

The Coal Measures bedrock comprises an interbedded succession of sandstone, siltstone and mudstone, with coal seams and associated seat earths.

The geological map indicates the conjectural outcrop of several coal seams near the site. Four possible seams are shown to outcrop to the south of the site, these include the Big and Finery seams. Three other coal seams, which look to be unnamed, or thin outcrop on and to the north of the site.

All the outcrops generally follow a west to east pattern in the valley and the map also indicates the strata to dip to the north, at around 30° to 40°. Therefore, a possible six seams, including the Finery and Big are expected to underlie the site. Other seams in the valley will also underlie the site but are not discussed as they are expected to be at a suitable depth not to present a risk the site.

The geological map does not indicate the presence of any Made Ground below the site associated with the possible flue. The up-to-date geological mapping online indicates artificial ground in the lower parts of the valley, measuring some 100m to the south. A former coal tip is located some 100m west is also labelled as artificial ground.

2.7.2 Available BGS Borehole Records

Reference to the website of the British Geological Survey (BGS, 2023) indicates the available records of four boreholes within 200m of the site, all are located within a 'tip', as noted in the historical map review to the west of the site and as discussed above in section 2.7.1. Copies of the available

borehole records along with a plan showing their positions relative to the site are presented in Appendix D.

The boreholes were all drilled at Tewgoed Tips, Cwmavon via shell and auger methods and typically look to have recorded the thickness and composition of the site and stopped shortly after encountered natural soils, the records indicate the following:

SS79SE455-BH1; drilled to 12m depth and the tip was 10.9m thick;

SS79SE456-BH2; drilled to 13m depth and the tip was 11.70m thick;

SS79SE457-BH3; drilled to 14m depth and the tip was 12.50m thick; and

SS79SE458-BH4; drilled to 11m depth and the tip was 10m thick.

2.7.3 Available Previous Investigation Records

We are not aware of any previous site investigation information for the site.

2.8 Hydrogeology

2.8.1 Aquifer Classification

Reference to the aquifer maps published in the environmental data report (Appendix C) indicates that the the bedrock (Middle coal measures) is classed as Secondary A Aquifer.

Secondary A Aquifers generally correspond with the previously classified minor aquifers, and comprise permeable layers capable of supporting water at a local, rather than strategic, scale and in some cases form an important base flow to rivers. Secondary A Aquifers are sensitive to pollution.

2.8.2 Anticipated Groundwater Bodies

Based on the available information, we consider that the shallowest main groundwater body is likely to be located within the coal measures strata. However, localised perched water bodies within the possible Made Ground cannot be discounted.

The historical maps indicate a possible flue under the site, and this may hold a groundwater body, or act as a preferential pathway for groundwater.

2.8.3 Abstractions and Groundwater Vulnerability

The environmental data report (Appendix C) indicates that there are no groundwater abstractions or Source Protection Zones within 500m of the site.

2.8.4 Groundwater Movement

Groundwater movement within the coal measures bedrock is likely to be controlled by fracture flow, and it considered likely to flow downward and southward. Bedding is noted to the north, and it is possible this may influence the groundwater flow.

As discussed in Section 2.8.2, a flue is possible below the site which may provide a preferential pathway for water to flow.

It should be appreciated that in former mining areas, such as this, groundwater conditions may still be changing in response to the cessation or reduction in pumping from underground coal workings (see Section 2.10.1).

2.9 Environmental Setting

2.9.1 Summary of Environmental Data

The site exists in a historically industrial, and now a rural setting. An environmental data report has been obtained for the site and is presented in Appendix C, and the relevant data therein is summarised in the table below. The report should be consulted for further detail.

Table 2 - Summary of Environmental Data

Feature	On the Site	In the Immediate Vicinity
Environmentally Sensitive Sites ^{2,3}	None identified.	None recorded within 250m of the site.
Potentially Contaminative Land Use	See section 2.9.2.	See section 2.9.2.
Historical Tanks, PFS, Garages, Energy Facilities	None identified.	A substation is located to the south of the site.
Potentially Infilled Land	None identified in environmental data rpt	See Section 2.9.2.
Discharge Consents	None identified.	None recorded within 250m of the site.
List 1 and 2 Dangerous Substances Sites	None identified.	None recorded within 500m of the site.
Radioactive Substance Sites	None identified.	None recorded within 500m of the site.
Pollution Incidents	None identified.	None recorded within 500m of the site.
Contaminated Land under Part 2A EPA 1990.	None identified.	None recorded within 500m of the site.
Waste Management Facilities	None identified.	The tip 98m west and another 229m northwest are recorded as historical landfills. See Section 2.9.2.
Current Industrial/ Commercial Sites	None identified.	With the exception of substations, no features recorded within 250m of the site.
Notes: - Full details of features presented in environmental data report (Appendix C). - Sensitive land uses include Sites of Special Scientific Interest, Nature Reserves, National Parks, Special Areas of Conservation, Special Protection Areas, Ramsar sites, World Heritage sites and Ancient Woodland. - Nitrate vulnerable areas relate to the agricultural use of fertilizers and are not considered further in this assessment.		

2.9.2 Further Discussion on Salient Environmental Features

Potentially Contaminative Land Use

The environmental data report lists several possible former contaminative land uses to be on site, including a copper works, disused flue and unspecified pit. Other features are listed near the site, including refuse tip, disused pits, railway sidings, coal slants/workings and cuttings.

Copper works

The historical maps show that the site was within a largely residential area, anticipated to be housing for workers of the nearby Rio Tinto Copper Works. The maps show the main warehouses and works off site and near the valley base; as such, the copper works were not on site. The presence of nearby copper works will possibly have an impact on shallow soils from particulate matter fallout in the area.

Unspecified pit

The source information for the 'unspecified disused pit' on the environmental data report is the 1957 historical map, review of this map shows no evidence of a pit on site. A label for a Pit (disused) is nearby but this refers to an old coal mining shaft or pit some 110m to the east. The map also shows some possible earthworks to the southeast of the site.

Flue

The historical maps showed the potential presence of a flue on, or under the site. The environmental data report also identifies a flue, and the source of that is likely to be from the historical maps.

It is assumed that the flue originated from the Copper works to the south, however this is unknown and could possibly have a different source. If it originated from the Copper Works, it would have provided a pathway for exhaust, steam, discarded gas to the chimney at the northern end of the flue, as indicated on the historical maps. As such, contaminant laden gases would have passed through the flue and could therefore be under the site, or within soils surrounding the flue. The flues construction is not known.

Potentially Infilled Land and Landfill

The environmental data report labels two landfills, one 98m west and another 229m northwest of the site. The environmental data report does not list normal landfill information, such as: licence information, operators, waste type and operational dates for example.

These same areas are labelled on the geological mapping as Made Ground (undivided) - Artificial Ground. The historical maps label the same areas as tips and given their proximity to coal levels, its assumed that they comprise coal mining spoil.

As discussed in Section 2.7.2, there are records of four BGS borehole drilled by cable percussion methods on the tip. The borehole records are dated 1977 and all indicate the tip to comprise greyish black colliery shale with cobbles, gravel and boulders which all overlie soils logged as boulder clay.

2.9.3 On-Site Bulk Liquid Storage

The historical maps and field reconnaissance visit have provided no evidence of any past or recent above ground or underground bulk liquid (e.g., fuels/oils) storage on site.

2.9.4 On-Site Bulk Materials and Waste Storage

Observations during the field reconnaissance visit indicated the storage of soil including Japanese knotweed in the southern part of the site.

2.10 Preliminary Geotechnical Risk Register

The potential for various geotechnical and geomorphological hazards at the site is provided in the environmental data and geological data report (Appendix C). The potential hazards, as defined by the British Geological Survey (BGS) and reported in the above report, along with any salient further information has been considered in the preparation of this report.

Where a potential geotechnical hazard has been identified, it is discussed further in subsequent sections.

2.10.1 Past Coal Mining

As discussed in Section 2.7, the site is underlain by bedrock of the Middle Coal Measures, which contains several seams of coal (and bands of ironstone).

2.10.1.1 Historical and Geological Information

Eight seams are plotted to outcrop near the site; depending upon the accuracy of those plots, they may all underlie the site at a shallow depth. The mapping indicates that six of those seams do underlie the site, of these they include the Finery and Big seam.

The Finery (two feet nine) is shown to outcrop approximately 60m south of the site. The published geological map suggests that the seam is 2ft 9 inches (84cm) in thickness in the area. The Big seam outcrops some 120m south of the site and the published geological map suggests that the seam is 6ft 9 inches (2m) between the Finery and Big seam is the Sulphury seam, which is below the Finery and the geological map indicates that to be 3ft thick (0.92m). Below the Sulphury is the Four Feet (Upper and Lower) and then two thin coal seams.

2.10.1.2 Coal Authority Website

Reference to the Coal Authority website (CA, 2023) provides the following salient information:

- The outcrop of one or more unnamed coal seam(s) to the south of the site is shown to cross in an east-west direction. Reference to the published geology (Section 2.7.1) suggests that this could be the Finery Seam, or others lower in the succession.
- A Development High Risk zone is shown with these seams to the south, and it appears that the site is not within that zone.
- There appears to be no outcrop, or development high risk zones on or immediately to the north of the site (this indicates that the thin conjectured seams on the geological sheet are not present or not shown).

- No recorded or probable past shallow coal mining is indicated on or in the immediate vicinity of the site.
- No mine entries are shown within the site boundary.

2.10.1.3 Coal Authority Mining Report

A consultant's mining report has also been obtained from the Coal Authority and is presented in Appendix E. This indicates that, based on the available Coal Authority records:

- There are recorded workings in at least four seams of coal beneath the site, at depths of between 60 and 189m. These workings were associated within the Meadow colliery and an unnamed colliery. The last working date of these coal seams was 1900.
- The shallowest workings were within the Finery, or two feet nine coal seam, and the extraction thickness is reported to have been 1.22m.
- There are no recorded entries within 20m of the site – see below for further discussion.
- There are no recorded geological faults or fissures recorded beneath the site.
- There are no recorded damage notices or claims for the subject property, or any property within 50m of the site boundary, since 31st October 1994.
- There is no record of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991.
- No mine gas emission has been recorded within 500m of the property.
- There is no proposed future mining or licensing proposed.
- No notices have been given under Section 46 of the Coal Mining Subsidence Act 1991 stating that the land is at risk of subsidence.
- The site located in an area of historical coal mining activity.

2.10.1.4 Preliminary Coal Mining Risk Assessment

The Coal Authority indicate recorded workings within several seams at depth of between 61m and 189m below the site. It is known that Coal Authority records are incomplete, partly because there was no statutory and mandatory requirement on colliery owners to survey and submit records of the extent of their mine workings to the Secretary of State until the Coal Mine Regulation Act of 1872. Therefore, given the potential age of the possible workings, no surveys may ever have been undertaken on them.

The historical maps, Coal Authority data and geological maps all indicate that the area was heavily exploited for coal and coal workings below the site are likely to be present. On the basis of the lines of evidence available, it is considered likely that the workings are at a suitable depth (given the likely zone of subsidence risk relative to the extraction height) and as such that there is considered to be a low to moderate risk of subsidence at the site.

Unrecorded mine entries, (bell pits, adits or shafts) may possibly be on the site, or within close proximity that may impact the site, and this should also be considered in future design and risk assessments.

A proportionate site investigation should be carried out to understand the coal mining setting/ground model to confirm a low subsidence risk.

It should be appreciated that all coal reserves, including abandoned workings are under the ownership of the Coal Authority (or the Forestry Commission in the Forest of Dean), and their permission must be obtained before any investigation can be undertaken to intercept these features.

2.10.2 Shrinkable and Swelling Soils

The underlying weathered bedrock can contain fine grained horizons that are susceptible to volume change with changes in moisture content (shrinkage and swelling). Therefore, we consider that the potential for shrinkable/swelling soils at the site should be advanced from that reported in the environmental data report (Very Low) to Low.

2.10.3 Landslides

The environmental data report outlines a possible moderate risk of landslides at the site. Whilst natural landslides are within the wider valley, none are noted nearby in the same geological setting and the risk is likely to be lower, however, instability could occur, and a detailed assessment should be carried out in tandem with a suitable site investigation.

2.10.4 Collapsible Ground

Some soils (both natural and man-made) can collapse (i.e., suffer a rapid reduction in volume) when loaded or saturated, which can then lead to significant damage to structures and utilities.

Based on the geological setting of the site, we consider that the risk from collapse of natural soils is low. However, man-made soils (Made Ground) are anticipated on the site which could suffer future collapse.

As discussed in previous sections, coal mining was widespread in the area and colliery spoil could be present beneath the site. Mudstone-rich colliery spoil when used as backfill to opencast workings or pits can collapse when saturated.

We anticipate a deep groundwater level, and as such the risk of collapsible soils is reduced. If shallow groundwater is encountered, then the risk from collapsible soils should be considered further.

Therefore, we consider that the potential for collapsible ground at the site should be advanced from that reported in the environmental data report (Very Low) to Low/moderate.

2.10.5 Volumetrically Unstable Slag Materials

The potential for volumetrically unstable slag material to be present on the site is not considered in the environmental data report. Slag was a waste product from iron and steel manufacture and varies chemically depending on the manufacturing process involved. There are three main types of slag, blast furnace slag, basic steel slag and acid steel slag, along with further associated refractory products. Some forms of slags, such as fresh blast furnace slag and acid steel slag, are generally volumetrically stable but, depending on their chemistry, some such as basic steel slags and weathered blast furnace slags can be extremely unstable when hydrated, which can lead to significant heave at the surface and damage to buildings and hard surfaces.

In our experience, near former industrial site such as this, there is the potential for slag materials to be present within the Made Ground. Given the currently available information, we cannot discount that the slag present on site could be volumetrically unstable, and we consider that the risk from such instability should be considered Moderate at this desk study stage.

2.10.6 Historical Underground Structures

Historical information indicates that a possible flue may be present under the site. Its construction details are unknown at this stage, but it is postulated that the flue provided a preferential pathway for fumes to escape from the copper works to a higher point on the valley site, where a chimney is noted at the end of the flue.

It is unclear whether foundations/underground structures associated with the former flue remain in the ground.

This will need to be investigated further. If the flue is remaining, or any other structures will need to be grubbed up as part of the redevelopment and if extensive, this may have cost (larger machinery, backfill materials, disposal costs etc.) and time implications for the development.

Care should be executed to avoid damaging the underlying formation, to avoid the requirement for further deepening of the foundations beyond the disturbed ground.

2.10.7 Pyritic Ground

The environmental data report does not consider the potential risk from sulphate rich or pyritic ground.

The soils underlying the site are not anticipated to contain elevated levels of pyrite, which could oxidise to sulphates.

Depending on its origin, the Made Ground anticipated beneath the site may also contain elevated levels of pyrite.

Given the above, we consider that the potential for sulphate/pyrite attack on buried concrete would be **Moderate**.

2.10.8 Unexploded Ordnance

The environmental data report does not consider the potential risk from unexploded ordnance at the site.

A Preliminary (Pre-Desk Study) UXO Desk Study assessment of risk has been completed by a specialist Ordnance consultant in accordance with CIRIA guidelines (Stone et al, 2009) and is presented in Appendix F (Zetica, 2022).

The assessment concludes that 'a detailed desk study, whilst always prudent, is not considered essential in this instance'.

2.11 Radon Hazard

Radon is a colourless, odourless, radioactive gas, which can pose a risk to human health. It originates in the bedrock beneath the site, where uranium and radium rich minerals are naturally present, and can move through fractures in the bedrock, and overlying superficial deposits, to collect in spaces within/beneath structures.

The environmental data report (Appendix C) indicates that the site lies in a radon affected area as defined by the Health Protection Agency, with between 3 and 5% of properties above the action level.

Reference to the UK radon maps published by Public Health England (PHE, 2015) indicates that the site lies in an area classified as a maximum radon potential of less than 1%.

These maps indicate the worst level of radon potential, based on existing information gathered mainly from residential properties within the 1km square in which the site is located. It is designed as a preliminary evaluation only.

Reference to the published BRE guidance in BRE 211 (Scivyer, 2007) indicates that the site lies in a 1km square where the maximum requirements are for basic radon protection measures in new buildings (domestic or non-domestic).

Given the currently available information, the risk from radon is considered **Moderate**.

3 Preliminary Geo-Environmental Risk Assessment

3.1 Phase One Conceptual Site Model

3.1.1 Background

The Phase One Conceptual Site Model lists the potential sources of geo-environmental risk (both contamination and hazardous gas), the receptors at risk (both human and non-human), and any feasible pathways between the two. These are discussed in the following sections.

3.1.2 Potential Soil Contamination Sources

The site history has shown that the site was possibly a track or area of rough ground near to residential housing. A flue possibly passed under, or across the site, presumably providing a preferential pathway for exhaust fumes from a nearby copper works.

From the available information, we consider that the following features on site could prove sources of diffuse and point source contamination that could impact on the development, environment or site users:

- Made Ground – general diffuse contamination, including colliery spoil and slag;
- Former flue – linear feature.
- Stockpiles of Japanese knotweed and knotweed on site.

3.1.3 Potential Contaminants Present

The potential contaminants associated with the above potential sources have been identified from various guidelines published by DEFRA, the Environment Agency and others. The particular guidance referenced includes the Industry Profile for Metal Manufacturing, refining and finishing works (non-ferrous works (DoE, 1995).

Whilst the copper works were located nearby, it is noted that the site is within a residential area and only fumes from the copper works are likely to be a source on site and as such much of the possible contaminants in the DoE profile are not considered applicable at this time.

Based on this guidance and our experience, we consider that the following contaminants could be present on the site:

- heavy metals and semi-metals (arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc);
- cyanide, sulphate, sulphide;
- polycyclic aromatic hydrocarbon (PAH) compounds;
- phenols; and
- asbestos.

No evidence has been identified from the desk study to suggest that radioactive substances may be present on the site. The potential presence of radon is discussed in Section 2.11

3.1.4 Potential Sources of Hazardous Ground Gas

This section considers the potential sources of hazardous gases such as methane, carbon dioxide and hydrocarbon vapours. The potential for radon was discussed in Section 2.11.

The desk study showed that there are two 'tips' within the vicinity of the site, these are located to the west and northwest and historical maps indicate that they are colliery spoil tips. BGS borehole records on one of the tips confirm that the material is colliery spoil. The borehole records also indicate a layer of boulder clay at the base of the tip, suggesting that the tip was placed on ground level, and not dug, into the ground, i.e., a quarry. Given the likely composition of the tips, their age, over 120 years old (last workings for coal in the area noted to be 1900 in Coal Authority report) and that any gasses escaping would freely escape into the atmosphere as a preferential pathway, they are not considered to be a source of ground gas.

A large area of artificial ground is labelled to the south of the site, which has been developed with housing from the later part of the last century. It is not considered likely that this area represents a significant source of ground gas to the site.

There may be deep made ground on site, if a buried flue is/was present which may provide a source of ground gas. Coal mine workings can be a source of gas, the preliminary conceptual ground model indicates no outcrops of workable seams or mine entry on or immediately near the site and thus the risk is considered to be low but this will need to be confirmed with appropriate investigation.

The flue, or made ground in its former route may provide a preferential pathway for ground gas.

3.1.5 Potential Receptors

We consider that the most vulnerable receptors with regards to any contamination or hazardous ground gas present are likely to be as follows.

- Future residents, the critical receptors being young children playing in private garden areas.
- Construction and maintenance workers.
- Buried concrete (foundations, drainage etc.).
- The water quality in the River Afan located 500m to the southeast.
- The groundwater within the Middle Coal Measures Formation (Secondary A Aquifer) beneath the site.

3.1.6 Potential Migration Pathways

Based on the Conceptual Site Model discussed in the previous sections, the following are considered the most likely migration pathways with regard to any contamination or hazardous ground gas present beneath the site.

Site Users:

- Ingestion of soils and inhalation of dust in garden areas (front and rear of the development).
- Ingestion of edible plants and dust associated with such plants.
- Dermal contact with contaminated soils.
- Exposure to asbestos containing materials within the shallow soils.
- Potential explosive risk from flammable ground gas/vapours from on-site sources.
- Potential risk from toxic ground gas/vapours from on-site sources.

- Potential exposure to flammable or toxic ground gas/vapours originating from off-site sources – via flue if present.
- Chronic (long term) exposure to unacceptable levels of radon.

Construction and Maintenance Workers:

- Exposure to asbestos containing materials within the shallow soils.
- Ingestion of soils and inhalation of dust across site.
- Dermal contact with contaminated soils.
- Potential explosive risk from flammable or toxic ground gas/vapours from on-site sources.
- Potential explosive risk from flammable or toxic ground gas/vapours from off-site sources.

Groundwater:

- Leaching of mobile contaminants into the water-bearing strata within the bedrock.

River Afan:

- Leaching of mobile contaminants to the groundwater beneath the site, and then into surface water course.

Buildings:

- Sulphate attack on buried concrete (foundations, drainage etc.).
- Potential explosive risk from flammable ground gas/vapours from on-site sources.
- Potential explosive risk from flammable ground gas/vapours from off-site sources.

3.2 Preliminary Risk Evaluation & Plausible Pollutant Linkages

The land use history of the site and surrounding area, as established from the desk study and walkover, has identified a number of potential contamination linkages due to ground conditions or former operations either on, adjacent to, or in the vicinity of the site. Note that these potential linkages will need to be later assessed and re-established using actual site data obtained from an exploratory investigation.

3.2.1 Introduction to Risk Evaluation Methodology

The general methodology set out in CIRIA C552 Contaminated Land Risk Assessment – A Guide to Good Practice (Rudland et al, 2001), has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action.

Whilst at a later stage, this methodology may be informed by quantitative data (such as laboratory test results) the assessment is a qualitative method of interpreting findings to date and evaluating risk.

The methodology requires the classification of:

- The magnitude of the potential consequence (severity) of risk occurring (Table A1 in Appendix A):
- The magnitude of the probability (likelihood) of risk occurring (Table A2 in Appendix A).

The classifications defined above are then compared to indicate the risk presented by each pollutant linkage, allowing evaluation of a risk category (Tables A3 and A4 in Appendix A). These tables have been revised slightly by ESP from those presented in CIRIA C552, to allow for the circumstances where no plausible linkage has been identified and, therefore, no risk would exist.

The methodology described above has been used to establish Plausible Pollutant Linkages (PPL) based on the Conceptual Site Model generated for the site and proposed development, and to

evaluate the risks posed by those linkages, using information known about the site, at this desk study stage. This is presented as Table 3 in Section 3.2.2 below.

3.2.2 Tabulated Preliminary Risk Evaluation & Plausible Pollutant Linkages

Table 3: Preliminary Risk Evaluation & Plausible Pollutant Linkages (PPL)

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	Likely ²	Moderate Risk	Sampling of near-surface soils to confirm levels of total contamination present.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Low likelihood ²	Very Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A Aquifer	Low likelihood ²	Moderate/Low Risk	
	Leaching of soil contaminants	Impact on River Afan	Medium – site lies adjacent to river	Low likelihood ²	Moderate/Low Risk	
Asbestos in shallow soils	Inhalation of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Likely ³	Moderate Risk	Sampling of shallow soils for asbestos.
Soil sulphate and pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	Likely ⁴	Moderate/Low Risk	Sampling of soils to confirm levels of sulphate, pH, and groundwater.
Hazardous ground gas/vapours	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	Likely ⁵	High Risk	Investigate to understand if deep Made Ground present or flue. Install and monitor gas wells if needed.
	Damage through explosion.	Building/Property	Severe – acute risk.		High Risk	
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.		High Risk	
Radon gas	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	High Likelihood ⁶	High Risk	See Section 7.3.2

Notes:

1. Methodology and details of risk consequence, probability and category based on CIRIA C552 (2001) and presented in Section 3.2.1.
2. Although Made Ground is anticipated, the presence of contamination has yet to be confirmed on site. See Section 3.1.
3. No obvious asbestos materials have been observed in the Made Ground soils. Surrounding area developed when asbestos used regularly in construction.
4. If present on site, Made Ground can potentially contain sulphates/pyrite.
5. Possible sources of ground gas exist, deep made ground, flue coal mine workings. Site investigation to confirm.
6. Radon risk identified in environmental data report. See Section 2.11.
7. The above risk evaluation is updated following the intrusive investigation and testing in Section 6.2.

4 Exploratory Investigation

4.1 Investigation Points

4.1.1 Introduction

The intrusive investigation was undertaken on the 8th December 2022 in general accordance with BS5930:2015 and BS10175:2017, and was designed to investigate geo-environmental hazards identified in the desk study (Section 2). It was to comprise trial pitting, however, upon arrival at the site Japanese knotweed was on site and this precluded the use of a mechanical excavator. In light of this, five shallow hand dug pits were advanced to gain an understanding of the shallow soils across the site in areas where Japanese knotweed looked to be absent.

The exploratory holes were supervised and logged by an engineering geologist in general accordance with BS5930:2015 and the investigation point positions are shown on Figure 1.

The coordinates shown on the investigation point records are approximate only and have been interpolated from the topographical survey/recent Ordnance Survey maps.

4.1.2 Investigation Strategy

As discussed above, the investigation strategy was altered given the emerging conditions on site and a suitable strategy in accordance with BS10175:2017 was not possible. However, shallow trial pits were excavated across the site to gain an understanding of the shallow soils.

4.1.3 Trial Pits

Five hand excavated trial pits (HP01 to HP04 and HP04a) were excavated across the site on the 8th December using hand tools to a maximum depth of 1.2m.

The trial pit records are presented as Appendix G, and their positions are shown on Figure 1.

Disturbed samples were collected from the trial pits for laboratory testing as shown on the trial pit records.

On completion, the trial pits were backfilled with arisings in layers tamped back with hand tools. The arisings were left slightly proud of the adjacent surface to allow for future settlement.

4.2 Sampling Strategy

4.2.1 Soil Sampling

Soil samples were collected from the exploratory holes as discussed in the previous sections. The sampling procedures were selected on the basis of the suitability for the laboratory testing proposed.

A non-targeted, random sampling strategy was used to obtain representative information on soil contamination across the site as a whole.

Environmental samples (denoted as ES on the exploratory holes records) were collected for possible geo-environmental laboratory testing and generally comprised a plastic tub, an amber glass jar and an amber glass vial. The sample containers provided clean by the testing laboratory appropriate for the

proposed testing to be scheduled. Immediately after collection the samples were placed in sealed cool boxes with ice packs where they remained during storage and transport to the laboratory.

Samples for logging and geotechnical laboratory testing purposes were collected at regular intervals within the exploratory holes.

4.3 Evidence of Site Contamination Found During Site Works

With regard to potential hazards identified in the desk study and Preliminary Risk Assessment, the following observations were made.

Made Ground was noted in all investigation positions and the base was only confirmed in one location, HP01. The Made Ground across the site was noted to contain fragments of slag, metal, plastic, fabric and coal.

4.4 Geotechnical Laboratory Testing

It was proposed to undertake geotechnical laboratory testing on samples from the suitable quality classes recovered from the exploratory holes in order to obtain information on the geotechnical properties on the soils beneath the site. However, natural soils were only encountered in one position, therefore, it has only been possible to undertake a single geotechnical test, which was Atterberg limits on a sample of fine-grained soil.

The test was undertaken by a UKAS accredited laboratory, in accordance with the methodologies presented in BS1377:1990. The result is presented in Appendix H.

Selected samples were also analysed for soil sulphate and pH value in accordance with the analytical methods specified in BRE Special Digest SD1 (BRE, 2005). The results of the sulphate testing are included with the geo-environmental test results in Appendix I.

4.5 Geo-environmental Laboratory Testing

Laboratory testing has been undertaken to identify the levels of selected contaminants within samples of soil recovered during the investigation.

The geo-environmental analyses were carried out by a UKAS accredited testing laboratory with detection limits being generally compatible with the relevant guideline values adopted in the assessment (see Sections 5.3).

In order to allow an initial assessment of the potential chronic risks posed to human health, a total of three selected samples of the Made Ground have been analysed for contaminants typically found on brownfield sites in the UK.

The general suite of geo-environmental laboratory testing undertaken comprised:

- Arsenic, barium, beryllium, boron, cadmium, total chromium, chromium VI, copper, lead, mercury, nickel, selenium, vanadium, zinc;
- US EPA 16 polycyclic aromatic hydrocarbon (PAH) compounds;
- Total monohydric phenols;
- Total cyanide, asbestos qualitative screen (presence or absence);
- Soil organic content, pH value;

- Asbestos quantification analysis.

The geo-environmental soil test results are presented in Appendix I.

5 Development of the Revised Conceptual Model

5.1 Conceptual Ground Model - Geology

The exploratory holes indicate Made Ground to cover much of the site. Suspected natural soils were encountered in the southeastern corner of the site in HP01.

Made Ground: encountered to a maximum depth of 1.2m, initially as a dark brown sandy gravelly silt with fragments of concrete, brick and sandstone with roots and buried branches which was interpreted as a placed Topsoil, which extended to a maximum depth of 0.3m.

The underlying soil comprised dense black mottled grey silty gravelly sand with boulders and cobbles. It included fragments of slag, coal, sandstone, concrete, brick, metal and plastic.

Middle Coal Measures Bedrock: was encountered in a single location, HP01 and comprised stiff gravelly sandy clay.

5.2 Conceptual Ground Model - Hydrogeology

The investigation did not identify any groundwater to a depth of 1.2m. However, the exploratory holes were completed within one working day and the near-surface soils were fine-grained in nature. Therefore, due to the soils low permeability, it is possible that groundwater may be present within the depth of investigation, but there was insufficient time for it to be recorded.

5.3 Chronic Risks to Human Health – Generic Assessment of Risks

5.3.1 Assessment Methodology

The long-term risks to health have been assessed using methodologies and frameworks determined by the Environment Agency within documents SR2, SR3, SR4 and the CLEA Technical Review published to support the Contaminated Land Exposure Assessment Model (CLEA). Where applicable, reference has been made to the supporting toxicological reports (TOX Series) and the Soil Guideline Value reports (SGV Series). It is assumed that the reader is familiar with the above documents, and it is not intended to repeat these described methodologies in detail, for further information, please refer directly to the specific documents.

In order to provide an initial 'screen' to identify elevated levels of contaminants, a Generic Quantitative Risk Assessment (GQRA) has been undertaken using the most appropriate Generic Assessment Criteria (GAC) determined by assessment of exposure frequency/duration relevant to the critical receptor.

5.3.2 Assessment Criteria

In 2013, CL:AIRE published the Category 4 Screening Levels (C4SL – CL:AIRE, 2013) for use in Part 2A determinations. The C4SL are designed to be more pragmatic, but still strongly precautionary, assessment criteria compared to the previous assessment criteria (SGV – see below) used to assess chronic human health risks. The C4SL have been calculated for a limited number of contaminants at this stage, and range of land uses including residential, commercial and public open space, but are

based on a 'low level' of risk rather than the 'minimal level' of risk adopted by the Environment Agency in preparing their Soil Guideline Values (SGV). The C4SL have also only been published for a limited number of contaminants commonly identified in contaminated land risk assessments at present (arsenic, cadmium, chromium VI, lead, benzene, benzo[a]pyrene). However, the C4SL have been published for a range of land uses, including residential, commercial, allotments and two types of public open space.

The C4SL are designed for use in deciding whether land is suitable for use and definitely not contaminated, and DEFRA and the Welsh Government have recommended that they be used in assessing human health risks during the planning regime (i.e., as part of standard development investigations). The Welsh Local Government Association and Natural Resources Wales (WLGA/NRW) have confirmed that, 'where the site conditions are applicable to the land use scenarios adopted in their calculation, the C4SL levels can be used as screening tools' for development site risk assessments (WLGA/NRW, 2017). The C4SL have also been accepted by the NHBC for use as generic screening levels on residential developments in England and Wales (NHBC, 2014). Given this, where available and applicable, the C4SL have been adopted as the Generic Assessment Criteria in this assessment.

Where no C4SL is currently available, the Suitable For Use Levels (S4ULs) published in January 2015 by the Chartered Institute of Environmental Health (CIEH) and Land Quality Management (LQM) (Nathanail et al, 2015) have been adopted. These assessment criteria adopt updated toxicological data and exposure models, and the same 'minimal level' of risk as the SGV (i.e., unlike the C4SL). The S4ULs have been published for a large number of contaminants typically found on brownfield sites in the UK, and for the same range of land uses as the C4SL, i.e. including public open space scenarios.

Where no C4SL or S4UL is available, the Soil Guideline Values (SGV) published by the Environment Agency have been adopted as the Generic Assessment Criteria (GAC) – note several SGV have been withdrawn since originally published. However, the SGV are only available for a limited number of contaminants for three proposed land uses (residential, commercial and allotments – and not public open space).

For more exotic, predominantly organic, compounds no SGV, S4UL or C4SL assessment criteria have been published. In this instance, GAC published by CL:AIRE and the Environmental Industries Commission (CL:AIRE/EIC, 2010) have been adopted. These GAC have also been developed using the CLEA UK software based on a 'minimal level' of risk and for the same land use scenarios as the SGVs (i.e. not public open space).

Details of the Generic Assessment Criteria (GAC) adopted for each contaminant are presented on the assessment tables in the following section.

The proposed development comprises a conventional residential property with private gardens. Therefore, the GAC appropriate for the residential land use with plant uptake have been adopted in this assessment.

The GAC for most organic compounds are dependent on the organic content of the soil. Analysis has shown that the soil organic content in the soils analysed ranged from 2.8 to 4.1%. Therefore, for the purposes of this assessment, GAC for a soil organic content of 1% has been adopted. This again is considered a conservative approach for the majority of the soils at the site.

5.3.3 Generic Quantitative Risk Assessment

The samples analysed for soil contaminants comprised three samples of Made Ground. At this stage, all samples have been considered across the site as one averaging area. If any exceedances are identified, a statistical analysis based on particular averaging areas may be undertaken to further assess the risks. The risks from asbestos are considered further in Section 5.3.4.

The results of the Generic Quantitative Risk Assessment for the proposed development are presented in the table below. It should be appreciated that if the development were to change, the following assessment should be reviewed and, if necessary, updated.

Table 4 - Generic Assessment of Human Health Risks

Determinand	Range Recorded	GAC	Source of GAC	Exceedances
Metals and Semi-metals				
Arsenic	30 - 230mg/kg	37mg/kg	C4SL ²	2 of 3
Barium ⁶	100 - 140mg/kg	1,300mg/kg	CL:AIRE/EIC ⁵	0 of 3
Beryllium	0.8 – 0.9mg/kg	1.7mg/kg	S4UL ⁴	0 of 3
Boron	<0.2mg/kg	290mg/kg	S4UL ⁴	0 of 3
Cadmium	0.3 – 0.9mg/kg	26mg/kg	C4SL ²	0 of 3
Chromium (total) ⁷	14 - 27mg/kg	910mg/kg	S4UL ⁴	0 of 3
Chromium (hexavalent)	<0.1 mg/kg	21mg/kg	C4SL ²	0 of 3
Copper	93 – 230mg/kg	2,400mg/kg	S4UL ⁴	0 of 3
Lead	56 - 77mg/kg	200mg/kg	C4SL ²	0 of 3
Mercury ⁸	0.8 – 0.12mg/kg	40mg/kg	S4UL ⁴	0 of 3
Nickel	22 - 29mg/kg	130mg/kg	S4UL ⁴	0 of 3
Selenium	<0.5 – 0.7mg/kg	250mg/kg	S4UL ⁴	0 of 3
Vanadium	23 - 41mg/kg	410mg/kg	S4UL ⁴	0 of 3
Zinc	120 - 150mg/kg	3,700mg/kg	S4UL ⁴	0 of 3
Polyaromatic Hydrocarbons (PAH)				
Acenaphthene	<0.03 – 0.03mg/kg	210mg/kg	S4UL ^{4,9}	0 of 3
Acenaphthylene	<0.03mg/kg	170mg/kg	S4UL ^{4,9}	0 of 3
Anthracene	0.03 – 0.04mg/kg	2,400mg/kg	S4UL ^{4,9}	0 of 3
Benzo(a)anthracene	0.11 – 0.18mg/kg	7.2mg/kg	S4UL ^{4,9}	0 of 3
Benzo(a)pyrene	0.06 – 0.14mg/kg	5mg/kg	C4SL ^{2,9}	0 of 3
Benzo(b)fluoranthene	0.12 – 0.25mg/kg	2.6mg/kg	S4UL ^{4,9}	0 of 3
Benzo(ghi)perylene	<0.03 – 0.08mg/kg	320mg/kg	S4UL ^{4,9}	0 of 3
Benzo(k)fluoranthene	0.04 – 0.09mg/kg	77mg/kg	S4UL ^{4,9}	0 of 3
Chrysene	0.14 – 0.25mg/kg	15mg/kg	S4UL ^{4,9}	0 of 3
Dibenzo(a,h)anthracene	<0.03mg/kg	0.24mg/kg	S4UL ^{4,9}	0 of 3
Fluoranthene	0.35 – 0.57mg/kg	280mg/kg	S4UL ^{4,9}	0 of 3
Fluorene	<0.03 – 0.04mg/kg	170mg/kg	S4UL ^{4,9}	0 of 3
Indeno(123-cd)pyrene	<0.03 – 0.07mg/kg	27mg/kg	S4UL ^{4,9}	0 of 3
Naphthalene	<0.03mg/kg	2.3mg/kg	S4UL ^{4,9}	0 of 3
Phenanthrene	0.17 – 0.30mg/kg	95mg/kg	S4UL ^{4,9}	0 of 3
Pyrene	0.27 – 0.43mg/kg	620mg/kg	S4UL ^{4,9}	0 of 3
Other Organic Compounds				
Phenol	<0.3mg/kg	280mg/kg	S4UL ^{4,9}	0 of 3
Notes: 1. Assessment for residential land use <u>with home-grown produce uptake</u> (apart from barium – see Note 6 below). 2. C4SL: Category 4 Screening Level, published by CL:AIRE. 3. SGV: Soil Guideline Value published by Environment Agency. 4. S4ULs Suitable 4 Use Levels. Copyright Land Quality Management Limited, reproduced with permission; Publication No. S4UL3156. All Rights Reserved. 5. CL:AIRE/EIC GAC published by CL:AIRE and Environment Industries Commission. 6. GAC for barium for residential use without plant uptake. No GAC published for plant uptake risk drivers. 7. In the absence of Chromium VI, all chromium present likely to be Chromium III. GAC for Chromium III adopted. 8. GAC for inorganic mercury adopted. 9. Exceedances highlighted in red and bold. 10. Laboratory results presented in Appendix I.				

The levels of arsenic were found to be elevated above the adopted GAC in two of the three sample of Made Ground tested.

5.3.4 Asbestos

No evidence of asbestos was identified in the samples analysed.

5.4 Sulphate Attack

The assessment of the concrete protection against sulphate attack has been undertaken in accordance with BRE SD1 (2005).

5.4.1 Classification of Site

Due to the presence of Made Ground on the site, we consider that it should be considered as 'brownfield' in terms of concrete classification.

5.4.2 Groundwater Setting

No groundwater was encountered in the exploratory holes to a depth of 1.2m. However, no long-term monitoring (in excess of 24 hours) of groundwater levels has been undertaken. Therefore, in accordance with the BRE guidelines, we recommend that groundwater be considered as 'mobile' in terms of foundation concrete assessment.

5.4.3 Sulphate Levels

Laboratory test results indicate the levels of water-soluble sulphate (as SO_4) in the Made Ground soils to be 16 and 17mg/l. As levels of water-soluble sulphate are less than 3,000mg/l, there is no need to consider the levels of magnesium present in the soils. Levels of acid soluble sulphate were both 0.07% and total sulphur was 0.04% in both samples tested. From these results, the calculated level of total potential sulphate is 0.12%, and oxidisable sulphides of 0.05%. As the levels of oxidisable sulphide are well below 0.3%, pyrite is unlikely to be present.

pH values in the Made Ground varied between 6.9 and 9, indicating near neutral to slightly alkaline soil conditions to exist. As the pH levels all exceed 5.5, there is no need to further assess the soils for the types of acids present (e.g. hydrochloric and nitric acids).

5.4.4 Preliminary Foundation Concrete Design:

Using the above results, we consider that the following characteristic values are applicable for the shallow soils at the site (all as SO_4):

Water soluble sulphate:	17mg/l;
Total potential sulphate:	0.12%;
pH value:	6.9

6 Phase Two Geo-Environmental Risk Assessment

6.1 Discussion on Occurrence of Contamination and Distribution

The investigation carried out was limited due to the presence of Japanese knotweed. As such the full geo-environmental ground model has not been defined and further investigation, testing and assessment is needed.

The trial pits show a covering of Made Ground across the site, that appears to vary in depth. The Made Ground contained fragments of man made materials such as brick, concrete, metal, plastic, fabric and testing on three samples of Made Ground showed elevated levels of arsenic in two of the three samples tested.

6.2 Revised Risk Evaluation & Relevant Pollutant Linkages

As discussed in detail within Section 3.2.1, the methodology set out in CIRIA C552 (2001) has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action.

The risks evaluated at the desk study stage of this report (Table 3, Section 3.2.2) have been updated and revised in Table 5 following information learned from the exploratory works and results of monitoring and laboratory testing.

Table 5 - Revised Risk Evaluation & Relevant Pollutant Linkages (RPL)

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	Likely ²	Moderate Risk	See section 7.1.2 for further discussion.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Low likelihood ²	Very Low Risk	See section 7.1.4 for further discussion.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A Aquifer	Low likelihood ²	Moderate/Low Risk	See section 7.2 for further discussion.
	Leaching of soil contaminants	Impact on River Afan	Medium – site lies adjacent to river	Low likelihood ²	Moderate/Low Risk	
Asbestos in shallow soils	Inhalation of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Low likelihood ³	Moderate/Low Risk	See section 7.1.1 for further discussion
Soil sulphate and pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	Low likelihood ⁴	Low Risk	See section 7.4.2 for further discussion.
Hazardous ground gas/vapours	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	Likely ⁵	High Risk	See Section 7.3 for further discussion.
	Damage through explosion.	Building/Property	Severe – acute risk.		High Risk	
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.		High Risk	
Radon gas	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	High Likelihood ⁶	High Risk	See Section 7.3.2
Notes: 1. This table updates Table 3 in Section 3.2.2 using results of the investigation. Methodology and details of risk consequence, probability and category presented in Appendix A. 2. Levels of arsenic exceed the Generic Assessment Criteria in shallow soils. 3. Asbestos not identified in samples screened. 4. Further sulphate testing required. Initial testing of made ground indicates low levels. 5. Further investigation required to understand sources of ground gas on the site. 6. Radon risk identified in environmental data report (see Appendix C).						

7 Remedial Strategy for Contamination Risks

The following recommendations are based on interpretations made from the shallow and limited site investigation data obtained to-date, and do not form the full Options Appraisal stage of CLR11. Further investigation is required to fully inform the remedial strategy for contamination risks at the site. If at any stage of the construction works, contamination or a potential for such contamination is identified that is different to that presented within this report, all of the following should be reviewed, and the advice of a geo-environmental specialist sought immediately.

7.1 Risks to Health

7.1.1 Asbestos

No evidence of asbestos was detected at the site. However, the site has been previously developed and Made Ground is present across the site. As such the presence of asbestos in the shallow Made Ground cannot be discounted. Further investigation should test for asbestos and if any suspected asbestos containing materials (ACM) are identified during development, the advice of a suitably qualified specialist should be sought immediately. Any identified ACM would need to be removed from site by a licensed specialist contractor.

There is no clear UK guidance on what would constitute an acceptable concentration of asbestos in soil. Working with asbestos (even within soils) is governed by the Control of Asbestos Regulations (2012). This requires that the excavation and removal of the asbestos contaminated soils must be undertaken by a licensed contractor.

The following sections presume that any risks from asbestos materials at the site are mitigated.

7.1.2 Site End Users

Only a limited site investigation has been carried out and further investigation should be completed once the Japanese knotweed has been removed. This risk assessment should be reviewed after confirming the ground model and obtaining further geo-environmental testing information.

The proposals at the site will see parts of the site reduced in level to enable the development platform for the house and rear gardens. It is anticipated that the cut in the rear of the site will be larger than at the front, where levels may largely remain the same to tie into the existing road network. In this instance, much of the Made Ground will be removed and should thus remove any contaminants off site, thus removing the potential sources of contamination.

In addition, it is anticipated that shallow soils may be removed from the site as part of a treatment plan for the knotweed, however, this is unknown at this stage. If this process removes all the Made Ground, it is likely that the risk from contamination will be lower, however, the further investigation mentioned above would need to confirm this.

The present information indicates that arsenic is elevated above the generic assessment criteria and, therefore, present at unacceptable levels with respect to the users of the proposed residential development. Appropriate measures would need to be taken prior to development to break the pollutant linkage and mitigate these risks in areas of soft surfacing (e.g., gardens). In areas of hard surfacing (e.g. beneath structures, driveways, roads and other hardstandings), the

hard surface would break the pollutant linkage and no further risk mitigation would be required in terms of risks to human health.

One option of mitigating risks posed by non-volatile contaminants such as arsenic could be to isolate the contaminated soils beneath a surface cover layer of clean, inert soil. The thickness and make up of this layer would need to be agreed with the regulators. For preliminary design and costing purposes, we consider that the clean cover layer would need to be at least 600mm in thickness (to include placed Topsoil) and would need to be proven to be 'suitable for use' by an appropriate scale of validation testing.

In accordance with CLR11, the preferred risk mitigation strategy should be detailed within a remediation strategy and implementation plan and supervised and validated by a geo-environmental specialist. On completion, a validation report should be prepared to demonstrate to regulators and insurance providers that the risk has been successfully mitigated. This is included as part of Condition 6 of the planning approval.

Given the site levels and proposals, it may be necessary to remove some of the contaminated soils in order to provide sufficient space to allow a minimum 600mm thickness of clean cover to be constructed.

A suitable geotextile should be placed at the base of the cover layer and immediately overlain by a capillary break layer to prevent contaminants being drawn up into the cover system.

7.1.3 New Service Connections

The current water industry guidance for the suitability of pipe materials on potentially contaminated sites (Blackmore et al, 2010) has onerous requirements and it is likely/possible, based on this guidance, that the levels of contaminants on site may prevent the use of plastic pipework. We recommend that enquiries are made to the local water authority to confirm their requirements for underground service materials for this development.

7.1.4 Risk to Construction and Maintenance Workers

Further assessment will need to be carried out to understand the ground model and this assessment should be reviewed; the below is provided for information purposes only.

Short term (acute) risks to construction and maintenance workers are generally poorly understood within the industry, certainly when compared to the volume of research undertaken on long term risks. However, we anticipate that the levels of contamination at the site are not likely to pose a severe acute risk to construction workers or future maintenance workers. Ground workers would need to undertake their own assessment of the risks to their workers.

We recommend that construction workers adopt careful handling of the potential contaminants and good standards of personal hygiene should be adopted to reduce the risk of possible ingestion and skin contact should any hotspots be encountered. The contractor should comply with the appropriate current Health and Safety at work legislation.

7.1.5 General Public/Neighbouring Properties

Although further investigation should confirm, we do not anticipate any significant risks to the general public from the development of the site. However, careful dust control measures should be adopted during construction to minimise the risk (and nuisance) to the general public and neighbouring residents.

7.2 Risks to Controlled Waters

No specific assessment of the risks to controlled waters has been undertaken to date. However, the following points are considered salient.

- No significant past contaminative use has been identified at the site, the presence of a flue on site is yet to be determined, understood.
- Made Ground has been identified on the site.
- The levels of soil contaminants measured to date are generally below the GAC adopted.
- The proposed development comprises a conventional residential house which will include an area of car parking which is anticipated to be hard surfaced – surface drainage from these areas could contain leached oils and fuels from vehicle spills and leaks.
- Soakaways are not being considered for the development.
- The site is underlain by fine-grained weathered bedrock which contains a high fine-grained fraction in its upper layers.
- The bedrock beneath the site is classified as a Secondary A aquifer. Groundwater is anticipated within the weathered bedrock at depth.
- The River Afan lies some 500m to the east at its closest point.

Given the above, we consider that the overall risk to controlled waters from the development of the site is likely to be low. The above should be reviewed following further assessment.

7.3 Risks from Ground Gas

7.3.1 Risk to the Development – Degradation of Organic Material

Further investigation is required at the site to understand if there is an onsite ground gas source, and if ground gas monitoring is required.

7.3.2 Risk to the Development – Radon

As discussed in Section 2.11, basic radon protection is required.

7.3.3 Risk to Construction and Maintenance Workers

Further Investigation should be carried out to understand if there is any risk to construction or maintenance workers. If there is an underground flue on site, it may potentially trap, or channel ground gas and this should be considered in further ground investigations.

7.4 Risks to Property

7.4.1 Spontaneous Combustion

Further investigation is required to understand the risks to the property.

7.4.2 Sulphate Attack on Buried Concrete

Further investigation is required to provide characteristic values for the design of concrete at the site.

Preliminary testing indicates that the site could be classed as Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete Class AC-1, allowing for mobile groundwater. However, this needs to be confirmed with further testing.

8 Preliminary Geotechnical Comments

As discussed in Section 1.2, the scope of works was to provide information to work toward discharge of planning Condition 5, contamination. This section provides generic geotechnical advice based on the limited investigation we have to date, and as such further investigation is required to understand the ground model.

8.1 Site Preparation and Earthworks

8.1.1 Unexploded Ordnance

As discussed in Section 2.10.8, a specialist preliminary assessment has concluded that 'a detailed desk study, whilst always prudent, is not considered essential in this instance'. Notwithstanding this, on any development site, we cannot totally discount the risk from buried ordnance as records are not complete. Therefore, although no special precautions are considered necessary, a careful watch should be maintained during all excavation and any suspected ordnance identified should be investigated further by specialists. Ordnance awareness is recommended during site inductions.

8.1.2 Invasive Plants

Japanese Knotweed has been identified on the site, it was also noted in a stockpile at the front of the site.

Japanese Knotweed is an invasive plant which would need to be eradicated from the development site. It has extremely powerful growth potential and has been recorded to penetrate and subsequently destroy concrete and tarmac surfaces and damage foundations. Therefore, if it were not treated sufficiently it could have a significant deleterious impact on the development.

There are a number of treatment options available for the eradication of Japanese Knotweed, including its excavation and treatment by herbicides (which may take several growing seasons). Any treatment or removal should be undertaken by specialist, qualified contractors, and it should be appreciated that it is an offence to allow the spread of these plants (e.g. on excavator tracks).

8.1.3 Existing Foundations and Services

The desk study showed that a possible flue may be present below the site, and this should be investigated further. If present, it may contain a void, or a backfilled flue, and as such may require high capacity machines to excavate.

A suspected service was encountered in HP04, and further investigations should be carried out to identify this service and see if it can be removed, diverted or altered.

8.1.4 New Services

For new services, flexible pipework and connections should be provided as a safeguard against potential settlements. Consideration could be given to increasing the gradients on sewage connections to mitigate against possible settlements.

8.2 Geotechnical Risk Register

The scope of works was not to fully consider the geotechnical risks at the site and the limited site investigation has not been able to provide sufficient information to help declassify the geotechnical risks as described in our desk study, Section 2.10.

Further investigation is recommended to:

- confirm the possible low coal mining hazard via rotary boreholes, or if grouting of possible underground coal mining is required;
- Understand the possibility of underground structures, a flue is labelled on the historical maps on the site and it is not known if this is a buried feature and is still present below the site and its condition (voided, removed or backfilled);
- Slag was noted in the trial pits and pockets of slag may be present on the site that could potentially pose a risk to the development;
- Understand the shrinkage and swelling potential of shallow weathered bedrock soils;
- Understand the requirement of buried concrete in terms of pyrite in the made ground and natural soils at founding depth;
- Collapsible ground;
- Services crossing the site; and
- Further consideration to the landslide hazard following site investigation information to develop the ground model.

8.3 Outline Foundation Considerations

As discussed in Section 8.2, there are possibly significant features on site that may dictate the foundation selection; deep made ground, coal mining subsidence hazard.

If deep made ground is encountered across the site, it may preclude the use of traditional spread foundations and deeper, trench fill or some form of piles/mini piles may be required. The selection in foundation will need to be done in tandem with knowledge of the risk from coal mining subsidence. For example, piles may be at a greater risk of subsidence than shallow spread foundations.

Once the ground model is confirmed, the earthwork requirements will be better understood and the foundation selection could be suitably made.

Foundation design will need to account for the risk of radon, as basic protection measures are required, and the further investigation recommended will also help understand if ground gas protection measures are required.

Removal, or treatment of soils containing Japanese knotweed, including roots may also have an impact on the foundation solution at the site and should be considered in design.

9 Recommendations

We consider that the following further investigation and assessment would be required or prudent prior to development:

Required Further Actions:

- Removal of Japanese knotweed under direction/instruction of competent person/company and records should be kept to confirm its removal process;
- Further investigation to understand ground model across the site, to include presence, condition of flue, depth and composition of Made Ground and other ground conditions and groundwater data;
- Rotary open hole boreholes to confirm the probable low risk of coal mine subsidence.
- Additional geotechnical and geo-environmental soil testing of all strata on site, including sulphate testing to enable the correct concrete class to be selected.
- Undertake a period of research to determine the ownership of a service crossing the site and an identification survey (PAS128).
- Consideration of the installation and monitoring of gas wells depending upon emerging conditions, coal mining, made ground gas source or pathway via flue.

10 References

BLACKMORE K, BRIERE DE L'ISLE B, GARROW D, JONSSON J, NORRIS M, TURRELL J, TREW J and WILCOX S. 2010. Guidance for the Selection of Water Supply Pipes to be Used in Brownfield Sites. UK Water Industry Research Ltd. Report ref. No 10/WM/03/21.

BRITISH GEOLOGICAL SURVEY (BGS). 2023. Website accessed February 2023.

BRITISH STANDARDS INSTITUTION (BSI). 2002. Geotechnical Investigation and Testing: Identification and Classification of Soil, Part 1. Identification and Description. BS EN ISO 14688-1. HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2018. Geotechnical Investigation and Testing: Identification and Classification of Soil, Part 2. Principles for Classification. BS EN ISO 14688-2:2018. HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2017. Investigation of Potentially Contaminated Sites – Code of Practice. BS10175, HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2015. Code of Practice for Ground Investigation. BS5930:2015. HMSO, London.

BUILDING RESEARCH ESTABLISHMENT (BRE). 2007. Radon: Guidance on Protective Measures for New Dwellings. BR211. BRE, Garston.

BUILDING RESEARCH ESTABLISHMENT (BRE). 2005. Concrete in Aggressive Ground. Third Edition. Special Digest 1 (SD1). BRE, Garston.

CONTAMINATED LAND: APPLICATIONS IN REAL ENVIRONMENTS (CL:AIRE). 2013. Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. CL:AIRE Report SP1010.

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA) AND THE ENVIRONMENT AGENCY. 2004. The Model Procedures for the Management of Land Contamination. R&D Publication CLR11.

DUCKWORTH G. 2011. The Definition of Waste: Development Industry Code of Practice. CL:AIRE. Version 2.

ENVIRONMENT AGENCY. 2008a. Human Health Toxicological Assessment of Contaminants in Soil. Science Report SC050021/SR2.

ENVIRONMENT AGENCY. 2008c. Updated Technical Background to the CLEA Model. SC050021/SR3.

HEALTH & SAFETY EXECUTIVE. 1991. Protection of Workers and the General Public During the Development of Contaminated Land. HMSO, London.

HEALY P.R. AND HEAD J.M. 1984. Construction over Abandoned Mine Workings. CIRIA Special Publication SP32/PSA Civil Engineering Technical Guide 34.

NATHANAIL P, JONES A, OGDEN R, and ROBERTSON A. 2014. Asbestos in Soil and Made Ground. A Guide to Understanding and Managing Risks. CIRIA C733.

NATHANAIL P, McCAFFREY C, GILLET A, OGDEN R and NATHANAIL J. 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham.

NATIONAL HOUSE BUILDING COUNCIL (NHBC). 2019. NHBC Standards, Technical Guidance. Chapter 4.1, Land Quality.

NATIONAL HOUSE BUILDING COUNCIL (NHBC). 2019. NHBC Standards, Technical Guidance.

NATIONAL HOUSE BUILDING COUNCIL (NHBC). 2014. Publication of Category 4 Screening Levels for Land Affected by Contamination. Technical Extra Issue 15.

NATURAL RESOURCES WALES (NRW). 2023. Website accessed February 2023.

SCIVYER C. 2007. Radon: Guidance on Protective Measures for New Buildings. Building Research Establishment, BRE 211.

WELSH DEVELOPMENT AGENCY. 1998. The Eradication of Japanese Knotweed. WDA: Cardiff.