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AFAN VALLEY

Geo-environmental Assessment

(Condition 29 & Reserved Matters Application)

Report Reference: ESP.8053.3747-06

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Proposed Adventure Park Afan Valley Resort Geo-environmental Assessment

(Condition 29 & Reserved Matters Application)

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Revision	Status	Date	Written by	Checked by	Approved by
0	Draft	July 2022			
1	Draft	July 2022			
2	Final (Amended)	August 2022			
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4	Final (Amended)	August 2022			
5	Final (Amended)	August 2022			
6	Final (Amended)	September 2022			
Signature:					
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EXECUTIVE SUMMARY

Wildfox Resorts – Afan Valley., is considering the development of the subject site for redevelopment as an Adventure Resort. ESP have undertaken a Desk Study and 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 occupied by open grassland and areas of wood. Two ponds are noted in the southeastern extent.
	Identified Ground Conditions.	-	Thin topsoil overlies a thin to moderate layer of weathered bedrock which in turn is underlain by intact rock of the Brithdir, Rhondda and Llynfi Members. Coal seams within the bedrock below the site have been worked in areas. Deep peat is present in an isolated area of the site, near the southeastern extent. Reworked natural soils were encountered near access tracks and comprised no anthropogenic materials and no olfactory signs of contamination. Landslides and areas of faulting are on site.
	Groundwater Conditions.	-	The site is underlain by a Secondary A Aquifer and groundwater is anticipated to be within 10m to 30m of the site surface. A shallow groundwater body is present in the area of deep peat and is anticipated to be hydraulically connected to two ponds.
	Historical Land Use.	-	Coal mines (adits and shafts) were located on site in some areas, some isolated quarries were also present however information suggests that these were not generally backfilled. A forestry was once located on site which has been largely removed/harvested.
Geo-environmental	Potential Contamination Sources	Low	Generally, there are no significant contaminative former uses. Some mining for building stone and coal occurred in isolated areas however significant contaminant not anticipated based upon desk study. No asbestos identified in walkovers, and none identified in samples screened.
	Chronic Risks to Human Health	Low	With the exception of arsenic, samples tested show no elevated levels of contaminants above generic screening criteria. Arsenic has been found to be elevated (above the adopted GAC for Public Open Space (Park)) in some samples of topsoil, which are within what would be expected to be normal background concentrations.
	Risks to Controlled Waters	Low	There are no significant contaminative sources on site and levels of contaminants in the soil indicate no levels of contaminants of concern. On the basis of the findings to date, the risk to controlled waters is considered to be low.
	Hazardous Ground Gas	Moderate	Potential sources of ground gas include deep peat and coal seams. Locally high risk sources have been identified (Mine entries, shallow mine workings) Gas monitoring is on-going with a further 8no. visits to be undertaken. An addendum report will be provided with an assessment and recommendations for mitigation measures to reduce the risk to an acceptable level, if required. Initial readings have shown gas flow and methane concentrations to be below the limit of detection. Carbon dioxide was generally up to 5%, with one location recording a reading of 7.2%. Basic radon protection measures will be required in a small portion of the site.
Others	UXO	-	A preliminary UXO assessment undertaken by a specialist suggests that the risk from UXO is not considered to be elevated higher than the 'background risk' of UXO within the UK.
	Flooding	Low	The environmental data report suggests a low risk of flooding for the site.

Note: The above is intended to provide a brief summary of the conclusions of the Desk Study and Geo-environmental 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.

1.0 INTRODUCTION

BACKGROUND

- 1.1 Wildfox Resorts – Afan Valley, (hereafter known as the Client) are proposing to redevelop the subject site for leisure purposes. The Earth Science Partnership Ltd (ESP) were instructed by Stantec UK Ltd., acting on behalf of Wildfox Resorts Afan Valley Ltd., to undertake a preliminary, integrated geotechnical and geo-environmental investigation and assessment to identify and evaluate potential ground hazards which could impact on the proposed development.
- 1.2 This report forms the Desk Study and Geo-environmental assessment that assess potential geo-environmental hazards which could impact on the proposed development; to satisfy Condition 29 of Outline Planning Permission (Planning Application Reference P2018/0493).
- 1.3 The general site location is shown on Insert 1, a detailed site location plan with the red line boundary for this assessment is shown on Figure 1.
- 1.4 ESP have previously undertaken a Geomorphological Assessment and Ground Investigation Scoping Report, Ref. ESP.8053.3708 – 03 (ESP, July 2022a) and Peat Site Investigation Report, Ref. ESP.8052.3713 – 03 (ESP, July 2022b).

OBJECTIVE AND SCOPE OF WORKS

- 1.5 The objective of the investigation was to obtain initial information on the geotechnical character and properties of the ground beneath the site, potential risks posed by contamination and ground gas, and to allow an assessment of these ground conditions with particular reference to the potential impact on the proposed development. This report forms the findings of the integrated geotechnical and geo-environmental desk study and preliminary geo-environmental assessment only. The geotechnical findings and assessment will be presented in a separate report.
- 1.6 Outline Planning Permission has been granted subject to conditions by Neath Port Talbot County Borough Council (NPTCBC) in January 2022 (Planning Application Reference P2018/0493). This report provides information to assist with the discharge of planning condition 29; with regard to contamination as detailed below.

Condition 29

- 1.7 *As part of or before the first reserved matters consent relating to each phase of development as identified in condition 7 a scheme to assess the nature and extent of any contamination on the site, and confirmation of whether or not it originates on the site shall be submitted to and agreed in writing with the Local Planning Authority. The investigation and risk assessment must be undertaken by competent persons in accordance with the following document:-Land Contamination: A Guide for Developers (WLGA, WAG & EAW, July 2006) and shall be submitted as a written report which shall include:*
 - (a) *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) identifying all plausible pollutant linkages to be assessed.*
 - (b) *A survey of the extent, scale and nature of contamination.*

- (c) *An assessment of the potential risks to: human health, ground waters 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*
- (d) *An appraisal of remedial options, and proposal of the preferred remedial option(s).*
- 1.8 *Reason: To ensure that information provided for the assessment of the risks from land contamination to the future users of the land, neighbouring land, controlled waters, property and ecological systems is sufficient to enable a proper assessment.*
- 1.9 *The aim of this assessment is to provide sufficient information to establish general principles of development considering the above outline planning conditions.*
- 1.10 *The scope of works for this assessment was mutually developed with the Client by ESP within an agreed budget. 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 28th March 2022 (ref: 8053 – ESP Offer Letter Rev 4).*
- 1.11 *The scope of works for the ground investigation 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, ground investigation and reporting.*
- 1.12 *Between May and July 2022, a ground investigation was carried out across the site to provide information of the ground conditions, including the potential for contamination on site. The fieldwork and laboratory testing were carried out under the supervision and technical direction of ESP. The ground investigation comprised windowless sample boreholes, machine excavated and hand excavated trial pits and trenches and rotary boreholes.*
- 1.13 *A period of gas monitoring is underway and results available at the time of writing are provided; once the monitoring is complete, an addendum or revision of this report will be provided.*

METHODOLOGY AND GUIDANCE

- 1.14 The geo-environmental ground investigation and assessment has been carried in general accordance with the following documents, but restricted based upon access limitations noted during site walkovers:
- BS5930:2020 Code of Practice for Ground Investigations;
 - BS EN 1997-1:2004+A1:2013 & BS EN 1997-2:2007 Eurocode 7: Geotechnical Design;
 - BS1377:1990 Methods of Tests for Soils for Civil Engineering Purposes;
 - BS10175:2017 Investigation of Potentially Contaminated Sites. Code of Practice;
 - Welsh Local Government Association/Environment Agency (2012): Development of Land Affected by Contamination: A Guide for Developers;
 - Coal Authority. 2014. Risk Based Approach to Development Management. Guidance for Developers;
 - CL:AIRE, 2021. Good practice for risk assessment for coal mine gas emissions. CL:AIRE, Buckinghamshire. ISBN 978-1-905046-39-3: and
 - Parry and Chiverell. 2019. Abandoned Mine Workings Manual. CIRIA C758D.

PROPOSED DEVELOPMENT

- 1.15 The proposed development will comprise a large mixed use adventure resort comprising 570 lodges, 30 apartments and a 50-bed hotel, along with restaurants, retail units, leisure activities and other outdoor sports. The development is still in the master planning phase and the final development layout is currently being finalised.
- 1.16 The current proposed development layout plan is presented as Figure 2.1.5.

REPORT FORMAT

- 1.17 This report includes the desk study and field reconnaissance reports, and details of the investigation undertaken of Eurocode EC7 and BS5930:2020, along with the Preliminary Risk Assessment stage and Generic Quantitative Risk Assessment of the land contamination risk management (LCRM) guidelines (formerly CLR11). An 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 7 and 8. An updated conceptual ground model is presented in Section 5.
- 1.18 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).

LIMITATIONS OF REPORT

- 1.19 This report represents the findings of the brief relating to the proposed end use and geotechnical category of structure(s) as detailed 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. Should an alternative end use or structure be considered, the findings of the assessment should be re-examined relating to the new proposals.
- 1.20 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.
- 1.21 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.
- 1.22 Investigation positions had to be pre-determined due to ecological clearance requirements and as a result ad-hoc positions were not available after the assessment had commenced without further ecological clearance. The investigation point locations were positioned to maximise the information that could be obtained and provide a spatial spread, allowing for the constraints imposed by the physical features on site including vegetation, steeply sloping ground and the known site constraints.
- 1.23 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.

PREVIOUS ASSESSMENTS, INVESTIGATIONS AND SPECIFICATIONS

- 1.24 The following reports, specifications, desk-based and intrusive ground investigation works have been undertaken by others:
- Ashfield Solutions Group (2021) Specification for Ground Investigation Works (132621-S01);
 - AECOM Limited (2017) Coal Mining Assessment Report (AECOM, 2017);
 - AECOM Limited (2017) Initial Peat Survey (AECOM, 2017);
 - Breakwell Sumner Partnership Limited (BSP) (2017) Geo-Environmental Phase I Desk Study (Ref. 16255);
 - Terra Firma (Wales) Limited (2017) Afan Valley Development – Landslip Potential (Ref. GCL/14536/Let1);
 - AECOM Limited (2018) Summary of Findings in Relation to Peat Survey (AECOM, 2018); and
 - Terra Firma (Wales) Limited (2018) – Preliminary Findings, Peat Survey (Ref. DE/14510/Let2).
- 1.25 The reports listed above should be referred to in full alongside this assessment.
- 1.26 In addition to the above, ESP have previously undertaken the following desk based and ground investigation works:
- Earth Science Partnership (July 2022a). Geomorphology Assessment and Ground Investigation Scoping Report. (Ref.ESP.8053.3708-03) and;
 - Earth Science Partnership (July 2022b). Peat Site Investigation. (Ref. ESP.8052.3713–04).
- 1.27 The previous ESP reports (ESP 2022a and 2022b) should be referred to in full, though salient parts of the report are included in this report for clarity.

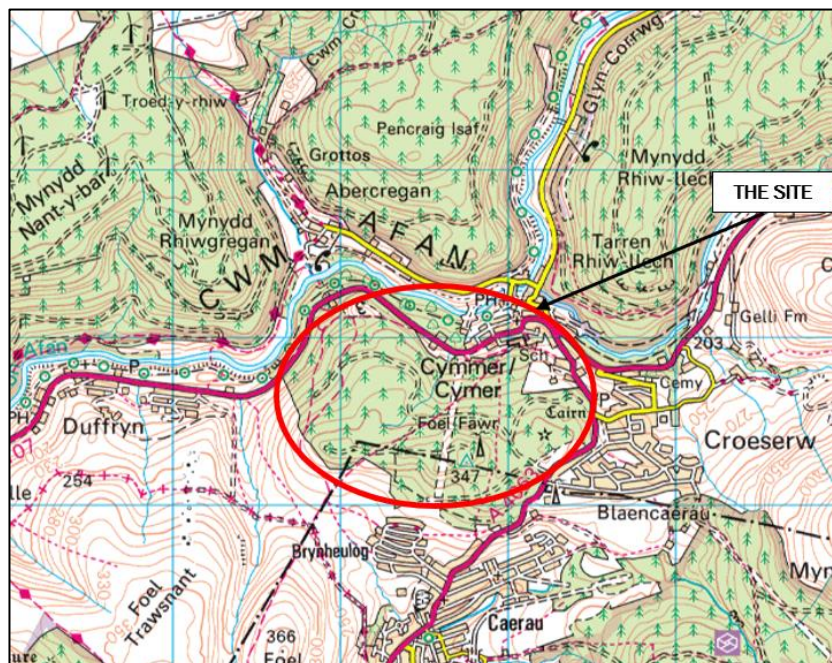
2.0 DESK STUDY AND FIELD RECONNAISSANCE VISIT

SOURCES OF INFORMATION

- 2.1 The information presented in Section 2.0 was obtained from desk-based research of information outlined below. As discussed in Section 1, information from previous ground investigations and assessments has been included where relevant.
- 2.2 Updated desk study information was obtained by ESP as outlined below;
- Groundsure (2022) Historical Mapping (small and large scale) (ESP-8597136_SS_1_1) Appendix B;
 - Groundsure (2022) Environmental and Geological Insight Report (ESP-8597137) Appendix C; and
 - Coal Authority (2022). Consultants Mining Report (Ref. 51003007499001) Appendix D.

SITE LOCATION AND DESCRIPTION

- 2.3 The site description is based on a series of walkovers, but largely based on a field reconnaissance and geomorphological site inspection visit on 13th and 14th April 2022 during overcast and intermittently wet weather.
- 2.4 The site is located on the southern side of the Afan Valley, south of Cymmer, north of Caerau and west of Croeserw, South Wales. The National Grid Reference for the centre of the site is 285523 195668 and covers an area of approximately 130 hectares (Ha). The general site location is shown on Insert 1 below.



Insert 1: General Site Location from Ordnance Survey 1:50,000 scale map.
Reproduced with permission (OS License No.: AL100015788).

- 2.5 The site is located south of Cymmer and generally comprises undulating high ground along the ridge named Foel Fawr along the southern boundary of the site with locally very steep slopes. The site is

currently largely undeveloped and generally comprises recently cut coniferous forest represented by stumps and brushwood with areas of open moorland in the eastern extent. A forested area remains in the northeastern to central extent.

- 2.6 A topographical survey (Ref. 5906-01, First Point Surveys, 2017) indicates that the highest point is in the southern central area on Foel Fawr with an elevation of 347.14m AOD (at a trig point) with the majority of the site sloping north and northwest, occasionally steeply, towards the River Afan. The northwestern boundary is at an elevation of approximately 170mAOD rising to approximately 220m AOD towards at the north-eastern boundary extent.
- 2.7 The site is currently accessed from the east, off Maesteg Road (A4063), with vehicular access across the site gained via gravel tracks. Various smaller paths branch off the main access track allowing foot access however, large portions of the site remain relatively inaccessible for vehicles. In some areas of the site, pedestrian access is possible but challenging due to vegetation, old tree stumps and discarded tree trunks or branches from the site former use as a forestry.
- 2.8 The western and northern boundaries are typically governed by the A4107, Brytwn Road and several private properties along it. The eastern boundary is partly the A4063 and private property in the northeast. The southern boundary of the site is part formed by the boundary between Local Authority areas, with Neath Port Talbot County Borough Council and Bridgend County Council.
- 2.9 A disused railway tunnel is located below the site generally trending north to south across the central portion. Recent mapping indicates that the northern entrance to the tunnel is located to the north of a public transport bus station north of the site boundary (immediately north of Brytwn Road/A4017). The southern entrance to the tunnel is located some 800m south of the site on the northern margins of Caerau. The elevation of the north and south access points are at approximately 190 and 192 mAOD respectively. Based on the current ground levels, the tunnel is anticipated to be at significant depth across the majority of the site, from ground level at the north to approximately 145m depth at the southern boundary.
- 2.10 A mast and associated infrastructure are located on Foel Fawr and a covered reservoir is located in the southeast. Two ponds are located in the southeast, surrounded by soft and marshy/peat ground. The current site layout is shown on Figure 1.

SITE HISTORY

Published Historical Maps

- 2.11 ESP have undertaken a review of updated historical Ordnance Survey County Series and National Grid maps. Extracts from the historical maps are presented in Appendix B.
- 2.12 In the wider vicinity of the site, the land to the west was and remains largely undeveloped with the exception of coal mining infrastructure. Cymmer to the north is a well-established town with residential and historic coal mining infrastructure. While the town of Croeserw to the east became more developed in the 1950/1960's comprising predominantly residential land-use. The site itself remains largely undeveloped to date with the exception of the historic Pen Y Castell buildings and more recent telecommunication mast on Foel Fawr, these are discussed further in the sections below alongside other salient information obtained from the historical map review.

Vegetation

- 2.13 As early as 1877 the northwest boundary is indicated to be covered by shrub, the remainder is shown as rough pasture. In 1965 an area of forest has been planted south of the site, partially encroaching

the southeast boundary. Between 1972 and 1987, the majority of the site is shown to be covered by coniferous trees. In 1993, a large portion of the trees are no longer shown though some remain today in the central/eastern extent.

Cymmer Tunnel

- 2.14 The Cymmer Tunnel is shown in its current alignment in the earliest mapping from 1876-1877. The tunnel is noted to be 'in construction' in the first maps. From 1971, the railway at the northern entrance is shown as dismantled and from 1986 the tunnel is shown as disused.

Former Quarries

- 2.15 From 1897, three quarries are shown at the central-northern boundary within the site. Further small quarries are shown immediately north and northeast of the boundary. From 1914, the western most is shown as old and from 1947, the remaining quarries on site are shown as old. In 1986, a track is shown to cut through one of the old quarries in the northeast. The off-site quarries immediately northeast are shown until 2010.
- 2.16 Three old quarries and one quarry are shown in the central site portion in the 1879 mapping. In 1899 the quarries are no longer labelled. The small-scale mapping indicates a quarry to be a reservoir.
- 2.17 In 1962 most northernly quarry is no longer shown (likely backfilled) and in 1972 a new track is shown to traverse one of the former quarries. Depressions are noted on the LiDAR imagery in the general locations of these former quarries (and reservoir) with the exception of the most northernly quarry which is less well defined.

Adits & Mine Shafts

- 2.18 Dyffryn Colliery (level and trial level) is shown 700m south in the earliest mapping in 1876 and subsequently disused /old from 1897.
- 2.19 Between 1897 and 1919, Glyncymmer Colliery is indicated immediately north with a coal level off site and an air shaft within the site boundary. The air shaft is not shown in the 1919 mapping. The infrastructure is not referenced beyond this date.
- 2.20 A trial level is shown on the first map, dated 1877 just beyond the east of the site. The 1897 map labels it as old.

Cracks/Fissures

- 2.21 An arcuate feature is indicated immediately south of the location of the existing mast, mapped as exposed rock, slopes and possible loose rock. The large feature trends generally east to west, with a second small feature with a similar trend towards the southwest and a north-south trending small feature to the north. The smaller feature southwest is only shown in 1899. From 1919, the arcuate feature is not shown as being continuous in its central portion.
- 2.22 A series of linear east to west trending features are indicated in the southeastern extent indicated to be loose rock/boulders and exposed rock (cliff type features). The features are indicated from the earliest mapping in 1877. The 1962 mapping indicates that rough grass is present within the largest linear (fissure type) feature. The southernmost feature is mapped to extend towards the west from in 1971.

Reservoirs

- 2.23 A reservoir is labelled in the central portion of the site in 1897 (previously labelled as a quarry (1877) and also referenced as an old pit), the feature remains until at least 1964-65. Site walkovers show a feature remains in this area though the nature of the feature is unknown.
- 2.24 A reservoir and access track in the southeast is shown from 1962 and is shown to be covered from 1986. Although not shown on the recent mapping, the reservoir remains at the time of this report and is shown on Figure 1.

Structures

- 2.25 Prior to 1961, the area of the mast is occupied by a trig point (pillar) and from 1971 a lookout tower is indicated on Foel Fawr. In 1986, the lookout tower is not labelled, and a mast is indicated immediately east.

Pen y Castell

- 2.26 Craggs and loose rock are shown at Pen y Castell in the northwest extent from 1878, at the time the land to the north and west is largely forested however this is later indicated to be rough pasture from 1919.
- 2.27 Small buildings (possible farmstead) are indicated immediately southeast of Pen y Castell hill and craggs from as early as 1878. The buildings are no longer shown in 1987.

Ponds

- 2.28 From 2001, two ponds are recorded in the south easter site extent, west of the covered reservoir.

CONTACT WITH REGULATORY BODIES & LOAL INFORMATION SOURCES

- 2.29 The following departments of the Local Authority (Neath Port Talbot County Borough Council) have been contacted as part of this assessment:
- Environmental Services/Health/Pollution Control
 - Building Control
 - Trading Standards (Petroleum Officer)
- 2.30 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.

GEOLOGY

Regional Geology

- 2.31 The Upper Coal Measures, now the Pennant Measures, in South Wales outcrop within a large east to west trending synclinal basin with subsidiary folds and faulting, forming an upland plateau with deeply incised river valleys (South Wales coalfield).
- 2.32 The Upper Coal Measures were deposited in the Carboniferous period within a fluvio-deltaic

environment. The cyclical sedimentary succession consists of coarsening upwards series of mudstones, siltstones and fine-grained sandstones, seatearths and coals. Periodic intrusion of the sea during deposition created numerous marine bands.

- 2.33 Variscan deformation resulted in extensive post-deposition deformation (folding and faulting) though this is largely confined to the Lower and Middle Coal Measures, whilst the Upper Coal Measures remains relatively undeformed. The most common structural faults in the coalfield generally trend northwest to southeast.
- 2.34 Devensian glaciation occurred across Wales with the Welsh Ice extending to south Wales which resulted in deep excision of the valleys, oversteepening of valley sides and extensive deposition glacial drift deposits.

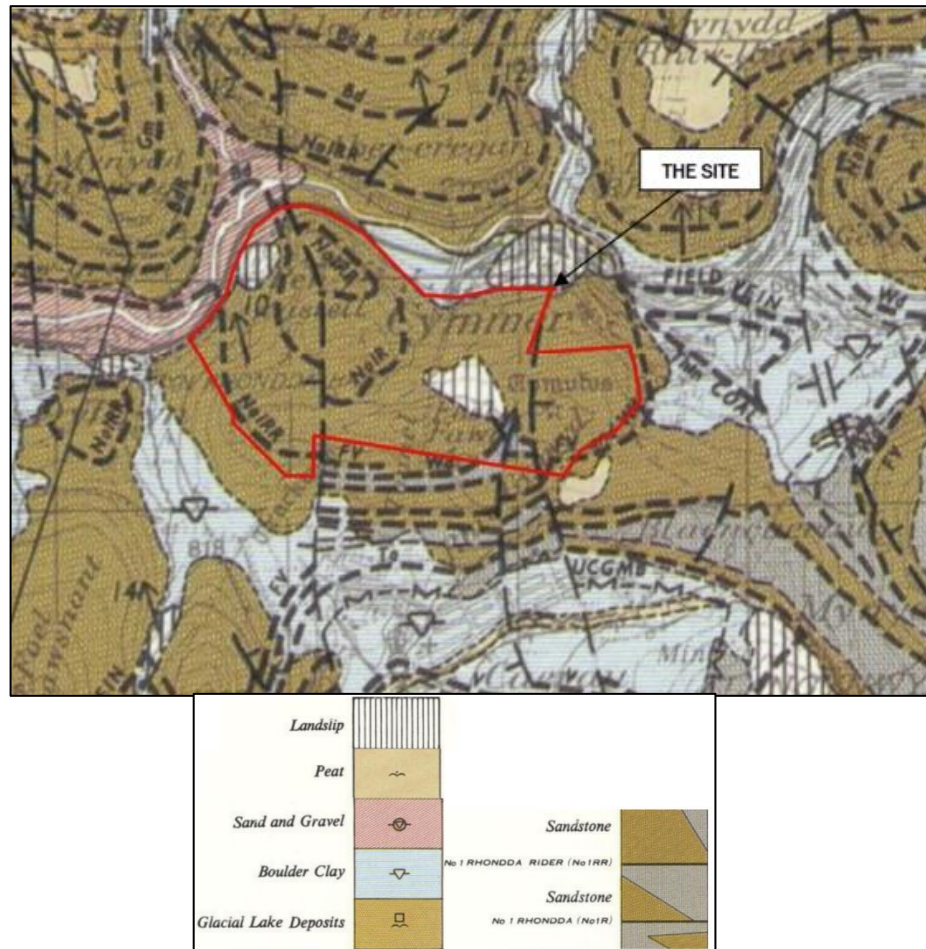
SITE GEOLOGY

Published Geological Mapping

- 2.35 The published 1:10:560 scale geological mapping of the area (Sheets XXVI NW, 1947 and XVII SW, 1959, Insert 2a and 2b) indicates the site primarily be underlain directly by Upper Coal Measures bedrock, Lower Pennant Measures comprising the Brithdir Beds, Rhondda Beds and Llynfi Beds. A geological setting plan is shown as Figure 3.
- 2.36 The majority of the site is directly underlain by Rhondda Beds sandstone with the Llynfi Beds underlying, shown to outcrop south of the site and partially encroaching the southeastern extent. The No. 2 Rhondda coal seam forms the boundary between these strata. The Brithdir Beds are shown to outcrop in the northwestern extent of the site.
- 2.37 There are 6no. records of bedding dip and dip direction within the site. Four of these suggest a dip amount of 10° below the horizon and dip direction towards the north and northwest.
- 2.38 A measurement of the bedding about 100m to the east of Pen y Castell (dwelling) has a dip amount of 12° and dip direction of northwest. The bedding near the summit of Pen y Castell (northwest of the site) was measured to have a dip of 20° below the horizon toward the west.

base of the Member is placed at the base of the No.2 Rhondda Coal seam. The 1:10,000 mapping indicates that locally the Rhondda Member contains abundant coal streaks and some ironstone pellets. The Llynfi Member would be expected to comprise similar strata with the upper portions often containing seatearth and mudstone. The top of the Llynfi Member is taken at the base of the No. 2 Rhondda coal seam, directly underlain by thin seatearths and mudstone (Waters, et al., 2009).

- 2.42 Numerous coal seams are indicated to outcrop on and near the site and shown in Insert 3 and Figure 3 and Figure 4. A Consultants Mining Report (Appendix D) confirms the presence of mine entires and shallow workings below the site as discussed further in our Scoping report (ESP 2022a).



Insert 3: Extract from BGS Geological Map Sheet 248 original 1:50,000 scale.
Reproduced with permission (BGS licence number: C15/05 CSL).

- 2.43 A number of north to south trending faults are shown on the site, including the Pen-y-Castell fault in the western portion. The Pen-y-Castell fault is indicated to be a normal fault, with down-throw to the west recorded between 160 to 180m.
- 2.44 North-south normal faults are indicated in the eastern extent, which are indicated to have a down-throw to the west and east on the geological mapping. Reference to abandonment plans indicates displacement of these eastern faults to be between 2.5 and 8.5m. A smaller northwest southeast trending fault is indicated near the south of the site.

Published Geological Memoirs

- 2.45 Reference to the geological memoir for the area (Woodland and Evans, 1964) provides further details of the anticipated geology as summarised below.
- 2.46 The Pennant Measure cyclothems (cyclical strata successions) differ from those of the Lower and Middle Coal Measures. The Lower Pennant Measures are generally formed of significantly thicker continuous sandstone strata lying immediately upon or close to coal seams, mudstone strata may be present between the sandstone and coal seams.
- 2.47 The predominantly argillaceous Llynfi Beds (Member) within the lower Afan Valley generally include two thin coal seams which have been locally mined, The Wernpistyll and the Wernpistyll Rider, are generally found at between 80 to 135ft (approximately 24.0 to 41.0m) and 30 to 50ft (9.0 – 15.2m) respectively, below the top of the group. The coal seams are separated with mudstones and thin sandstones.
- 2.48 The base of the Rhondda Beds (Member) is marked by the No. 2 Rhondda coal seam which is heavily worked. Locally the seam is split with the lower coal (No. 2 Rhondda/Wernddu/Rock Fawr or Malthouse) generally between 3 to 4ft thick (0.9 – 1.2m). The upper coal (Field Vein) is approximately 2ft thick (0.60m) and has been found to be separated from the lower coal by as much as 120ft (36.5m). Local to the Afan Valley, the No. 1 Rhondda is noted to be discontinuous affected by washouts. The No. 1 Rhondda Rider is found across most of the area.
- 2.49 The Brithdir Beds are typically arenaceous with thin coal seams, including the Brithdir and Brithdir Rifer coal seams which are generally not of significant working thickness or quality with only sporadic records of workings.

Landslides

- 2.50 The following landslides are recorded on the geological mapping (Sheet 248 and Sheet XVI NW) on or immediately adjacent to the site. The reference number adopted related to the UK National Landslide Database (NLD) (maintained by the British Geological Survey (BGS)). The BGS mapped location of the landslides are displayed on Figure 3.

Table 1: NLDB Features in site

NLD No	Name	Detail
3632	Foel Fawr (SWC: AA17)	Located 0.7km southwest of Cymmer on the north flank of Foel Fawr.
3624	Cymmer (SWC: AA16)	Located on the south slope of the Afan valley opposite Glyncorrwg.
3633	Pencastell Bungalow (SWC: AA18)	Located on the south side of the valley on a northwest facing slope, 50m south of Pencastell Bungalow above A4107 Afan Valley road.

- 2.51 A detailed assessment of the landslides on site including geomorphological mapping has been undertaken by ESP as part of the Ground Investigation Scoping Report (GISR) (Ref. ESP.8053.3708-01).

HYDROGEOLOGY

Hydrogeological Setting

- 2.52 The Upper Coal Measures forms a large synclinal basin that contains large quantities of water. Historically the Upper Coal Measures were divided to a number of aquifers in the sandstone bedrock divided by the lower permeability mudstone horizons.

Anticipated Groundwater Bodies

- 2.53 Based on the available information, we consider that the shallowest main groundwater body is likely to be located within the Pennant Sandstone Formation bedrock strata. However, localised perched water bodies cannot be discounted.
- 2.54 A groundwater body near the ponds and surrounding area of peat in the southeastern area of the site is likely.

Groundwater Movement

- 2.55 Groundwater movement within the superficial deposits (Glaciofluvial Deposits and Glacial Diamicton) will be controlled by intergranular flow whilst, in the Pennant Sandstone Formation, fracture flow is likely to be dominant. The site is in an area influence by general north to south trending normal faults which will impact the groundwater movement across the site.
- 2.56 Reference to Hydrogeological Map 17 (BGS, 1986) indicates that the Upper Coal Measures sandstone is hard and dense with a low porosity of typically 2%, and locally lower where deformation (folding/faulting) has resulted in secondary cementation. Discontinuities within the bedrock create secondary permeability, allowing vertical (downward) movement and storage of groundwater. Mudstone beds with relatively low permeability act as barriers, preventing vertical movement of water.
- 2.57 The extensive disturbance and deformation of the rock caused by the extraction of coal has in places resulted in hydrogeological continuity of the sandstone aquifers within the Upper Coal Measures. Furthermore, the faulting in the Pennant Sandstone Formation may have caused lateral compartmentation of the aquifers. 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.
- 2.58 The main groundwater body is anticipated to be within the Pennant Sandstone Formation bedrock likely at depths greater than 10m. The primary hydraulic gradient is anticipated to follow the bedding to the north and the groundwater to flow towards the River Afan to the north/northeast. Given the site setting, we consider that the groundwater within the bedrock aquifer may be providing base flow to the River Afan.
- 2.59 A possible shallow groundwater body is anticipated to be present near two ponds located in the eastern portion of the site. Deep peat has been noted to surround these ponds and a perched, shallow groundwater body is likely to flow through the peat toward the ponds at a relatively slow rate.

Aquifer Classification

- 2.60 Reference to the aquifer maps published in the environmental and geological data report (Appendix

C) indicates that the Glaciofluvial Deposits in the northwest extent are classed as Secondary A and the Glacial Diamicton Deposits in the central northern extent are classed as Secondary Undifferentiated. The remainder of the site is not indicated to be underlain by superficial deposits. The bedrock (Pennant Sandstone Formation) is classed as Secondary A Aquifer.

- 2.61 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.
- 2.62 Secondary Undifferentiated Aquifers are assigned by the Environment Agency where it has not been possible to categorize an aquifer in either Secondary A or B. In most cases this is attributable to a unit being classified as both minor and non-aquifers in different locations due to the variable characteristics of the rock type. These strata can be sensitive to pollution.

Groundwater Abstractions and Vulnerability

- 2.63 The environmental data report (Appendix C) indicates that there are no groundwater abstractions or Source Protection Zones within 500m of the site.
- 2.64 Enquiries to the Local Authority (Neath Port Talbot County Borough Council) have been made regarding groundwater abstractions. At the time of report issue, we have not yet received a response however, it should be noted that it is possible that unrecorded abstractions may be located on or within the vicinity of the site.
- 2.65 The groundwater vulnerability is shown in the environmental data report be secondary bedrock aquifer, high vulnerability.

Groundwater Chemistry

- 2.66 Groundwater within the Coal Measures varies from good quality with low total dissolved solids to highly mineralised. Within the Upper Coal Measures (Pennant Measures), sulphate concentrations generally increase with depth. Waters pumped from depth (often associated with old workings) are generally of poor quality with low pH, high iron and sulphate concentrations and levels of dissolved solids with the possible presence of sulphuric acid (BGS, 1986).
- 2.67 It should be noted that localised variations in groundwater quality occur and will likely be affected by past coal mining.

HYDROLOGY

Surface Water Features

- 2.68 The nearest major surface water feature to the site is the River Afan which generally flows to the west and southwest approximately 200m west and north of the site at its closest point. A number of streams are indicated in the western extent of the site, observed as slow running during geomorphological mapping (ESP, 2022a) , and two ponds are located in the southeastern extent, (Appendix C).
- 2.69 The ponds in the east of the site are associated with an area of peat indicated by previous assessments, ESP, 2022b.
- 2.70 A covered potable water reservoir is located on site.

Surface Water Abstractions

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

FLOODING

- 2.72 A preliminary review of the risk of flooding has been undertaken for the site. The following sections do not comprise a Flood Risk Assessment and the potential for flooding is not addressed further in this report.

Rivers and Seas

- 2.73 From a review of topographical plans and flooding maps presented in the environmental data report and on the Natural Resources Wales (NRW), 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).

Surface Water

- 2.74 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.
- 2.75 From a review of information available on the Natural Resources Wales (NRW) website (2022), the majority of 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).
- 2.76 However, isolated areas are indicated to be at low to high risk where streams and ponds are present.
- 2.77 A Low risk means that in each year, the area has a chance of flooding of between 0.1% (1 in 1000) and (1%) and 1 in 100.
- 2.78 A medium risk means that each year, the area has a chance of flooding of between 1% (1 in 100) and 3.3% (1 in 30).
- 2.79 A high risk means that each year, this area has a chance of flooding of greater than 3.3% (1 in 30).

Groundwater

- 2.80 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.

- 2.81 The environmental and geological data report (Appendix C) indicates that the majority of the site is not at risk from groundwater flooding however, a small portion in the northwestern extent and northern extent are shown to be Low risk of groundwater flooding at surface.
- 2.82 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.
- 2.83 The environmental and geological data report (Appendix C) indicates that the majority of the site is not at risk from groundwater flooding however, a small portion in the northwestern extent and northern extent are shown to be Low risk of groundwater flooding at surface.

ENVIRONMENTAL SETTING

Summary of Environmental Data

- 2.84 The site exists in a historically rural, and now a semi-rural setting.
- 2.85 Information on the industrial setting, pertinent Environmental Regulation Permits and authorisations for the site and the immediate area is presented in the Groundsure data report (Appendix C). 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}	2no. records on site. See below.	7no. recorded within 250m of the site.
Historical Industrial Land Use	60no. records on site. See below.	152no. recorded within 250m of the site.
Historical Tanks, Petrol filling stations (PFS), Garages, Energy Facilities	None identified.	14no. recorded within 250m of the site.
Potentially Infilled Land	89.no records on site. See below.	177no. recorded within 250m of the site.
IPPC Authorisations	None identified.	None recorded within 500m of the site.
Discharge Consents	1no. record on site (consent expired).	8no. 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.
Enforcements	None identified.	None recorded within 500m of the site.
Pollution Incidents	None identified.	2no. recorded within 250m of the site. See below.
Contaminated Land under Part 2A EPA 1990.	None identified.	1no. recorded at 169m north (historical permit).
Waste Management Facilities	None identified.	16no. recorded within 250m of the site.
Current Industrial/Commercial Sites	2no. records on site. See below.	17no. recorded within 250m of the site.
Historic railways/railway/tunnel features	11no. records on site. See below.	43no. recorded within 250m of the site.
Notes: 1. Full details of features presented in the data report (Appendix C). 2. 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. 3. PFS – Petrol Fuel Stations		

Further Discussion on Salient Environmental Features

Environmentally Sensitive Sites

- 2.86 Two records are held on site, both for Plantation on Ancient Woodland and they are generally shown on the northwestern and northern fringes and of the site.
- 2.87 Ecological and archaeological restraints are present on site and are discussed further below.

Potentially Contaminated Land Use

- 2.88 A total of 60no. potentially contaminated land uses are recorded for the site which comprise of mining features, quarries, unspecified tips and heaps. It should be noted that some are duplicated

due to the same features being recorded on different map dates. These are discussed in subsequent sections.

- 2.89 Some features are primarily located off-site to the north and their boundary crossing over the northern boundary of the site.

Potentially infilled Land – Relating to historic mining and quarrying

- 2.90 89no. records are held for potentially infilled land, primarily relating to former coal mining and quarrying activities. These are summarised in the table below.

Table 3: Summary of historic land use relating to mining/quarrying.

Groundsure Ref.	Location on site	Type	Date	Additional Observations
A	Central area	Quarry	1948 – 1905	Feature relates to BGS mapped landslide backscarp. No obvious Made Ground infill identified.
B & K	Both Northeast boundary	Quarry/Pit/Heap	B - 1897 – 1921 K - 1897 – 1948	Features predominantly off site, mapping shows boundary to cross site boundary. No obvious Made Ground identified on site.
C	Central area	Pit/ Ground workings	1914 – 1981	No significant expression of this noted on site and no obvious Made Ground identified on site.
D	Northwest boundary	Pit	1914 – 1948	Feature mapping boundary crosses site boundary. Possible pit adjacent to Pen Castell dwelling. No obvious Made Ground identified on site.
F	Central north boundary	Colliery, Pit, Heap, Quarry	1877 – 1981	Glyncymmer Colliery.
G	Central area	Pit	1897 – 1965	Feature is in the location of a cutting for the track crossing the site, no made ground noted.
H & I	Southern boundary	Pit	1897 – 1981	Relating to large possible landslide scarp feature and not a pit.
J	Southwest area	Quarry, Heap, Pit	1877 – 1981	No significant expression of this noted on site and no obvious Made Ground identified.
4	Southern boundary	Pit	1897 – 1981	Relating to large possible landslide scarp feature and not a pit.

Notes:

1. Full details of features presented in the data report (Appendix C).
2. Vegetation where dense may obscure signs of Made Ground.
3. Based on walkover only, no exploratory investigation carried out at this stage.

- 2.91 The features summarised above are generally in keeping with the features identified on the historic mapping. Features H, I and 4 relate to the large scarp/fissure feature located in the southern portion which is of geological origin. Feature A is also considered of geological origin as this is a rear scarp of a landslide. Other pits across the site were inspected and no obvious made ground was observed.

Potential sources of contamination at the site are discussed below.

Pollution Incidents

- 2.92 The nearest pollution incident is recorded at 29m north, dated 2003. The record indicates a Category 3 (Minor) land impact and Category 4 (No Impact) water and air impact. These historical pollution incidents are not considered to have an impact on the site or the proposed development taking into account the time that has passed since the incidents and the type of incident recorded.

Recent Industrial Land Use

- 2.93 The two records held on site relate to a telecommunications mast and pylon in the southern extent of the site as previously identified. Further overhead electrical cables and poles are noted across the site.

Historic Rail Features - Cymmer Tunnel

- 2.94 6.no records are held on site for a tunnel (Cymmer Tunnel), dated between 1877 and 1965. The records are in keeping with the features identified in the historical mapping.

On-Site Bulk Materials and Liquid Storage

- 2.95 A review of the historical maps (Appendix B) and on-site observations identified a covered reservoir in the southeastern extent of the site.
- 2.96 The historical maps and field reconnaissance visit have provided no evidence of any past or recent above ground or underground bulk liquid such as fuels/oils storage on site.

On-Site Bulk Materials and Waste Storage

- 2.97 Isolated areas of fly-tipped material and fire damaged vehicles have been noted on site. The field reconnaissance visit indicated no other evidence of significant waste storage.

RADON HAZARD

- 2.98 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.
- 2.99 The environmental data report (Appendix C) indicates that a small portion in the southern extent of 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. The remainder of the site is not shown in a radon affected area. We consider that the area of Radon generally coincides with the mapped Llynfi Member, see radon map displayed in Appendix C (pg. 160).
- 2.100 Given the currently available information, the risk from radon is considered **Moderate** and basic radon protection measures will be required for new buildings in the area identified in the southern portion of the site. The remainder of the site is not indicated to require radon protection.

KNOWN SITE CONSTRAINTS

Peat

- 2.101 Deep peat has been identified and any future ground investigation and construction works will need to consider the presence of deep peat, as discussed in ESP July 2022b.

Ecology

- 2.102 Based on information provided by Stantec, 2022, it is understood that the key ecological considerations related primarily to common lizards, breeding birds, invasive non-native species and general land of ecological value. As part of the proposed development, two locations to the south (Solar Farm Site (SFS)) and southwest (Dyffryn Tips Site (DTS)) have been identified for use as a compensation strategy, specifically with relation to the relocation of reptiles and nightjars. The ecological impact and status of the site are being managed by ecological specialists (Keystone Environmental).
- 2.103 A number of constraints have been imposed for ground investigation works including:
- 2.104 Proposed ground investigation points and access routes are to be agreed in advance and cleared of vegetation with the client team and Principal Contractor;
- All works are to be overseen by an Ecological Clerk of Works (ECoW) and pre-commencement inspection will be undertaken prior to works starting (1 week and 2 days prior) and weekly therein;
 - All excavations will either be infilled or covered at the end of each working day; and
 - Prior to leaving the site all vehicles and footwear will be cleaned to prevent the spread of non-native invasive plant species (Stantec, 2021).

Archaeology

- 2.105 Previous assessment undertaken (Dyfed Archaeological Trust 2017 and 2018), identified a number of locations within the development boundary and two historic assets are considered to be of high archaeological importance, the Glyncymmer Bronze Age cairn and the Heol Y Moch trackway, which are to be retained as part of the development. Mitigation measures will be required during ground investigation and construction works including archaeological watching brief and monitoring. The aforementioned high importance features are to remain undisturbed.

Services

- 2.106 The Client has provided ESP with a series of plans showing the locations of recorded underground services in the vicinity of the site. The services records are presented as Appendix F.
- 2.107 Site observations and the utility plans indicate the following services:
- 11kV electricity cables on pylons crossing the site;
 - Medium pressure gas mains along the eastern boundary, crossing the site in the southeast corner;
 - Water trunk main in the eastern extent generally crossing the site from north to south; and
 - Openreach telecommunication cables in the south and southeastern extent and around the site boundary.
- 2.108 It is understood that in the southern central portion, ducting is in place for Openreach assets

however, on site observations indicate that no cables are currently present within the ducting. The Principal Contractor (Keystone Environmental) informed ESP that fibre optic cables are located in the southeastern portion of the site that trend toward the telecommunication mast near the southern boundary, or highest point of the site. Keystone Environmental had no drawings to show their location.

- 2.109 A covered reservoir is location in the southeastern extent of the site which is understood to provide water supply to the nearby towns of Cymmer and Croeserw. The water trunk main discussed above crosses the eastern extent of the site towards the covered reservoir in the southeast eastern extent.

Preliminary UXO Assessment

- 2.110 The environmental data report does not consider the potential risk from unexploded ordnance. A Preliminary UXO Risk assessment has been completed by a specialist Ordnance consultant in accordance with CIRIA guidelines (Stone et al, 2009) and is presented in Appendix E (1st Line Defence, 2022).
- 2.111 The assessment concludes that ‘the risk from UXO is not considered to be elevated higher than the ‘background risk’ of UXO within this area of the UK. Whilst it would be possible to conduct a Detailed UXO Risk Assessment, it is not anticipated that any further findings would significantly alter the risk of encountering unexploded ordnance within the site. It is therefore recommended to that no further action is taken.’

3.0 PRELIMINARY GEO-ENVIRONMENTAL RISK ASSESSMENT

PHASE ONE CONCEPTUAL SITE MODEL

Background

- 3.1 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.

Potential Soil Contamination Sources

- 3.2 The desk study review has identified that the site has remained largely undeveloped and there are no significant sources of contamination on site. There are potential localised contaminative uses that have been identified on site and in the immediate vicinity which include potentially infilled land relating to quarrying/groundworks and construction of the recent telecommunications mast and reservoir.
- 3.3 Based on the information available we consider that the following sources of contamination may be present on site in localised areas:
- Made Ground –inc. relating to mast/reservoir and track construction– general diffuse contamination near to these features (both technically outside red line planning boundary and off-site);
 - Made Ground – potentially historic infilled ground from mining/quarrying/unspecified pits, or spoil heaps, given age infill likely to comprise mining spoil/discarded quarry stone, walkover suggest no obvious sign of contamination;
 - Possible contamination within Topsoil - general diffuse contamination;
 - Fly tipped material providing isolated point sources; and
 - Made Ground and Coal Measures bedrock – potentially contain pyrite, diffuse source.

Potential Contaminants Present

- 3.4 The potential contaminants associated with the above potential sources have been identified from various guidelines published by DEFRA and the Environment Agency.
- 3.5 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;
 - polyaromatic hydrocarbon (PAH) compounds;
 - petroleum hydrocarbons, including methyl-tert-butyl-ether (MTBE);
 - phenols; and
 - asbestos.

Potential Sources of Hazardous Ground Gas

- 3.6 This section considers the potential sources of hazardous gases such as methane, carbon dioxide and hydrocarbon vapours. The potential for radon was discussed previously.
- 3.7 Based on the available desk study information, the following potential sources of hazardous ground gas have been identified on, or in close vicinity of, the site:
- General Made Ground – on site source;
 - Peat – on site source;
 - Infilled mining features/quarries with Made Ground – on site source;
 - Abandoned coal mine workings – on and off-site source; and
 - Abandoned tunnel – on and off-site source.
- 3.8 Based on the guidelines presented by O’Riordan and Milloy (1995) and revised by Wilson et al (2009), the above potential gas sources would generally be classified as of very low (General Made Ground) to low/moderate (abandoned, flooded coal mine workings).
- 3.9 Reference to CL:AIRE (October 2021) Good Practice for Mine Risk Assessment for Coal Mine Gas Emissions suggests that the site is in a high risk zone, due to some of the following factors; mine entries on site, shallow workings and faults connecting surface to workings. A detailed Mine Gas Risk Assessment in accordance with CL:AIRE 2021 is underway and will be provided in an addendum report following completion of gas monitoring.
- 3.10 Enquiries to the Coal Authority were made by Stantec UK Ltd., regarding a Mine Gas Emissions Report, the Coal Authority (2022) provided the following response:
- “As there hasn’t been any gas recorded at these 2 sites since 2009, we stopped monitoring them. So, unfortunately, there is not enough information to produce a report...”*
- 3.11 As such, a Mine Gas Emissions Report has not been obtained.

Potential Receptors

- 3.12 We consider that the most vulnerable receptors with regards to any contamination or hazardous ground gas present are likely to be as follows:
- Human health/future site users (holiday stay), the critical receptors being young children playing in soft landscaping areas.
 - Future employees, the critical receptors being employees outside during their break periods.
 - Future site users - guests using activities and not partaking in a residential stay;
 - Construction and maintenance workers.
 - Buried concrete (foundations, drainage, services etc.).
 - The water quality in the River Afan located approximately 100m (at its closest point) to the north and west (downslope).
 - The groundwater within the Pennant Sandstone Formation strata beneath the site and probable shallow groundwater within the peat deposits.
 - Water within surface water features e.g., ponds on site.
 - Ecology on site.
 - Neighbours to site, including residents in dwellings.
 - Disused tunnel below site.
 - Archaeological sites.

- 3.13 Not all the above receptors have a risk posed to them by all potential sources on site, the risk assessment with linkages is provided below.

Potential Migration Pathways

- 3.14 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 landscaping areas.
- Dermal contact with contaminated soils.
- Inhalation of asbestos containing materials within the shallow soils.
- Potential migration of from flammable ground gas/vapours from on-site sources.
- Potential migration of from flammable ground gas/vapours from off-site sources.
- Migration of Radon gas providing chronic (long term) exposure to unacceptable levels.

Construction and Maintenance Workers:

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

Groundwater:

- Migration and leaching of mobile contaminants into the water-bearing strata within the bedrock via groundwater.
- Migration and leaching of mobile contaminants into the water-bearing strata within the bedrock via anthropogenic pathways e.g., boreholes, pipes, culverts.

River Afan:

- Leaching of mobile contaminants to the groundwater beneath the site, and then on to the nearby surface water course.
- Surface run-off of contaminated leachate to surface water features e.g., ponds.
- Deposition of blown dust

Buildings:

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

Ecology:

- Direct deposition of particles/dust of contaminated material, windblown or flooding
- Ingestion of vegetation/water/soils by animals on site.

- Potential inhalation of flammable or toxic ground gas/vapours from on-site sources.
- Potential inhalation of flammable or toxic ground gas/vapours from off-site sources.
- Inhalation of dust arising from site during construction or whilst site in operation.
- Indirect deposition through watering.

Site Neighbours:

- Inhalation of dust arising from site during construction or whilst site in operation.

- 3.15 It should be noted that the abandoned tunnel beneath site may provide a preferential potential pathway for gas migration; both tunnel portals are located off-site. Former mine workings, mine entries and faults that interact with coal workings may provide a preferential pathway for mine gases to travel. It is understood that no re-use of existing site Topsoil material is proposed for the development and that imported material will be utilised for areas of soft landscaping.

PRELIMINARY RISK EVALUATION & PLAUSIBLE POLLUTANT LINKAGES

- 3.16 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.

Introduction to Risk Evaluation Methodology

- 3.17 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.
- 3.18 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).
- 3.19 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.
- 3.20 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 4.

Table 4: 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
Localised fly tipped and burnt materials including nearby shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Likely ²	Moderate Risk	Sampling of near-surface soils to confirm levels of total contamination present. Remove fly tipped material (source) and impacted soils.
		Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Likely ²	Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A	Likely ²	Moderate Risk	
		Impact on River Afan	Medium – site lies 100m south of river	Likely ²	Moderate Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Likely ²	Moderate Risk	
Potential contaminants in mining/quarry/ unspecified pit discard	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Low Likelihood ³	Moderate/Low Risk	Sampling of near-surface soils to confirm levels of total contamination present.
		Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Low Likelihood ³	Very Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A	Low Likelihood ³	Moderate/Low Risk	
		Impact on River Afan	Medium – site lies 100m south of river	Low likelihood ³	Moderate/Low Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Low Likelihood ³	Moderate/Low Risk	
Potential contaminants in Possible Made Ground across site (forestry work, Made Ground near mast, reservoir)	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Likely ⁴	Moderate Risk	Sampling of near-surface soils to confirm levels of total contamination present. Imported material is to be used for areas of soft landscaping.
		Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Likely ⁴	Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A	Likely ⁴	Moderate Risk	
		Impact on River Afan	Medium – site lies 100m south of river	Likely ⁴	Moderate Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Likely ⁴	Moderate Risk	
Potential contaminants within Topsoil	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Low Likelihood ⁵	Moderate/Low Risk	Sampling of near-surface soils to confirm levels of total contamination present. It is understood that the existing site Topsoil is not to be used as part of the development and imported material is to be used for areas of soft landscaping.
		Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Low Likelihood ⁵	Very Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A	Low Likelihood ⁵	Moderate/Low Risk	
		Impact on River Afan	Medium – site lies 100m south of river	Low Likelihood ⁵	Moderate/Low Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Low Likelihood ⁵	Moderate/Low Risk	
Asbestos in shallow soils	Inhalation of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Low Likelihood ⁵	Moderate / Low Risk	Sampling of shallow soils for asbestos.
Soil sulphate and pyrite	Direct contact of aggressive groundwater	Buried Concrete	Mild – damage to structures	Likely ⁷	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 ⁸	High Risk	Install and monitor gas wells.
	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 (guests)	Medium – potential for chronic levels	Likely ⁹	Moderate Risk	See Section 7.

Notes:
1. Methodology and details of risk consequence, probability and category based on CIRIA C552 (2001). 2. Walkover indicated burnt cars on site and others may be present. 3. Although quarry spoil/waste anticipated, the presence of contamination has yet to be confirmed. 4.The presence of contamination has yet to be confirmed. 5. The presence of contamination within Topsoil on site has yet to be confirmed. 6. ACM not anticipated but maybe present, associated with fly tipped materials. 7. Made Ground and Coal Measures bedrock can potentially contain sulphates/pyrite. 8.Potential sources of hazardous ground gas identified on and off site. 9. Radon risk identified in data report. 10. Risk to neighbouring receptors not shown; assessed separately and discussed below. 11. The above is updated following the intrusive investigation and testing in Table 9.

4.0 INITIAL EXPLORATORY INVESTIGATION

INVESTIGATION POINTS

Introduction

- 4.1 An intrusive investigation was undertaken by ESP between 12th April and 10th June 2022 in general accordance with BS5930:2020 and BS10175:2017 and was designed to investigate both geo-environmental and geotechnical hazards identified in the Ground Investigation Scoping Report (ESP, 2022a). It comprised hand excavated and machine excavated trial pitting and trial trenching, windowless sample boreholes, rotary open hole and rotary cored boreholes, the installation and monitoring of gas and groundwater wells, vibrating wire piezometers and inclinometers.
- 4.2 The exploratory holes were supervised and logged by an engineering geologist from ESP, in general accordance with BS5930:2020, BS EN ISO 14688-1:2002, BS EN ISO 14688-2:2018, and BS EN ISO 14689:2018, along with published weathering schemes. The investigation point positions are shown on Figure 5.
- 4.3 The ground levels and coordinates of the mechanical trial pits and boreholes (windowless sampling and cored) were surveyed by ESP on completion and are shown on the various hole records. The accuracy of the surveyed positions is indicated on the relevant records.
- 4.4 For the remaining investigation points, the ground levels are approximate only and have been interpolated from the topographical survey provided by Stantec UK Ltd (First Point Surveys, 2017). The positions were located based on co-ordinates provided by Stantec UK Ltd.
- 4.5 All investigations points were cleared of vegetation and assessed by the ecologist on site (Keystone Environmental Ltd.) prior to undertaking the works.
- 4.6 A ground investigation and assessment of deep peat has previously been undertaken by ESP in April 2022, the findings of which are reportedly separately (ESP, July 2022b).

Initial Investigation Strategy

- 4.7 The aim of this initial assessment is to provide sufficient information to establish general principles of development considering the outline planning conditions (notably Condition 29). Detailed assessment will be carried out in due course with the aim of confirming the findings and developing the risk assessments in this report.
- 4.8 The initial investigation strategy was designed in general accordance with BS10175:2017, considering the additional potential for geotechnical hazards to be present. Detailed investigation will be carried out as part of future development and design stages improving on exploration spacing, depths and testing frequencies as described within the relevant guidance and standards.
- 4.9 The investigation point locations were positioned to maximise the information that could be obtained and provide a spatial spread, allowing for the constraints imposed by the physical features on site including vegetation, steeply sloping ground and the known site constraints.
- 4.10 Investigation positions had to be pre-determined due to ecological clearance requirements and as a result ad-hoc positions were not available after the assessment had commenced without further ecological clearance. Notwithstanding the above, we consider that the investigation undertaken has

been sufficient to initially classify the key ground hazards.

4.11 Potential sources of contamination were identified as detailed above, the following investigation points were located to target these sources allowing for constraints discussed:

- Made Ground –inc. relating to mast/reservoir construction– Y31;
- Made Ground – potentially historic infilled ground from mining/quarrying/unspecified pits, or spoil heaps – Y22, 24, 25, 26; and
- Fly tipped material – Y19

4.12 The remaining hand pits were located to target the remaining sources including possible general diffuse contamination relating to Topsoil and possible hydrocarbons associated with localised spills due to forestry works.

Hand Excavated Trial Pits

4.13 52no. trial pits (Y01 to Y41 and TP17) were excavated across the between 12th and 6th May 2022 using hand tools. The trial pits were excavated to depths of between 0.3 and 1.2m. The trial pit records are presented as Appendix G, and their positions are shown on Figures 5a and 5b.

4.14 Hand pits Y16 to Y36 were primarily undertaken to allow for collection of shallow soils samples for geo-environmental assessment purposes. Hand pits Y37 to Y41 were undertaken as part of the detailed peat assessment, to delineate the depth of peat and obtain samples for geotechnical testing.

4.15 Disturbed samples were collected from the hand excavated trial pits for laboratory testing as above and shown on the trial pit records.

4.16 On completion, the trial pits were backfilled with arisings in layers compacted with hand tools, and the Topsoil reinstated on the surface. The arisings were left slightly proud of the adjacent surface to allow for future settlement.

Trial Pits

4.17 26no. trial pits (TP1 to TP26) were excavated across the site between 28th April and 4th May 2022 using a tracked hydraulic excavator. The trial pits were excavated to depths of between 0.85 and 3.40m. Due to access, trial pit TP17 was undertaken as a hand excavated pit.

4.18 The trial pit records are presented as Appendix H, and their positions are shown on Figure 5.

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

4.20 On completion, the trial pits were backfilled with arisings in layers compacted with the excavator bucket, and where present, the Topsoil reinstated on the surface. The arisings were left slightly proud of the adjacent surface to allow for future settlement.

Trial Trenches

4.21 4no. trial trenches (TT04 – TT07) were excavated across the site between 21st and 28th June 2022 using a tracked hydraulic excavator. The trial trenches were excavated to depths of between 2.5 and 3.50m. The trial trench records are presented as Appendix I-a, and their positions are shown on

Figure 5.

- 4.22 The trial trenches were typically 45 to 50m in length, access dependant and the purpose of the trenches was to identify and record evidence of ground disturbance possibly relating to faulting.
- 4.23 On completion, the trial trenches were backfilled with arisings in layers compacted with the excavator bucket, and where present, the Topsoil reinstated on the surface. The arisings were left slightly proud of the adjacent surface to allow for future settlement.
- 4.24 3no. trial trenches (TT01 – TTO3) were previously undertaken by Stantec UK Limited between 20th and 21st April 2022. The trial trench records are presented as Appendix I-b, and their positions are shown on Figure 5.

Window Sampling

- 4.25 12no. windowless sample boreholes (WS1 to WS12) were constructed between 25th and 27th April 2022 to depths between 0.25 and 2.80m. The borehole records are presented as Appendix J, and their positions are shown on Figure 5.
- 4.26 A hydraulically powered rig was used to drive plastic lined sampling tubes into the ground, with the soil recovered within the tubes, which are then split to allow sampling and logging. Disturbed samples were obtained throughout the boreholes for identification and laboratory testing purposes, as shown on the borehole records. The windowless sampling provided generally good recovery to the depth of refusal.
- 4.27 At the commencement of each borehole, a service inspection pit excavated by hand to a depth of 1.2m or refusal depth if shallower.
- 4.28 As required in BS5930:2020, the SPT N-values shown on the borehole records are the direct, uncorrected results obtained in the field.
- 4.29 Depending on the nature of the test undertaken and the soils subjected to testing, field SPT N-values may require correction before using in design.
- 4.30 On completion, monitoring instrumentation was installed in selected boreholes. Below the instrumentation, the borehole was backfilled with arisings. Where no installation was installed, the boreholes were backfilled with arisings.

Rotary Cored Boreholes

- 4.31 11no. rotary cored boreholes (BH01 to BH11) were constructed to depths of between 13.4 and 53.7m between 9th May and 10th June 2022. The borehole records are presented as Appendix K, and their positions are shown on Figure 5.
- 4.32 At the commencement of each borehole, a service inspection pit excavated by hand to a depth of 1.2m or refusal depth if shallower.
- 4.33 Given that the objective of the boreholes was to intercept coal seams/workings, they were constructed under license to the Coal Authority (Permit ref. 24875).
- 4.34 The ODEX 115 system of simultaneous drilling and casing was used in the superficial deposits, and the depth of casing in each borehole is shown on the borehole records.

- 4.35 The soils within the borehole were recovered using continuous drive sampling, whereby the soil was collected within plastic lined sampling tubes, which were then split to allow sampling and logging. Disturbed samples were obtained throughout the boreholes for identification and laboratory testing purposes, as shown on the borehole records. The continuous drive sampling provided generally good recovery to the depth of refusal.
- 4.36 Standard Penetration Tests (SPT) were carried out using a solid cone in the boreholes in accordance with BS EN ISO 22476-3 (2005) and BS5930 (2020). As required in BS5930:2020, the SPT N-values shown on the borehole records are the direct, uncorrected results obtained in the field.
- 4.37 Depending on the nature of the test undertaken and the soils subjected to testing, field SPT N-values may require correction before using in design
- 4.38 Rock cores of nominal 72mm diameter were recovered in plastic liners using a rotary core triple tube barrel system, over runs of nominal 1.5m length. Where recovery was poor, the core length was reduced for the next run to maximise the chances of good recovery. The recovered cores were sealed in the plastic liners and placed in solid core boxes to prevent disturbance and swelling before logging. The plastic liners were only cut immediately prior to logging and sampling. In addition to the nature of the rock material, the identified fractures within the rock mass were also logged in accordance with BS5930:2020 and BS EN ISO 14689:2:2018. The Rock Quality Designation (RQD) recorded was for rock core 100mm or greater in length, unless otherwise stated. The fracture state of the recovered cores (in terms of number of fractures per metre run) is presented on the borehole records.
- 4.39 Given the distance to the nearest property (>100m), compressed air was used as a flushing medium to keep the drill bits cool and return chippings to the surface. In accordance with Coal Authority requirements, levels of ground gas were recorded at the borehole during the drilling works. The levels of gas recorded during drilling are presented on the borehole records.
- 4.40 On completion, instrumentation was installed in boreholes. Below the instrumentation, the borehole was backfilled with bentonite as required by the Coal Authority.

Rotary Open-Hole Borehole

- 4.41 1no. 100mm diameter rotary percussive open-hole borehole (BH09a) was constructed to a depth 50.0m of between 9th and 13th June 2022 adjacent to BH09. The borehole record is presented in Appendix K, and the position shown on Figure 5. The borehole was constructed adjacent to BH09 to allow for the installation of a gas and groundwater monitoring well.
- 4.42 At the commencement of the borehole, a service inspection pit excavated by hand to a depth of 0.7m where it refused on 'bedrock'.
- 4.43 Given the distance to the nearest property (>100m), compressed air was used as a flushing medium to keep the drill bits cool and return chippings to the surface. In accordance with Coal Authority requirements, levels of ground gas were recorded at the borehole during the drilling works. The levels of gas recorded during drilling are presented on the borehole records.
- 4.44 During the drilling process, the rock chippings returned to the surface were described by the driller and the rate of progress monitored. When large voids were encountered (such as abandoned workings), the drilling rotation was stopped, and the drill rods lowered down the hole and the

estimated depth of void recorded. It should be noted that, although adequate for identification purposes, the nature of the drilling method does not permit an accurate description of the strata.

- 4.45 On completion, instrumentation was installed in the borehole.

INSTRUMENTATION

Gas and Groundwater Well Installations

- 4.46 A 50mm diameter monitoring well was installed in selected boreholes (BH01 to BH09a and WS01 to WS12) in accordance with BS8576:2013 to allow monitoring of hazardous ground gases and groundwater.
- 4.47 The wells were positioned to target specific sources of ground gas to provide an indication of the gas conditions at sources that will impact the site. Ground gas hazards and risks vary due to the underlying geology and mining history. For example, to the west of the Pen-y-Castell fault, mine workings are anticipated to be deeper and less faulting in the bedrock is expected; this may yield a lower risk. In comparison, in the eastern portions, the workable coal seams are shallower and more mine entries exist and evidence of faulting is present; in these locations, the risk from ground gas may be higher.
- 4.48 The wells, comprising slotted plastic pipe with a gravel surround (the response zone), bentonite seals above the response zone, and a lockable vandal proof cover, were installed as detailed on the borehole records and summarised in the table below.

Table 5: Gas Well Installations

Well ID	Date of Installation	Response Zone depth (m)	Installation Type	Response Zone Stratum
BH01 (s)	20/05/2022	1.0 - 4.0	19mm SP	Weathered Brithdir Member
BH01 (d)	20/05/2022	9.0 - 21.0	50mm SP	Brithdir Member Bedrock
BH02	23/05/2022	9.0 - 24.0	50mm SP	Rhondda Member and No.1 Rhondda Coal Seam
BH03	18/05/2022	1.0 - 10.0	50mm SP	Rhondda Member bedrock
BH04 (s)	25/05/2022	1.0 - 3.0	19mm SP	Weathered Rhondda Member
BH04 (d)	25/05/2022	24.0 - 27.0	50mm SP	No 2. Rhondda Coal Seam (Both Field Vein and Wernddu)
BH05 (s)	19/05/2022	1.0 - 4.0	19mm SP	Weathered Rhondda Member
BH05 (d)	13/05/2022	31.2 - 40.2	50mm SP	Field Vein Coal Seam
BH06 (s)	13/05/2022	1.0 - 4.0	19mm SP	Weathered Rhondda Member
BH06 (d)	13/05/2022	24.0 - 33.0	50mm SP	Llynfi Member and Wernpistyll Rider Coal Seam
BH07	26/05/2022	3.0 - 16.5	50mm SP	Rhondda and Llynfi Member and Wernpistyll Rider. Near deep peat.
BH08 (s)	13/05/2022	2.0 - 5.0	19mm SP	Weathered Rhondda Member
BH08 (d)	13/05/2022	2.0 - 31.0	50mm SP	Rhondda Member and Field Vein coal seam
BH09A	13/06/2022	28.0 - 49.0	50mm SP	Rhondda and Llynfi Member including Field Vein and Wernddu, possibly Wernpistyll Rider coal seams
WS01	27/04/2022	0.3 - 0.8	50mm SP	Weathered Rhondda Member
WS02	27/04/2022	0.5 - 2.8	50mm SP	Weathered Rhondda Member
WS03	26/04/2022	0.3 - 0.65	50mm SP	Weathered Rhondda Member
WS04	27/04/2022	0.3 - 0.8	50mm SP	Weathered Rhondda Member
WS05	26/04/2022	0.5 - 2.8	50mm SP	Weathered Rhondda Member
WS06	26/04/2022	0.2 - 0.7	50mm SP	Weathered Rhondda Member
WS07	26/04/2022	0.3 - 0.7	50mm SP	Weathered Rhondda Member
WS09	27/04/2022	0.1 - 0.6	50mm SP	Weathered Rhondda Member
WS10	26/04/2022	0.5 - 2	50mm SP	Weathered Rhondda Member
WS11	25/04/2022	0.5 - 1	50mm SP	Weathered Rhondda Member, near deep peat
WS12	25/04/2022	0.3 - 0.4	50mm SP	Weathered Rhondda Member, near deep peat

Notes:

1. Details of each monitoring well are presented on the individual borehole records (Appendices I and J).
2. SP – HDPE standpipe

'Spot' Gas Monitoring

- 4.49 Monitoring of the installed gas wells has been undertaken on a 'spot' monitoring basis (periodic visits to monitor gas levels at the time of the visit). CL:AIRE (2021) and CIRIA C665 (Wilson et al, 2007) provides guidance on the number and frequency of monitoring visits required for installed gas wells. These depend on the gas generation potential of the source and the sensitivity of the development to gas risk and are designed as a typical minimum only.

- 4.50 The most significant source in the vicinity of the site in terms of gas risk, abandoned mine workings, is classified as being of low to moderate gas generation potential. The proposed development of an adventure park with holiday accommodation (residential) is classified as of high sensitivity in terms of gas risk. Therefore, based on the guidelines in CIRIA C665, a minimum of 12 monitoring visits (fortnightly) are required over a 6 month period. Two sets of readings should be at low and falling atmospheric pressures.
- 4.51 To date, the installed wells have been monitored for levels of groundwater and ground gas on 4no. occasions between 16th June and 28th July 2022. The results of the 'spot' gas and groundwater monitoring undertaken to date are presented in Appendix L. During each visit, Gas Data LMSxi G3.18e portable monitoring equipment was used to measure levels of the following ground gases within the airspace in the wells and the flow rates from the wells:
- Methane - total and percentage of Lower Explosive limit (LEL);
 - Carbon dioxide;
 - Oxygen; and
 - Hydrogen sulphide.
- 4.52 The percentage of nitrogen is also calculated by difference. The equipment uses infra-red methane (CH₄) and carbon dioxide (CO₂) detectors, coupled with pressure (barometric and well), temperature and flow sensors. A photo-ionisation detector (PID) was used during the monitoring to measure the levels of volatile organic compounds present in the well.
- 4.53 Following measurement of flow rates and gas concentrations, the well cap was removed, and groundwater levels were measured using a dipmeter from the site surface.
- 4.54 Atmospheric pressure has been recorded for the two days prior to and following the monitoring visits, measured using an installed barometer on site, and records held for the closest weather station at Cardiff Airport, some 35km southeast. Full details of the atmospheric pressure are displayed in the gas monitoring results in Appendix L.

Inclinometer

- 4.55 3no. inclinometers were installed to a maximum depth of 7.2m using 70mm easy-connect inclinometer casing and the borehole backfilled with a bentonite cement ground mix. A summary of the installs is shown in the table below.

Table 6: Summary of Inclinometer and Vibrating Wire Piezometer installations

Borehole ID	Depth (m)	Summary of Response Zone
BH09	35.5	Rhondda Member Bedrock
BH10	34.0	Rhondda Member Bedrock
BH11	13.4	Rhondda Member Bedrock
Notes:		
1. Details of each inclinometer and the ground conditions are presented on the individual borehole logs (Appendix J)		

- 4.56 To date, the inclinometers have been monitored on 1no. occasion on 12th July 2022.

Vibrating Piezometer

- 4.57 Vibrating Wire Piezometers were installed in boreholes BH09 to BH11 upon completion as detailed in Table 10 above. The details of the installations are displayed in the borehole records in Appendix F. The vibrating wire piezometers are connected to a datalogger which has been set to monitor every 3 hours. A data logger with built in barometer is installed in borehole BH09.
- 4.58 To date, the vibrating wire piezometers have been monitored on 1no. occasion on 12th July 2022. The interpreted data collected to date from the data loggers is shown in a series of graphs in Appendix M.

SAMPLING STRATEGY

Soil Sampling

- 4.59 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.
- 4.60 A non-targeted sampling strategy was used to obtain representative information on soil contamination across the site as a whole for a site with an overall low potential for contamination to be present.
- 4.61 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.
- 4.62 Samples for logging and geotechnical laboratory testing purposes were collected at regular intervals within the exploratory holes.

EVIDENCE OF SITE CONTAMINATION FOUND DURING SITE WORKS

- 4.63 With regard to potential hazards identified in the desk study and Preliminary Risk Assessment, the following observations were made.
- 4.64 No significant visual/olfactory evidence of contamination was identified in any of the exploratory holes.

Monitoring of Volatile Hydrocarbons

- 4.65 A photo-ionisation detector (PID) was used during the hand excavated trial pits to measure the levels of total volatile hydrocarbons present in the recovered soils.
- 4.66 Headspace analyses were undertaken whereby samples of the soil were collected in sealed plastic bags from the exploratory holes and then left for a period of time (in the sun to allow any volatiles present to escape into the headspace above the soil). The PID was then used to measure the levels of total volatile organic compounds (VOC) within the headspace above the sampled soils.

Table 7: Summary of Volatile Hydrocarbon Monitoring in hand pits

Point ID	Depth (m)	Reading (ppm)	Point ID	Depth (m)	Reading (ppm)
Y01	0.2	0.3	Y21	0.4	0.1
Y01	0.4	0.1	Y22	0.1	0.3
Y02	0.1	0.2	Y22	0.2	0.1
Y02	0.3	0.1	Y23	0.2	0.2
Y03	0.1	0.5	Y23	0.5	0.1
Y03	0.3	0.1	Y24	0.1	0.4
Y04	0.1	0.2	Y24	0.3	0.2
Y04	0.3	0.2	Y25	0.1	0.0
Y05	0.1	0.5	Y25	0.4	0.3
Y05	0.3	0.1	Y26	0.1	0.1
Y06	0.1	0.1	Y26	0.3	0.0
Y06	0.3	0.1	Y27	0.1	0.2
Y07	0.1	0.5	Y27	0.3	0.2
Y07	0.3	0.2	Y28	0.1	0.3
Y08	0.1	0.3	Y28	0.35	0.4
Y08	0.4	0.2	Y29	0.1	0.1
Y09	0.1	0.1	Y29	0.3	0.0
Y09	0.4	0.1	Y30	0.1	0.1
Y10	0.05	0.3	Y30	0.3	0.3
Y10	0.2	0.1	Y33	0.1	0.0
Y11	0.1	0.1	Y33	0.3	0.0
Y11	0.3	0.1	Y34	0.1	0.0
Y12	0.1	0.2	Y34	0.3	0.1
Y12	0.3	0.1	Y35	0.1	0.1
Y13	0.1	0.4	Y35	0.4	0.2
Y13	0.3	0	Y36	0.1	0.1
Y14	0.2	0.3	Y36	0.3	0.0
Y14	0.4	0.2	Y37	0.8	0.4
Y15	0.1	0.1	Y37	1	0.6
Y15	0.2	0.1	Y38	0.2	0.3
Y16	0.1	0.1	Y38	0.5	0.2
Y16	0.2	0.2	Y39	0.5	0.5
Y19	0.1	0.0	Y39	1.1	0.4
Y19	0.3	0.0	Y40	0.7	0.2
Y20	0.15	0.2	Y40	0.9	0.2
Y20	0.3	0.1	Y41	0.3	0.1
Y21	0.1	0.1	Y41	0.5	0.0

4.67 The full results of the headspace testing are presented in the hand excavated trial pit records in Appendix G.

Table 8: Summary of Volatile Hydrocarbon Monitoring in mechanical pits

Point ID	Depth (m)	Reading (ppm)	Point ID	Depth (m)	Reading (ppm)
TP01	0.1	0	TP13	0.05	0.3
TP01	0.6	0	TP13	0.3	0.1
TP01	0.9	0.1	TP14	0.3	0.3
TP01	1.7	0.1	TP14	0.8	0.1
TP01	2	0	TP15	0.5	0
TP02	0.4	0.5	TP15	0.9	0.1
TP02	1.2	0.1	TP16	0.05	0.2
TP03	0.2	0.3	TP16	0.3	0.1
TP03	0.6	0.2	TP16	0.7	0.1
TP03	0.9	0.2	TP18	0.3	0
TP04	0.1	0.3	TP18	0.4	0.1
TP04	0.5	0.2	TP18	1	0.2
TP04	1	0	TP18	2.5	0.2
TP04	1.8	0.1	TP19	0.2	0.4
TP05	0.5	0	TP19	0.5	0.2
TP05	1.2	0.1	TP20	0.1	0.3
TP05	1.4	0	TP20	0.4	0.2
TP06	0.2	0.3	TP20	0.8	0.2
TP06	0.5	0.1	TP20	1.4	0.1
TP06	0.7	0.1	TP21	0.2	0.2
TP07	0.3	0.4	TP22	0.4	0.1
TP07	0.7	0.2	TP22	1	0.3
TP07	1	0.3	TP22	2.4	0.1
TP07	1.2	0.1	TP23	0.1	0.6
TP08	0.6	0.2	TP23	0.3	0.5
TP08	0.9	0.1	TP24	0.1	0.1
TP09	0.4	0.1	TP24	0.5	0.2
TP09	0.6	0.5	TP24	0.9	0.1
TP10	0.5	0.4	TP25	0.1	0.3
TP10	1.5	0.1	TP25	0.3	0.1
TP11	0.05	0.6	TP25	0.5	0.2
TP11	0.5	0.2	TP25	0.8	0.2
TP11	0.6	0.1	TP26	0.1	0.1
TP11	1.4	0.1	TP26	0.4	0.1
TP12	0.1	0.2	TP26	1.2	0
TP12	0.3	0.3	Y41	0.3	0.1

- 4.68 The full results of the headspace testing are presented in the mechanical trial pit records in Appendix H.

GEO-ENVIRONMENTAL LABORATORY TESTING

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

- 4.70 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.
- 4.71 To allow an assessment of the potential chronic risks posed to human health, a total of 51no. selected samples of the shallow soils have been analysed for the contaminants identified, plus other determinands typically present on brownfield sites in the UK.
- 4.72 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 polyaromatic hydrocarbon (PAH) compounds;
 - Total monohydric phenols;
 - Total cyanide, asbestos qualitative screen (presence or absence); and
 - Soil organic content, pH value;
- 4.73 The geo-environmental soil test results are presented in Appendix N.

5.0 CONCEPTUAL GROUND MODEL

INTRODUCTION

- 5.1 As discussed in the Desk Study (Section 2), the Pennant Measures (formally the Upper Coal Measures) outcrops across the entire site and there is a regional dip toward the north of the bedrock strata. The pennant Measures include beds of sandstone, siltstone, mudstone and seams of coal of economical worth that were extracted in the past.
- 5.2 There are several marked/recorded faults, generally trending north to south that result in outcrop variation.

GEOLOGY

- 5.3 The exploratory holes have identified the site to be generally underlain by a thin veneer of Topsoil, fine- and coarse-grained soils of the weathered bedrock and the Pennant Measures bedrock. A summary of the strata encountered is provided below:
- 5.4 Reworked Natural Soils: Reworked Natural Soils were encountered in TP02, TP03, TP07 to TP11, TP15, TP18 and in BH04 and was typically thin, to depths of between 0.1m and 0.3m. It was deeper in BH04 (1.2m), TP02 (1.0m) and TP07 (0.8m).
- 5.5 This material generally comprised gravelly silty sand with cobbles, which is interpreted as reworked shallow natural bedrock associated with a track on site.
- 5.6 Topsoil or Organic Rich Topsoil: Topsoil was encountered from the surface in the majority of investigation positions and varied and extended to a maximum depth of 0.5m (TP1). It typically extended to a depth of between 0.1m and 0.2m and comprised soft brown gravelly clayey silt with abundant rootless.
- 5.7 As discussed in previous sections, each investigation position was located within an ecological clearance area and in some instances this work removed some upper portions of the topsoil. The depths on the records are of the ground conditions encountered and at the time of excavation.
- 5.8 Deep Peat: Peat with a thickness greater than 0.5m was delineated to the southeastern extent of the site (ESP, 2022b). Generally, where deep peat is considered to be present, the results of the investigation indicated depths of less than 1.0m. However, in some areas the depth was recorded as being in excess of 1m and in one location anticipated to be greater than 3.5m where probing was terminated within soft material.
- 5.9 Hand excavated pits identified the peat to typically comprise, brown very compressible amorphous non-fibrous to fibrous peat with moderate to strong organic odour. Generally muddy water was released on compression and abundant brown to black organic material was recorded throughout.
- 5.10 Weathered Lower Pennant Measures bedrock: Rhondda Member weathered bedrock was encountered across much of the site comprising grey gravelly sandy clay to a greyish brown sandy silty gravel with cobbles to a brown gravelly cobbles with many boulders extending to depths of between 1.2m and 3.4m. Weathered Brithdir Member bedrock was encountered in the west of the site, it comprised medium dense to dense sandy silty gravel or a gravelly sand with cobbles and boulders of sandstone.

- 5.11 Lower Pennant Measures bedrock: comprising Rhondda Member, Brithdir Member (in west of site) and Llynfi Member, encountered below Rhondda Member bedrock across the site. The lower Pennant Measures bedrock was encountered to a maximum depth of 53.7m and generally comprising sandstones, siltstone, mudstone, conglomerate, coal seams and evidence of localised backfilled workings.
- 5.12 The full detailed ground conditions and material properties will be provided as part of the Ground Investigation reporting which is currently being compiled by ESP.

HYDROGEOLOGY

- 5.13 The groundwater conditions identified in the investigation are summarised in the table below.

Table 9: Summary of Groundwater records during investigation.

Hole ID	Stratum	Comment on groundwater encountered
BH01	Lower Pennant Measures Bedrock	No groundwater strike recorded during drilling. Core liner recorded as damp between 17.2 and 18.7m depth. Groundwater standing level at between 16 and 27.0m during drilling.
BH02	Lower Pennant Measures Bedrock	No groundwater strike recorded during drilling. Groundwater standing level at between 17.9 and 18.1m during drilling.
BH03	Lower Pennant Measures Bedrock	No groundwater strike recorded during drilling. Groundwater standing level at 26.0m on completion.
BH04	Lower Pennant Measures Bedrock	No groundwater strike recorded during drilling. Core liner recorded as wet at 28.2m depth. Groundwater standing level at 25.1m on completion.
BH05	-	No groundwater strike recorded during drilling. Borehole dry on completion.
BH06	Lower Pennant Measures Bedrock	No groundwater strike recorded during drilling. Groundwater standings at 34.1m depth on completion.
BH07	Lower Pennant Measures Bedrock	No groundwater strike recorded during drilling. Core liner recorded as wet at 8.5m depth. Groundwater standing level at between 7.0 and 7.7m during drilling.
BH08	Lower Pennant Measures Bedrock	No groundwater strike recorded during drilling. Groundwater standing level at between 28.3 and 36.7m during drilling.
BH09	Lower Pennant Measures Bedrock	Groundwater strike recorded at 44.0m depth rising to 40.0m after 20 minutes. Groundwater standing level at between 39 and 42.0m during drilling.
BH09A	Lower Pennant Measures Bedrock	Groundwater strike recorded at 44.0m depth rising to 40.0m after 20 minutes. Groundwater standing level at between 37 and 40m during drilling.
BH10	-	No groundwater strike recorded during drilling. Borehole dry on completion.
BH11	-	No groundwater strike recorded during drilling. Borehole dry on completion.
Hand Pits Y37 – 38 and Y41	Peat/Deep Peat	Minor groundwater ingress recorded at between 0.2 and 0.4m depth. Groundwater level did not rise.
WS Boreholes and Trial Pits	-	Groundwater not encountered.
Notes:		
1. Full details of groundwater ingress presented on exploratory hole records in Appendices E to I.		

- 5.14 To date, 3no. gas and groundwater monitoring visits have been undertaken between 16th June and 12th July 2022. The results of the groundwater monitoring are summarised in the table below.

Table 10: Summary of groundwater monitoring.

Hole ID	Response Zone Stratum	Response Zone depth (m)	Groundwater Depth (m) Range	Groundwater Elevation Range (m AOD)
BH01 (d)	Brithdir Member Bedrock	1.0 - 4.0	15.9 – dry	238.2 – <243.6
BH01 (s)	Weathered Brithdir Member	9.0 - 21.0	Dry	<256.5
BH02	Rhondda Member and No.1 Rhondda Coal Seam	9.0 - 24.0	16.9 – 18.4	269.4 – 277.1
BH03	Rhondda Member bedrock	1.0 - 10.0	9.5 – dry	314.4 - <304.6
BH04 (d)	No 2. Rhondda Coal Seam (Both Field Vein and Wernddu)	1.0 - 3.0	8.8 – 19.3	266.2 – 280.8
BH04 (s)	Weathered Rhondda Member	24.0 - 27.0	2.6 – 2.8	286.5 – 287.2
BH05 (d)	Field Vein Coal Seam	1.0 - 4.0	13.4 – 31.7	299.1 – 317.3
BH05 (s)	Weathered Rhondda Member	31.2 - 40.2	Dry	<326.7
BH06 (d)	Llynfi Member and Wernpistyll Rider Coal Seam	1.0 - 4.0	31.1 – 32.9	263.9 – 265.7
BH06 (s)	Weathered Rhondda Member	24.0 - 33.0	3.0 - 3.9	292.7 – 292.8
BH07	Rhondda and Llynfi Member and Wernpistyll Rider. Near deep peat.	3.0 - 16.5	5.6 – 6.6	294.1 – 295.1
BH08 (d)	Rhondda Member and Field Vein coal seam	2.0 - 5.0	28.3 – dry	272.39 - <276.0
BH08 (s)	Weathered Rhondda Member	2.0 - 31.0	Dry	<299.9
BH09A	Rhondda and Llynfi Member including Field Vein and Wernddu, possibly Wernpistyll Rider coal seams	28.0 - 49.0	33.2 - dry	295.63 – <299.9
WS01	Weathered Rhondda Member	0.3 - 0.8	0.72 – 0.74	250.8 – 250.8
WS02	Weathered Rhondda Member	0.5 - 2.8	0.83 – dry	300.24 - <302.2
WS03	Weathered Rhondda Member	0.3 - 0.65	Dry	<302.1
WS04	Weathered Rhondda Member	0.3 - 0.8	0.8 – 0.9	276.8 – 276.9
WS05	Weathered Rhondda Member	0.5 - 2.8	1.8 – dry	280.53- <281.5
WS06	Weathered Rhondda Member	0.2 - 0.7	Dry	<291.9
WS07	Weathered Rhondda Member	0.3 - 0.7	Dry	<290.8
WS09	Weathered Rhondda Member	0.1 - 0.6	Dry	<293.9
WS10	Weathered Rhondda Member	0.5 - 2	Dry	<296.8
WS11	Weathered Rhondda Member, near deep peat	0.5 - 1	Dry	<300.8
WS12	Weathered Rhondda Member, near deep peat	0.3 - 0.4	Dry	<305.8

Notes:

1. Full details of groundwater monitoring are presented in Appendix L.

- 5.15 Based on the above findings and the Conceptual Ground Model, we consider that the main groundwater body beneath the site is within the Lower Pennant Measure bedrock, at varying depths, typically between approximately 10 to 30m depth. A shallow water body is noted within the peat deposits in the southeastern extent at between 0.2 and 0.4m depth. Morning also shows a shallow water body within some of the shallow wells within weathered Lower Pennant Measures bedrock. It is anticipated that this water is perched within some of the well construction and not representative of a shallow water body side wide.

- 5.16 The hydrogeological setting of the site is anticipated to be complex due to the history of coal mining (disturbed beds) and geological faults. The groundwater conditions may still be changing in response to the cessation or reduction in pumping from underground coal workings.

6.0 PHASE TWO GEO-ENVIRONMENTAL RISK ASSESSMENT

RISKS TO HEALTH

Assessment Methodology

- 6.1 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.
- 6.2 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.

Assessment Criteria

Site End Users

- 6.3 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. However, the C4SL have been published for a range of land uses, including residential, commercial, allotments and two types of public open space.
- 6.4 The C4SL are designed for use in deciding whether land is suitable for use. 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.
- 6.5 Where a C4SL is not 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.

- 6.6 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).
- 6.7 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).
- 6.8 Details of the Generic Assessment Criteria (GAC) adopted for each contaminant are presented on the assessment tables in the following section.
- 6.9 The proposed development comprises an adventure park with holiday accommodation, hotels, commercial land use, e.g., shops and restaurants, and outdoor sports activity areas. There are currently no GAC published for such an end use.
- 6.10 The critical receptors for the proposed development are considered to be construction workers, employees and maintenance workers for the adventure park and park visitors including children playing in areas of soft landscaping.
- 6.11 The most similar end use scenario to the proposed development for which there are published assessment criteria is Public Open Space (POS), for which there are two exposure scenarios, public open space near residential housing (POSresi) and public open space park (POSpark). The differences are illustrated below.

POS resi

- 6.12 This generic scenario is based on consideration of a largely grassed area next to housing that is used by children on a regular basis. The key assumptions for the ‘public open space near residential housing’ model are as follows:
- Critical receptor is a child covering CLEA age classes 4-9 and exposure duration is 6 years (with the exception of contaminants where lifetime averaging applies (such as cadmium) where average daily exposure is estimated for age classes 4-18 over a 71 year duration);
 - Land is grassed or landscaped area and in close proximity to housing (leading to potential tracking back of soil to the home);
 - Exposure pathways include direct soil and indoor dust ingestion, skin contact with soil and dust, inhalation of vapours outdoors and inhalation of soil-derived dust indoors and outdoors

POS park

- 6.13 This generic scenario is based on consideration of a public park that is used by children on a regular basis. The key assumptions for the ‘public open space park’ model are as follows:
- Critical receptor is a child covering CLEA age classes 1-6 and exposure duration is 6 years (with the exception of contaminants where lifetime averaging applies (such as cadmium) where average daily exposure is estimated for age classes 1-18 over a 74 year duration);

- Public park is grassed and may also contain landscaped areas and children's play equipment;
 - Exposure pathways include direct soil ingestion, skin contact with soil, inhalation of vapours and of dust outdoors;
 - There are no buildings; and
 - Land is predominantly grassed and not in close proximity to housing and thus tracking back of soil to the home is not considered a significant pathway
- 6.14 The POSresi criterion is appropriate for ground around lodges (noting that some types of lodge have decking and no outside space), the Plaza and similar facilities. However, the proposed development has introduced mitigation through design in these areas as Topsoil will be imported to provide an adequate growing medium. The minimum thickness will 100mm and even this will be sufficient to break all the exposure routes, except for vapours.
- 6.15 Therefore for the purposes of this assessment, the published GAC for public open space (park use), have been adopted.
- 6.16 It should be recognised that the use of the assessment criteria for public open space (park use), not around residential properties is considered to be conservative for the site settings bearing in mind the transient nature of the site users. As the exposure frequency/duration are different for this use, using these GACs is considered a reasonably protective approach and an exceedance does not necessarily indicate an unacceptable risk.
- 6.17 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 0.1 to 20%. 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.

Maintenance and Construction Workers

- 6.18 Limited guidance is available regarding the short term (acute) risks to construction and maintenance workers. However, Acute Generic Assessment Criteria (AGAC) for a range on contaminants has been developed by the Society of Brownfield Risk Assessment (SoBRA) including an AGAC for arsenic (SoBRA, 2020).
- 6.19 The AGAC values for arsenic for an adult based on occupational exposure (on-site worker during excavation activities) are as follows:
- Oral – 7,000 mg/kg
 - Dermal – Not Derived
 - Inhalation – 14,000,000 mg/kg

Generic Quantitative Risk Assessment

- 6.20 The samples analysed for soil contaminants comprised 41no. samples of Topsoil/Organic Rich Topsoil and 9no. of weathered Lower Pennant Measures bedrock including Reworked Natural Soils. The risks from asbestos are considered separately.
- 6.21 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 11: Generic Assessment of Human Health Risks (Public open space (park use) not near residential properties)

Determinand	Topsoil/Organic Rich Topsoil (41no. Samples)	Weathered Lower Pennant Measures inc. reworked soil (9no. Samples)	GAC	Source of GAC	Exceedances
Metals and Semi-metals					
Arsenic	3.7 - 380 mg/kg	5.2 - 73 mg/kg	168mg/kg	C4SL ²	4 of 41 in Topsoil/Organic Rich Topsoil
Barium ⁶	7.6 - 43 mg/kg	7.5 - 25 mg/kg	1,300mg/kg	CL:AIRE/EIC ⁵	None
Beryllium	<0.2 – 0.5 mg/kg	<0.2 – 0.8 mg/kg	63mg/kg	S4UL ⁴	None
Boron	<0.2 – 1.2 mg/kg	<0.2 – 0.3 mg/kg	46,000mg/kg	S4UL ⁴	None
Cadmium	<0.1 – 1.7 mg/kg	<0.1 – 0.4 mg/kg	880mg/kg	C4SL ²	None
Chromium (total) ⁷	2.1 - 22 mg/kg	4.1 – 22 mg/kg	33,000mg/kg	S4UL ⁴	None
Chromium (hexavalent)	<1.0 mg/kg	<1.0 mg/kg	250mg/kg	C4SL ²	None
Copper	7.4 - 95 mg/kg	15 - 46 mg/kg	44,000mg/kg	S4UL ⁴	None
Lead	7.9 - 180 mg/kg	7.6 – 58 mg/kg	1,300mg/kg	C4SL ²	None
Mercury ⁸	<0.05 - 0.19 mg/kg	<0.05 – 0.06 mg/kg	240mg/kg	S4UL ⁴	None
Nickel	1.6 – 2.6 mg/kg	3.8 - 35 mg/kg	800mg/kg	S4UL ⁴	None
Selenium	<0.5 – 2.0 mg/kg	<0.5 – 2.1 mg/kg	1,800mg/kg	S4UL ⁴	None
Vanadium	4.6 - 37 mg/kg	8.3 - 29 mg/kg	5,000mg/kg	S4UL ⁴	None
Zinc	9.3 - 72 mg/kg	11 - 90 mg/kg	170,000mg/kg	S4UL ⁴	None
Polyaromatic Hydrocarbons (PAH)					
Acenaphthene	<0.03 – 0.03 mg/kg	<0.03 mg/kg	15,000mg/kg	S4UL ^{4,9}	None
Acenaphthylene	<0.03 mg/kg	<0.03 mg/kg	15,000mg/kg	S4UL ^{4,9}	None
Anthracene	<0.03 – 0.05 mg/kg	<0.03 mg/kg	74,000mg/kg	S4UL ^{4,9}	None
Benzo(a)anthracene	<0.03 – 0.11 mg/kg	<0.03 mg/kg	29mg/kg	S4UL ^{4,9}	None
Benzo(a)pyrene	<0.03 – 0.09 mg/kg	<0.03 mg/kg	10mg/kg	C4SL ^{2,9}	None
Benzo(b)fluoranthene	<0.03 – 0.15 mg/kg	<0.03 mg/kg	7.1mg/kg	S4UL ^{4,9}	None
Benzo(ghi)perylene	<0.03 – 0.04 mg/kg	<0.03 mg/kg	640mg/kg	S4UL ^{4,9}	None
Benzo(k)fluoranthene	<0.03 - 0.05 mg/kg	<0.03 mg/kg	190mg/kg	S4UL ^{4,9}	None
Chrysene	<0.03 – 0.19 mg/kg	<0.03 mg/kg	57mg/kg	S4UL ^{4,9}	None
Dibenzo(a,h)anthracene	<0.03 mg/kg	<0.03 mg/kg	0.57mg/kg	S4UL ^{4,9}	None
Fluoranthene	<0.03 – 0.36 mg/kg	<0.03 mg/kg	3,100mg/kg	S4UL ^{4,9}	None
Fluorene	<0.03 – 0.04 mg/kg	<0.03 mg/kg	9,900mg/kg	S4UL ^{4,9}	None
Indeno(123-cd)pyrene	<0.03 – 0.04 mg/kg	<0.03 mg/kg	82mg/kg	S4UL ^{4,9}	None

Determinand	Topsoil/Organic Rich Topsoil (41no. Samples)	Weathered Lower Pennant Measures inc. reworked soil (9no. Samples)	GAC	Source of GAC	Exceedances
Naphthalene	<0.03 – 0.06 mg/kg	<0.03 mg/kg	4,900mg/kg	S4UL ^{4,9}	None
Phenanthrene	<0.03 – 0.35 mg/kg	<0.03 mg/kg	3,100mg/kg	S4UL ^{4,9}	None
Pyrene	<0.03 – 0.27 mg/kg	<0.03 mg/kg	7,400mg/kg	S4UL ^{4,9}	None
Other Organic Compounds					
Phenol	<0.3 – 4.1 mg/kg	<0.3 – 2.1 mg/kg	760mg/kg	S4UL ^{4,9}	None

Notes:

1. Assessment for public open space (park use), not around residential properties.
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. GAC for organic compounds based on 1% soil organic content.
10. Exceedances highlighted in red and bold.
11. Laboratory results presented in Appendix N.

- 6.22 With the exception of arsenic, all the determinands analysed were below their respective GAC.

Arsenic – Further Discussion

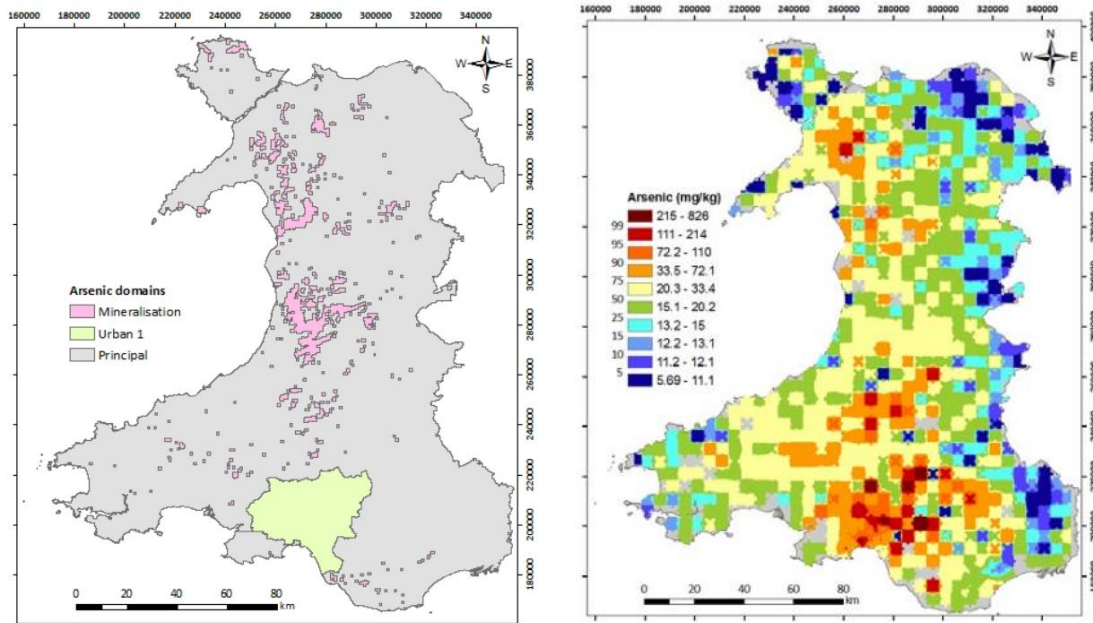
- 6.23 The levels of arsenic were found to be elevated above the adopted GAC in four samples of Topsoil and Organic Rich Topsoil at 0.1m depth as detailed in the table below:

Table 12: Summary of arsenic exceedances (above GAC of 168 mg/kg) - Topsoil/Organic Rich Topsoil

Hole ID	Arsenic
Y06	170
Y07	250
Y08	380
Y31	170
Notes:	
1. GAC - Assessment for public open space (park use), not around residential properties.	
2. C4SL: Category 4 Screening Level, published by CL:AIRE.	

- 6.24 Within the Topsoil/Organic Rich Topsoil, the levels of arsenic varied between 3.7 and 380 mg/kg with a sample mean of 65.6mg/kg for a sample size of 41. Detailed assessment will be carried out in due course with the aim of confirming the findings and developing the contamination risk assessment.
- 6.25 The British Geological Survey have derived 'normal' background concentrations (NBC) for arsenic across Wales.
- 6.26 The arsenic natural background concentrations are seen as a typical and widespread in Topsoils (depth 0-15cm) and include contributions from both natural and diffuse anthropogenic sources.
- 6.27 Arsenic (As) is a chemical element that is naturally found in trace amounts in our environment. A significant source of As released into the surface environment is as a result of oxidation of sulphide minerals. Phosphate-rich rocks, ironstones and coal-bearing strata can also contain high levels of As.
- 6.28 General diffuse anthropogenic sources of As are from dust particles and waste materials from historical metalliferous mining, smelting processes and coal burning. In the built environment increased levels of As may be related to specific historical land use, especially metallurgical industries. Chromium-copper-arsenate (CCA) was developed in 1933 as a wood preservative and, although restricted by regulation from 2004, is a potential source of widespread contamination.
- 6.29 Welsh soils have developed on a diverse range of parent materials, including those hosting metalliferous mineralisation, and therefore are inherently variable in their chemical composition (Figure 4b). These soils have also been subjected to a long history of diffuse pollution, particularly around the South Wales Coalfield.
- 6.30 Higher concentrations of arsenic are found where the parent material is in areas where metalliferous mineralisation and historical mining activity have resulted in elevated levels of As in the soil environment; and those areas associated with urbanisation and industrialisation.
- 6.31 Therefore, two domains associated with elevated As in soils were defined, the Mineralisation Domain and the Urban 1 Domain. The area not covered by these two domains is referred to as the Principal Domain (Insert 4a). The site lies within Urban Area 1 which is classified as having an NBC of 250mg/kg for arsenic. Reference to Insert 4b indicates that the levels of arsenic local to the site are typically higher.

- 6.32 Coal mining areas may also contain soils enriched in As due to the spreading of pyrite-bearing coal mine spoils, the As being released when the pyrites is oxidised. Similarly, peaty areas may contain organic matter-rich soils with high As concentrations (Welsh Government, 2013).



Insert 4a: Arsenic domain map for Wales (Welsh Government, 2013)

Insert 4b: Map showing arsenic in topsoil as a percentile classified interpolated image (Welsh Government, 2013)

- 6.33 At this stage, the adopted GAC is considered to be a conservative approach given the temporary duration of the site users (visitors) visiting the site. It should be noted that the levels of arsenic fall well below the GAC for commercial land use (640mg/kg).
- 6.34 No significant on-site source of arsenic has been identified and the elevated levels of arsenic identified on site are considered to be a result of surrounding coal mining/industrial land-use (e.g. environmental deposition from off-site sources). Examples of this include 'Copperopolis' and large ports of Swansea and Port Talbot to the southwest which processed coal and other ores before being shipped across the globe. These areas provide a potential source of off-site contamination to have been windblown on site from the UK's predominant south-westerly wind direction. The risks associated with arsenic are discussed further in Chapter 7.

Asbestos

- 6.35 No evidence of asbestos was identified in any of the 50no. samples analysed.

Discussion on Occurrence of Contamination and Distribution

- 6.36 The preliminary risk assessment identified potential sources of contamination across the site relating to the site history including; historic coal mining, quarrying and subsequent land infilling. Samples of soil (Y24, Y25 and Y26) taken near to previous quarries indicated no elevated concentrations of contaminants.

- 6.37 There are two separate isolated burnt-out cars on site which were abandoned, fly-tipped. Some surface scaring, from burning was evident next to these locations. A sample from Y19, comprising Organic Rich Topsoil, excavated near to one of the identified burnt cars showed no elevated levels of contaminants tested including PAH's; suggesting that widespread contamination from these point sources is not likely.
- 6.38 With the exception to the fly-tipping discussed above, no obvious visual or olfactory evidence of contamination was encountered during the ground investigation. Reworked Natural Soils were encountered to shallow depths locally onsite where track/roads are present. Made Ground was not identified in any of the exploratory holes. Samples of Reworked Natural Soils tested showed no elevated concentrations of contaminants.
- 6.39 The results of the geo-environmental analysis indicates that the majority of determinants analysed fell below the adopted GAC value for the proposed development. However, slightly elevated levels of arsenic against the adopted GAC value were occasionally identified at a shallow depth (to 0.1m) within Topsoil and Organic Rich Topsoil. The exceedances recorded in 4no. samples are generally located as a cluster in the southwestern extent (Y06 - Y08). The exceedance in Y31 is recorded in the southeastern extent near the area of deep peat. Detailed assessment will be carried out in due course with the aim of confirming the findings and developing the contamination risk assessment.
- 6.40 No significant point source of arsenic contamination was previously identified in the preliminary risk assessment however, as discussed above, natural background concentrations (NBC) of arsenic are known to be elevated across South Wales and relating to former mining areas. No further determinants tested were found to be elevated within the Topsoil or Organic Rich Topsoil, so we do not consider them to be indicative of general Made Ground. It is considered likely that the slightly elevated concentrations of arsenic measured in the shallow Topsoil tested is indicative of industrial and mining legacy of the South Wales coalfield as previously discussed.
- 6.41 Monitoring of volatile hydrocarbons was undertaken during hand excavated trial pitting with the results of the analysis indicated levels below 0.6ppm. The numerical output of the monitoring of volatile organic compounds cannot be directly compared to measured soil concentrations of contaminants of concern. Nevertheless, as a rule of thumb readings above 100 ppm are considered to be an indicative of potential presence of elevated volatile organic compounds (VOC's) in the soil.
- 6.42 The PID readings indicate that the soils screened do not contain significantly elevated concentrations of VOC's.

HAZARDOUS GROUND GAS

Degradation of Organic Materials

- 6.43 25no. gas wells have been installed in boreholes and monitored for hazardous gases on 4no. occasions over a 6-week period to date. 8no. further visits are to be completed. An updated assessment for coal mine gas in accordance with CL:AIRE (2022), BS8485:2018 and BS8576:2013 will be presented in an addendum report on completion of the outstanding monitoring visits.
- 6.44 Ground gas conditions will vary spatially and with depth, linked to geology and mining history. Therefore, hazards and risks require discreet assessment. This variance is not ascertained in detail in this assessment and should be considered during detailed design. Nevertheless, the monitoring currently underway will provide information on gas at the anticipated sources of ground gas, mine workings and should enable the outline risks from ground gas to be understood.
- 6.45 A summary of the results obtained to date is provided in the table below. The current monitoring

data has indicated no detectable levels of methane, levels of carbon dioxide of between 0.1 to 7.2% and no gas flow has been recorded. The first, third and fourth monitoring visits were undertaken during steady pressures, the second had rising pressures. Full details of the atmospheric pressure are displaced in the gas monitoring results in Appendix L.

Table 13: Summary of gas monitoring maximum levels recorded to date.

Well	Response Zone depth (m)	Response Zone Stratum	No visits	Maximum Methane (%)	Maximum Carbon dioxide (%)	Maximum Gas Flow (L/hr)
BH01 (s)	1.0 - 4.0	Weathered Brithdir Member	4	nd	5.9	nd
BH01 (d)	9.0 - 21.0	Brithdir Member Bedrock	4	nd,	3.3	nd
BH02	9.0 - 24.0	Rhondda Member and No.1 Rhondda Coal Seam	4	nd	0.7	nd
BH03	1.0 - 10.0	Rhondda Member bedrock	4	nd	1.6	nd
BH04 (s)	1.0 - 3.0	Weathered Rhondda Member	4	nd	4.6	nd
BH04 (d)	24.0 - 27.0	No 2. Rhondda Coal Seam (Both Field Vein and Wernddu)	4	nd	0.1	nd
BH05 (s)	1.0 - 4.0	Weathered Rhondda Member	4	nd	2.5	nd
BH05 (d)	31.2 - 40.2	Field Vein Coal Seam	4	nd	0.1	nd
BH06 (s)	1.0 - 4.0	Weathered Rhondda Member	4	nd	1.5	nd
BH06 (d)	24.0 - 33.0	Llynfi Member and Wernpistyll Rider Coal Seam	4	nd	1.0	nd
BH07	3.0 - 16.5	Rhondda and Llynfi Member and Wernpistyll Rider. Near deep peat.	4	nd	0.7	nd
BH08 (s)	2.0 - 5.0	Weathered Rhondda Member	4	nd	0.9	nd
BH08 (d)	2.0 - 31.0	Rhondda Member and Field Vein coal seam	4	nd	02	nd
BH09A	28.0 - 49.0	Rhondda and Llynfi Member including Field Vein and Wernddu, possibly Wernpistyll Rider coal seams	4	nd	0.9	nd
WS01	0.3 - 0.8	Weathered Rhondda Member	4	nd	2.3	nd
WS02	0.5 - 2.8	Weathered Rhondda Member	4	nd	7.2	nd
WS03	0.3 - 0.65	Weathered Rhondda Member	2 ⁴	nd	0.9	nd
WS04	0.3 - 0.8	Weathered Rhondda Member	4	nd	2.1	nd
WS05	0.5 - 2.8	Weathered Rhondda Member	4	nd	3.1	nd
WS06	0.2 - 0.7	Weathered Rhondda Member	4	nd	2.3	nd
WS07	0.3 - 0.7	Weathered Rhondda Member	4	nd	1.4	nd
WS09	0.1 - 0.6	Weathered Rhondda Member	4	nd	0.4	nd
WS10	0.5 - 2	Weathered Rhondda Member	4	nd	4.5	nd
WS11	0.5 - 1	Weathered Rhondda Member, near deep peat	4	nd	2.6	nd
WS12	0.3 - 0.4	Weathered Rhondda Member, near deep peat	2 ⁵	nd	4.7	nd

Notes:

1. nd – 'none detected' with instrument (detection limits: <0.2% for methane, <0.1% for carbon dioxide and 0.1l/h for flow).
2. Full monitoring results presented in Appendix L.
3. BH4 (s) – shallow well. BH4 (d) – deep well.
4. Cover buried by ecological works.
5. Nest within cover, works to remove underway to allow monitoring continuation.
6. Groundwater conditions can be seen in the subsequent table, No. 14.

- 6.46 With the exception of the Topsoil/Organic Rich Topsoil and deep peat located in the southeast of the site, the ground investigations did not record significant amounts of organic rich or degradable matter.

Groundwater Conditions

- 6.47 A summary of the groundwater conditions relative to the targeted gas source in relation to potential coal workings is provided in the table below:

Table 14: Summary of groundwater conditions relative to gas monitoring response zones.

Hole ID	Response Zone Stratum	Groundwater Range (Elevation - m AOD)	Top of Response Zone (m AOD)	Comment on Groundwater Levels ²
BH01 (d)	Brithdir Member Bedrock	238.2 – <243.6	250.5	Groundwater levels range across Brithdir coal seam
BH02	Rhondda Member and No.1 Rhondda Coal Seam	269.4 – 277.1	285.07	Groundwater levels below No.1 Rhondda coal seam
BH03	Rhondda Member bedrock	314.4 - <304.6	313.42	Groundwater levels above Possible Field Vein Horizon
BH04 (d)	No 2. Rhondda Coal Seam (Both Field Vein and Wernddu)	266.2 – 280.8	265.3	Groundwater levels above Field Vein and Wernddu coal seams
BH05 (d)	Field Vein Coal Seam	299.1 – 317.3	299.57	Groundwater levels above possible Field Vein coal seam
BH06 (d)	Llynfi Member and Wernpistyll Rider Coal Seam	263.9 – 265.7	272.77	Groundwater levels above Wernpistyll coal seam. Groundwater levels range to partially within and above possible backfilled workings of Wernpistyll Rider coal seam
BH07	Rhondda and Llynfi Member and Wernpistyll Rider. Near deep peat.	294.1 – 295.1	297.68	Groundwater levels above possible backfilled workings of Wernpistyll Rider coal seam
BH08 (d)	Rhondda Member and Field Vein coal seam	272.39 - <276.0	302.33	Groundwater levels below possible backfilled workings of Field Vein coal seam Groundwater levels above possible Wernddu and Wernpistyll Rider coal seam
BH09A	Rhondda and Llynfi Member including Field Vein and Wernddu, possibly Wernpistyll Rider coal seams	295.63 – <299.9	271.98	Groundwater levels range to above and below possible backfilled workings of Field Vein and Wernpistyll Rider coal seam
Notes:				
1. Full details of groundwater monitoring are presented in Appendix L.				
2. Unless specified, groundwater levels refers to minimum and maximum range recorded.				

- 6.48 The summary above indicates that within boreholes BH03, BH04, BH05, BH07 and BH08, the groundwater levels recorded to date have been consistently above the level of targeted coal seams/possible workings.
- 6.49 In boreholes BH06 and BH09a, the range of groundwater levels recorded indicates that groundwater levels are rising and falling within possible backfilled workings.
- 6.50 As discussed above, 8no. further gas and groundwater monitoring visits (of 12no. proposed over six

months) are scheduled and an updated full gas mining assessment in accordance with current guidance (CL:AIRE, 2021) will be presented in an addendum report on their completion.

REVISED RISK EVALUATION & RELEVANT POLLUTANT LINKAGES

- 6.51 The methodology set out in CIRIA C552 (2001) has been used to assess whether 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 4) have been updated and revised following information learned from the exploratory works and results of monitoring and laboratory testing.

Table 15: 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
Localised fly tipped and burnt materials including nearby shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Unlikely ²	Low Risk	Fly-tipped material should be removed. See Section 7 for further discussion.
		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	Unlikely ²	Low Risk	
		Impact on River Afan	Medium – site lies 100m south of river	Unlikely ²	Low Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Unlikely ²	Low Risk	
Potential contaminants in mining/quarry/ unspecified pit discard	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Unlikely ³	Low Risk	See Section 7 for further discussion.
		Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Low likelihood ³	Very Low Risk	See Section 7 for further discussion.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A	Unlikely ³	Low Risk	See Section 7 for further discussion.
		Impact on River Afan	Medium – site lies 100m south of river	Unlikely ³	Low Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Unlikely ³	Low Risk	
Potential contaminants in Possible Made Ground across site (forestry work, Made Ground near mast, reservoir)	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Unlikely ⁴	Low Risk	See Section 7 for further discussion.
		Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Unlikely ⁴	Very Low Risk	See Section 7 for further discussion.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A	Unlikely ⁴	Low Risk	See Section 7 for further discussion.
		Impact on River Afan	Medium – site lies 100m south of river	Unlikely ⁴	Low Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Unlikely ⁴	Low Risk	
Potential contaminants within Topsoil	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (guests)	Medium – potential for chronic levels.	Low likelihood ⁵	Moderate/Low Risk	See Section 7 for further discussion. Additional testing underway.
		Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Likely ⁵	Low Risk	See Section 7 for further discussion.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A	Unlikely ⁵	Low Risk	Laboratory analysis identified 4no. exceedances of arsenic above the adopted GAC. See Section 7 for further discussion.
		Impact on River Afan	Medium – site lies 100m south of river	Unlikely ⁵	Low Risk	
		Impact on surface water features (ponds)	Medium – ponds located on site	Unlikely ⁵	Low Risk	
Asbestos in shallow soils	Inhalation of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Unlikely ⁵	Low Risk	See Section 7 for further discussion.
Soil sulphate and pyrite	Direct contact of aggressive groundwater	Buried Concrete	Mild – damage to structures	Low likelihood ⁶	Low Risk	The risks associated with soil sulphate and pyrite will be reported separately as part of the Ground Investigation Report.
Hazardous ground gas/vapours	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	Low likelihood ^{7,8,9}	Moderate Risk	See Section 7 for further discussion. Note – gas monitoring ongoing.
	Damage through explosion.	Building/Property	Severe – acute risk.		Moderate Risk	
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.		Moderate Risk	
Radon gas	Migration into Buildings	Site Users (guests)	Medium – potential for chronic levels	Likely ⁸	Moderate Risk	See Section 7

- Notes:
1. This table updates Table 4 using results of the investigation. Methodology and details of risk consequence, probability and category presented in Appendix A.
 2. Target sampling and laboratory testing indicated levels below the adopted Generic Assessment Criteria (GAC)
 3. Target sampling and laboratory testing indicated levels below the adopted Generic Assessment Criteria (GAC)
 4. Made Ground not encountered. Target sampling and laboratory testing indicated levels below the adopted Generic Assessment Criteria (GAC)
 5. Levels arsenic exceed the GAC within the shallow Topsoil. It is understood that the existing site Topsoil will not be utilised as part of the development and imported soil will be used in landscaped areas.
 6. Generally low levels of sulphates recorded within the Reworked Natural Soils and Rhondda Member bedrock. Elevated levels of sulphate recorded locally within Organic Rich Topsoil.
 7. Levels of carbon dioxide >5% locally identified and levels of methane and flow below detection were recorded within shallow wells during monitoring of installed gas wells in visits to date. Further gas monitoring visits are scheduled to be undertaken with a full gas assessment to be undertaken upon completion.
 8. Generally low levels of carbon dioxide, methane and gas flow have been recorded within deep gas wells (coal mining source) in the visits to date. Further gas monitoring visits are scheduled to be undertaken with a full gas assessment to be undertaken upon completion.
 9. Localised high risk areas of ground gas have been identified on site associated with mine entries and shallow abandoned mine workings.
 10. Radon risk identified in data report (see Appendix C).

7.0 OUTLINE OPTIONS APPRAISAL AND REMEDIAL STRATEGY FOR CONTAMINATION RISKS

- 7.1 The following recommendations are based on interpretations made from the ground investigation data obtained to-date. It should be noted that further site wide and structure specific ground investigations will be carried out to confirm the findings of this study and provide further information in relation to design. Should at any stage of the supplementary ground investigations or subsequently during the construction phase contamination or a potential for such contamination is identified that is different to that presented within this report, the following remediation strategy will need to be evaluated, and the advice of a geo-environmental specialist sought immediately.

SITE RECEPTORS

- 7.2 The risks associated with the following receptors, as outlined in the planning document (NPTCBC, 2018), has been undertaken:
- human health;
 - ground waters and surface waters;
 - adjoining land (neighbours);
 - property (existing or proposed) including buildings, crops, livestock, pets, woodland and service lines and pipes;
 - ecological systems – no significant risk identified; and
 - archaeological sites and ancient monuments – no significant risk identified.

OUTLINE OPTIONS APPRAISAL

- 7.3 The ground investigation generally identified low levels of contamination and no evidence of Made Ground material. In general, all the contaminants tested were found to be below the assessment criteria for public open space (park use). Slightly elevated levels of arsenic above the adopted GAC were identified in four samples tested, predominantly located in the southwestern site extent. It is considered that the elevated levels are in line with natural background concentrations. Depending on the findings of further assessment, mitigation measures may be required e.g. site zoning or cover system to break pollutant linkage.
- 7.4 With the exception of localised burnt cars, no significant sources of contamination have been identified that would require treatment of source removal.
- 7.5 Risk reduction will be delivered through pathway management with mitigation measures to prevent exposure to identified receptors.

RISKS TO HEALTH

- 7.6 The fly-tipped cars and any surrounding burnt soils and loose debris should be scraped off and removed off site. This will remove the source of this potential contamination and mitigate all potential risks to receptors. A suitably qualified person should oversee the removal to confirm all impacted soils are removed on site, testing remaining soils as necessary as part of site validation requirements.

Asbestos

- 7.7 No evidence of asbestos was detected. Although no evidence has been identified in the investigation, on any historic site, it cannot be discounted that former hollows in the site surface may have been infilled in the past, and asbestos containing materials (ACM) may have been included in any backfill materials.
- 7.8 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.
- 7.9 The following sections presume that any risks from asbestos materials are mitigated.

Site End Users

- 7.10 The ground investigation identified that in general, all the contaminants tested were below the generic assessment criteria for public open space (park space). Some locally elevated levels of arsenic above the generic assessment criteria for public open space (park space) not in residential settings, were identified within Organic Rich Topsoil and Topsoil at shallow depths (0.1m) at four sampling locations.
- 7.11 No source of arsenic has been identified. As discussed above, Natural Background Concentration (NBC) for arsenic in South Wales, can be elevated. The site is located within the Urban 1 domain, where NBC values for arsenic are in the region 250mg/kg; the maximum level recorded on site was 380mg/kg. Additionally, this could be associated with historical industrial development in the area. Further ground investigations will be required on a plot by plot, structure specific basis as part of detailed design. Geo-environmental testing including arsenic will be carried out as part of these investigations to confirm the findings of this report.
- 7.12 The adopted GAC is considered to be conservative at this stage given the temporary duration of stays of site visitors and commercial aspects of the site workers. As the exposure frequency/duration are different for this use, an exceedance does not necessarily indicate an unacceptable risk. It should be noted that the levels of arsenic fall below the GAC for commercial land use (640mg/kg).
- 7.13 It is understood that as part of the development, the following mitigation measures with regards to Topsoil;
- No private gardens are proposed for the holiday (lodge) accommodation. Where soft landscaping is required, it is proposed to use imported material; and
 - Where soft landscaping is planned around communal buildings e.g. hotel, spa etc., it is proposed to use imported material.
- 7.14 As discussed, the exposure/frequency of visitors will generally be infrequent and short term and therefore, an exceedance above the adopted GAC does not necessarily indicate an unacceptable risk.
- 7.15 On the basis of the findings to date, it is likely that in addition to areas of hardstanding (e.g., beneath structures, driveways, roads and other hardstanding), the measures outlined above will break the pollutant linkage and no further risk mitigation would be required in terms of risks to human to health.
- 7.16 It should be noted that further site wide and structure specific ground investigations will be carried out to confirm the findings of this study and provide further information in relation to design.

- 7.17 The chosen risk mitigation strategy should be based on any new information and detailed within a remediation strategy/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 mitigated.

New Service Connections

- 7.18 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 possible, based on this guidance, that the levels of contaminants on site will require the use of barrier pipe for the protection of potable water supply pipes.
- 7.19 AGS documentation (AGS, 2011) indicates that the UK Water Industry Research guidance (UKWIR, 2011) does not include guidance relating to arsenic. Further site wide and structure specific investigation should confirm the findings of this assessment and we recommend that proposals are confirmed with the local water authority at detailed design stage.

Risk to Construction and Maintenance Workers

- 7.20 Occasionally elevated levels of arsenic have been identified within the shallow soils. However, the levels recorded fall well below the AGAC values outlined previously and as such, we anticipate that the levels of locally elevated concentrations of arsenic recorded 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.
- 7.21 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.

General Public/Neighbouring Properties and Ecology

- 7.22 It is likely that any mitigation measured adopted to lower risks to site end users and construction workers will also reduce risks to the sites neighbours and we therefore do not anticipate any significant risks to the general public from the development of the site. However, the site is publicly accessible and careful dust control measures should be adopted during construction to minimise the risk (and nuisance) to the general public and neighbouring residents.
- 7.23 In addition to the above, the assessment has indicated no Made Ground on site and risks to ecology are likely to be low on the basis that risks to end users and construction workers are reduced to acceptable levels.

CONTROLLED WATERS RISK ASSESSMENT

- 7.24 No direct assessment of the risks to controlled waters has been undertaken to date. However, the following points are considered relevant.
- No significant past contaminative land use has been identified.
 - Made Ground was not identified in the ground investigation points.
 - The concentrations of soil contaminants are generally low, noting that a few samples recorded Arsenic concentrations that have been identified as potential localised point sources.

- Soakaways are being implemented for the development and will reduce the infiltration rate through attenuation.
- The site is generally underlain by weathered Rhondda Member bedrock which was found to be both fine and coarse grained in nature.
- There are no groundwater abstractions or Source Protection Zones within 500m of the site.
- There are no surface water abstractions within 250m of the site.
- No evidence of a private water supply has been identified at the site.
- The bedrock beneath the site is classified as a Secondary A aquifer.
- Groundwater is anticipated within Rhondda Member bedrock at approximate depths of between 10 – 30m.
- There is a shallow groundwater body in the south-eastern extent where deep peat was encountered.
- The River Afan lies some 100m to the north at its closest point.

7.25 On the basis of the findings to date, we consider that the overall risk to controlled waters from the development of the site is likely to be low.

7.26 The design of any shallow infiltration systems including soakaways for the discharge of surface water as part of the proposed development including contamination risk mitigation is required to be carried out in accordance with the guidance given by Natural Resources Wales, CIRIA Report Infiltration Drainage 156 (1996), BRE DG 356 (2016) and the SuDS Manual C753 (CIRIA, 2015).

7.27 It should be noted that further site wide and structure specific ground investigations will be carried out to confirm the findings of this study and provide further information in relation to design

RISKS FROM GROUND GAS

7.28 At the time of writing, only part of the required gas monitoring has been completed. Further assessment, including a Detailed Mine Gas Risk Assessment (CL:AIRE 2021) and considering C665:2007 and BS8485:2019 will be carried out upon completion of the monitoring.

Risk to the Development – Hazardous Ground Gas

7.29 The current monitoring has indicated levels of methane below detection levels, levels of carbon dioxide up to 0.1 to 7.2% and no detectable flow rates have been recorded. Following the guidance in BS8485:2019 and based on the initial data available, whilst the majority of the results across the site meet the criteria for Characteristic Situation CS-1, localised elevated levels of carbon dioxide exceed the maximum for CS-1 in at least one visit.

7.30 On completion of the remaining 8no. scheduled gas monitoring visits, we will prepare a gas assessment addendum report, detailing the monitoring results, the recommended characteristic situation and any gas protection if required, assessed in accordance with BS8485:2019 and CL:AIRE, 2021.

7.31 The monitoring to date suggests that standard protection measures are likely to be sufficient to mitigate risks from ground gasses at the site. This will be discussed in detail in further assessments and following future investigation and gas monitoring. Portions of the site would be classed as high risk zones (CL:AIRE 2021) due to the presence of mine entries, shallow workings and faults on the site. Further structure specific ground investigations will be carried out at detailed design stage and the ground investigations will include supplementary gas monitoring. Structure specific assessments will be carried out as part of detailed design to confirm structure specific gas protection measures

requirements.

Risk to the Development – Radon

- 7.32 A small portion in the southern extent of the site lies in a radon affected area as defined by the Health Protection Agency. Based on the current masterplan it is expected that structures will not be positioned in this part of the site. In any case, any new buildings within this area should include basic Radon protection measures. Radon protection measures outside this area are not expected to be required.

Risk to Construction and Maintenance Workers

- 7.33 Slightly elevated levels of carbon dioxide have been recorded within both shallow and deep ground gas monitoring wells during the visits to date. Carbon dioxide is a particular risk as it is heavier than air, it can displace it at the base of excavations, which can then lead to workers being at risk from asphyxiation. At this stage, we recommend good site practice and all excavations should be considered potentially confined spaces and suitable precautions taken prior to man entry. The risks should be reviewed on completion of all monitoring visits.

POSSIBLE UNIDENTIFIED CONTAMINATION

- 7.34 The investigation to date was undertaken with investigation points positioned to maximise the information that could be obtained and provide a spatial spread, allowing for the constraints imposed by the physical features on site including vegetation, steeply sloping ground and the known site constraints.
- 7.35 If any previously unidentified Made Ground or obviously contaminated soils are encountered during construction phases, further sampling and analysis should be undertaken.

8.0 CONCLUSIONS

- 8.1 The aim of this assessment is to provide sufficient information to establish general principles of development considering the outline planning conditions. It should be noted that further site wide and structure specific ground investigations will be carried out to confirm all the findings of this study and provide further information in relation to design.
- 8.2 The desk study has not identified significant sources of site contamination and no significant covering of Made Ground has been identified in any of the locations investigated. This assessment has shown that geoenvironmental contamination risks can be managed through mitigation and future design alterations in due course.
- 8.3 Except for rare elevated arsenic levels recorded within some samples of Topsoil/Organic Rich Topsoil, testing of soil samples has shown low levels of contaminants across the site, all below the adopted GAC. Point sources of arsenic contamination were not identified in the preliminary risk assessment and therefore it is considered likely that the levels reflect the natural background concentrations (NBC) of arsenic in South Wales.
- 8.4 The locations of the identified outliers will be investigated further, noting that should these be identified as indicative of an area of contamination, the proposed mitigation of provision of a localised simple cover system will be implemented, if these areas are outside of those where the development design provides inherent protection.
- 8.5 Private gardens are not proposed for the lodges and imported materials will be utilised for areas of soft landscaping in communal areas. Therefore, based on the findings to date, it is unlikely that the arsenic levels present a significant risk to end users.
- 8.6 On the basis of the findings to date, we consider that the overall risk to controlled waters from the development of the site is likely to be low.
- 8.7 The gas monitoring carried out to date identified generally low concentrations of carbon dioxide, with methane or gas flow below detection levels. Further ground gas monitoring is ongoing and a full gas risk assessment including CL:AIRE 2021 risk assessment will be provided as part of an addendum report with recommendations once the 8no. further visits are complete. The site is in a high risk zone (CL:AIRE 2021) and detailed site works will include further investigation and monitoring to confirm gas risks due to specific features (mine entries, faults etc.) which will require some targeted monitoring wells and increased spacing.
- 8.8 Based on the historical land use and site settings it is expected that once gas monitoring visits are complete and based on the proposed mitigation measures with regards to risks to human health, that the ground investigation carried out to date is considered suitable to discharge Planning Condition 29 for the outline scheme.
- 8.9 It is expected that further structure specific ground investigations will be required at detailed design stage. The ground investigations will include geo-environmental testing and supplementary gas monitoring. The findings and recommendations of his report will be verified as part of these future assessments.
- 8.10 The actions summarised below will likely also be required and should be reviewed as part of detailed development design:

- Verification testing of any soils imported to site is likely to be required.
- WM3 assessment of soils to be disposed of off-site is likely to be required. WAC testing may be required if disposal to landfill is proposed.
- Materials management plan for re-use of soils on site if required. -
- We assume soakaways will be required and soakaway testing will be required, and locations should be reviewed with an appropriate assessment in line with relevant guidance (BRE, 2016).

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