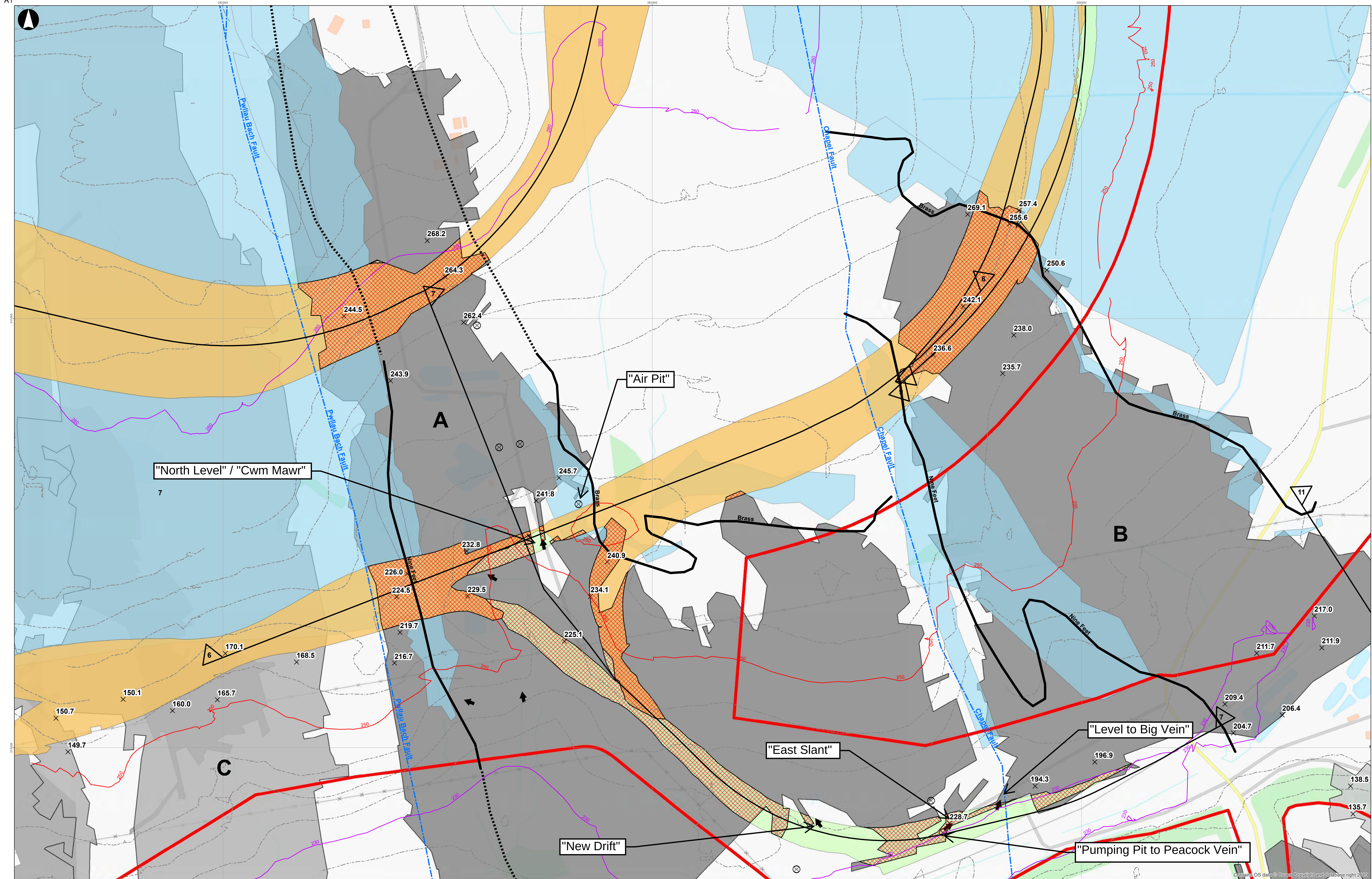




Legend

- Site Boundary
- Embankment
- Cutting
- Previously Opencast Sites
- Working Levels
- Adits
- Shafts
- Observed Seam Outcrop
- Inferred Seam Outcrop
- Dulais Peacock
- Abercrae Four Feet
- Recorded shallow workings
- Potential unrecorded shallow workings

Coordinate System: British National Grid

P01	07-05-2020	JC	TW	DR
Rev	Date	By	Chkd	Appd

ARUP

4 Pierhead Street
Capital Waterside
Cardiff CF10 4QP
United Kingdom

Client
Welsh Government

Project Title
Global Centre of Rail Excellence

Drawing Title
Risk Zone A

Scale at A1
1:2,000

Role
Geotechnical

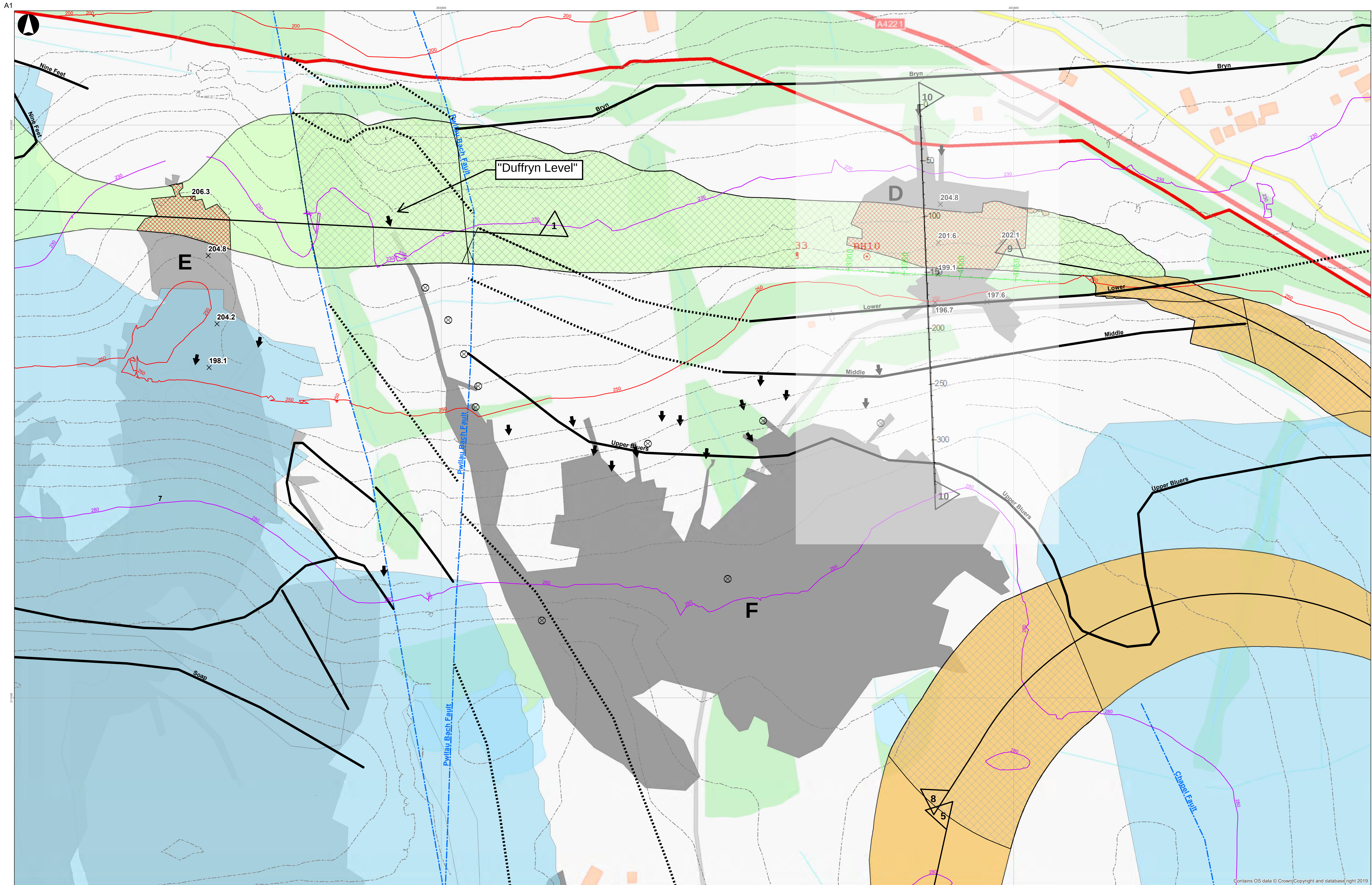
Suitability
For Information

Arup Job No
264904

Name
P01

Rev
P01

Figure 2



Legend

Site Boundary

Embankment

Cutting

Previously Opencast Sites

Adits

Shafts

Working Levels

Oberseved Seam Outcrop

Inferred Seam Outcrop

Cwmtawe Bryn

Abercrave Big

Duffryn Bluers

Recorded shallow workings

Potential unrecorded shallow workings

Coordinate System: British National Grid

ARUP

4 Pierhead Street
Capital Waterside
Cardiff CF10 4QP
United Kingdom

P01	15-05-2020	JC	TW	DR
Rev	Date	By	Chkd	Appd

Client

Welsh Government

Project Title

Global Centre of Rail Excellence

Drawing Title

Risk Zone B

Scale at A1

1:1,500

Role

Geotechnical

Suitability

For Information

Arup Job No

264904

Name

Figure 3

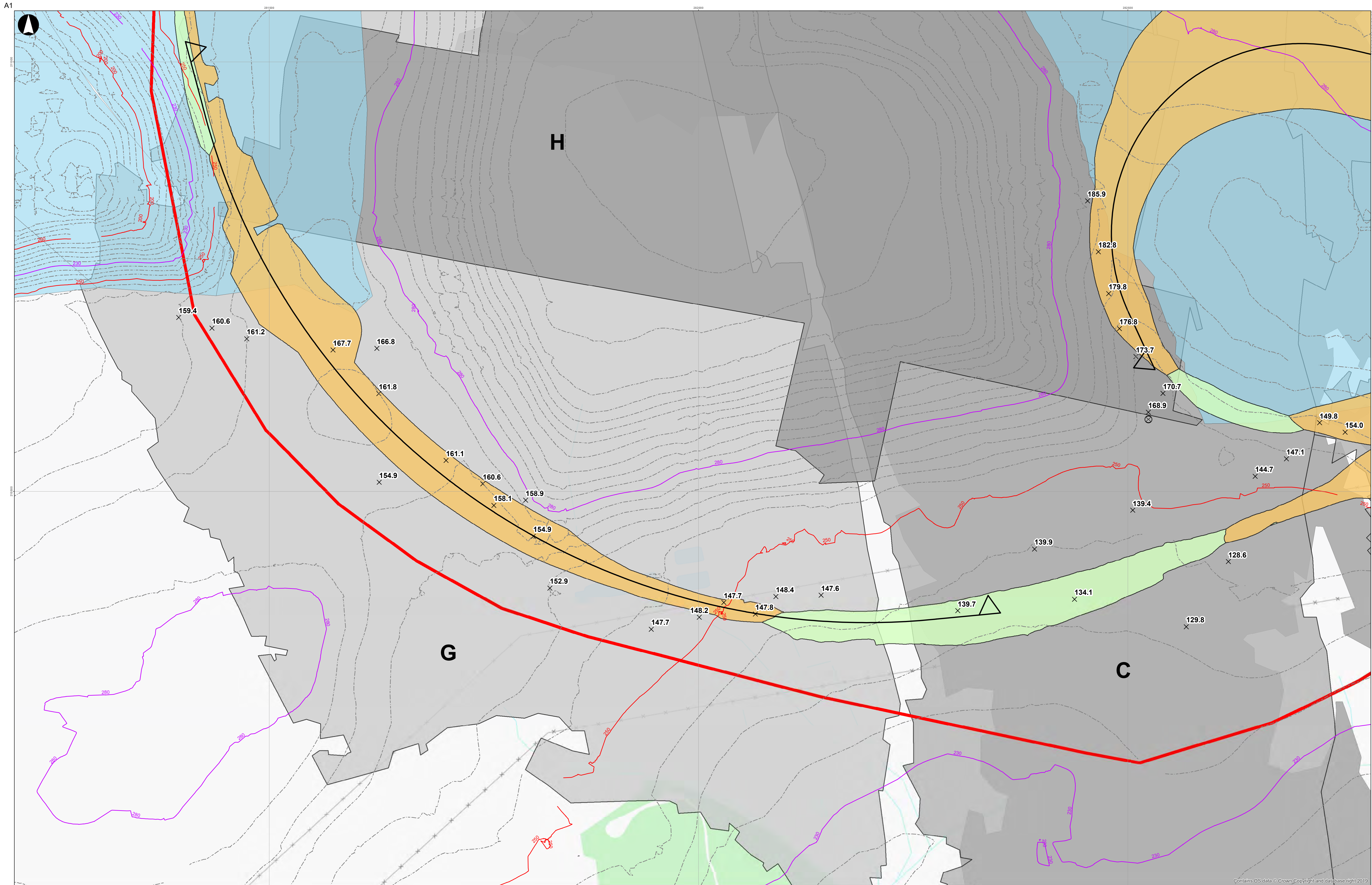
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Legend

Site Boundary

Embankment

Cutting

Previously Opencast Sites

Working Levels_Dulais Peacock

Adits

Shafts

Abercrave Four Feet

International Four Feet

Abercrave White

Recorded shallow workings

Potential unrecorded shallow workings

Coordinate System: British National Grid

P01	07-05-2020	JC	TW	DR
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Cardiff CF10 4QP
United Kingdom

Client

Welsh Government

Project Title

Global Centre of Rail Excellence

Drawing Title

Risk Zone C

Scale at A1

1:2,000

Role

Geotechnical

Suitability

For Information

Arup Job No

264904

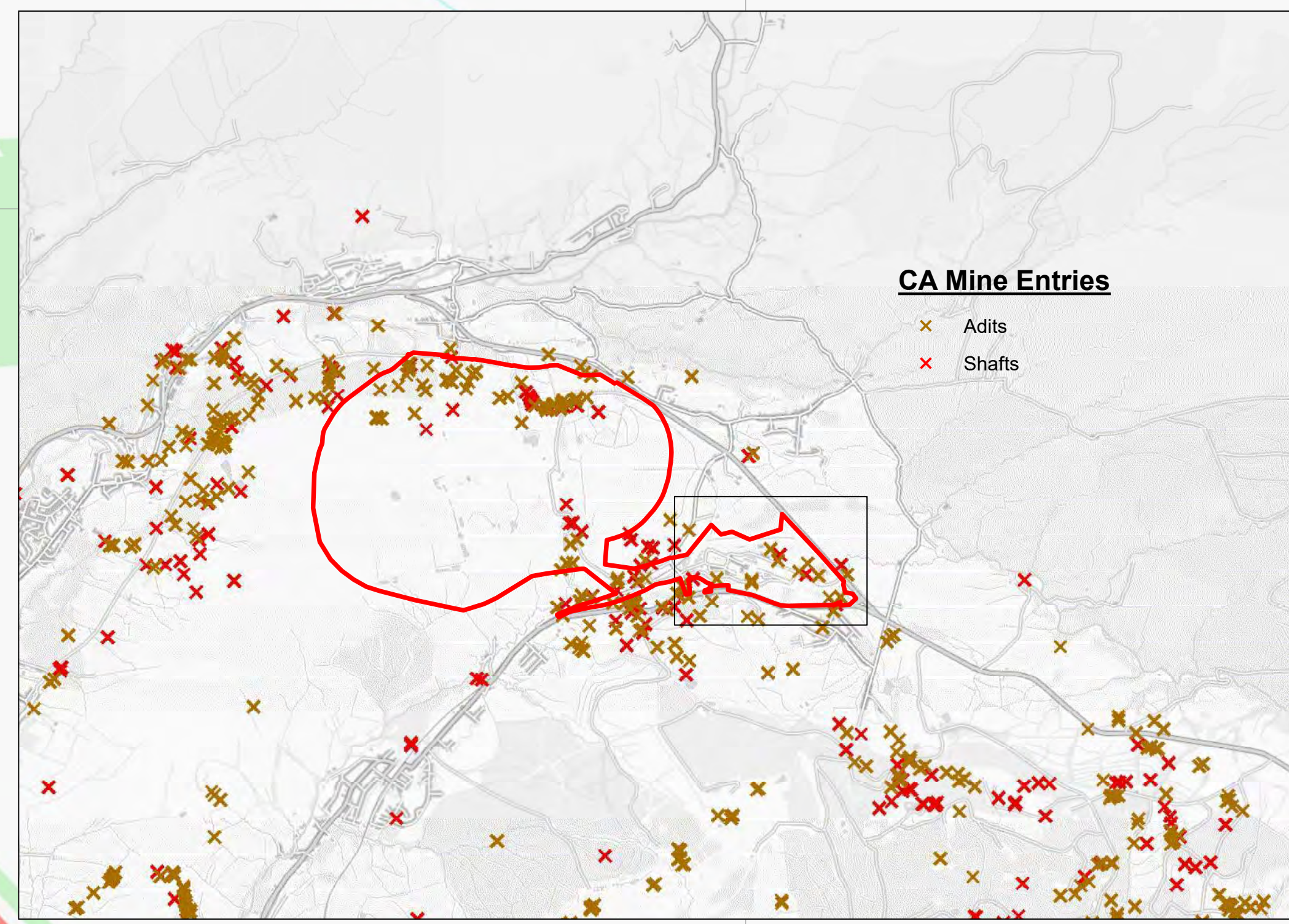
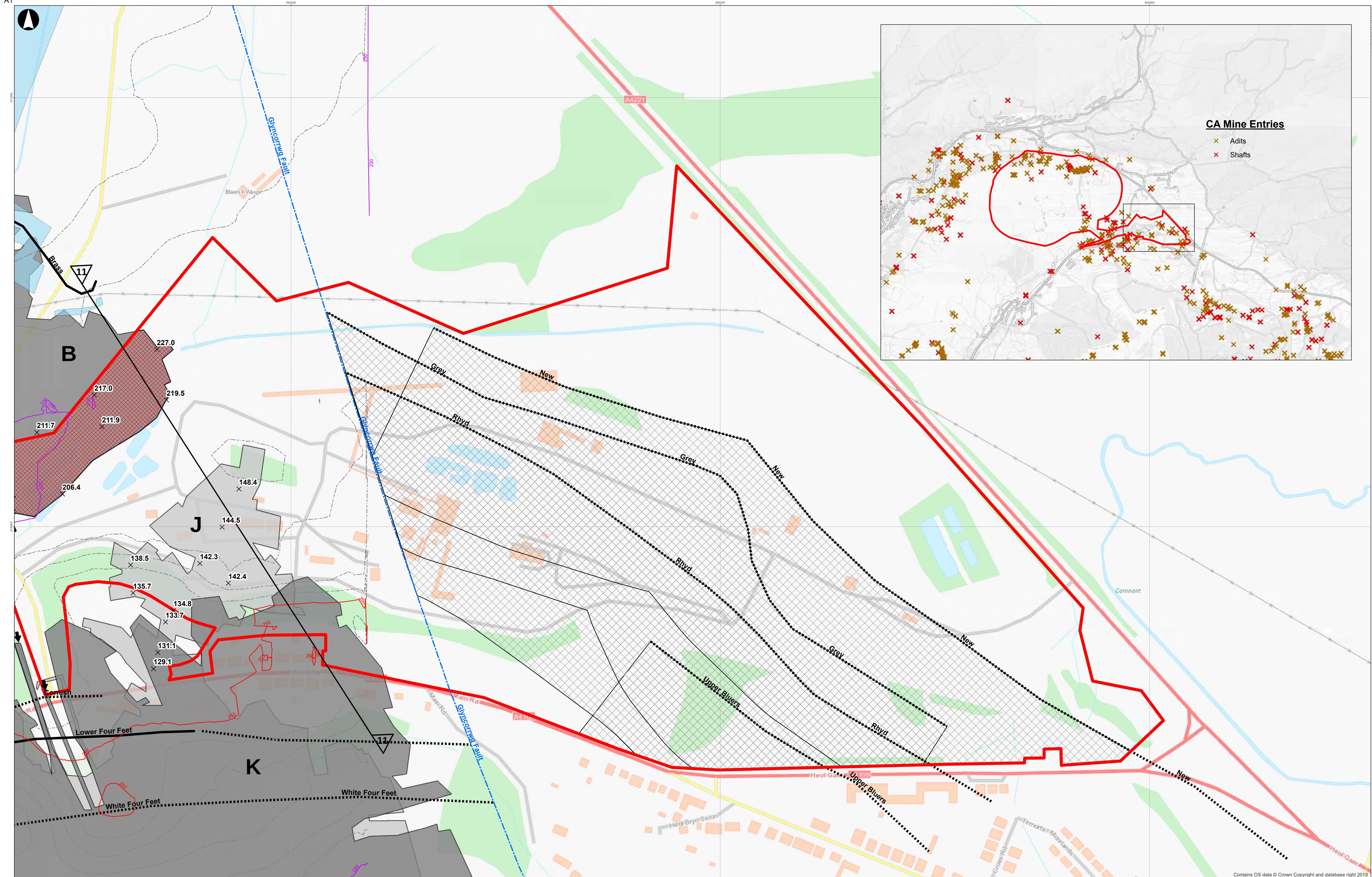
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Figure 4

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Legend

Site Boundary

Previously Opencast Sites

Working Levels

Adits

Shafts

Observed Seam Outcrop

Inferred Seam Outcrop

Dulais Peacock

Onllwyn Bluers

Onllwyn Brass

Recorded shallow workings

Potential unrecorded shallow workings

0 50 100 200

Metres

Coordinate System: British National Grid

P01	15-05-2020	JC	TW	DR
Rev	Date	By	Chkd	Appd

ARUP

4 Pierhead Street
Capital Waterside
Cardiff CF10 4QP
United Kingdom

Client
Welsh Government

Project Title
Global Centre of Rail Excellence

Drawing Title
Risk Zone D

Scale at A1
1:2,000

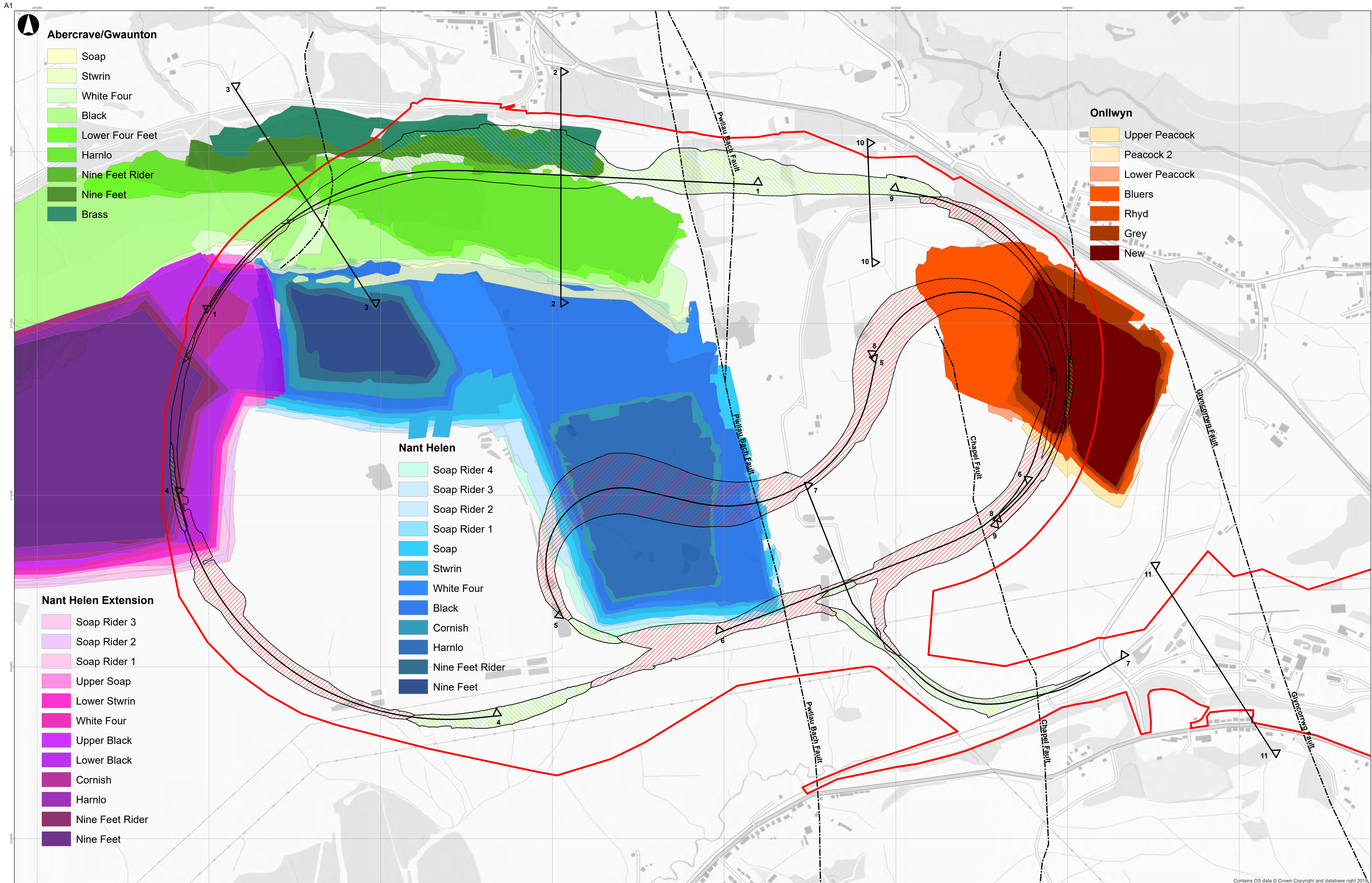
Role
Geotechnical

Suitability
For Information

Arup Job No
264904

Name
Figure 5

Rev
P01



Appendix F – Mine gas risk assessment

Technical Note

Project title Global Centre of Rail Excellence
Job number 284523
File reference
cc
Prepared by Nick Kontochristos
Date 10 October 2022
Subject Preliminary Mine Gas Risk Assessment Note

4 Pierhead Street Capital Waterside Cardiff CF10 4QP United Kingdom

t +44 29 2047 3727

arup.com

1. Introduction

Celtic Energy Nant Helen site and Onllwyn Washery are to be developed by Global Centre of Rail Excellence Ltd. (GCRE Ltd.) as a rolling stock and rail infrastructure testing facility. The site is currently an operational opencast coal mine and an associated washery site.

The site is located within a Coal Authority defined Coal Mining Reporting Area and has been subject to a long history of mine exploration including deep, shallow and open cast mining. Therefore, there is a risk of mine gas migration from abandoned workings underlying the site to the surface either through existing pathways or as a result of the proposed development. Consequently, in accordance with the published guidance¹, a mine gas risk assessment is required.

This technical note presents the preliminary mine gas risk assessment focusing on setting out the site conceptual model and deriving the level of mine gas risk, in line with the CL:AIRE guidance with recommendations on the next steps. It is intended that this note will support the partial discharge of the following planning condition:

GCRE Condition 22 (Powys & NPT)

No development shall take place in each phase of development as identified in condition 7 (including demolition, ground works, site, or vegetation clearance) until a site investigation of the nature and extent of contamination has been carried out, by a suitably qualified competent person, in accordance with a methodology which has previously been submitted to and approved in writing by the local planning authority. A written report of the findings of the site investigation shall be made available to the local planning authority before any development begins. A mine gas risk assessment should form part of the overall assessment.

¹ CL:AIRE, 2021. Good practice for risk assessment for coal mine gas emissions. CL:AIRE, Buckinghamshire. ISBN 978-1-905046-39-3.

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2. Proposed development

Celtic Energy are required to restore the Nant Helen site in accordance with regulatory requirements and agreements with Powys County Council (PCC). The Nant Helen Complementary Earthworks scheme which includes the creation of 17.5m wide plateaus on the Nant Helen site has been approved through the Planning process. This will involve extensive reprofiling of the site through cut and fill. The proposed development will allow the site to be re-purposed now that the opencast mining activities have ceased. The site is in the process of being restored.

The proposed GCRE rail test track is composed of two rail tracks on sleepers set in a ballast track foundation, associated Overhead Line Equipment (OLE) to support electric trains and all other required supporting infrastructure. The tracks are proposed to be located on the plateaus provided by the Complementary Earthworks scheme. The tracks include a larger outer loop as well as a smaller inner loop. A vehicle access track is proposed adjacent to the proposed rail loops.

The GCRE rail depot and storage facility is proposed to be located on the site of the coal washery. This development consists of the installation of multiple sidings for train stabling, as well as inspection and maintenance sheds, fuelling roads and carriage wash facilities. In addition to the track elements, the southern area of the colliery wash site is proposed to include a number of buildings forming an Innovation Hub as well as further Industrial/Commercial developments.

3. Completed studies and investigations

A preliminary geotechnical and geoenvironmental desk study was carried out by Arup in 2019² which provided a review of the coal mining activity within the site. The desk study was based on a limited dataset, predominantly sourced from records provided by Celtic Energy (CE), and it was recommended that a comprehensive set of mine abandonment plans be sourced from the Coal Authority in order to gain a greater appreciation for where shallow mine workings are likely to be present beneath the proposed development.

A detailed review of the available mine abandonment plans for the site is presented in the detailed Mine Workings Study note³ prepared by Arup in 2020, which is included in Appendix E of Arup's 2022 Ground Investigation Report for GCRE⁴.

The site has been subject to preliminary intrusive ground investigations, which involved ground gas monitoring, as summarised in Section 3.1 below. The interpretation and assessment of the results is presented in the Arup Ground Investigation Report⁵. This comprised a preliminary ground gas risk assessment to inform on potential risks posed from gas emissions from the made ground and coal mine workings under the site. The assessment followed the framework for ground gas risk

² Arup, "Land at Nant Helen and Onllwyn Coal Washery - Geotechnical and Geoenvironmental Desk Study," Welsh Government, 2019.

³ Arup, "Global Centre or Rail Excellence Detailed Mine Workings Study." June 2020.

⁴ Arup, "Global Centre or Rail Excellence Ground Investigation Report." May 2022

⁵ Arup, "Global Centre or Rail Excellence Ground Investigation Report." May 2022

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assessment as set out in BS 8485:2015 + A1:2019 (British Standards Institution, 2015)⁶ with some specific requirements for mine gas risk assessment.

3.1 Scope of preliminary ground investigation

The desk study carried out has indicated that there are unflooded mine workings less than 150m depth under the main site and a number of shafts / mine entries within both the main site and the washery. Plausible source-pathway-receptor linkages (PPLs) related to mine gas have been identified in relation to the main site and the washery.

An initial ground investigation was carried out between 15th November 2021 and 19th January 2022 to inform the key geotechnical and geoenvironmental risks to the proposed GCRE development (including the identified mine gas risks in accordance with BS8576⁷). It should be noted that the details on proposed buildings within the washery were not available at the time of the GI and a detailed GI will follow when detailed proposals are confirmed. The initial GI included groundwater level monitoring to confirm likely variations of the permanently flooded mine workings and to confirm the thickness and nature of any low permeability layer which may act as a barrier to potential gas migration.

The completed scope of works is summarised in Table 1 below. Locations of the exploratory holes for the GCRE initial ground investigation are presented on Drawings 2 and 3. Further details on the GI are included in Arup's Ground Investigation Report (May 2022)⁸.

Table 1: Scope of initial ground investigation for GCRE

Fieldwork component	Description
Exploratory holes	35no boreholes between 19.2m and 61.5m depth drilled using either cable percussive, open hole rotary, rotary coring, or sonic coring methods. In the original scope ten of the holes were to be completed using sonic drilling within the areas of open cast backfill. After three holes it was found that sonic drilling was less effective (slower and could achieve less depth) than conventional rotary drilling, so the remaining holes scheduled to be undertaken with sonic drilling were undertaken using rotary methods to the maximum depth that could be achieved with these rigs.
	40no trial pits. 11no of which were to investigate anomalies identified by the geophysical surveys and eight to undertake soakaway testing.
Geophysical surveys	Magnetic, electromagnetic and microgravity surveys undertaken across 4 areas within the Washery area of the site to investigate the locations of recorded mine entries.

⁶ British Standards Institution (BSI), 2015. BS 8485:2015 + A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. London: BSI.

⁷ British Standards Institution (BSI), 2013. BS 8576:2013. Guidance on investigations for ground gas. Permanent gases and volatile organic compounds (VOCs). London: BSI.

⁸ Arup, "Global Centre of Rail Excellence – Ground Investigation Report," Global Centre of Rail Excellence Ltd, May 2022 (Reference CG3600).

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Fieldwork component	Description
Installations and monitoring	16no. holes were fitted with 50mm standpipes to allow for groundwater level/ground gas monitoring. Two of these holes were also fitted with 19mm standpipes to allow for water monitoring in a deeper stratigraphy. Groundwater and ground gas monitoring has been undertaken fortnightly for 12 weeks from the completion of the site works.

4. Overview of the mine gas risk assessment methodology

The 2021 CL:AIRE guidance sets out the methodology for assessment of mine gas risk. It broadly follows the principles of land contamination risk management. In principle, a mine gas risk assessment should be carried out for all site located within a Coal Mining Reporting Area.

The first stage is a desk based review informing a development of a preliminary conceptual site model (CSM, part of a preliminary risk assessment), the outcomes of which would inform the design of the investigations including gas monitoring.

The guidance sets out a decision support tool for mine gas risk assessment to provide a consistent and transparent approach, which based on the gathered information allows characterisation of the site with respect to a risk level and depth of the required assessment e.g. sites located away from mine entries and/or underlain only by deep mineworkings would be classed as negligible risk zones, whereas sites underlain by shallow mineworkings with pathways connecting surface to unflooded working would be classed as a high risk zone and requiring a detailed risk assessment.

5. Summary of site information

This section summarises the key information from the desk study, detailed mine workings study and completed ground investigations, which is relevant to the mine gas risk assessment.

5.1 Location, description and topography

The Nant Helen site is located approximately 20km north-west of Swansea, immediately south of Abercraf (refer to Drawing 1). The site boundary and track proposals are shown on the illustrative masterplan Drawing 003A. For ease of identification, the site has been split into the “main site” and the “washery” portions. The main portion refers to the area that has been largely subject to opencast activity and is proposed to contain the rail test tracks, whereas the washery portion refers to the extension of the site to the southeast incorporating the Onllwyn Washery.

The site is located on a hill with the highest point located roughly in the centre of the main site (~335m AOD) and with ground levels falling away in all directions from this point. The ground levels fall more substantially towards the north; down to about 200m AOD, whereas the eastern, southern, and western extents of the main site fall to around 240 – 260m AOD. Immediately to the west of the site boundary (off-site) is part of the opencast workings that has been active till recently. Its lowest point is at approximately 90m AOD (approximately 150m below surrounding natural ground level). The proposed restoration ground levels near the Nant Helen Extension are between 250m AOD and 255m AOD. The washery is sat at a lower elevation of approximately 230 - 240m AOD.

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The currently active mine produces high quality anthracite coals from up to thirteen individual coal seams lying up to 150 metres below the surface. The site is being mined by shovel and truck methods utilising a fleet of dump trucks and hydraulic excavators. These prime movers are supplemented by various ancillary plant such as bulldozers, graders, drilling rigs and other support equipment. This equipment facilitates a digging capacity in the order of 6 million cubic metres of overburden per year.

All mined coal is transported directly via internal roads to the nearby processing and distribution centre at Onllwyn for onward shipment by rail and road to customers in the domestic, industrial and power generation sectors.

5.2 History

A detailed review of the site history based on historical maps dating back to 1867 is provided in the desk study (ref. 2). In summary, several collieries were located along the northern and southern boundaries of the site between 1876 and 1977. The majority of the collieries were located on the lower slopes of Mynydd Drum and workings were accessed via both drifts and vertical shafts. The Abercrave and Gwaunclawdd Collieries were present on the earliest historical mapping from 1876/77. Where the coal seams are known to be relatively shallow, in the north and the south of the site, they may have been worked by bell pitting (near surface shafts of typically less than 10m depth). Depressions, which may be the result of bell pitting, were observed on an aerial image from 1945. Onllwyn Colliery was the last shown to be active on the 1977 aerial photography.

Further details on the underground workings are provided in section 5.6 of this note.

From review of mine abandonment plans and aerial images opencast working is understood to have started in 1946 in the Onllwyn excavation. The subsequent aerial photographs show evidence for the working of the second Onllwyn (maximum depth of excavation of around 82m bgl), the Abercraf/Gwaunton (around 40m bgl), the Nant Helen (around 130m bgl) and the Nant Helen Extension opencast sites (around 150m bgl). With the exception of the Nant Helen Extension, the rest of the opencast workings have now been backfilled. Refer to Figure 6. The opencast exploration encountered and consequently removed some of the shallow workings. However, many remain, as summarised in Table 1. Interaction between the shallow mine workings and open cast is shown on Figures 2-5.

Since the map dated 1876, various rail tracks and tramways are shown to have crossed through and run along the boundaries of the site. The washery has contained rail tracks/sidings and tramways since the earliest historical mapping and towards the end of the 20th century the extent of coal mining washery infrastructure and stockpile/spoil heaps increased.

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5.3 Geology and encountered ground conditions

The geology beneath the site has been interpreted through a review of published geological sources and completed ground investigations. These sources include the following:

- British Geological Survey (BGS) 1:10,560 geological mapping (sheet SN 81 SW)⁹
- BGS 1:50,000 geological mapping (Sheet 231)¹⁰
- BGS GeoIndex online viewer¹¹
- Arup 2022 GIR¹²

Refer to Drawing 2 and Drawing 3 throughout, which show BGS 1:50,000 geological mapping and locations of the completed ground investigations.

A summary of the encountered ground conditions during the 2021 investigations is presented in Table 2 below.

Table 2: Summary of ground conditions

Stratum	Thickness (m)	Description	Comments
Topsoil	0.05 – 0.9	Brown clayey sandy gravel or Brown sandy gravelly clay	Encountered mainly within the eastern side of the main site and south of the main site in one hole, near the railway.
Peat	0.2 - 2	Dark brown peat or soft brown fibrous peat	Encountered in the southern part of the main site in two locations (thickness 0.2 – 0.4m). Encountered locally in three locations within the washery site (thickness 1 – 2m).
Made ground	1.2 – 8.0	Loose black or dark grey slightly clayey slightly sandy gravel of angular to sub-angular mudstone coal, ash, concrete, clinker, bricks, timber, cable, steel rope, metal sheeting and plastic	Encountered in all holes within the washery except for one.
Backfill from opencast workings	0.3 – >61.5	Dark grey/black slightly sandy clayey gravel with medium cobble content or soft to firm grey slightly sandy gravelly clay (at shallow depths)	Encountered in the majority of the holes within the main site. Thicknesses of colliery spoil were encountered outside of the known areas of opencast working. This is presumably associated with the movement and stockpiling of the material around the site.

⁹ British Geological Survey of Great Britain (England and Wales), 1:10,560 scale geological map SN 81 SW, Geological Survey of Great Britain (England and Wales), 1979.

¹⁰ British Geological Survey (BGS), “1:50,000 Series, Merthyr Tydfil, Sheet 231, Solid Edition,” Geological Survey of Great Britain, 1979. [Online]. Available: <http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=10>. [Accessed 2022].

¹¹ British Geological Survey (BGS), “GeoIndex online viewer,” [Online]. [Accessed February 2022].

¹² Arup, “Global Centre or Rail Excellence Ground Investigation Report.” May 2022

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Stratum	Thickness (m)	Description	Comments
Glacial till	0.7 – 4.4	Firm brown sandy gravelly clay with medium cobble and boulder content. Gravel is fine to coarse sub-angular to sub-rounded mudstone, siltstone, and sandstone. Cobbles are rounded to sub-rounded sandstone	Encountered in the southern edge of the main loop, the north-south transect between the Onllwyn and the Nant Helen excavations and within approximately half of the exploratory hole locations in the washery, primarily the ones towards the southeast. Two locations (norther and southern part of the main site) encountered glacial till 10m and 11m thick respectively.
South Wales Coal Measures	Not proven (0.3 – 7.5 for the Sandstone beds)	Weak to medium strong mudstone/siltstone with beds of sandstone, coal, and conglomerate to a lesser extent	Encountered across the site. Coal seams were encountered in ten of the holes on the main site. These are outside the areas of backfill, in the south and east of the main site. The coal encountered ranged in thickness from 0.2m to 1.7m and ranged in depth from 10.7 to 36.2m bgl. It is typically described as weak black coal. In the Washery, a coal seam was encountered in each of the boreholes except for one. It ranged in thickness from 0.6m to 3.2m and ranged in depth from 11.8 to 28.1m bgl. It is typically described as weak black coal. Voids, assumed to be a result of historical underground coal mining, were recorded in few locations (south eastern part of the main site and washery). The recorded depths were as shallow as 3.9 to 7.9m bgl in the main site and 9.7m bgl in the washery (void thicknesses ranging between 0.3m and 2m)

5.3.1 Made ground

There are several areas of artificial ground shown on the geological maps. In the main site, these are associated with areas of backfilled opencast workings. The completed investigations encountered the colliery spoil backfill down to 61.5m bgl but is anticipated to be up to 150m thick in the Nant Helen Extension. The backfill was typically described as a *dark grey/black slightly sandy clayey gravel with medium cobble content*. Boulders were also commonly encountered in the trial pits. In some holes it is described as a *soft to firm grey slightly sandy gravelly clay*, which was generally at shallow depths (less than 4.5m), with the exception of BH21 where it is 33m thick. Thicknesses of colliery spoil were encountered outside of the known areas of opencast working. This is presumably associated with the movement and stockpiling of the material around the site.

Geology maps also show made ground shown beneath the washery site, which is likely associated with levelling this area for the railway sidings and buildings. The completed investigations encountered between 1.2 and 8m of made ground typically described as a *loose black or dark grey slightly clayey slightly sandy gravel*. Locally thicker deposits could be encountered in the locations of any stockpiles/spoil heaps within the washery site.

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5.3.2 Superficial deposits

The geology mapping shows the main site, for the most part, to be devoid of superficial deposits, the exceptions being: an area of peat in the centre of the main site and in the north and west of the washery; glacial till, in the south and west of the main site and along the eastern boundary of the washery. The peat in the centre of the main site and the glacial till in the west of the main site are on areas of opencast working, so are unlikely to be present.

In areas of the site that have not been subject to historical opencasting in the main site as well as in the washery site, peat deposits with thicknesses of circa 1-2m was encountered during the completed investigations at depths ranging from 2 to 7.8m bgl.

The completed investigations encountered glacial till, within the main site, where it was not excavated through the open casting activities as well in the south eastern part of the washery site, typically between 0.7m and 4.4m thick, locally 10-11m thick. In some locations it was overlain by colliery spoil. It was typically described as a *firm brown sandy gravelly clay with medium cobble and boulder content. Gravel is fine to coarse sub-angular to sub-rounded mudstone, siltstone, and sandstone. Cobbles are rounded to sub-rounded sandstone.*

With regards to the washery, glacial till (firm to stiff grey/brown clay with various mudstone, siltstone and sandstone gravel inclusions) was encountered beneath the made ground. Where encountered, the glacial till material beneath the washery portion of the site ranged between 0.2m and 2.4m thick. In some locations within the washery portion of the site, no natural superficial materials were encountered; in these locations the made ground material (described above) was encountered directly overlying the weathered bedrock.

Refer to Drawing 2 for location of superficial deposits (geological mapping).

5.3.3 Bedrock

The bedrock beneath the site is part of the South Wales Middle and Lower Coal Measures. They typically comprise rhythmic sequences of mudstones (commonly containing pyrite), siltstones, sandstones, grits, fireclays, seatearths and coals; the coals found in these measures tend to be amongst the thickest and most economically significant in South Wales.

The western half of the site is underlain by solid geology denoted as South Wales Middle Coal Measures Formation and the eastern half of the site is shown to be underlain by South Wales Lower Coal Measures Formation. Refer to Drawing 3 for bedrock geology.

Dip angles for the bedrock bedding shown on the 1:10,560 geological mapping typically dip in a west south-westerly direction at angles ranging from between 5° and 15° (ref. 9). However, there are localised variations to this, with a number of anticlines and synclines shown.

Three named faults are shown on the published geological maps crossing the site with a NNW-SSE strike, as well as two other parallel unnamed faults, which protrude into the northern boundary of the site. The three major faults the Pwllau Bach Fault and the Chapel Fault (main site) and the Glyncorrwg Fault (washery), ordered from west to east, divide the bedrock beneath the site into three fault blocks as shown on Drawing 3. As well as the two unnamed faults that extend into the

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northern part of the main site, it is likely that there are other unidentified faults within the site boundary.

From review of the vertical sections presented on the opencast completion plans for the Onllwyn site (1949), the base of the Nine Feet and Brass seams were encountered at 3.2m and 11.9m bgl ground level respectively. In addition, reference to the base of the Upper Peacock and Peacock seams were shown to have been encountered at 5.1m and 11.9m bgl respectively on the vertical section presented on the opencast completion plan for the Onllwyn site (1982).

As a result of the historical opencast workings within the site area, the depth to rockhead will vary greatly depending on location. Within the areas of the main site that have not been subject to opencast mining, the depth to rockhead is anticipated to be relatively shallow, with recorded depths ranging between 1.8m and 3.6m. However, in the locations that have been subject to opencast activity and have since been backfilled, the depth to rockhead could vary significantly over short distances (as detailed above). The bedrock material is anticipated to comprise interbedded mudstones and siltstones with occasional sandstone bands.

The detailed descriptions from boreholes progressed within the washery portion of the site suggest that the mudstones and siltstones are slightly to moderately weathered and are moderately weak to strong. The materials are generally grey to dark grey in colour and occasionally micaceous. Where encountered close to surface, bedrock was recovered as highly weathered fragments of mudstone and sandstone within a clay matrix. Given this description, it is likely to be difficult to distinguish between the weathered head of bedrock and the overlying Glacial Till material.

5.4 Groundwater conditions

The hydrogeological regime beneath the site is anticipated to be complex and highly varied across the site. Significant underdraining through abandoned workings is likely to dictate the groundwater levels within the areas that have been previously opencast. The site is transacted by geological faults, which may act as barriers or conduits to groundwater movements.

The topography of the site generally rises inwards from the site boundary. The central portion of the site sits at around 280m AOD with localised peaks reaching approximately 295m AOD. The washery sits lower than the main portion of the site at roughly 230-240mAOD.

The groundwater levels beneath the site have been interpreted through the 2021 ground investigation, historical logs held by the BGS and review of documents provided by Celtic Energy. Groundwater data presented on the logs held by the BGS is limited in nature and only pertains to the washery portion of the site.

5.4.1 2021/2022 Groundwater monitoring

During the 2021 ground investigations, groundwater monitoring was undertaken fortnightly for a period of 12 weeks from 15no. groundwater installations. The results are summarised in Table 3 below.

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Table 3: Groundwater monitoring results

Borehole	Response zone depth m bgl	Response zone stratigraphy	Water level range mbgl (mAOD)
Washery			
BH30	3 - 4	Made ground	3 - 3.6 (235.5 - 236.2)
BH31	1 - 5	Made ground	4.1 - 4.6 (234 - 234.5)
BH34	1 - 3.3	Made ground	2.6 - 2.9 (227.4 - 228.1)
BH29	12 - 15	South Wales Coal Measures	0.3 - 1 (229.7 - 230.4)
BH31	16 - 21	South Wales Coal Measures	4.3 - 4.9 (233.7 - 234.3)
BH32	12.5 - 17.5	South Wales Coal Measures	2.9 - 4.8 (226.0 - 227.8)
BH33	15 - 20	South Wales Coal Measures	0.1 - 1.1 (229.6 - 230.6)
BH34	11 - 13	South Wales Coal Measures	4.5 - 5.8 (224.9 - 225.9)
Main site			
BH15	1 - 5	Fill/glacial till/SWCM	0.4 - 1 (248.6 - 249.3)
BH07	8 - 10	South Wales Coal Measures	Dry (to base of installation at 261.3)
BH16	8 - 10	South Wales Coal Measures	3.8 - 4.8 (276 - 276.9)
BH19A	25.2 - 28.2	Backfill	Dry (to base of installation at 227.1)
BH22	29 - 34	Backfill	32.8 - 33 (180 - 180.3) (dry on four occasions)
BH25	39.2 - 49.2	Backfill	4.9 - 15.1 (242.6 - 252.8)
BH28	39.2 - 49.2	Backfill	Dry (to base of installation at 228.2)

5.4.2 Washery site

The monitored groundwater level within the washery ranged between 2.6 and 4.6 m bgl in the made ground (~228-235mOD) and 0.1 and 5.8m bgl (~230 and 234 mAOD) in the underlying bedrock. The monitored levels indicate that the groundwater monitored in the made ground and underlying bedrock is likely to be in hydraulic continuity.

Historical investigations monitored groundwater between 3.4m and 7.2m below ground level. Shallower strikes and slight seepages were also noted as shallow as 1.0m bgl.

Based on the monitored groundwater levels it is considered that the workings underlying the washery site are permanently flooded (groundwater levels were consistent with a maximum fluctuation of 1m). The monitoring has taken place between January and April 2022 and there is no information available on any groundwater level variation through the summer months. However, due to the presence of the underlying peat, it is considered unlikely that the groundwater levels will vary significantly to the ones recorded.

5.4.3 Main site

Extensive exploratory drilling was undertaken by British Coal in the late 1990s in the location of the Nant Helen Extension opencast, overlapping with the western end of the proposed development.

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Only a small proportion of these boreholes is located within or close to the proposed development and majority pertains to the land immediately to the west of the proposed development. The boreholes were progressed to known workings within the “Nine Feet” and “Brass” seams and the water levels within each were recorded. The groundwater level within these workings was recorded to be standing at approximately 126m AOD beneath the easternmost extent of the Nant Helen Extension opencast site and approximately 100m AOD at the westernmost extend of the Nant Helen Extension opencast site. Based on current LiDAR elevation data, this would put the groundwater level between ~170m below current ground level (east) and ~50m below current ground level (west); the disparity in these levels is due to the existing Nant Helen Extension void in the west and the overburden storage area to the east.

Available groundwater monitoring information from two boreholes progressed as part of the investigation by British Coal, one in the area of former Gwaun Clawdd Colliery and another in the area of former Ynyscedwyn Colliery area between 2003 and 2016 (with an additional measurement taken in 2020) indicate that the groundwater level sits between 97m AOD and 110.1 mAOD with an average of 106.3m AOD; and between 98.3m AOD and 103.6m AOD with an average of 100.7m AOD, respectively. Based on the available information, groundwater is anticipated at significant depth of between 130-200m bgl within the main site area. It is however anticipated that groundwater will be present at shallower depth within isolated bands of sandstone, where bedrock has not been disturbed by historical deep or opencast mining.

It is understood that dewatering operations within the Nant Helen Extension opencast site currently aim to maintain the water level at approximately 100m AOD. With regard to the Nant Helen Extension opencast, the lowest level of excavation within the Nine Feet seam is as low as 76m AOD. As dewatering would be required to reach this depth, it is likely that the groundwater level would be locally reduced to a similar level.

Post completion of opencast excavation in the area it is possible that the groundwater levels will rebound to a similar level that was encountered within the boreholes progressed during the British Coal ground investigation in the 1990s (between ~100m AOD and ~120m AOD)¹³. This is similar to the level being currently maintained (~170m below current ground level to the east and ~50m below current ground level to the west within the Nant Helen Extension site).

Groundwater monitoring carried out as part of the initial ground investigation in 2021-2022. The installations in the backfill of the former opencast Nant Helen, Nant Helen Extension and Abercraf/Gwaunton workings have predominantly been dry. This is not surprising as the installations have a minimum elevation of 171m AOD and it is anticipated that the surface of the groundwater is likely less than 120mAOD.

One borehole installed within the backfill of the Onllwyn excavation recorded groundwater levels between 4.9m bgl and 15.1m bgl (242.6 - 252.8m AOD), which is up to approximately 1m below the proposed track level. This suggests that the groundwater in the Onllwyn backfilled opencast workings is not in hydraulic continuity with the Nant Helen opencast working and that the rate of

¹³ Celtic Energy, Nant Helen Remainder Surface Coal Mine, Environmental Statement, Volumes 1-3, 2011.

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drainage through fractures and/or adits from within the opencast working is relatively low compared to the backfilled excavations to the east.

Two boreholes located on the main site outside of the backfilled opencast areas (BH15, BH16), have recorded shallow groundwater (3.8 mbgl to 5m bgl). It is assumed that the flow of water encountered during drilling is facilitated through fractures, coal seams and sandstone bands.

5.5 Completed ground gas monitoring and assessment

As part of the preliminary 2021 ground investigations, ground gas monitoring was undertaken within the main site and the washery site. The results informed a ground gas risk assessment as presented in the GIR⁸. The ground gas monitoring results which are relevant to this mine gas risk assessment has been taken into consideration and are further discussed in Section 7.

Ground gas monitoring was undertaken from standpipes installed across the site. The response zones targeted the identified sources of ground gas under the site including:

- Made ground/fill under the washery;
- Colliery spoil under the main site;
- South Wales Coal Measures under both the main sites and the washery.

There were no monitoring installations within the peat underlying the site. However, based on the ground investigation carried out, peat was only encountered locally in the washery. Based on the geographical distribution and the encountered thickness of the peat (maximum 2m) the potential source is likely to be scattered and localised and therefore the anticipated volume of potential ground gas produced from the peat is likely to be low and limited. The potential ground gas risk from peat is therefore low and it was not targeted as part of the initial GI.

The monitored gases included methane (CH₄), carbon dioxide (CO₂), oxygen (O₂), carbon monoxide (CO) and hydrogen sulphide (H₂S).

Six rounds of post works ground gas spot monitoring were completed within the main site and the washery. The monitored holes are summarised in Appendix A. The monitoring was carried out during falling atmospheric pressure conditions on two monitoring events. Slightly falling pressure occurred during the 22 February 2022 event (1012mb to 1001mb) and a sharp fall in pressure occurred on the 6 April 2022 (999mb to 990mb). Only the event of the 6 April 2022 is considered to represent worst case pressure conditions (highest concentrations were recorded during that event).

Table 4 presents a summary of the maximum recorded peak values over the six monitoring events, with the exception of O₂ where the lowest concentration is provided. In accordance with BS 8485 (2015)¹⁴, the response zone of the gas monitoring wells should be wholly or partly above groundwater level to provide valid data. Therefore, the assessments did not take into account data from flooded wells. It should be noted that all installations within the SWCM in the washery were flooded and therefore, excluded from the assessment.

¹⁴ British Standards Institution (BSI), 2015. BS 8485:2015 + A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. London: BSI.

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Table 4: Maximum recorded gas concentrations

Hole ID	Location	Response Zone	Peak CH ₄ (% v/v)	Peak CO ₂ (% v/v)	Minimum O ₂ (% v/v)	Peak CO (ppm)	Peak H ₂ S (ppm)	Peak Flow (L/hr)
BH19A	Nant Helen main site	Colliery Spoil	0	1.30	19.90	0	0	0
BH28	Nant Helen main site	Colliery Spoil	0.10	4.10	15.90	0	0	0.10
BH07	Nant Helen main site	MDST (SWMCM)	0.50	3.50	8.70	0	0	0.10
BH22	Nant Helen main site	SLTST (SWMCM)	0.10	2.70	13.20	0	0	0
BH30	Washery site	MG-FILL	0.80	5.20	3.20	0	0	0.40
BH31 (shallow)	Washery site	MG-FILL	0.10	4.80	16.10	0	0	0.40
BH34 (shallow)	Washery site	MG-FILL	0.60	5.40	10.40	0	0	0.10

A preliminary assessment of the available ground gas monitoring data from the initial GI was completed and is presented in Arup GIR. This assessment placed the proposed development site in Characteristic Situation 1, which means a very low risk from ground gas. In accordance with the 2021 CL: AIRE guidance¹, the assessment of Gas Screening Values (GSV) may not be suitable for mine gas risk assessment if high risk factors are present on site and it should never be used on its own for mine gas assessment. The GSVs have been used to give an indication only of the potential ground gas regime under the site. The ground gas monitoring dataset is limited and additional gas monitoring data will need to be collected through a detailed GI to confirm the mine gas risks identified.

5.6 Coal mining

The majority of the main site and part of the washery site are situated within a Coal Authority ‘Development High Risk Area.’ A ‘Development High Risk Area’ is defined as an “area which contains one or more recorded coal mining related features which have the potential for instability or a degree of risk to the surface from the legacy of coal mining operations”¹⁵. These “features” typically include mine entries (shafts and adits) and shallow coal workings (recorded and probable).

5.6.1 Mine entries

Based on review of the Coal Authority online viewer and abandonment plans, a total of 95No. mine entries have been identified within the site boundary.

¹⁵ The Coal Authority, Online interactive map viewer (online), <https://mapapps2.bgs.ac.uk/coalauthority/home.html>

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5.6.1.1 Main site

Sixty-four of the entries, both shafts and adits, are shown to be located within the Main site (known depths ranging between 4m bgl and 17m bgl – refer to Table 5 for details). Some of those entries are in areas of previously opencast sites (refer to Appendix B, the Mining Study Figures 1 - 6).

In the north-western portion of the site a total of 24No. mine entries have been identified; seven of these entries are shown to be shafts (no depths provided) and the remaining seventeen are shown to be adits (Ref. 15). Based on the location, these entries are anticipated to have been associated with the Abercrave and International Collieries; it should be noted that these entries have most likely been excavated out during the opencast mining activities associated with the Abercrave/Gwaunton opencast site (1973) and are therefore unlikely to still be present. This is in an area of proposed embankment as part of the outer track loop.

In the north-eastern portion of the site a total of 28No. mine entries are shown to have been present; nine of the entries have been identified as shafts and the remaining nineteen entries pertain to adits. Of the nine shafts identified, depths for three of the shafts were provided and range between 5.5m and 9.15m. Based on review of historical mapping, these entries are likely to have been associated with the Glynllech/Cwm Tawe Colliery. Two of the adits shown are located within the extent of the Abercrave/Gwaunton opencast site and have likely been excavated out. However, the majority are shown to be located in an area that has not been opencast and are therefore both the shafts and associated mine workings are still potentially present. This is in an area of proposed embankment as part of the outer track loop.

A total of 12No. mine entries were identified to be present within the south of the site. Six of these entries pertained to shafts with known depths ranging between 3.6m and 4.6m and the remaining six entries were shown to be adits. These entries are likely to be associated with the Dulais Colliery and based on review of abandonment plans, the entries accessed the “Nine Feet” and “Brass” workings. This is in an area of proposed cutting as part of the inner track loop.

The presence of coal seams at shallow depth beneath the ground surface (both in the north and south of the site) means that they could be worked by bell pitting (near-surface and shafts rarely extending beyond 10-12m in depth). From review of historical aerial photography from 1945, surface depressions have been identified that could be the result of bell pitting activities, see Figure 1 below.

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Figure 1: Extract from 1945 aerial photography showing potential “bell pitting”

The identified mine entries, both shafts and adits, which coincide with the current extent of proposed earthworks have been grouped based on the associated colliery and underground working. Refer to Table 5 for a summary of the identified entries and refer to the relevant figures noted (Appendix B, Figures 2 & 3 of the mining study). Where provided on the abandonment plans, the anticipated shaft depths have been interpreted and are also presented in Table 5.

Table 5: Mine entries within proposed earthworks area (main site only)

Entry name	Interpreted location		Location / Figure	Shaft depth noted on abandonment plans
	Easting	Northing		
Dulais Colliery West Slant				
“North Level” or “Cwm Mawr Level”	283373	210740	Main site – South eastern portion of outer track loop and access track & Central portion of inner track loop (Figure 2)	n/a
“New Drift”	283684	210410		n/a
“Air pit”	283414	210784		12ft (~4m)
Dulais Colliery East Slant				
“East Slant”	283846	210410	Main site – South eastern portion of outer track loop and access track & Central portion of inner track loop (Figure 2)	n/a
“Level to Big Vein”	283904	210436		n/a
“Pumping Pit to Peacock Vein”	283838	210402		54ft (~17m)
Duffryn Colliery				
“Duffryn Level”	282957	211907	Main site – Northern portion of track (Figure 3)	n/a

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5.6.1.2 Washery site

A total of 31 No. mine entries were identified to be present within the washery where the GCRE rail depot and storage facility, Innovation Hub as well as further Industrial/Commercial developments are proposed. The thirty-one entries within the zone include eight recorded shafts and twenty-three recorded adits. No depths were provided for the shafts identified on the Coal Authority viewer.

As part of the 2021 ground investigations, magnetic, electromagnetic (conductivity) and microgravity geophysical surveys were undertaken by Terradat (UK) Ltd. in the Washery around the locations where Coal Authority mine abandonment plans record mine entries not associated with known workings, potential areas of unrecorded mineworkings. The findings of the geophysical surveys are presented in the GIR⁸.

Anomalies identified by the geophysical surveys were investigated with trial pits. None of the trial pits encountered anything to suggest the presence of a mine entry. Three of the trial pits within the washery (TP14, TP35 and TP38) proved the base of the made ground, where it overlay glacial till, whilst the rest of the holes failed to prove the thickness of made ground, meaning that mine entries could still be present at these locations.

5.6.2 Underground workings

Through review of abandonment plans provided by Celtic Energy, the plan area extent and anticipated depth to workings for identified coal seams have been reviewed. The Coal Authority online viewer shows that the majority of the site is underlain by some form of underground workings.

Given the age and geographical location of the workings, ‘partial extraction’ methods are anticipated to have been used. As a result, residual voids associated with mining roadways and open stalls are likely to be present in the worked seams lying beneath the site.

Underground workings at depths shallower than 30m below the proposed ground level post development are anticipated to be present beneath both the main site and the washery site. It should be noted that cuttings (~10m) are currently proposed through the area that is anticipated to be underlain by the identified shallow workings. These cuttings will lower the rock cover and in some instances underground workings may be encountered during excavation of the cuttings currently proposed.

Based on observed and inferred seam outcrops, the areas where ‘unrecorded underground shallow workings’ could be present within 30m of ground level have been mapped beneath the track earthworks.

In addition to the known areas of underground working, 4 No. inferred coal seam outcrops of the New, Grey, Rhyd and Upper Bluers are shown to be present within the washery to the east of the Glyncorrwg Fault. No abandonment plans have been received detailing working to the east of the Glyncorrwg Fault within the washery. From review of CA data, covered under an Open Government Licence, numerous adit and shaft mine entries are shown to be present in the locale of

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the inferred outcrops. There is the potential that shallow workings associated with these entries are present in this area. These may also comprise area of ‘unrecorded underground shallow workings’.

A summary of the anticipated workings under the site is presented in Table 6 below.

Table 6: Historical collieries identified within the site area

Location	Seam	Colliery (abandonment/ completion plans dates)	Working level (mAOD)	Current surface level (mAOD)	Proposed surface level (mOAD)	Anticipated depth post development, m bgl	Flooded?
Inner track loop -south (Figure 2)	Peacock (a.k.a. Brass)	Dulais Colliery West Slant	~264~244	~276	~263	~0 -20	No data (possibly flooded or partially flooded)
	ID A Figure 2 Cross section 5,7	(1927 – 1939)					
Outer track loop -south and access track (Figure 2)	Peacock (a.k.a. Brass)	Dulais Colliery West Slant	~232~225	~261 - ~259	~250	~15 -25	Flooded
	ID A Figure 2 Cross section 6,7	(1927 – 1939)					
	Peacock (a.k.a. Brass)	Dulais Colliery East Slant	~237	~260	~250	~10 - 15	Partially flooded
	ID B Figure 2 Cross section 6,7,8,9	(1927 – 1939)					
Outer track loop – north (Figure 3)	Four feet (a.k.a. Cornish)	Abercrave Colliery	~170	~260	~251	~80	No data but likely to be dry
	ID C Figure 2 Cross section 6	(1953, completion 1973)					
	Gnapog (a.k.a. Bryn)	Cwmtawe Colliery	~205 – ~197	~234 – ~250	~245	~25 - 50	
	ID D Figure 3 Cross section 10	(1929)					
	Big (a.k.a. Nine Feet)	Abercrave Colliery	~205	~235	~238	~30 - 35	Dry
	ID E Figure 3 Cross section 1	(1941, completion 1973)					

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Location	Seam	Colliery (abandonment/ completion plans dates)	Working level (mAOD)	Current surface level (mAOD)	Proposed surface level (mOAD)	Anticipated depth post development, m bgl	Flooded?
Inner track loop – north (Figure 3)	Bluers ID F Figure 3	Duffryn Colliery (1916)		Not located directly beneath the inner loop embankment. An adit mine entry (“Duffryn Level”) beneath the embankment.			N/A
Outer track loop – west and Inner track loop - west (Figure 4)	Four feet (a.k.a. Cornish) ID G Figure 4 Cross section 4	International Colliery (1939)	~167 – ~148	~249 – ~275	~249 - ~255	~80 - 100	Dry
	Four feet (a.k.a. Cornish) ID C Figure 4 Cross section 4	Abercrave Colliery (1953, completion 1973)	~140	~253	~255	~115	Dry
	White (a.k.a. White Four Feet) ID H Figure 4 Cross section 5	Abercrave Colliery (1953, 1963, completion 1973)		Workings identified within the White seam do not directly underlie the southwestern portion of the outer track loop			Dry
Washery (Figure 5)	Peacock (a.k.a. Brass) ID B Figure 5 Cross section 7,11	Dulais Colliery East Slant (1927 – 1939)	~227~205	~235 - ~231	No change	~10-30	Flooded
	Bluers ID J Figure 5 Cross section 11	Onllwyn Colliery (1953, completion 1982)	~145	~234	No change	~90	Flooded
	Brass ID K Figure 5 Cross section 11	Onllwyn Colliery (1951, completion 1949)	~195 - ~180	~245 - ~260	No change	~50 - 80	Flooded
		Potential unrecorded shallow workings					Flooded

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5.6.3 Open cast mining

Open cast mining commenced in the 1950s with excavation of the first Onllwyn open cast in the eastern part of the main site. The Onllwyn was extended in the 1970s. By 1985 the Abercrave/Gwaunton open cast, located in the northern part of the main site was backfilled with works commencing on the Nant Helen open cast in the central site area. This was completed and restored by 1995, when the Nant Helen Extension commenced. The exploration of the Nant Helen Extension has only recently stopped.

Table 7: Historical collieries identified within the site area and interaction with open cast sites

Location	Seam	Colliery (abandonment/ completion plans dates)	Open Cast
Inner track loop - south (Figure 2)	Peacock (a.k.a. Brass) ID A Figure 2; Cross section 5,7	Dulais Colliery West Slant (1927 – 1939)	Not impacted by open casting
Outer track loop - south and access track (Figure 2)	Peacock (a.k.a. Brass) ID A Figure 2; Cross section 6,7	Dulais Colliery West Slant (1927 – 1939)	Not impacted by open casting
	Peacock (a.k.a. Brass) ID B Figure 2; Cross section 6,7,8,9	Dulais Colliery East Slant (1927 – 1939)	Not impacted by open casting
	Four feet (a.k.a. Cornish) ID C Figure 2; Cross section 6	Abercrave Colliery (1953, completion 1973)	Nant Helen open cast (until 1995)
Outer track loop – north (Figure 3)	Gnapog (a.k.a. Bryn) ID D Figure 3; Cross section 10	Cwmtawe Colliery (1929)	Not impacted by open casting
	Big (a.k.a. Nine Feet) ID E Figure 3; Cross section 1	Abercrave Colliery (1941, completion 1973)	Not impacted by open casting
Inner track loop – north (Figure 3)	Bluers ID F Figure 3	Duffryn Colliery (1916)	Not impacted by open casting
Outer track loop – west and Inner track	Four feet (a.k.a. Cornish) ID G Figure 4; Cross section 4	International Colliery (1939)	Nant Helen Extension open cast (until 2020s)
	Four feet (a.k.a. Cornish) ID C Figure 4; Cross section 4	Abercrave Colliery (1953, completion 1973)	Nant Helen open cast (until 1995)

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Location	Seam	Colliery (abandonment/ completion plans dates)	Open Cast
loop - west (Figure 4)	White (a.k.a. White Four Feet) ID H Figure 4; Cross section 5	Abercrave Colliery (1953, 1963, completion 1973)	Nant Helen open cast (until 1995) Nant Helen Extension open cast (until 2020s)
Washery (Figure 5)	Peacock (a.k.a. Brass) ID B Figure 5; Cross section 7,11	Dulais Colliery East Slant (1927 – 1939)	Not impacted by open casting
	Bluers ID J Figure 5; Cross section 11	Onllwyn Colliery (1953, completion 1982)	Not impacted by open casting
	Brass ID K Figure 5; Cross section 11	Onllwyn Colliery (1951, completion 1949)	Not impacted by open casting
	Potential unrecorded shallow workings		Not impacted by open casting

6. Conceptual site model

A preliminary Conceptual Site Model (CSM) has been developed for the main site and the washery site based on the available information. This is a fundamental stage of the risk assessment process as set out in the 2021 CL:AIRE guidance¹. The CSM represents the site specific ground conditions and the processes that control the generation, transport, migration and potential impacts of mine gas to receptors. The CSM relevant to the proposed development is presented below and is supported by a series of cross sections (Figures E1 to E3) and plans (Figures 1 – 6 of the Mining Study), all included in Appendix B to this note.

6.1 Main site

6.1.1 Potential sources

The underlying Coal Measures strata are a potential source of ground gas (methane). There is potential for the historic coal mining to have caused the stored ground gas to desorb into the mine workings or existing boreholes. Based on the available groundwater regime information, the underground mine workings beneath the Main site are unflooded and therefore, there is a potential for mine gas generation.

As discussed in section 5.6, in areas of opencast workings, the recorded mine entries (shafts/adits) have most likely been excavated out and the potential for mine gas generation is very low. There is only potential for mine gas generation from underground workings located outside of opencast working areas. The areas of these remaining underground mineworkings beneath the proposed development are highlighted on Figures 1-6 (see Appendix B).

Coal can contain a significant amount of methane, the majority of which is normally adsorbed on coal seam surfaces. Additional methane can be present as a dissolved phase in interstitial porewater and local groundwater and as gaseous methane. The methane may also be present in the rocks

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surrounding a seam. Methane can also be produced (and driven out of coal) as a product of self-heating reactions when temperatures rise above about 50°C, but this contribution is likely to be insignificant in most cases.

The methane in coal is not generally mobile (on non-geological timescales) and is not emitted to the surface in sufficiently large amounts to pose a risk unless mining takes place. When the coal is mined (or a borehole drilled into an intact seam) the coal is fractured and the stored gas desorbs into the mine workings or borehole (the rate and length of time over which desorption takes place is highly variable in practice). The desorption occurs because of a reduction in the lithostatic and groundwater pressure. This can also occur when unworked seams above and below a worked seam are disturbed by ground movements. Abandoned mines can continue to release methane until the workings are completely flooded or the gas reserve is depleted. The CL:AIRE guidance states that abandoned mine methane emissions are characterised by a high rate of release immediately following closure, then falling to much lower rates of emission over a period of 8 to 10 years, with emissions potentially completely stopping after 15 to 20 years in some cases. This is likely to assume that no changes to the mine state occur during that period, i.e. the mine reaches an equilibrium. Renewed gas emissions may occur should the coal deposits be disturbed. All underground workings within the site area were completed nearly 50 years ago, which means that methane emissions are likely to have ceased. However, open casting operations encountered some of the underground workings, as summarised in Table 7, which may have disturbed the coal seams and instigated gas generation. Open casting was undertaken from 1950s until recently and, as summarised in Table 7, it may have impacted Four Feet (a.k.a. Cornish) and White (a.k.a. White Four Feet) seams worked through International and Abercrave Collieries. This may have increased the risk of methane emissions from these unflooded mines.

There is however a potential for carbon dioxide generation in the coal mine workings due to the oxidation of coal (lack of flooding within the workings). Carbon dioxide emission is also accompanied by emission of ethane, carbon monoxide and hydrogen. The same processes also occur in the colliery spoil heaps or backfill present within the main site. However, the longer the time coal has been exposed the lower the risk. Based on the site history, only Abercrave Colliery operated beyond 1940s, until its completion in 1973. The risk for carbon dioxide generation in the coal mine workings due to oxidation of coal in the older mines is very low, with a higher risk, albeit relatively low, in the more recently explored colliery. As discussed above, there may also be an increased risk in collieries more recently disturbed due to open cast mining.

The potential for mine gas emissions occurring from unrecorded early workings is greatest close to coal outcrops at the ground surface, where there is shallow or no covering of overlying superficial deposits, which is where bell pits are most likely (potential indication of bell pitting was noted during the review of historic aerial photography). However, these are very old and the potential for mine gas emissions from these working is very low.

Carbon dioxide can also be produced when acidic mine water from workings reacts with carbonate in rocks or if it flows through open cast mine backfill. The reaction rates are normally low and rarely pose a risk of significant gas emissions. The potential for carbon dioxide to be produced from acidic mine water is very low.

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Based on the BGS logs, coal inclusions were recorded within the backfill. Oxidation of coal may produce carbon dioxide and methane. Therefore, the backfill is a potential source of ground gas and has been taken further into consideration (refer to the ground gas risk assessment presented in Arup's GIR⁸).

6.1.2 Potential receptors

It is understood that the proposed GCRE rail test track within the main site does not include any buildings. There will be limited relatively shallow confined spaces and these are drainage trenches. The following potential receptors to mine gas have been identified:

- During construction - construction workers involved in the earthworks to form the plateaus (provided by the Complementary Earthworks scheme) are potential receptors likely to be exposed to mine gas, particularly where the excavations would encounter mineworkings (area of inner track loop -south - Dulais Colliery West Slant - Peacock (a.k.a. Brass) seam). These receptors will need to be taken further into consideration in the assessment.
- During construction – mineworkings treatment - there is a risk to site neighbours (workers and residents of the nearest development present approximately 250m to the west off-site) should mine gas be displaced due to grouting of the underground mine workings (outside of opencast working areas) and migrate and cause gas emissions to increase off-site. These receptors will need to be taken further into consideration in the assessment.
- During operation - maintenance workers may be involved in excavations, although these are likely to be relatively shallow. Mine gas may accumulate in confined spaces associated with the site drainage or other service corridors. Site operators/maintenance workers may be exposed to accumulated mine gas. These receptors will be considered further in the assessment.

6.1.3 Potential pathways

The following potential pathways of mine gas migration in relation to the proposed development in the Main site have been identified:

- During construction - Grouting of the shallow mine workings recorded under the site is likely to displace mine gas in the short term or in the long-term change migration pattern, cutting off the existing venting or migration pathways and cause gas emissions to increase elsewhere off-site (nearest development present 250m west off-site). The sandstone layers within the SWCM may form a migration pathway due to their anticipated high permeability. In addition, interconnection of the underground mineworkings (including through faults) needs to be considered in this context. This pathway will need to be taken further into consideration in the assessment.
- During construction and operation - A number of recorded and potentially unrecorded shallow workings have been identified potentially at shallow depth. There are several old shafts/adits present under the site which are potentially connected to unflooded workings. Bell pit shafts can form pathways from the coal seam directly to the surface. There are also potentially unsealed site investigation boreholes within the site. These are all likely to act as a pathway to mine gas and can also cause pockets of trapped gas that are pressurised. This

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may pose a risk during excavation works as well as during operation should service trenches were constructed in their vicinity. This pathway will be considered further in the assessment.

- During construction and operation - The site for the most part is devoid of superficial deposits and where present, the thickness of the superficial deposits within the main body of the site is likely to be limited (~3m) and discontinuous. Permeable backfill is anticipated over potentially deeper mine workings (although anticipated to be limited, the majority having been removed in areas of opencast workings) and mine gas may migrate towards the surface where groundwater is below the workings. This may pose a risk during excavation works as well as during operation should service trenches were constructed in their vicinity. This pathway will be considered further in the assessment.
- During construction and operation - There are two named faults crossing the site with a NNW-SSE strike (Pwllau Bach Fault and Chapel Fault), as well as two other parallel unnamed faults which protrude into the northern boundary of the site. These are potentially connecting to unflooded workings (anticipated groundwater levels between ~170m bgl in the east and ~50m bgl in the west of the Nant Helen extension and 130-200m bgl within the main site area). The faults may act as potential pathways of mine gas being pushed towards the surface due to change in barometric pressure, rising groundwater or thermal gradient which varies seasonally and may cause increased gas emissions in summer. There is a risk to construction and maintenance workers and this pathway will be considered further in the assessment.

6.2 Washery

6.2.1 Potential sources

The underlying Coal Measures strata with worked coal seams are a potential source of ground gas (methane, ethane, carbon dioxide, carbon monoxide and hydrogen). There are recorded workings to the west of the Glyncorrwg Fault including the Dulais Colliery East Slant within the Peacock (a.k.a. Brass) seam (western end of the Washery site) and the Onllwyn Colliery within Bluers and Brass seams (western part of the site). To the east of the fault, there is a potential for unrecorded mineworkings beneath most of the eastern washery site area. There are numerous adits and shafts recorded in this site area, although the completed investigations did not identify the presence of mine entries.

Mining related voids in the unrecorded workings area could be as shallow as <10m below surface level. Voids were encountered by one of the boreholes (BH30) at ~10m and ~20m bgl, and further investigations are recommended to identify the extent of voiding beneath the site.

Based on the monitored groundwater levels (0.1 to ~7mbgl) these workings are likely to be permanently flooded with less than a meter in groundwater level variations. Therefore, as discussed in Section 6.1.1, carbon dioxide generation potential for these mineworkings is considered to be very low. In addition, as discussed in Section 6.1.1, methane potential generation decreases with time. The most shallow unrecorded mineworkings are likely to have been worked at least 50 years ago and therefore the methane emissions are likely to have ceased. Therefore, mine gas generation in these mineworkings is considered to be very low.

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The main area of risk is around former shafts or adits or where faults provide a preferential pathway to the surface. Based on the abandonment plans, the recorded mineworkings do not extend to the fault line although there is a risk of the rock being more fractured within the fault zone, which can extend to the mineworkings. The extent of the unrecorded mineworkings in relation to the fault is unknown.

The colliery spoil heaps and made ground anticipated to be present under the washery are also potential sources of ground gas. Refer to the ground gas risk assessment presented in Arup GIR⁸ for further details.

6.2.2 Potential receptors

The following potential receptors of mine gas migration in relation to the proposed development have been identified:

- During operation - End users of the development such as railway testing facilities workers and visitors of the testing facility are potential receptors via inhalation of mine gas emissions into the proposed buildings. These receptors will be considered further in the assessment.
- During operation - The proposed buildings are potential receptors with respect to potential combustion in relation to mine gas accumulation. These receptors will be considered further in the assessment.
- During construction - There is a risk to site neighbours (residents of the nearest housing development present approximately 60m to the south off-site) should mine gas be displaced due to grouting of the underground mine workings and migrate and cause gas emissions to increase off-site. These receptors will be further considered in the assessment.
- During construction and operation - construction workers involved in the construction of the GCRE rail depot and storage facility and buildings forming the Innovation Hub as well as further Industrial/Commercial developments. During operation, maintenance workers are also potential receptors. These receptors will be considered further in the assessment.

6.2.3 Potential pathways

The following potential pathways of mine gas migration in relation to the proposed development in the Washery have been identified:

- During operation - Areas of known shallow underground working (Peacock seam) and unrecorded workings to the east of the fault (area of inferred coal seam outcrops of the New, Grey, Rhyd and Upper Bluers) are shown to be present within the washery. Mining related voids could be as shallow as >10m below surface level. No recorded mine entries have been identified in the locale of the inferred outcrops. Based on the available information, the shallow workings are likely to be flooded with minimal groundwater level variation. Therefore, the risk from mine gas desorption within the workings and migration upwards is low (water pressure exceeds desorption pressure and limits availability of oxygen and transport of gases). However, seasonal fluctuation in groundwater levels under the washery, particularly in the summer drier months needs to be confirmed by further assessment.
- During construction and operation - Piles may be required to provide a suitable founding solution for some of the proposed structures with large loads or sensitive to ground

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movement within the washery. Subject to a selected piling technique, piles may create preferential flow paths allowing for vertical migration of mine gas into confined spaces within the structures/buildings (where these penetrate the limited low permeability superficial deposits). This will be considered further in the assessment.

- During operation - Deep drainage of soakaways (drainage trenches and networks) may allow shallow lateral migration of mine gas. Attenuation tanks and soakaways can facilitate secondary storage of significant volume of mine gas. These will need to be taken into consideration.
- During construction - Grouting of the shallow mine workings recorded under the site is likely to displace mine gas in the short term, cutting off the existing venting or migration pathways and cause gas emissions to increase elsewhere off-site (nearest development present 250m west off-site). The sandstone layers within the SWCM may form a migration pathway due to their anticipated high permeability. This pathway will need to be taken further into consideration in the assessment.
- During construction and operation - Permeable made ground is anticipated to be present under the site. Superficial natural deposits (peat or glacial till) are present but at limited thickness (~2-3 m), and are absent in some locations. There is potential (albeit low) for mine gas migration towards the surface and this pathway will be considered further in the assessment.
- During construction and operation - There is one named fault crossing the site with a NNW-SSE strike (Glynccorrwg Fault) dividing the bedrock beneath the site into different blocks. This fault may be connecting the recorded with unrecorded workings. Based on monitored groundwater levels, the underground workings are likely to be flooded however, groundwater seasonal fluctuations, particularly during drier summer months need to be further explored. This pathway will need to be taken further into consideration in the assessment.

6.3 Plausible source-pathway-receptor linkages

Plausible source-pathway-receptor linkages (PPLs) related to mine gas have been identified in relation to the main site and the washery as summarised below (also illustrated in Figures E1 – E3).

During construction, construction workers involved in earthworks including formation of the plateaus (provided by the Complementary Earthworks scheme) or involved in construction of foundations, are potential receptors of ground gas migration. During operation, maintenance workers involved in excavations are also potential receptors to ground gas. These receptors may be exposed to mine gas, while working in semi-confined spaces such as deep excavations, particularly where mineworkings or mine entries are encountered during the works. The risk will require management during construction/intrusive maintenance work via appropriate health and safety management systems. This plausible linkage will not be considered further in the assessment.

Main site

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PPL	Source	Pathway	Receptor
PPL 1	Shallow unflooded mineworkings (<30m depth)	Mine gas generation and migration to surface within scheme and accumulation in confined spaces (e.g. drainage network, underground services, etc)	Maintenance workers
	Mine entries within site		
PPL 2	Shallow flooded mineworkings (<30m)	Mine gas generation and migration to surface if seasonal GW fluctuations occur and accumulation in confined spaces (e.g. drainage, underground services, etc)	Maintenance workers
PPL 3	Shallow mineworkings requiring treatment	Displacement of mine gas due to mine workings treatment causing mine gas migration off-site	Scheme neighbours

Significant mine gas migration from mine workings deeper than 30m is unlikely. There is a potential for mine gas migrating upwards through the permeable backfill from deep workings bellow the backfilled opencast areas. However, the proposed scheme is unlikely to change the current regime for these deep mineworkings. The completed ground gas monitoring and assessment did not identify elevated concentrations of ground gas and therefore the risk to site workers from deep mines is considered very low.

Washery

PPL	Source	Pathway	Receptor
PPL 3 (common with main site)	Shallow mineworkings requiring treatment	Displacement of mine gas due to mine workings treatment causing mine gas migration off-site	Scheme neighbours
PPL 4	Shallow unflooded mineworkings (<30m depth)	Mine gas generation and migration to surface through permeable ground if seasonal GW fluctuations occur and accumulation in confined spaces (e.g. drainage network, underground services, etc)	Maintenance workers
	Mine entries (<20m from site)		
	Unrecorded shallow mineworkings		
PPL 5	Deep flooded mineworking (30-150m)	Mine gas generation and migration to surface through a fault zone if seasonal GW fluctuations occur and accumulation in confined spaces (e.g. drainage network, underground services, etc)	Maintenance workers
PPL 6	Shallow unflooded mineworkings (<30m depth)	Mine gas generation and migration to surface through foundations (including piles) if seasonal GW fluctuations occur and accumulation in buildings	End users (building users)
	Unrecorded shallow mineworkings		

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	Mine entries (<20m from site)		
PPL 7	Deep flooded mineworking (30-150m)	Mine gas generation and migration to surface through foundations (including piles) in area of fault zone if seasonal GW fluctuations occur and accumulation in buildings	End users (building users)

7. Initial mine gas risk classification

Based on both the preliminary desk study and initial ground investigation information, the mine gas risk classification process has been followed in accordance with the 2021 CL:AIRE guidance¹. The CL:AIRE guidance presents the flowchart of the risk classification.

7.1 Main site

The conceptual site model indicates the presence of flooded (with unconfirmed potential for variable groundwater level) and unflooded shallow (<30m) mineworkings as well as mine entries within the area of proposed development. In accordance with the guidance this classifies the site as high risk zone. However, taking into account the age of the abandoned unflooded shallow workings and the fact that these were not disturbed by open cast operations, the gas generation potential is considered very low, and therefore the overall moderate level of risk is more appropriate. Where the proposed development is likely to disturb the mineworkings, which potentially may lead to renewed gas generation, these mineworkings will be treated and as such the long-term pathway for gas migration into the development area would be eliminated.

There are no buildings / enclosed spaces proposed as part of the main site development. However, the testing tracks and immediate site will be served by utilities such as drainage and cabling. Mine gas migrating from shallow mineworkings or mine entries may accumulate in these spaces and pose a risk to maintenance workers. On confirmation of design and location of utilities in relation to the identified sources, further assessments will be required to confirm if the pathway is viable and allow review of the risk classification.

In areas of flooded mineworkings, more information on seasonal groundwater level variations in relation to the workings needs to be gathered to confirm if these workings pose a risk.

Several mineworkings have been identified as requiring treatment. The design of the treatment has not yet been derived and therefore the level of risk to off-site receptors cannot be assessed. On confirmation of the design, an assessment is required to identify the risks and mitigation.

7.2 Washery

The conceptual site model indicates the presence of flooded (with unconfirmed potential for variable groundwater level) shallow (<30m) and deep flooded (30-150m) mineworkings that may be connected with the surface through a fault zone. There are also mine entries within 20m of the area of proposed development. In accordance with the guidance this classifies the site as high risk zone. However, taking into account the age of the abandoned workings, the gas generation potential is very low, and therefore the overall moderate level of risk is also more appropriate.

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The proposed development in the washery site includes buildings / enclosed spaces with associated services. The buildings are likely to be founded on deep piled foundations. Mine gas migrating from shallow mineworkings or mine entries may accumulate in these spaces and pose a risk to maintenance workers. On confirmation of foundation design and location of buildings and utilities in relation to the identified sources, further assessments will be required to confirm if the pathway is viable and allow review of the risk classification.

As with the main site, in areas of flooded mineworkings, more information on seasonal groundwater level variations in relation to the workings needs to be gathered to confirm if these working pose a risk.

An area of shallow mineworkings has been identified as requiring treatment. As with the main site, the design of the treatment has not yet been derived and therefore the level of risk to off-site receptors cannot be assessed. On confirmation of the design, an assessment is required to identify the risks and mitigation.

8. Conclusions and recommendations

The preliminary mine gas risk assessment has identified potential plausible source-pathway-receptor linkages related to mine gas within the main site and washery. Based on the preliminary CSM the site is considered to be a moderate risk zone. In accordance with the guidance, this requires a detailed mine risk assessment to proceed with a risk based mitigation design.

The proposed development design is currently being developed and may render the identified plausible pollution linkages as no longer viable. In addition, there is currently insufficient data on groundwater levels in areas of the flooded mineworkings to give greater level of certainty with respect to low risk from flooded mineworkings and this requires further investigations. The completed investigations in the Washery area also identified areas where further investigations are needed to confirm the presence of shallow mineworkings or confirm the presence of recorded mine entries. In addition, data collection to confirm the gas emissions within the unflooded shallow mineworkings should be considered. Therefore, on confirmation of the design and with additional data, this preliminary risk assessment will require review to confirm if the identified PPLs are indeed plausible and review the risk classification of the site.

DOCUMENT CHECKING

	Prepared by	Checked by	Approved by
Name	Nick Kontochristos/ Agnieszka Lopez-Parodi	Tim Wilkinson	Charlie Martin
Signature			

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Date 10 October 2022

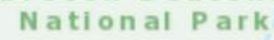
Drawings

Drawing 1 – Site Location Plan

Drawing 2 – Superficial cover, bedrock and ground investigation locations

Drawing 3 – Bedrock geology and completed ground investigation

Drawing 003A – Illustrative masterplan

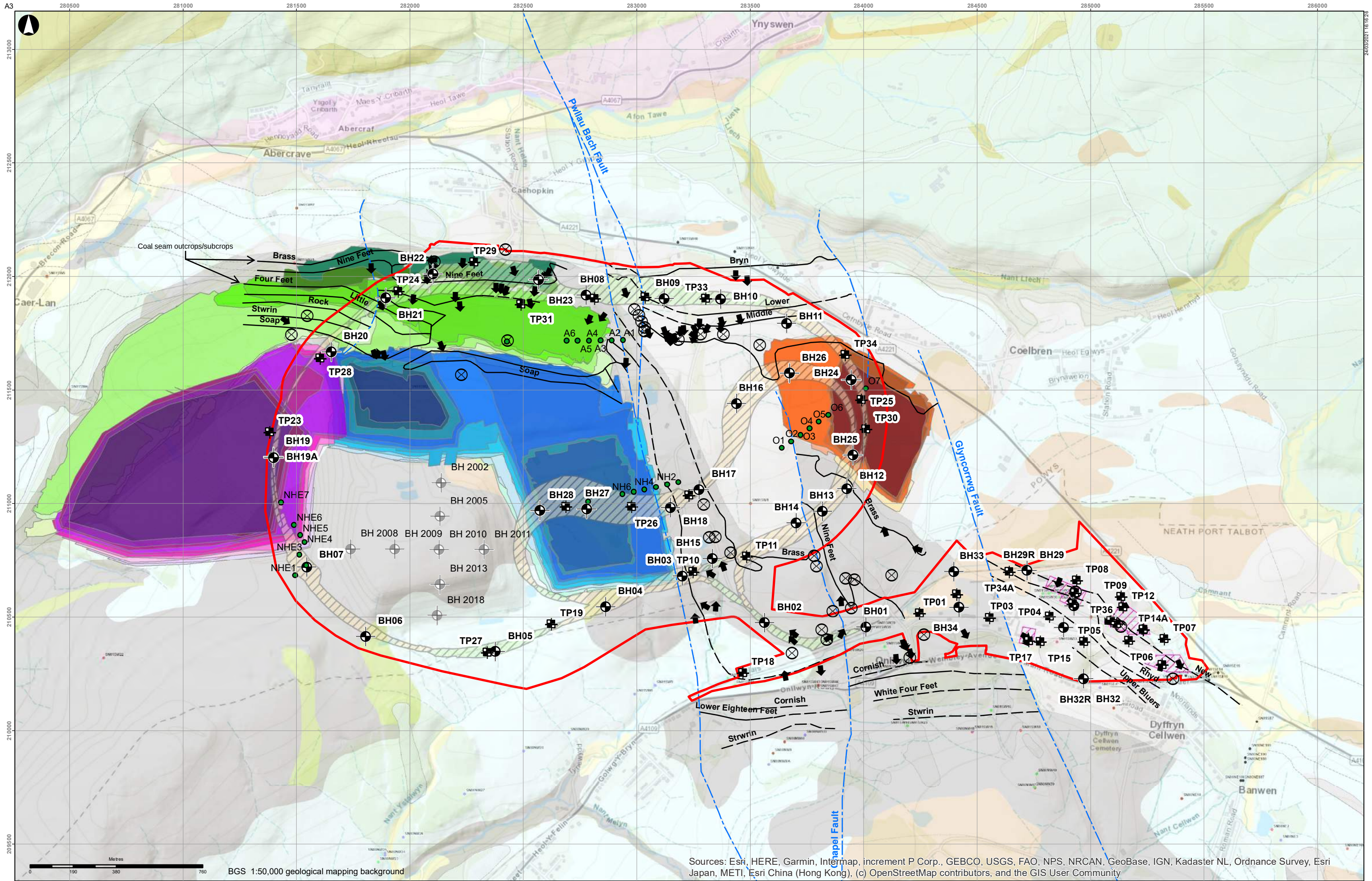


205000

 Site Boundary

Figure 1

Arup



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Legend

- Site boundary
- Shaft
- BH
- NH boreholes (1986)
- TP
- Adit
- Proposed embankment
- Proposed cutting
- Ground level monitoring pins
- Backfilled opencast sites
 - Gwaunton/Abercraf
 - Onllwyn
 - Nant Helen Extension
 - Nant Helen
- Geophysical survey areas

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Client

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Project Title

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Drawing Title

Drawing 2 - Superficial cover, bedrock and ground investigation locations

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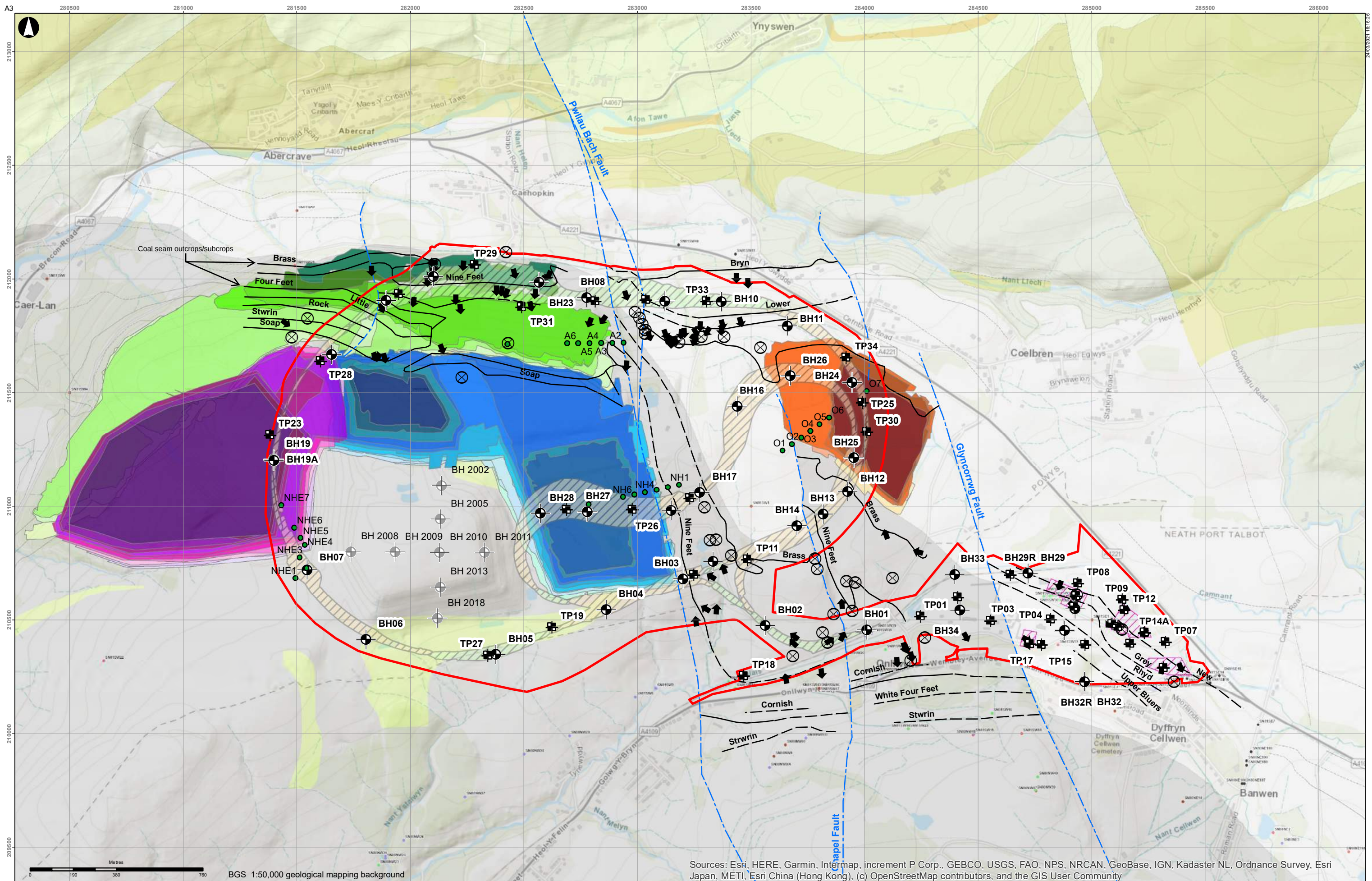
Role
Geotechnical

Suitability
For Issue

Arup Job No
264904

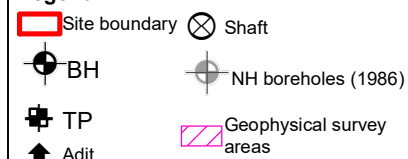
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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Legend



Backfilled opencast sites



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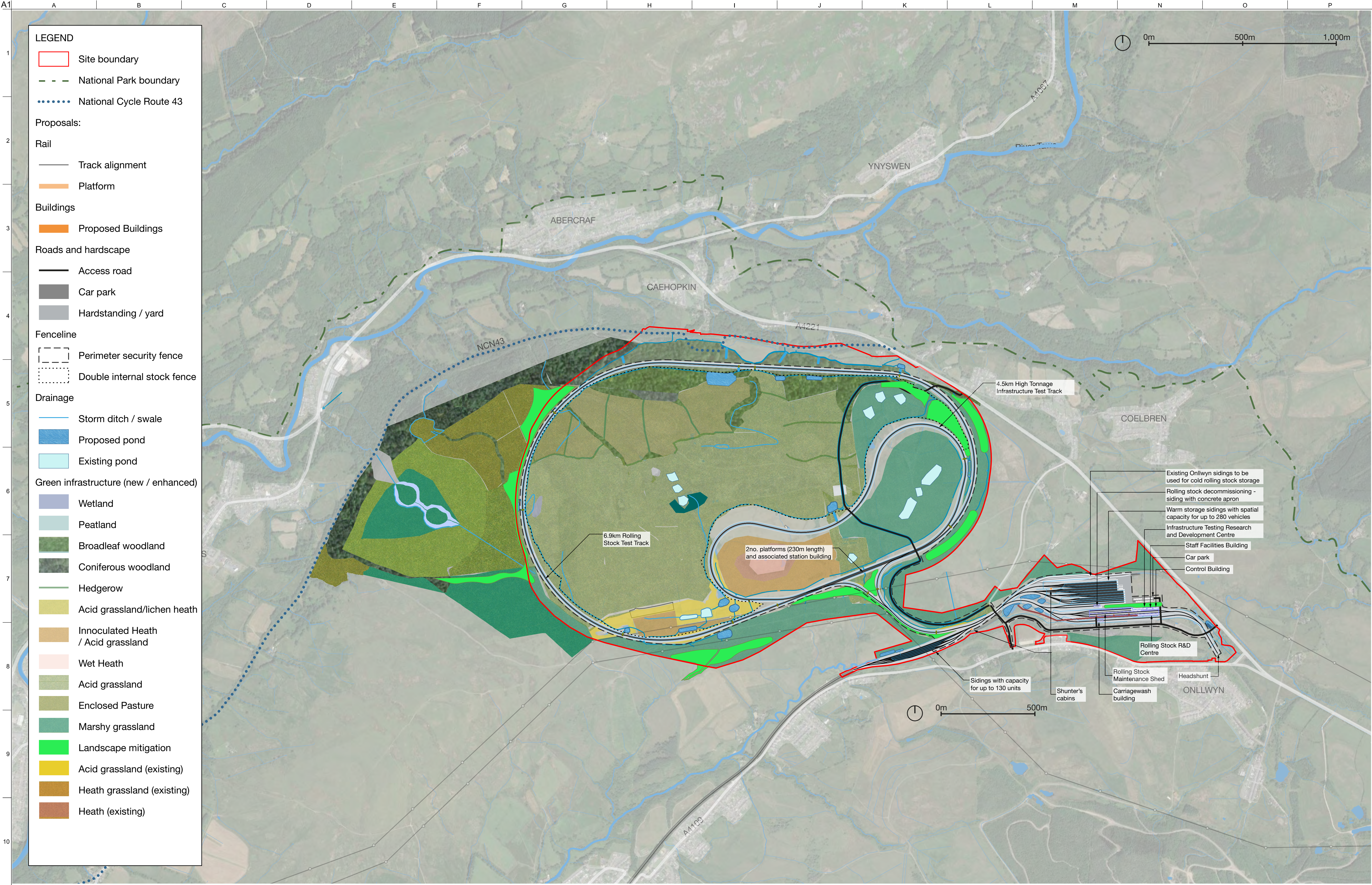
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Drawing Title

Drawing 3 - Bedrock geology and completed ground investigation

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Role	
Geotechnical	
Suitability	
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4 Pierhead St, Capital Waterside
Cardiff, CF10 4QP
T +44(0)29 20475727 F +44(0)29 20472277
www.arup.com

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Drawing Title

Illustrative Masterplan

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Discipline

Planning

Job No

264904-00

Drawing Status

PLANNING

Drawing No

003A

Issue

02

Job number 284523
Date 10 October 2022

Figures

Mining Study figures 1 – 6

Figure E1 – Sections 1 – 4 including CSM

Figure E2 – Sections 5 – 9 including CSM

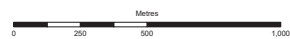
Figure E3 – Sections 10 – 11 including CSM



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Legend

- Site Boundary
- Embankment
- Cutting



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Site Location Plan

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Suitability

For information

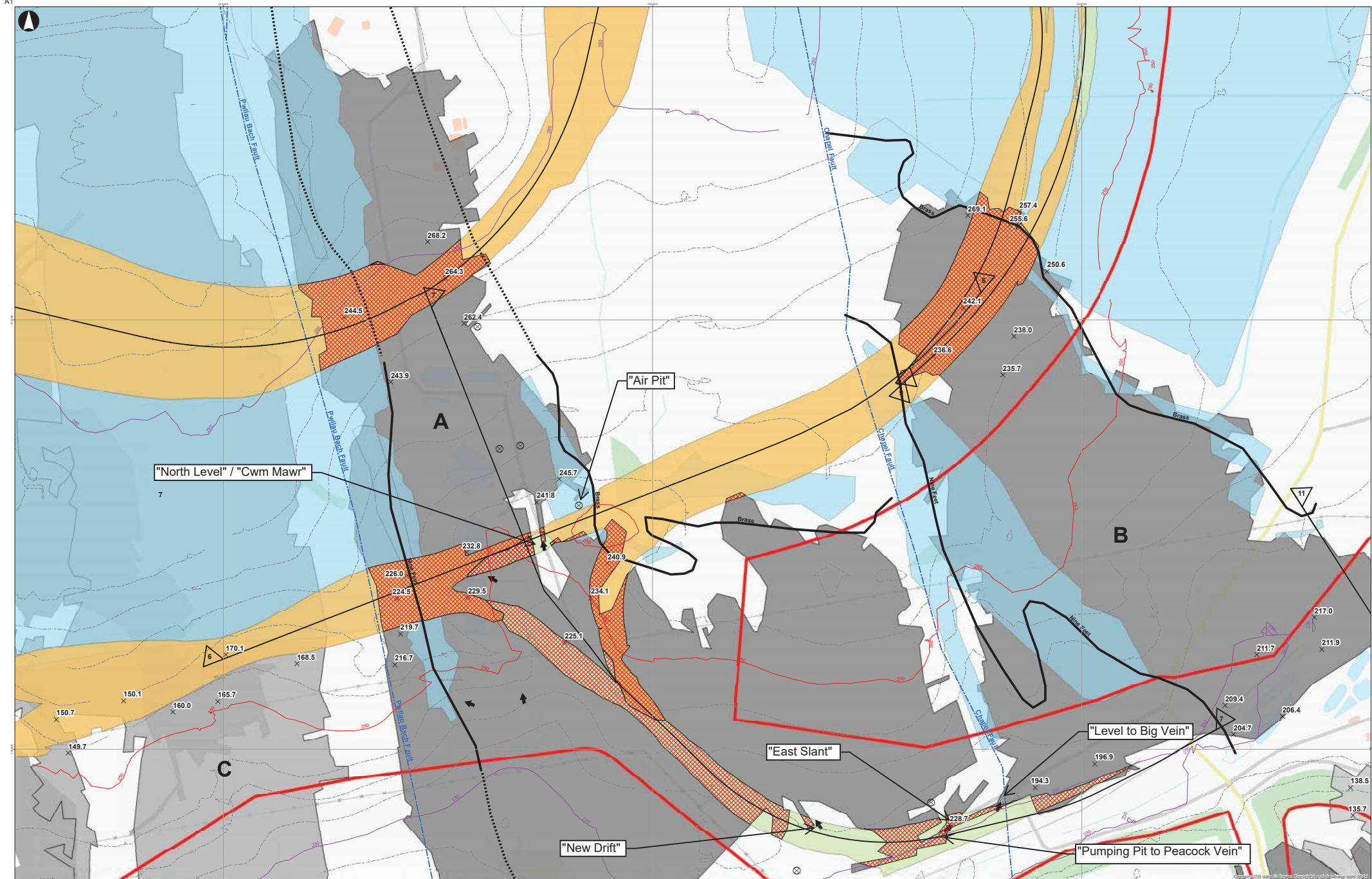
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Figure 1

P01



Legend

- Site Boundary
- Embankment
- Cutting
- Previously Opencast Sites
- Working Levels
- Adits
- Shafts
- Observed Seam Outcrop
- Inferred Seam Outcrop
- Dulais Peacock
- Abercave Four Feet
- Recorded shallow workings
- Potential unrecorded shallow workings

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Metres

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P01

Figure 2

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P01

Figure 2

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Figure 2

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Figure 2

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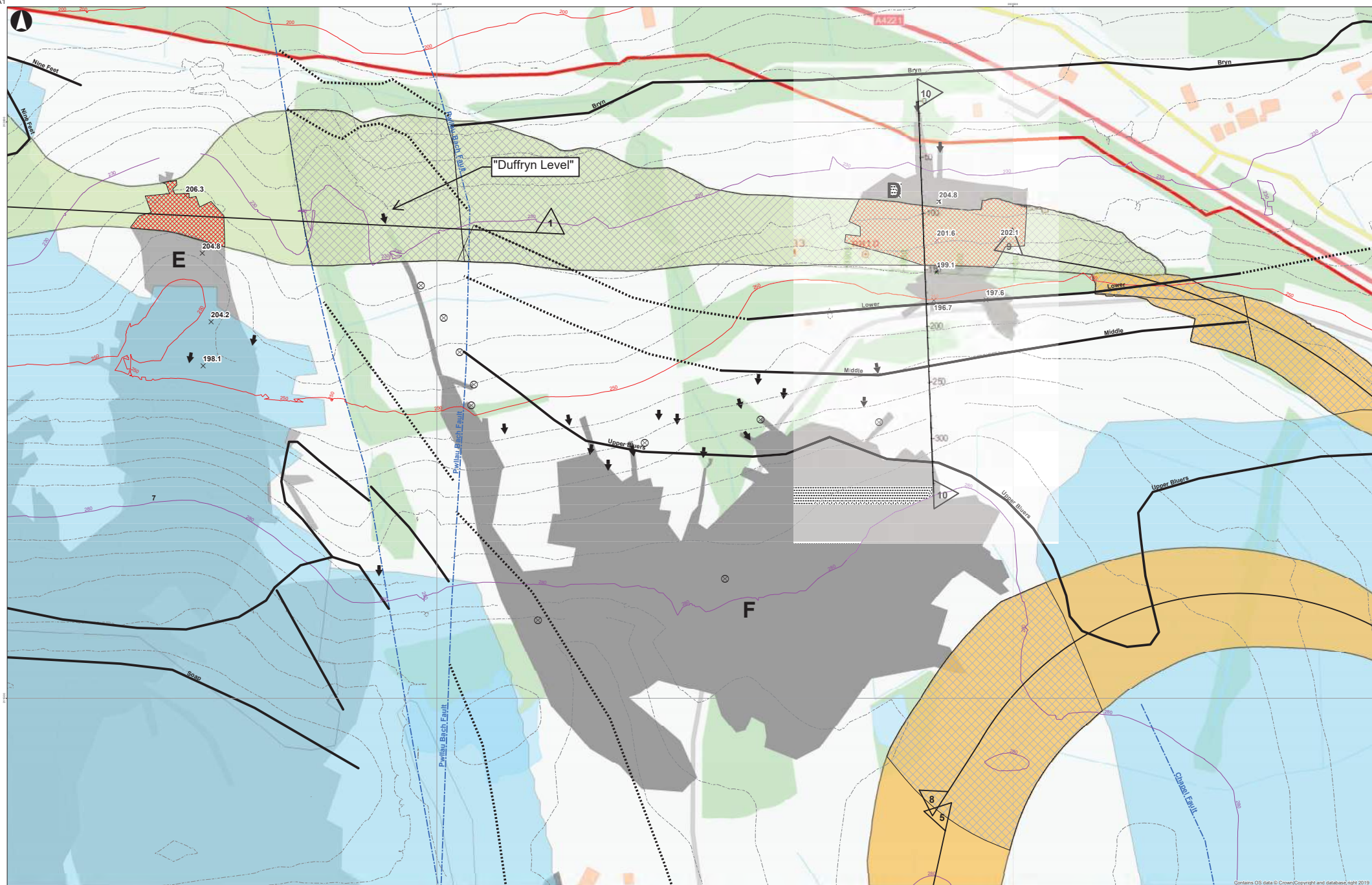
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Figure 2



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Legend

-  Site Boundary
  Embankment
  Cutting
  Previously Opencast Sites
  Adits
  Shafts
  Working Levels
  Observed Seam Outcrop
  Inferred Seam Outcrop
  Potential unrecorded shallow workings
  Cwmataw Bryn
  Abercrag Big
  Duffryn Bluers
  Recorded shallow workings
- 0 25

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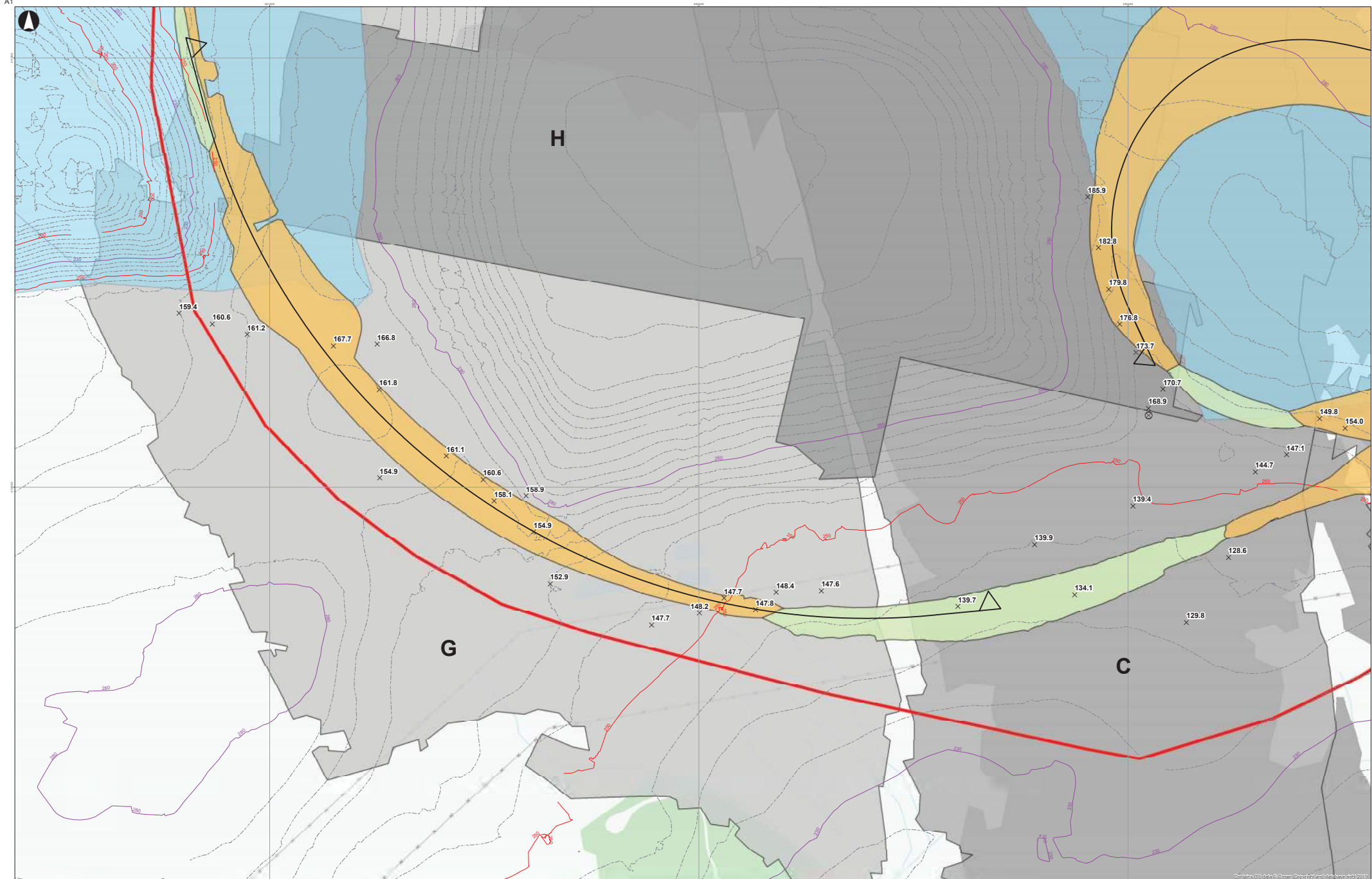
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Project Title
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Drawing Title
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Role	
Geotechnical	
Suitability	
For Information	
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Name	

Figure 3



Legend

- Site Boundary
- Embankment
- Cutting
- Previously Opencast Sites
- Working Levels_Dulais Peacock
- Adits
- Shafts
- Abercraive Four Feet
- International Four Feet
- Abercraive White
- Recorded shallow workings
- Potential unrecorded shallow workings

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Risk Zone C

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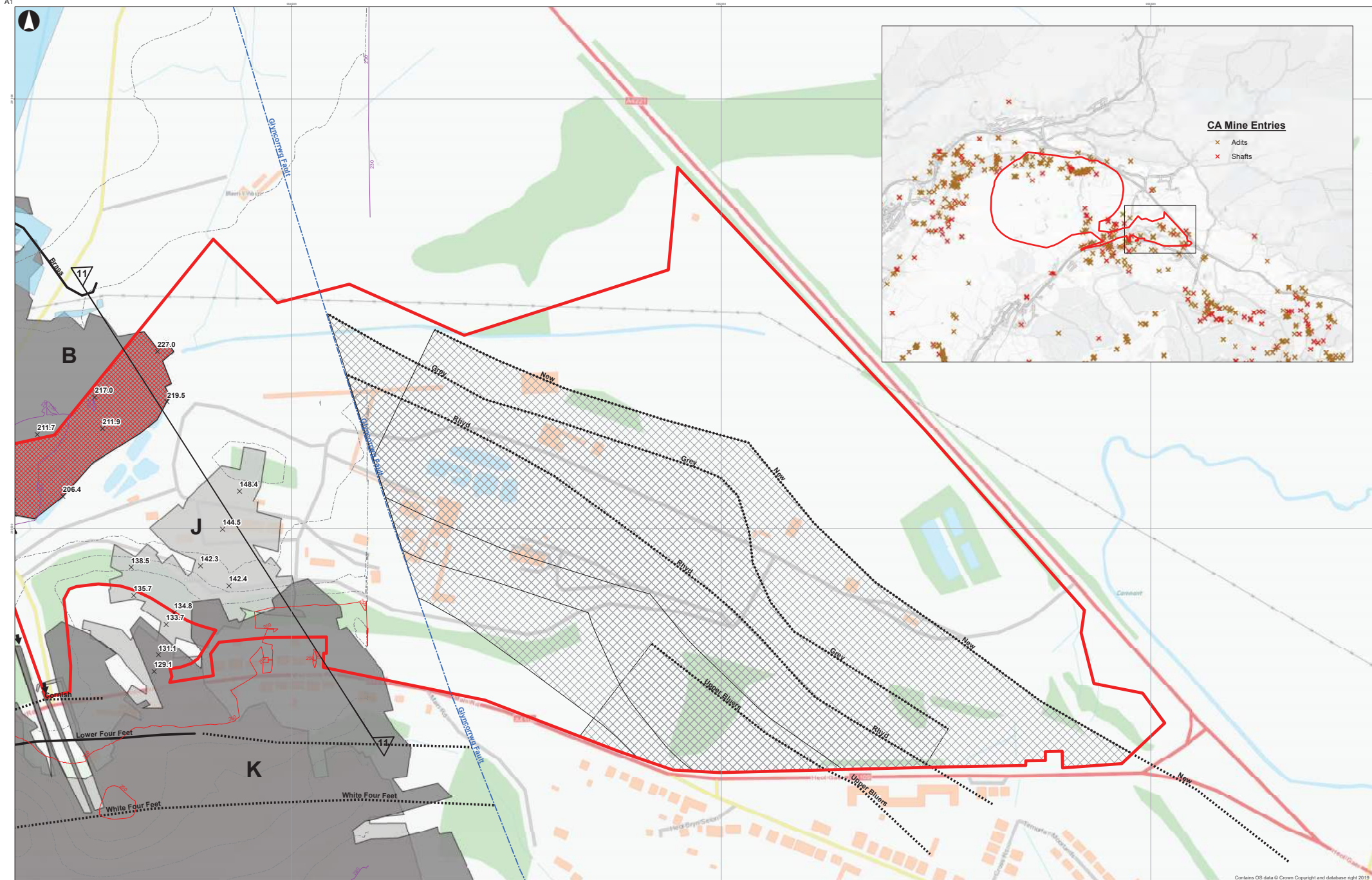
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Suitability
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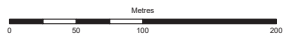
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**Legend**

- Site Boundary
- Previously Opencast Sites
- Working Levels
- Adits
- Shafts
- Observed Seam Outcrop
- Inferred Seam Outcrop
- Dulais Peacock
- Onllwyn Bluers
- Onllwyn Brass
- Recorded shallow workings
- Potential unrecorded shallow workings



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Project Title

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Drawing Title

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Suitability

For information

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Name

Figure 5

P01



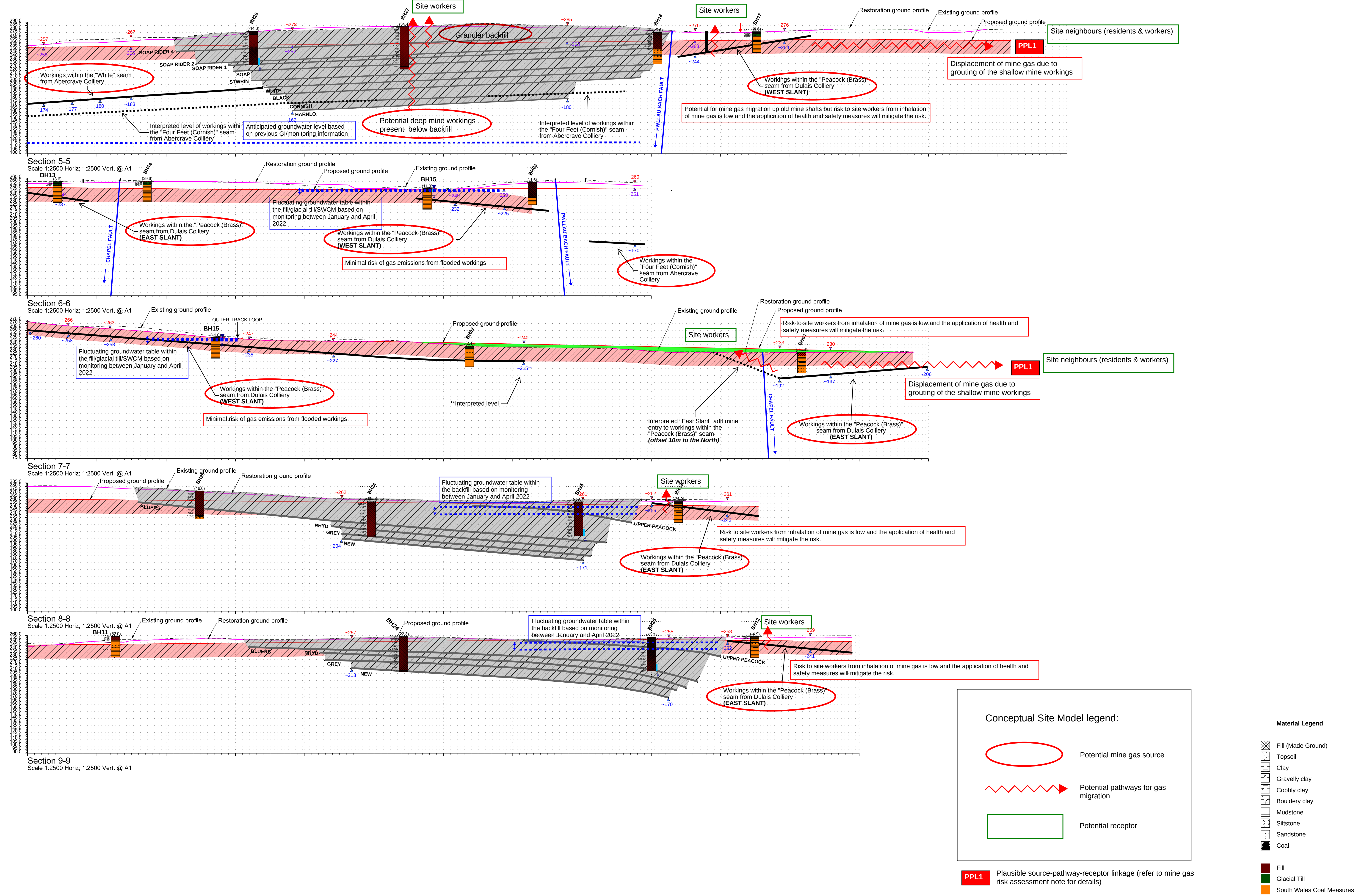
 Site Boundary
 Embankment
 Cutting
 Faults

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Opencast Sites

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Date 10 October 2022

Appendix A – Ground Gas Assessment Table

Borehole ID	GL (mAOD)	Installation Depth (mbgl)	Location	Response Zone (mbgl)	Stratum	Pipe Rn (diameter)	Date	Time (24hrs)	Atmos Pressure mBar	Differential Well Pressure mBar	Flow L/hr	CH ₄ %	CO ₂ %	O ₂ %	CO ppm	H ₂ S ppm	Water Level		Local Weather		Gas Screening Value		Characteristic Situation		Maximum Characteristic Situation
																	mbgl	mAOD	Recent	Current	Methane	Carbon Dioxide	Methane	Carbon Dioxide	Considering CH ₄ and CO ₂
BH07	271.278	10.00	Nant Helens main site	8.00-10.00	MDST (SWMCM)	A (50mm)	20/01/2022	08:00										Dry		Raining	Fine				
							31/01/2022	08:00	1018	0.00	0.00	0.00	2.60	18.90	0.00	0.00	Dry		Fine	Cloudy	0	0	1	1	1
							22/02/2022	08:00	1020	0.10	0.00	0.00	2.10	18.10	0.00	0.00	Dry		Raining	Raining	0	0	1	1	1
							09/03/2022		1015	0.00	0.00	0.00	1.90	18.10	0.00	0.00	Dry		Raining	Fine	0	0	1	1	1
							06/04/2022		967	0.02	0.00	0.50	3.50	8.70	0.00	0.00	Dry		Fine	Raining	0	0	1	1	1
							25/04/2022		989	0.00	0.10	0.00	0.00	21.20	0.00	0.00	Dry		Fine	Fine	0	0	1	1	1
BH15	236.953	5.00	Nant Helens main site	1.00-5.00	MG-BACKFILL /MDST (SWMCM)	A (50mm)	20/01/2022	08:15										0.93	236.02	Raining	Fine				
							31/01/2022	08:15	1018	0.00	0.00	0.00	1.80	19.40	0.00	0.00	0.4	236.55	Fine	Cloudy	0	0	1	1	1
							22/02/2022	08:15	1020	0.10	0.00	0.00	2.10	19.10	0.00	0.00	0.38	236.57	Raining	Raining	0	0	1	1	1
							09/03/2022		1015	0.10	0.00	0.00	1.50	19.30	0.00	0.00	0.35	236.6	Raining	Fine	0	0	1	1	1
							06/04/2022		968	0.06	0.00	0.10	0.20	21.00	0.00	0.00	0.5	236.45	Fine	Raining	0	0	1	1	1
							25/04/2022		990	-0.04	0.10	0.00	0.10	21.20	0.00	0.00	1	235.95	Fine	Fine	0	0.0001	1	1	1
BH16	280.709	10.00	Nant Helens main site	8.00 - 10.00	MDST (SWMCM)	A (50mm)	20/01/2022	08:30										4.53	276.18	Raining	Fine				
							31/01/2022	08:30	1018	0.00	0.00	0.00	1.40	19.30	0.00	0.00	4.52	276.19	Fine	Cloudy	0	0	1	1	1
							22/02/2022	08:30	1020	0.10	0.00	0.00	2.50	18.90	0.00	0.00	4.5	276.21	Raining	Raining	0	0	1	1	1
							09/03/2022		1015	0.10	0.00	0.00	1.90	19.00	0.00	0.00	4.45	276.26	Raining	Fine	0	0	1	1	1
							06/04/2022		966	0.12	0.00	0.10	0.10	21.70	0.00	0.00	4.75	275.96	Fine	Raining	0	0	1	1	1
							25/04/2022		986	-0.03	0.00	0.00	0.00	21.20	0.00	0.00	3.83	276.88	Fine	Fine	0	0	1	1	1
BH19A	255.32	28.20	Nant Helens main site	COLLIERY SPOIL	A (50mm)	20/01/2022	08:45											Dry		Raining	Fine				
						31/01/2022	08:45	1018	0.00	0.00	0.00	0.40	20.10	0.00	0.00	Dry		Fine	Cloudy	0	0	1	1	1	
						22/02/2022	08:45	1020	0.10	0.00	0.00	1.30	19.90	0.00	0.00	Dry		Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0.10	0.00	0.00	0.80	19.90	0.00	0.00	Dry		Raining	Fine	0	0	1	1	1	
						06/04/2022		969	0.01	0.00	0.00	1.20	20.30	0.00	0.00	Dry		Fine	Raining	0	0	1	1	1	
						25/04/2022		989	0.00	0.00	0.00	0.50	20.50	0.00	0.00	Dry		Fine	Fine	0	0	1	1	1	
BH22	213.006	34.00	Nant Helens main site	SLTST (SWMCM)	A (50mm)	20/01/2022	09:15											Dry		Raining	Fine				
						31/01/2022	09:15	1018	0.00	0.00	0.00	0.20	20.10	0.00	0.00	Dry		Fine	Cloudy	0	0	1	1	1	
						22/02/2022	09:15	1020	0.10	0.00	0.00	1.40	19.80	0.00	0.00	Dry		Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0.10	0.00	0.00	0.10	20.30	0.00	0.00	Dry				0	0	1	1	1	
						06/04/2022		970	-0.04	0.00	0.10	2.70	17.40	0.00	0.00	32.75	180.26	Fine	Raining	0	0	1	1	1	
						25/04/2022		993	-0.16	0.00	0.10	1.70	13.20	0.00	0.00	33.04	179.97	Fine	Fine	0	0	1	1	1	
BH25	257.707	49.20	Nant Helens main site	COLLIERY SPOIL	A (50mm)	20/01/2022	09:30											5.01	252.7	Raining	Fine				
						31/01/2022	09:30	1018	0.00	0.00	0.00	1.20	19.60	0.00	0.00	5	252.71	Fine	Cloudy	0	0	1	1	1	
						22/02/2022	09:30	1020	0.10	0.00	0.00	2.60	17.50	0.00	0.00	4.95	252.76	Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0.10	0.00	0.00	2.60	17.80	0.00	0.00	4.88	252.83	Raining	Fine	0	0	1	1	1	
						06/04/2022		969	-0.07	0.00	0.10	12.30	8.40	0.00	0.00	14.65	243.06	Fine	Raining	0	0	1	2	2	
						25/04/2022		989	0.00	0.10	0.10	10.90	9.80	0.00	0.00	15.05	242.66	Fine	Fine	0.0001	0.0109	1	2	2	
BH28	210.977	49.20	Nant Helens main site	COLLIERY SPOIL	A (50mm)	20/01/2022	09:45											Dry		Raining	Fine				
						31/01/2022	09:45	1018	0.00	0.00	0.00	3.20	15.90	0.00	0.00	Dry		Fine	Cloudy	0	0	1	1	1	
						22/02/2022	09:45	1020	0.10	0.00	0.00	2.60	16.20	0.00	0.00	Dry		Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0.10	0.00	0.00	3.00	16.10	0.00	0.00	Dry		Raining	Fine	0	0	1	1	1	
						06/04/2022		966	0.01	0.00	0.10	4.10	16.50	0.00	0.00	Dry		Fine	Raining	0	0	1	1	1	
						25/04/2022		992	-0.03	0.10	0.00	0.00	21.30	0.00	0.00	Dry		Fine	Fine	0	0	1	1	1	
BH29	230.736	15.00	Washery site	MDST (SWMCM)	A (50mm)	20/01/2022	10:00											0.31	230.43	Raining	Fine				
						31/01/2022	10:00	1018	0.00	0.00	0.00	2.90	18.20	0.00	0.00	0.83	229.91	Fine	Cloudy	0	0	1	1	1	
						22/02/2022	10:00	1020	0.10	0.00	0.00	2.40	17.80	0.00	0.00	0.78	229.96	Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0.10	0.00	0.00	2.00	18.00	0.00	0.00	0.7	230.04	Raining	Fine	0	0	1	1	1	
						06/04/2022		970	0.02	0.00	0.70	1.80	18.70	0.00	0.00	0.9	229.84	Fine	Raining	0	0	1	1	1	
						25/04/2022		992	-0.08	0.00	0.30	1.50	19.20	0.00	0.00	1.04	229.70	Fine	Fine	0	0	1	1	1	
BH30	230.738	4.00	Washery site	MG-FILL with coal and ash	A (50mm)	20/01/2022	10:15											3.04	227.70	Raining	Fine				
						31/01/2022	10:15	1018	0.00	0.0	0.0	2.0	18.4	0	0	3.2	227.54	Fine	Cloudy	0	0	1	1	1	
						22/02/2022	10:15	1020	0.10	0.0	0.0	2.4	18.0	0	0	3.01	227.73	Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0.10	0.0	0.0	2.0	18.2	0	0	2.95	227.79	Raining	Fine	0	0	1	1	1	
						06/04/2022		969	-0.19	0.4	0.8	5.2	3.2	0	0	3.1	227.64	Fine	Raining	0.0032	0.0208	1	2	2	
						25/04/2022		992	-0.08	0.1	0.4	0.0	20.2	0	0	3.6	227.14	Fine	Fine	0.0004	0	1	1	1	
BH31 (deep)	238.608	21.00	Washery site	MDST (SWMCM)	A (19mm)	20/01/2022	10:20											4.59	234.02	Raining	Fine				
						31/01/2022	10:20	1018	0	0	0	1.2	19.9	0	0	4.5	234.11	Fine	Cloudy	0	0	1	1	1	
						22/02/2022	10:20	1020	0	0	0	2.1	18.6	0	0	4.3	234.31	Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0	0	0	1.0	20.1	0	0	4.28	234.33	Raining	Fine	0	0	1	1	1	
						06/04/2022		969	0	0	0	0.0	21.3	0	0	4.9	233.71	Fine	Raining	0.0003	0	1	1	1	
						25/04/2022		992	-0.08	0	0.1	0.1	20.4	0	0	4.9	233.71	Fine	Fine	0.0002	0.0002	1	1	1	
BH31 (shallow)	238.608	5.00	Washery site	MG-FILL with coal	B (50mm)	20/01/2022	10:25											4.16	234.45	Raining	Fine				
						31/01/2022	10:25	1018	0.00	0.0	0.0	0.2	20.0	0	0	4.15	234.46	Fine	Cloudy	0	0	1	1	1	
						22/02/2022	10:25	1020	0.00	0.0	0.0	1.2	19.4	0	0	4.10	234.51	Raining	Raining	0	0	1	1	1	
						09/03/2022		1015	0.10	0.0	0.0	0.5	17.8	0	0	4.10	234.51	Raining	Fine	0	0	1	1	1	
						06/04/2022		969	0.05	0.4	0.0	4.6	16.1	0	0	Dry		Fine	Raining	0	0.0184	1	1	1	
						25/04/2022		992	-0.08	0.2	0.1	4.8	16.3	0	0	4.60	234.01	Fine	Fine	0.0002	0.0096	1	1	1	
BH32R	230.745	17.50	Washery site	220L J CONGLOMERATE (SWMCM)	A (50mm)	20/01/2022	10:30											2.91	227.84	Raining					

Appendix G. Factual Report AtkinsRéalis Ground Investigation 2022/2023

Global Centre of Rail Excellence (GCRE)

Stage 1 Ground Investigation

Factual Report

G22069

March 2023

GCRE Limited

Global Centre of Rail Excellence
Onllwyn
Neath Port Talbot
United Kingdom
SA10 9HN

Unit B3
Frams Enterprise Centre at Parc Busnes Edwards
Llantrisant
Pontyclun
CF72 8QZ

www.jacksongeo.co.uk



Report Control Sheet

Report Number

G22069

Date of Issue

March 2023

Site Address

Onllwyn Distribution Centre, Onllwyn, Neath, SA10 9HN

Report Preparation

Revision	Writer	Approver
Rev 0	Adam Putt BSc (Hons) FGS CGeol CSci EurGeol MEnvSc Registered Ground Engineering Professional	James Power BSc (Hons) FGS
	Signature 	Signature 
Rev 1	Adam Putt BSc (Hons) FGS CGeol CSci EurGeol MEnvSc Registered Ground Engineering Professional	James Power BSc (Hons) FGS
	Signature 	Signature 

Jackson Geo Services is a trading name of Jackson Drilling Holdings Limited – registered company number 06919550.

QMS ref: GEO-Q021

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1 Introduction

1.1 General

GCRE Limited entered into a contract with Jackson Geo Services (JGS) to complete a ground investigation at the Global Centre of Rail Excellence (GCRE) site (hereafter referred to as The Site). The contract was agreed during October 2022. As per the Construction Design and Management (CDM) Regulations (2015), parties were attributed the following responsibilities:

Table 1: Responsibility Under CDM

Client	GCRE Limited
Designer	Atkins (SNC-Lavalin)
Principal Contractor	Walters UK Limited
Sub-Contractor	Jackson Geo Services

1.2 Proposed Development

The site is proposed to be developed as a new rail testing and training centre, with the proposed development comprising a rail testing, storage and maintenance facility. The Phase 1 proposed works associated to this ground investigation comprise earthworks for the proposed rail depot and storage facility which will consist of the installation of multiple sidings for train stabling, inspection and maintenance sheds, fuelling roads and carriage wash facilities. In addition, to the track elements, it is also proposed to construct several buildings forming and Innovation Hub as well as further industrial/commercial developments.

1.3 Scope of Works

The scope of investigation was defined by Atkins and is detailed within specification document GCRE001-AWJV-EW-XX-SP-GE-00001 3.0 (dated November 2022) (hereafter referred to as The Specification). In summary, the scope of investigation comprised:

- ☑ Dynamic Sampling with Rotary Follow-on Coring
- ☑ Rotary open holing (probe holing) for mine workings
- ☑ Machine Excavated Trial Pitting
- ☑ In-situ Testing
- ☑ Geotechnical Testing
- ☑ Geoenvironmental Testing
- ☑ Factual Reporting
- ☑ Production of Digital Data in AGS4 format

1.4 Limitations

The project has been undertaken in accordance with The Specification and current standards and guidance as applicable (see References).

This report presents the observations made during desk based studies and the fieldwork period on a factual basis. Any observations within the report are limited to those which can be made based upon the information available at the time.

JGS consider the contents of the report have been produced accurately and the data presented is representative of the site conditions at the time. JGS assumes any third party data included in the report is accurate and correct. No responsibility is accepted by JGS for inaccuracies within third party data.

This report has been written to The Specification and is for use only in this context by the named Client and their advisers and is confidential to the named Client.

This report presents information on ground conditions, including groundwater, gas and contamination concentrations and soil properties, which are based upon the available dataset for the investigation. This dataset is considered representative of the site as whole, however is limited by the locations of investigation. Ground conditions, in particular Made Ground, can vary substantially and JGS do not accept responsibility for local unforeseen changes. Furthermore, groundwater, gas concentrations and chemical concentration can vary with time, atmospheric conditions and spatially dependent upon a variety of confining factors.

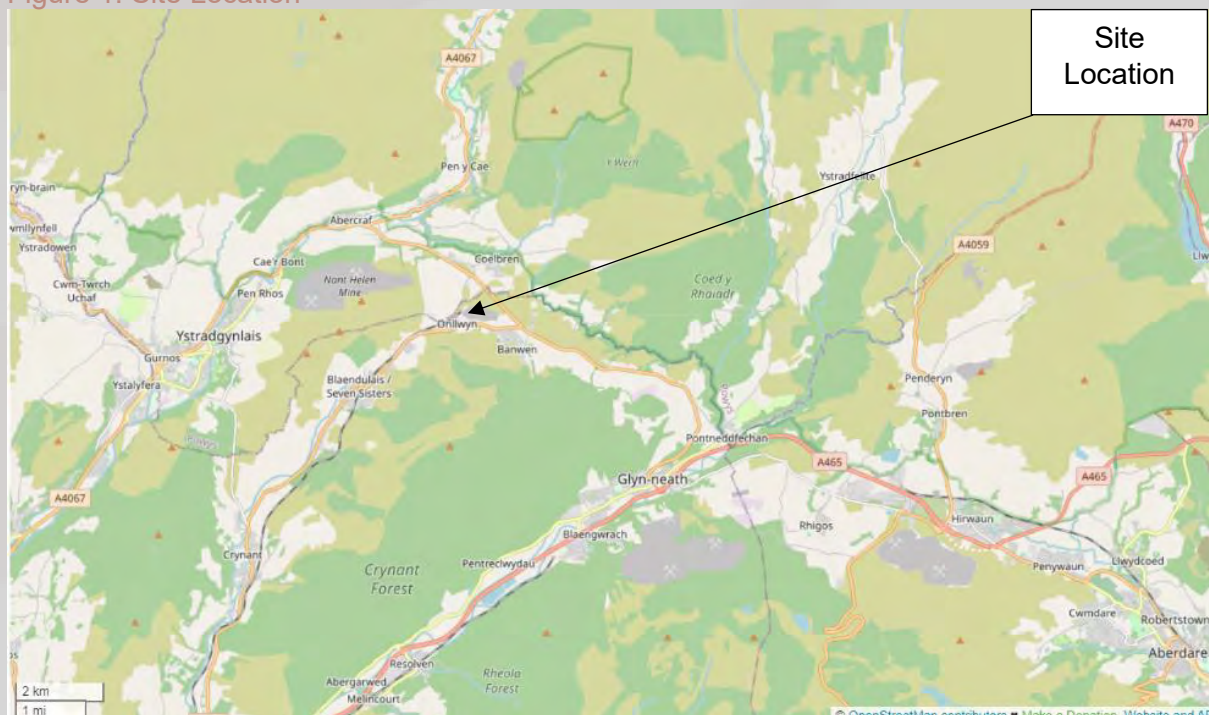
Consideration should be made as to the relevance of the information if the dataset is to be utilised after a significant period of time has elapsed from the date of investigation.

2 The Site

2.1 Site Location

The Site is situated at National Grid Reference (NGR) SN 844 104, and is approximately 200 m north of Onllwyn Welfare Hall. The location of The Site is shown in Figure 1:

Figure 1: Site Location



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2.2 Current Use

The Site comprises part of the now defunct Onllwyn Washery and Distribution Centre. It is pseudo-triangular in shape and measures approximately 830 m (west to east) and 170 m (north to south) along its longest axes. For descriptive purposes the site has been divided into two sections, the “main area” and the “northern embankment”.

Main Area

The Main Area was being decommissioned during the fieldwork period with many of the rail tracks, buildings, conveyors and related concrete slabs and basements in the process of being, or having already been, removed. There are several structures onsite relating to its previous use comprising a mixture of brick structures (substation and laboratory) and metal structures (fitting shops, stores, and associated buildings). Although the Main Area steps up in places (west to east) it is predominantly flat rising very gently from west to east. The exception to this is at the eastern most point of the Main Area where it rises moderately steeply from south to north. There are numerous drainage channels around the site that flow freely (east to west) during periods of rainfall. There are unnamed watercourse along the north and west of the site that feed in to (occasionally via settlement ponds) Avon Dulais. To the south of the Main Area are three brick buildings comprising a bath house, a main reception and a visitor's centre.

The northern boundary follows a railway track that was used to export the coal away from the site, beyond which is an area of grassy bog and grassland. The small settlement of Coelbren lies beyond the bog and grassland. The former Nant Helen Opencast Mine is to the north east. The west of the site is bound by Onllwyn Road, a highway. which also crosses the site via two bridges which are adjacent to each other. Beyond Onllwyn Road lies open grassland and the A4109 highway to the southwest which leads to Seven Sisters. Immediately to the south of the site are buildings and infrastructure associated with the washery, beyond which lie the settlements of Onllwyn and Bawneen, plus land associated with Mesgwyn Wind Farm and Walter's Arena further to the south. To the west the site is bounded by land associated with the washery including a weighbridge and a small independent coal merchant, beyond which lies grassland and woodland leading to The Brecon Beacons.

Northern Embankment

The Northern Embankment comprises a boggy grassed moorland area on the southern face of a east-west trending valley which heads towards Caehopkin. It is pseudo-triangular in shape and measures approximately 600 m (west to east) by 250 m (north to south) along its longest axes.

Parts of the site show signs that the Northern Embankment was once used as a tip for spoil (likely from mining at Nant Helen), however the majority if the area is covered in thick moorland type grass. Many areas of the site are very boggy. The area slopes steeply from south to north with a track in the centre of the site trending in the same direction which allows access. The area comprises approximately 6 fields with boundaries ranging from mesh fencing to hedgerows and banks.

Both northern and southern boundaries of the Northern Embankment are characterised by non-metalled tracks running east to west. The western boundary is another track (running north-south), and the eastern boundary comprises the A4221 highway.

There are two unnamed watercourses, both flowing north to south, however there are a number of routes that water takes during heavy rainfall.

2.3 Anticipated Ground Conditions

The anticipated ground conditions have been assessed using the data available on the British Geological Survey (BGS) GeoIndex (onshore) Map Viewer (2022) and the published BGS map (map no. 231, 1979), these are summarised within Table 2:

Table 2: Anticipated Ground Conditions

Artificial Ground	Made Ground	Artificial Deposit
Superficial Deposits	Peat in northern section of the site. None recorded in the remainder of the site.	Peat
Solid Geology	South Wales Middle Coal Measures Formation in the west of the site. South Wales Lower Coal Measure Formation in the east underlies the majority of the site.	Mudstone, Siltstone and Sandstone.

Areas of artificial ground, considered to be associated with the former washery and related mining activity are located to the south, south west and north east of the site only as isolated features.

There is an inferred fault of unknown displacement shown on the GeoIndex (onshore) Viewer. It trends south south-east to north north-west, through the site and also demarcates the geological boundary between the middle and lower South Wales Coal Measures.

It is known that mine workings associated with the South Wales Coal Measures are located beneath the site.

The Department for Environment, Food & Rural Affairs (DEFRA) MAGIC mapping system (2021) indicates The Site is located within an area where the bedrock is classified as a secondary A aquifer. The superficial (peat) deposits are not shown as being classified.

3 Fieldwork

3.1 General Information

The fieldwork was completed in two phases, the first phase was completed between 7 November and 23 December 2022, whilst the second phase was completed between 17 and 2 February 2023.

The ground investigation was undertaken in accordance with BS5930:2015+A1:2020. The works were supervised by a trained and competent JGS engineer.

The layout of the investigation locations and their unique identifiers were determined by Atkins and are listed within Schedule 2 of The Specification. This information was provided to JGS prior to works commencing onsite. Walters UK Limited set out the locations onsite using GPS survey equipment to set out the location to the co-ordinates provided.

Service drawings were provided to JGS by Walters UK Limited prior to works commencing on site and the location of the proposed investigation locations was checked against the service drawings prior to excavation.

Prior to excavation, each exploratory hole location was scanned using a Cable Avoidance Tool (CAT) to confirm the absence of services beneath the proposed excavation.

All exploratory hole locations, with the exception of machine excavated trial pits and rotary open (probe holes), were excavated to a depth of 1.20 m by hand prior to using mechanical plant. As hand excavation progressed, the excavations were scanned using a Cable Avoidance Tool (CAT) to continue to confirm the absence of services.

Where rotary open (probe) holes were completed, a trench was excavated to a depth of 1.20 m depth by hand around each proposed batch of drill hole locations to confirm no services had been laid into the area of investigation.

Where exploratory holes were extended into the Coal Measures, 5 in 1 gas monitors measuring carbon monoxide (CO), methane (CH₄), Carbon dioxide (CO₂), Oxygen (O₂) and Hydrogen Sulphide (H₂S) were placed at the well head during drilling in order to confirm gas concentrations, and 4 in 1 personal gas monitors were used within the drilling operatives breathing zones.

Photographs of the materials encountered were taken in accordance with The Specification and are presented in Appendix II.

Following completion of the fieldwork, all investigation locations been surveyed to National Grid and Ordnance Datum using GSP survey equipment. The location of the exploratory holes is shown on the drawing within Appendix I. The survey was completed by Walters UK Limited.

3.2 Exploratory Holes

The proposed numbers of exploratory holes, their unique identifiers, termination depths and installation requirements were provided to JGS within Schedule 2 of The Specification. The details of the as built exploratory holes, including the location ID, construction method, actual termination depth and installation detail, are listed within Table 3.

Table 3: Exploratory Hole Details

Exploratory Hole ID	Construction Method	Termination Depth (m)	Installation Details		
			Type	Internal Diameter (mm)	Response Zone (m bgl)
S1-BH101	Dynamic Sampling with Rotary Coring	24.60	SP	50	11.00 – 14.00
S1-BH102		30.00	SP	50	6.00 – 9.00
S1-BH103		30.80	SP	50	2.00 – 5.50
S1-BH105		30.80	SP	50	11.00 – 15.00
S1-BH106		20.00	Backfilled with Bentonite		
S1-BH107		8.00	Backfilled with Bentonite Cement Grout		
S1-BH107B		18.00	Packer installed at 14.50m depth. Backfilled with Bentonite Cement Grout above packer. High strength, fast setting grout was pressure injected through a non-return valve in the packer to base of hole.		
S1-BH108		30.00	SP	50	13.00 – 15.50
S1-BH109		15.90	Backfilled with Bentonite		
S1-BH110		12.00	Backfilled with Bentonite		
S1-BH112		30.40	SP	50	1.00 – 2.50
			SP	50	8.00 – 15.00
S1-BH113		30.00	SP	50	3.00 – 5.50
S1-BH114		9.00	Backfilled with Bentonite		
S1-BH114B	Dynamic Sampling	4.00	Backfilled with Bentonite Cement Grout		
S1-BH114C	Dynamic Sampling with Rotary Coring	21.00	Packer installed at 16.00m depth. Backfilled with Bentonite Cement Grout above packer. High strength, fast setting grout was pressure injected through a non-return valve in the packer to base of hole		
S1-BH116		17.40	Backfilled with Bentonite		
S1-BH121		10.50	SP	50	2.00 – 3.50
S1-BH122		10.50	SP	50	1.00 – 1.90
SOP001.1	Rotary Open Holing	25.00	Backfilled with Bentonite		
SOP001.2		15.00			
SOP001.3		15.00			
SOP001.4		15.00			
SOP001.5		15.00			
SOP001.6		15.00			
SOP001.7		15.00			
SOP001.8		15.00			
SOP001.9		15.00			
SOP001.10		15.00			
SOP001.11		15.00			
SOP001.12		15.00			
SOP001.13		15.00			
SOP001.14		15.00			
SOP001.15		15.00			
SOP001.16		15.00			
SOP001.17		15.00			
SOP001.18		15.00			
SOP001.19		15.00			
SOP001.20		15.00			
SOP002.1	Rotary Open Holing	20.00	Backfilled with Bentonite		
SOP002.2		15.00			
SOP002.3		11.50			
SOP002.4		11.50			
SOP002.5		11.50			
SOP002.6		11.50			
SOP002.8		11.50			
SOP002.9		11.50			
SOP002.10		11.50			
SOP002.11		11.50			
SOP002.12		11.50			
SOP002.13		11.50			
SOP002.14		11.50			
SOP002.15		11.50			
SOP002.16		11.50			
SOP002.17		11.50			
SOP002.18		11.50			
SOP002.19		11.50			
SOP002.20		11.50			
SOP002.21		11.50			