14 Geotechnical Risk Register

The Geotechnical Risk Register has been established and will be updated as the scheme progresses and when constraints or opportunities are identified.

Table 8 – Geotechnical Risk Register

Hazard		Consequence	Mitigation Measures
1.	Differential settlement between areas of undisturbed ground and infilled ground.	Potential for structural damage and serviceability issues with the test track and associated structures and infrastructure.	Ground investigation and testing to better understand the make-up of infill – determine geotechnical design parameters for undisturbed and infilled ground. Monitor existing ground movements in order to test theoretical information regarding ongoing ground movements in areas of backfilled opencast workings. Monitor groundwater and undertake detailed hydrogeological risk assessment to understand potential changes in the hydrogeology and potential for future inundation settlement.
2.	Continuing total and differential settlement of infilled areas (associated with backfilled former opencast works).		Develop masterplan and detailed design taking account of areas of higher risk and avoiding these where possible.
3.	Inundation settlement of the infilled areas due to groundwater rebound once dewatering stopped as a result of changes in groundwater regime due to installation of new drainage/soakaways.		Ensure that foundation solutions for structures make due allowance of potential ground movements during design life.
4.	Inundation settlement of the infilled areas due to creation of new drainage paths e.g. installation of drainage across the site.		Design for ground movements e.g. ensure flexible joints in any drainage pipes, incorporate suitable gradients for drainage runs to minimise risks of drainage backing up in the event of differential ground movements occurring.
5.	Potential for significant ground heave in areas of deep cuttings.		Design for regular maintenance, e.g. tamping of track as part of overall development strategy.
6.	Shallow underground coal workings and associated mine entries, including shafts and adits have been identified to be present beneath sections of the proposed cuttings and embankments	Potential subsidence as a result of underground working of mine entry collapse leading to failure of track and potential train derailment in the permanent case.	Comprehensive review of all available mine abandonment plans pertaining to workings that are closest to the surface of rockhead (~20m below rockhead).

Hazard		Consequence	Mitigation Measures
		Risk of encountering underground workings or intact coal seams in the areas of proposed cut. This will need to be considered both in terms of developing safe construction methodologies and permanent works to ensure stability and safety of the final earthwork.	Undertake ground investigation comprising a mixture of intrusive and non-intrusive (e.g. non-intrusive gravity surveys) works in order to locate potential shallow mine workings. If shallow mine workings are identified, mitigatory measures such as grouting of voids may be required to negate the risk of subsidence beneath the proposed track route.
6.	Oversteep slope angles in proposed cuttings and earthworks	Failure of earthworks: Cutting – material on the tracks causing derailment Embankment – failure of embankment and track causing derailment.	Ground investigation – design geotechnical parameters and slope stability calculations.
7.	Encountering potentially hazardous material from historical and current mining activities within the infilled areas.	Risk of encountering made ground which is potentially hazardous to human health and controlled waters.	Undertake ground investigation and sub-sequent sampling on geo-environmental samples gathered to determine the type and degree of contamination if present.
8.	Potential for instability within rock cuttings or beneath embankments as a result of failure along discontinuities and weak bedding layers within the coal measures (such as coal seat earths).	Large scale instability of rock cuttings.	Design appropriate cutting slopes and if necessary incorporate stabilisation measures such as rock anchors.
9.	Pyrite is known to be present within the Coal Measures bedrock.	Pyrite containing bedrock can present aggressive conditions to concrete foundations.	Undertake ground investigation and subsequent aggressivity testing of samples gathered to determine the potential threat to concrete foundations.

15 Conclusions and Recommendations for Further Work

Through undertaking this desk-based study of the 'Land at Nant Helen and Onllwyn Coal Washery' site the following conclusions have been made.

As identified through review of published geological sources, whilst the majority of the site is shown to have limited natural superficial soil cover, localised areas of glacial till and peat are likely to be encountered.

The superficial material is underlain by the South Wales Lower and Middle Coal Measures Formation. A significant number of coal outcrops are present within the site boundary. A number of approximately North-South trending faults cross the site. The solid geology beneath the site is likely to be complicated on account of the various anticline and syncline features which have been identified through review of published geological mapping sources.

The site has been significantly impacted by both opencast and underground coal mining activity. Large areas of the site have been subject to opencast mining activity. Most of the former opencast areas have been backfilled. The depth of backfill pertaining to each has been estimated from review of opencast completion plans with ~130m of backfill material likely to be present within the original Nant Helen opencast site. The Nant Helen Extension opencast site has reached depths of up to 150m, however this site is yet to be backfilled. The backfill material is likely to be settling at variable rates due to the varied depths of deposition and the assumed 'non-engineered' backfilling methods.

From review of limited abandonment plans provided by Celtic Energy, localised areas of shallow underground mine workings are present; in places these workings are anticipated to be within 20m of rock head. Based on review of the coal mining information provided on the site, four risk zones (A through D) have been identified. These risk zones cover the sections of proposed track where underground workings are likely to be present at less than 20m depth below rockhead; essentially these zones pertain to the sections of the track that are shown to lie on land that has not been opencast previously.

Numerous watercourses are shown to flow through and originate from certain sections of the main portion of the site. These watercourses are predominantly small in nature and are tributaries to the River Tawe, Dulais River and River Pryddin that surround the site. Multiple pond features have been identified within the site; these features are a mixture of natural and man-made features. The majority of the site is not at risk of flooding with only a very small section at the easternmost corner of the washery portion of the site being at risk.

The groundwater level beneath the site is relatively unknown as the Nant Helen Geotechnical borehole logs reviewed provided no information regarding the groundwater level. However, from review of the Nant Helen Extension Environmental Statement from 2011, the groundwater level in the west of the site was previously recorded to sit at around 120m AOD; this suggests that

groundwater is at around 170m below ground level in this location. Due to the extensive nature of the underground workings anticipated beneath the site, it is likely that the site is underdrained by these workings particularly by adit mine entries discharging to the River Tawe to the north of the site. Shallow groundwater strikes were recorded in the borehole scans reviewed pertaining to boreholes within the washery portion of the site.

The preliminary conceptual site model has identified the potential for certain pollutant linkages to be formed during future site works. These linkages pertain to the potentially contaminated nature of materials that will be encountered beneath the site. The level of contamination is yet to be assessed however a number of potential sources, primarily based on the site's industrial past, have been identified.

Following a preliminary unexploded ordnance (UXO) risk assessment, the risk of encountering UXO beneath the site is considered to be negligible. As a result, a detailed UXO risk assessment is not likely to be required.

15.1 Settlement Monitoring

In order to better understand the potential settlements that are occurring within the areas of opencast workings which have since been backfilled, settlement monitoring using permanent ground markers installed at surface is recommended. The monitoring information would be useful and would be supplemented with intrusive ground investigation as the project progresses.

Settlement monitoring will be useful to ascertain the current rate of ongoing creep settlement within the areas of backfill and potentially monitor settlements which occur post-inundation once dewatering activity associated with the current opencast workings is ceased. Groundwater level monitoring will be required to determine the rebound of the groundwater level that occurs once dewatering measures are stopped. The scope of settlement monitoring should be developed to allow an assessment of potential total and differential creep movements over the design life of the development to be better understood and provide greater certainty regarding the potential impacts of this; the monitored settlements can then be compared with the theoretical 'creep movements' determined as part of this study.

15.2 Detailed Mine Workings Study

Given the extensive nature of underground working shown to be present beneath the site it is recommended that an additional study is undertaken to provide a comprehensive review of the underground workings that are likely to be present beneath the site.

Through consultation with the Coal Authority, a total of 42No. abandonment plans have been identified in relation to the shallow workings beneath the site. It is recommended that these plans are purchased at a later date and a comprehensive review of the shallow workings recorded beneath the site is undertaken. This review would allow for the areas that are potentially at risk of subsidence to be

much better understood and will better inform the scope of ground investigation ultimately proposed.

15.3 Ground Investigation

It is recommended that ground investigations are undertaken. This ground investigation is likely to require both intrusive and non-intrusive works in order to ascertain information on the site that is currently lacking. Ground investigation is required to;

- Confirm the ground and groundwater conditions beneath the site, including the different areas of former opencast workings - primarily focusing on the current proposed track route. In-situ testing and geotechnical sampling with subsequent testing will be required to determine the geotechnical properties of the materials encountered which will then feed into the design of the cuttings and embankments proposed;
- Investigate the composition and in-situ properties of the fill material within the backfilled opencast sites which are located beneath the proposed track route. This is required to be able to better understand the potential settlements that are likely to arise as a result of long term creep settlement. Investigation of the groundwater level within these areas and interpretation of the change in groundwater level, post completion of all opencast activity, will help inform the likely inundation settlements that could occur as a result;
- Identify the potential presence and significance of contaminated ground and groundwater beneath the site. Geo-environmental testing with subsequent chemical analyses will be required to allow suitable risk assessments to be undertaken both for the discharge of planning conditions and for the design and specification of any necessary site remediation works required;
- Determine the depth to underground workings, if present, beneath the proposed track route through intrusive investigation (probing) and potentially also geophysical methods (e.g. Gravity surveys or magnetic surveys to locate shaft locations). If identified information will need to be suitable to allow for the design of treatment measures such as grouting of mining related voids. The information should also be sufficient to allow an assessment to be made of the potential impacts of mine-workings treatment on the hydrogeological regime.

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Figures

The following figures have been included in the main body of the report.

A3

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210000

205000

National Park

Bwlch y Ddeuwynt

Disgwylfa

Twynwalter

Carreg Goch

Twyn Du

Cefn Carn Fadog

Glyntawe

Carn yr Onnen

Carreg Cadno

Penwylit

Craig-y-nos

Sand Hill

A4067

Cribarth

Pen-y-cae

Bryn Bugeiliaid

Ynyswen

Abercraf / Abercrave

Caehopkin

A4067

Swansea Valley

A4221

Coelbren

Cwmgiedd

Cwm-twrch Uchaf

Cwm-twrch Isaf

Cwm Tawe / Swansea Valley

B4599

Ystradgynlais

Gorof

Y Gurnos / Gurnos

Glan-rhyd

Ystalyfera

B4599

A4067

Caeralem

Farteg Hill

Pantyffynnon

Nant-y-cafn

Hirfynydd

Tynewydd

Dyffryn Cellwen

Banwen

A4109

Blaendulais / Seven Sisters

A4109

Pontneddfechan

B4242

Glyn-Neath / Glyn-Neath

Pont-Walby / Pontwalby

Morfa Glas

A465

B4242

Blaengwrach

Cwmgwrach

Pentrechwydau

Crynant / Creunant

Cwm Rhydd-Gau

Cwm Gwrelych

Cwm Ceffyl

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Legend

Site Boundary

Coordinate System: British National Grid

Metres

0 500 1,000 2,000

Rev	Date	By	Chkd	Appd
P1	10-12-2019	JC	TW	DR

ARUP

13 Fitzroy Street
London W1T 4BQ
Tel +44 20 7636 1531 Fax +44 20 7580 3924
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Client
Welsh Government

Project Title
Land at Nant Helen and Onllwyn Coal Washery

Drawing Title
Site Location Plan

Scale at A3
1:50,000

Role
Geotechnical

Suitability
For Information

Arup Job No
264904

Rev
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Name
Figure 1

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Legend

- Site Boundary

Indicative Extent of Proposed Earthworks

- Cuttings
- Embankments
- Figure 11 Section Line

Coordinate System: British National Grid

Metres

0 400 800

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13 Fitzroy Street
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Project Title
Land at Nant Helen and Onllwyn Coal Washery

Drawing Title
Outline Scheme Earthworks Proposals

Scale at A3
1:15,000

Role
Geotechnical

Suitability
For Information

Arup Job No
264904

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Name
Figure 2

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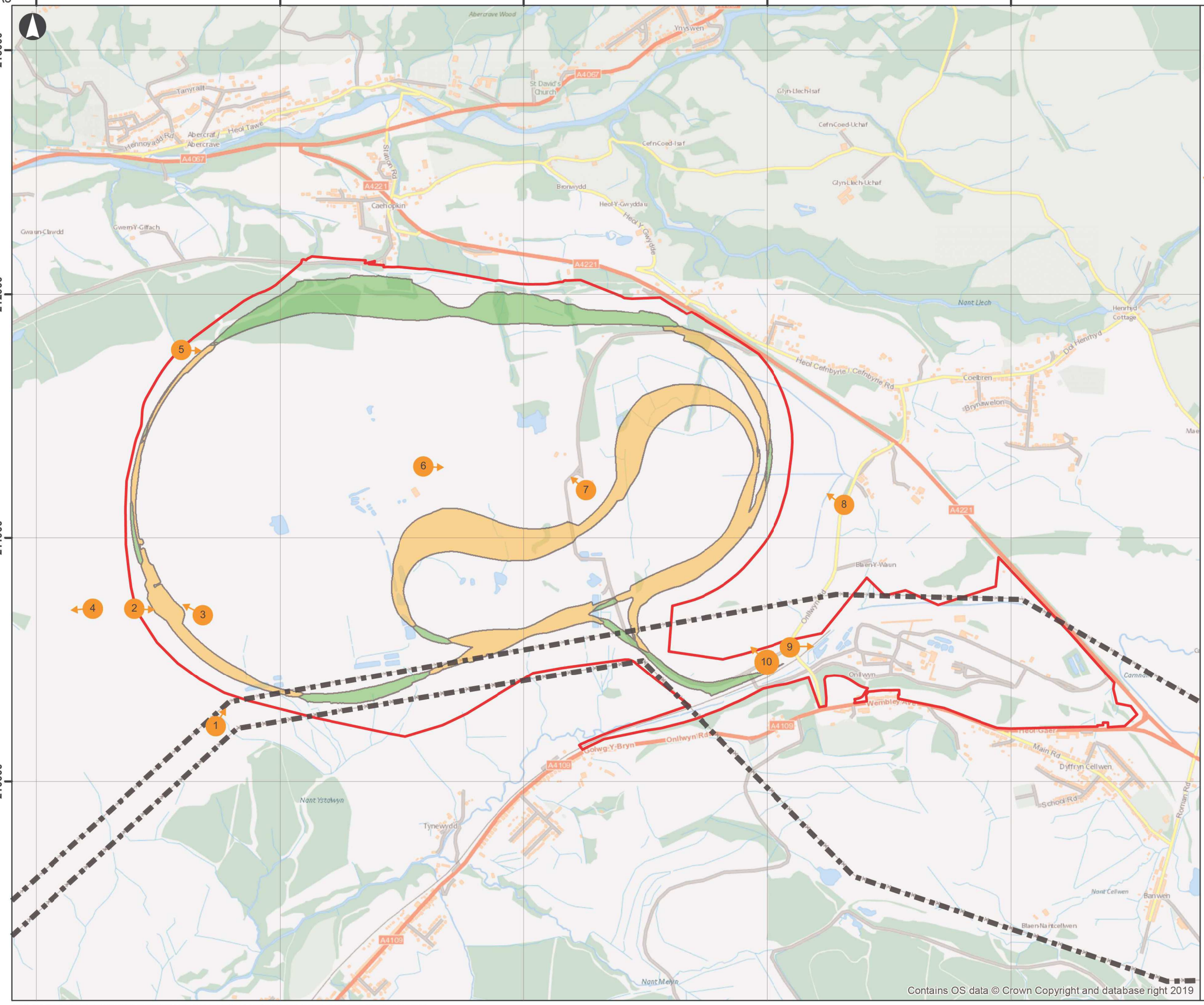

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Legend

- Site Boundary

Indicative Extent of Proposed Earthworks

- Cuttings
- Embankments
- # Photo Location
- Overhead Electricity Cables

Coordinate System: British National Grid

Refer to Appendix A for site walkover photographs.

Metres

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Site Walkover Photo Locations

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Role
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Suitability
For Information

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Figure 3

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Gwaunclawdd Colliery

Gwaunclawdd Colliery

Neath and Brecon Railway (Junction Line)

International Colliery

Abercrave Colliery

Unnamed Colliery

Glynllech/Cwm Tawe Colliery

Tramway

Tramway

Neath and Brecon Railway

Brecon Forest Tramroad

Dulais/Drym Colliery

Onllwyn Colliery

Seven Sisters Colliery

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Legend

- Site Boundary
- Rail & Tram Lines
- Collieries

Indicative Extent of Proposed Earthworks

- Cuttings
- Embankments

Coordinate System: British National Grid

Colliery locations and rail/tram line routes have been determined through review of OS historical mapping (Groundsure).

Refer to Figure 8 and Figure 9 for the identified extents of underground workings and opencast workings respectively.

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Drawing Title
Select Historical Features

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1:15,000

Role
Geotechnical

Suitability
For Information

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Figure 4

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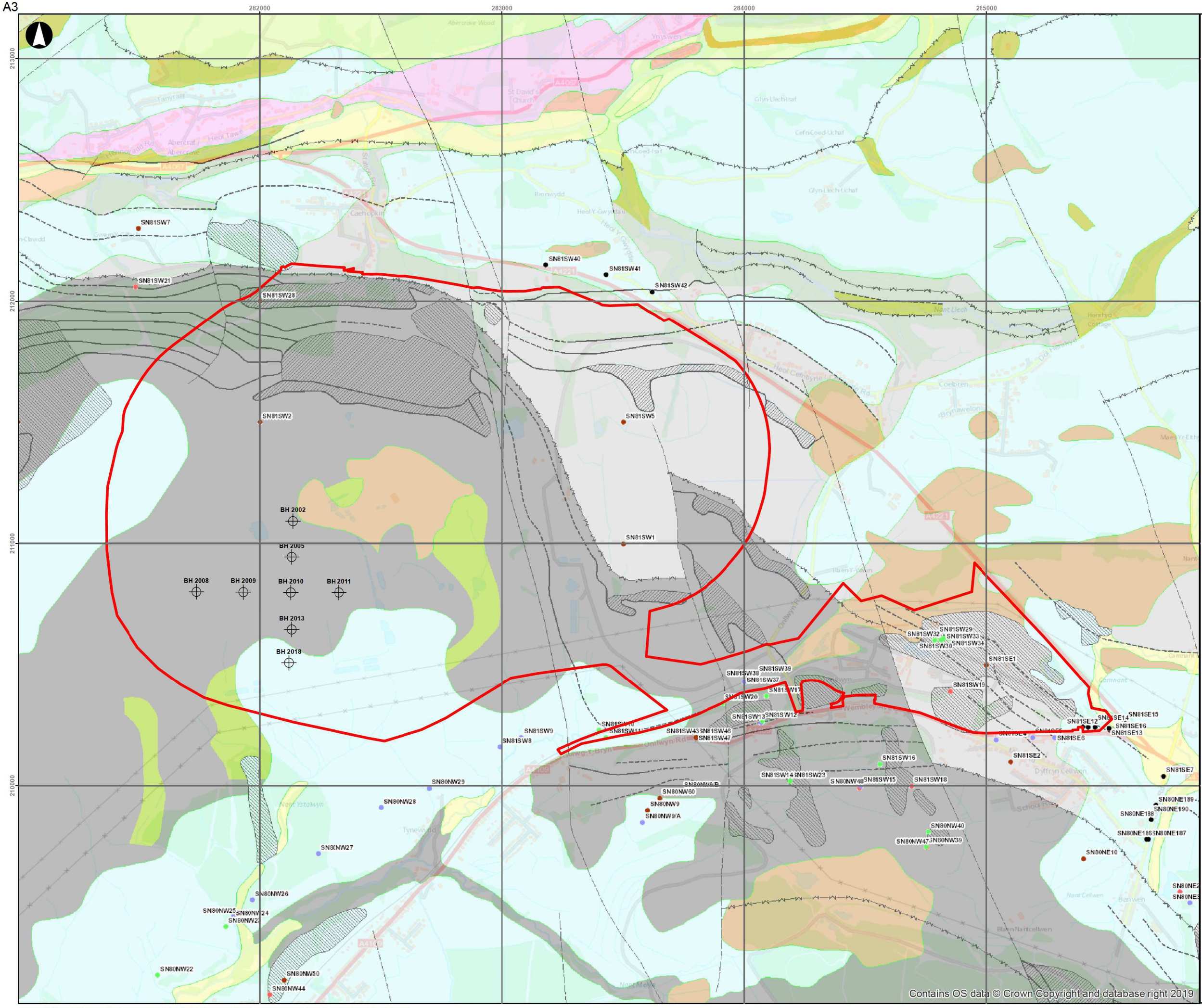

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Legend

- Site Boundary

Published Geology

- Made Ground
- Alluvium
- Peat
- Glaciofluvial Deposits
- Glacial Till
- South Wales Middle Coal Measures Formation - Mudstone, Siltstone and Sandstone
- South Wales Middle Coal Measures Formation - Sandstone
- South Wales Lower Coal Measures Formation - Mudstone, Siltstone and Sandstone
- BGS Borehole Scans
- Nant Helen Geotechnical Boreholes (1986)

Coordinate System: British National Grid

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Project Title
Land at Nant Helen and Onllwyn Coal Washery

Drawing Title
Solid and Drift Geology

Scale at A3
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Role
Geotechnical

Suitability
For Information

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Drawing No
Figure 5

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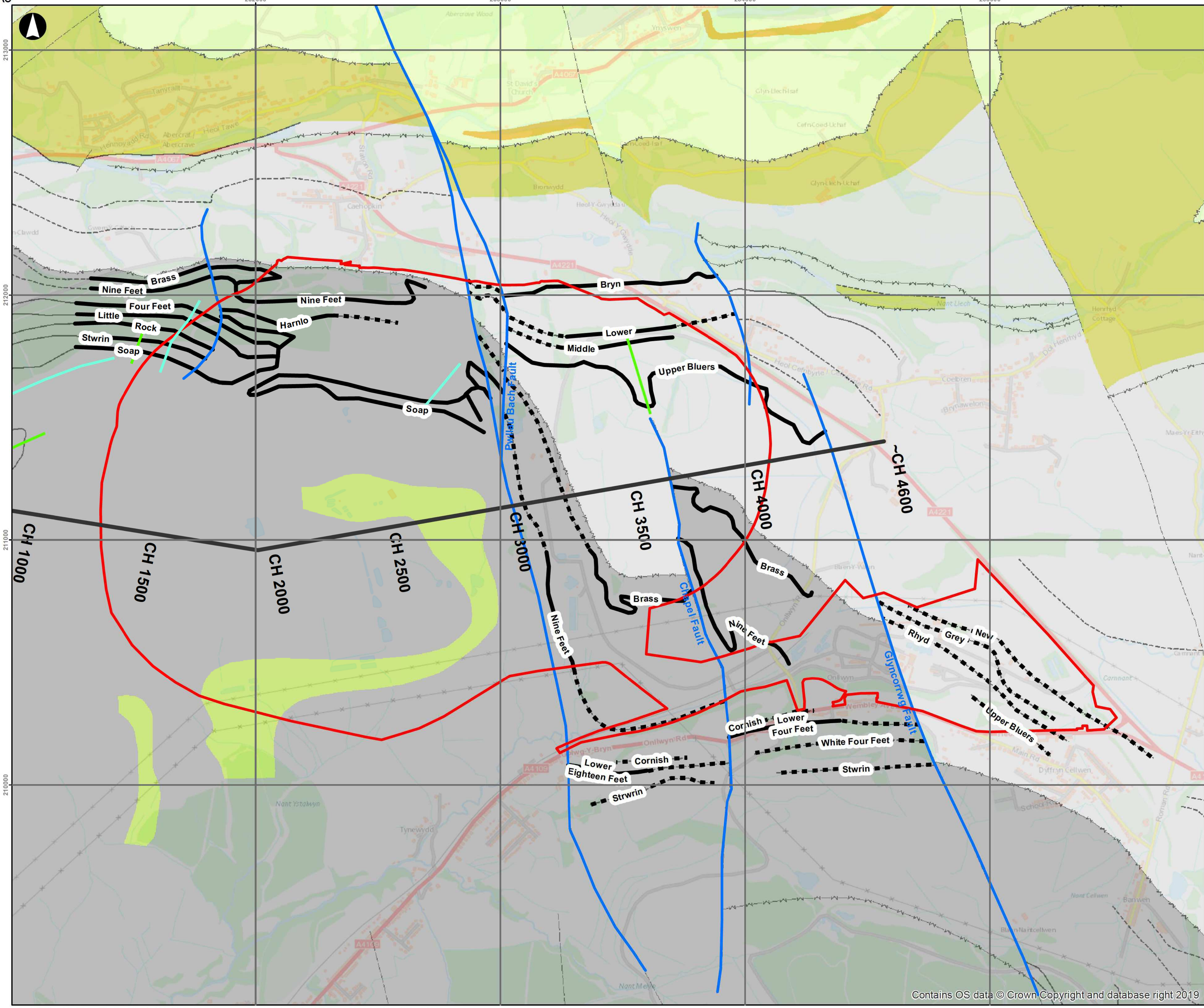

Legend

Site Boundary

Coal Seams

Observed

Inferred

Published Geology

South Wales Middle Coal Measures Formation - Mudstone, Siltstone and Sandstone

South Wales Middle Coal Measures Formation - Sandstone

South Wales Lower Coal Measures Formation - Mudstone, Siltstone and Sandstone

Faults

Anticlinal axis

Synclinal axis

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Project Title
Land at Nant Helen and Onllwyn Coal Washery

Drawing Title
Linear Geological Features

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Role
Geotechnical

Suitability
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Drawing No
Figure 6

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River Tawe

Nant Llech

Restored Pond Feature

Water Treatment Area

Water Treatment Area

Water Treatment Area

Camnant

Nany Ystalwyn

River Dulais

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Legend

- Site Boundary
- Surface Water Features
- Culverted Watercourses
- Existing Water Treatment

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Drawing Title
Hydrological Features

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Role
Geotechnical

Suitability
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Figure 7

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Gwaunclawcd Colliery

Gwaunclawdd Colliery

International Colliery

Unnamed Colliery

Abercrave Colliery

RISK ZONE B

Glynllech/Cwm Tawe Colliery

RISK ZONE C

CH 3000

CH 3500

CH 4000

~CH 4600

RISK ZONE A

RISK ZONE D

CH 1000

CH 1500

CH 2000

CH 2500

G

H

E

F

B

A

C

C

D

Onllwyn Colliery

Seven Sisters Colliery

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Legend

- Site Boundary
- Shafts
- Adits
- Collieries
- Cuttings
- Embankments

Old Workings

- Brass
- Peacock (Brass)
- Nine Feet
- Big (Nine Feet)
- Unnamed

- Risk Zones — *Risk of subisdence on account of potential shallow workings*
- Figure 11 Section Line

Old workings have been geo-referenced from files provided by Celtic Energy. The extents shown are for indicative puiposes only.

Coordinate System: British National Grid

Metres

0 400 800

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P1	22-11-2019	JC	TW	DR

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Tel +44 29 2047 3727 Fax +44 29 2047 2277
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Drawing Title
Identifed extent of below ground workings

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Suitability
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Drawing No
Figure 8

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