

## **Appendix 6A**

### **Geotechnical Desk Study**

Welsh Government

**Land at Nant Helen and Onllwyn  
Coal Washery**

**Geotechnical and Geoenvironmental  
Desk Study**

Issue | 18 December 2019

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# 1 Introduction

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The Welsh Government is considering the development of a rail testing facility in South Wales. The aspiration is for the development of a nationally significant rolling stock and infrastructure testing facility (Hereafter referred to as the ‘proposed development’).

Celtic Energy’s Nant Helen site and Onllwyn Washery, immediately to the north of Onllwyn village, has been identified as a potential site for the proposed development. The site is currently an operational opencast coal mine and coal washery. The proposed development would allow the site to be re-purposed once the opencast mining activities have ceased and the site has been restored.

Arup have been commissioned by the Welsh Government to undertake a desk study assessment for the proposed site near Onllwyn in Powys. This desk study includes a summary of the site’s history and ground conditions, including topography, geology, hydrogeology, hydrology and the coal mining legacy at the site. A preliminary conceptual site model and preliminary engineering assessment is then presented, together with a summary of the identified geotechnical and geoenvironmental risks and opportunities and recommendations for further work.

It is envisaged that 7km of cuttings and embankments will be constructed in two loops. Based on the complex topography of the site, the cuttings and embankments will likely require significant cut (~30m) and fill (~40m) earthworks to form the embankment level.

In addition to the track loops, it is envisaged that a platform environment, facilities for rail storage, train decommissioning areas and educational activities will also be included as part of the developed works. These are likely to be located both within the Nant Helen site and within the portion of the site currently occupied by the Onllwyn Washery.



## 2 Sources of Information

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The following sources of information have been reviewed in the preparation of this report:

- British Geological Survey (BGS) published geological and hydrogeological mapping
- British Geological Survey (BGS) online GeoIndex viewer
- Published environmental information (Lle)
- Information contained within the 2011 Nant Helen Extension Environmental Statement
- Historical aerial photographs (Welsh Government)
- Historical and present-day mapping sets (Groundsure)
- Opencast completion plans and select underground working abandonment plans (provided by Celtic Energy)
- Groundsure EnviroInsight and GeoInsight reports
- Coal Authority online viewer
- Coflein, National Monuments Record of Wales

## 3 Site Location and Description

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The Celtic Energy Nant Helen site is located approximately 20km north-west of Swansea, immediately south of the Brecon Beacons National Park (refer to Figure 1). The plan area of the site covers approximately 500 hectares and is located between the A4109 to the south, and the A4221 to the north-east. To the north the site is bounded by an area of forestry and by forestry access tracks from the Brecon Road to the north-west. The majority of the site is located within the Powys county boundary however the southern boundary of the site lies along the Powys/Neath-Port Talbot county border and a small portion of the site lies within the county of Neath-Port Talbot.

The site boundary is shown on Figure 2. For ease of identification, throughout the report the site (as a whole) has been split into the main and the “washery” portions. The main portion refers to the central body of the site which contains the proposed rail test track whereas, the “washery” portion refers to the extension of the site to the southeast incorporating the Onllwyn Washery.

The topography of the site is shown on Figure 2. The northern site boundary starts at ~250m AOD in the north-western corner before dropping in an easterly direction to ~195m AOD. The land then climbs back up to the eastern arc of the site boundary which approximately follows the 250m AOD contour line. The southern site boundary also approximately follows the 250m AOD contour line and locally drops to ~235m AOD. The western arc of the site boundary rises up from 250m AOD in the south to 270m AOD in the south-western corner.

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” portion of the site sits lower than the main portion of the site at roughly 230mAOD.

The Celtic Energy Nant Helen site is currently being used as an active open cast coal mine. The extreme west of the site contains the Nant Helen Extension opencast working which is typically 150m lower than the surrounding ground surface at its deepest point (refer to Figure 2). A series of access tracks are present across the site. These access tracks connect the current open cast workings in the west with the Onllwyn Washery located in the east of the site. The washery site accessed from the A4221 via a separate entrance, and is comprised several buildings, conveyer belts and material sorting facilities.

The central portion of the main site is dominated by a large ‘Overburden Storage Area’. The overburden storage areas are understood to be spoil heaps placed above the natural ground level. The maximum height of the spoil material is understood to be approximately 80m above the natural ground surface.

### 3.1 Site Walkover

A site walkover was undertaken by an Arup geotechnical engineer on 28<sup>th</sup> November 2018 with a representative from Celtic Energy. Pertinent site walkover photographs are presented in Appendix A which should be referred to throughout

this section. Refer to Figure 3 for the approximate locations of the site walkover photographs.

The images presented in Appendix A include Photograph 1 showing the large overburden storage area. Photograph 3 shows the current Nant Helen Extension opencast site. Photographs 3, 4, 5 and 6 show examples of the material excavated during the opencast mining activities.

Photograph 1 was taken facing approximately NNW and shows the southern face of the large overburden storage area centrally located within the site. Photograph 1 also shows the electricity pylons that cross the southern portion of the site; the route of which is indicated on Figure 3.

Photograph 2 was taken facing approximately eastwards and shows a small pond type feature which is located on the current proposed track route. The western slope of the large overburden storage area is shown behind the pond feature.

Photograph 3 was taken facing northwest and looks down into the current Nant Helen Extension opencast mine extent. The depth of the excavation is evident (~150m) and a large lake feature is present at the base of the excavation. Assuming backfilling activity has been undertaken as shown by the batter slopes shown on the right-hand side of the photograph.

Photographs 3, 4, 5 and 6 show examples of the material excavated during the opencast mining activities. The material shown is predominantly gravel sized with larger cobble and boulder sized inclusions. Evidence of fracturing is present on many of the larger inclusions. The material is anticipated to be mudstone/siltstone and is dark in colour. This material is anticipated to be the non-coal bearing arisings excavated during the opencast mining activity and is likely to be indicative of the material used to backfill the opencast sites post completion.

Photograph 5 is facing roughly eastwards and shows the coal haul route running eastwards towards the centrally located site compound and offices. The land rising to the south (right-hand side of the photo) is the northernmost extent of the overburden storage area. The current proposed track route is anticipated to run eastwards from this point running through the southern edge of the forestry shown on the left-hand side of the photograph.

Photograph 6 is facing approximately ESE and is located along the coal haul route. The photograph shows the various stockpiles either side of the roadway. From review of the site context figure provided by Celtic Energy (Appendix H), this area is the coal stocking area. The coal stocking area is located atop the backfilled extent of the original Nant Helen opencast site. The site compound and offices are located over the horizon shown on photograph 6.

Photograph 7 shows four cylindrical tanks located to the northwest of the site compound and offices. These tanks display flammable warning signs and are anticipated to be fuel tanks used for the various motorised plant vehicles. A large motorised plant vehicle is shown to be parked behind the tanks.

Photograph 8 was taken facing NW and looks out over the eastern half of the main portion of the site. The land is shown to rise gently towards the northwest

with the forestry that borders the northern half of the site shown to be present lining the horizon on the left-hand side of the photograph.

Photograph 9 is facing approximately eastwards and looks back towards the Onllwyn washery site. The washery infrastructure is shown in the background with a large pond shown in the foreground beyond the road.

Photograph 10 is facing NW and looks in towards the centre of the site. The photograph shows the eastern extent of the electricity pylons and the left-hand portion of the horizon marks the anticipated southern extent of the second Onllwyn opencast site (refer to Section 9).

## 4 Site History

Historical features and constraints have been identified through a review of historical mapping sets (1876 - 2019) and historical aerial photography (1945 – 2019). The mapping sets have been purchased from Groundsure and are referenced accordingly; the mapping sets cover a range of scales from 1:1,250 to 1:10,560. The aerial photographs have been acquired from Welsh Government and provide a higher level of detail for portions of the site covered. Current online aerially imagery has also been reviewed to supplement the historical sources. The mapping source material reviewed is presented within Appendix B.

In general, the site has been subject to extensive surface and sub-surface coal mining activities over the past century. The majority of relevant features and potential constraints identified are related to the site’s coal mining legacy. A detailed review of mining activity is discussed in further detail within Section 9 of this report.

Table 1 below provides a summary of each individual historical source reviewed. Refer to Figure 4, Figure 8 and Figure 9 throughout.

Table 1 – Summary of historical features and constraints

Source	Notable features and alterations
1876 / 1877 Historical Maps	<p>The Gwaunclawdd and Abercrave Collieries are shown to the north of the site with the latter shown to be located within the site boundary. To the south of the Abercrave Colliery, numerous ‘Old Quarry’ and ‘Old Coal Level’ features are shown to be located within an area which appears to have been heavily worked. The Neath and Brecon Railway (Junction Line) is shown to run along the northern boundary of the site following a rough east to west alignment. The “Junction Line” forms a network with the Neath and Brecon Railway main line (see paragraph below) and links the Collieries located to the north of Mynydd Drum (Abercrave &amp; Gwaunclawdd) to the Onllwyn Colliery and washery site to the south of Mynydd Drum.</p> <p>To the south of the southern main site boundary, the Neath and Brecon Railway runs from southwest to northeast before crossing into the “washery” portion of the site. The majority of the southern portion of the main site is shown to be undeveloped moorland with localised marshy areas; the marshy areas feed several streams which flow in a southerly direction to converge with the River Dulais. A selection of cuttings and embankments, labelled as an “Old Tramway”, is shown to cross the southern boundary of the site running along a rough east to west alignment. Based on review of</p>

Source	Notable features and alterations
	<p>the Transport Trust and Forest Fawr online sources, the Old Tramway believed to have originally formed part of the “Brecon Forest Tramroad”. The portion of the tramroad that passes through the site was called the ‘Claypon extension’ and was constructed circa 1827. The extension linked the existing Brecon Forest Tramroad network, constructed circa 1819, to the “Drum Coal Levels” (located ~500m to the southeast of the site) and to the Swansea Canal. In 1859 the majority of the Brecon Forest Tramroad was incorporated into the Neath and Brecon Railway; however, the Claypon extension, which crossed Mynydd Drum, was abandoned.</p> <p>An ‘Old Coal Level (Entrance)’ is shown to be located close to the southern boundary of the site. Numerous ‘Old Quarries’ are located towards the centre of the site, although these are all minimal in size.</p> <p>The washery portion of the site is shown as predominantly undeveloped moorland. A tramway links the Onllwyn Colliery to the Neath and Brecon Railway main line which passes through the washery portion of the site. The tramway initially follows the same alignment (SW to NE) of the Neath and Brecon Railway before spurring off in an easterly direction once past the Onllwyn Station. The tramway then runs along the northern boundary of the washery site before turning to the south east and running along the north-eastern boundary of the washery site towards the Maes-y-marchog Colliery. The land to the north of the washery portion of the site is a marshy area marked as Gors Llwyn.</p>
<p>1901/ 1903 Historical Maps</p>	<p>The Abercrave Colliery has increased in size and an additional colliery, the International Colliery, is shown to be located approximately 100m to the west of the Abercrave Colliery. The area to the south of the Abercrave Colliery is still shown to be heavily worked. Approximately 500m to the east of the Abercrave Colliery an ‘Old Tramway’ is shown. The tramway links a selection of ‘Old Levels’ and a singular ‘Air Shaft’ to the Neath and Brecon Railway (Junction Line). These workings are not named and are not shown on the mapping from 1876/77. The Gwaunclawdd Colliery is now shown in a new location approximately 500m to the east of the original location. The original site now contains an ‘Old Shaft’ and an ‘Old Quarry’.</p> <p>The southern portion of the main site has remained relatively unchanged. However, a tramway is now shown to links a singular coal level to the Dulais Colliery (marked as “Drym Colliery”); an air shaft, believed to be associated with the coal level, is shown to the north of the level (see Figure 8).</p> <p>The Onllwyn Colliery has expanded and moved location to be situated within the site boundary. The Dulais Colliery (marked as “Drym Colliery”) is shown within the site boundary to the north of the Neath and Brecon Railway main line which still runs through the washery portion of the site. The tramway identified within the washery portion of the site on the 1877 mapping is still present. A selection of ‘Old Coal Levels’, ‘Old Quarries’ and an ‘Old Coal Pit’ (all not shown on the 1877 mapping) are now present.</p>
<p>1914 Historical Maps</p>	<p>The Abercrave Colliery is shown to have expanded eastwards with a new tramway linking to new drift mine located approximately 400m to the east of the main colliery site. The ‘Old Tramway’ linking to the ‘Old Levels’ and ‘Air Shaft’ identified on the 1901/03 mapping is no longer present. The ‘Glynllech Colliery’ is now shown immediately to the east of the ‘Old Levels’ with an associated tramway spurring from</p>

Source	Notable features and alterations
	<p>the colliery in a north-eastern direction linking to the Neath and Brecon Railway (Junction Line).</p> <p>The tramway identified in the southern portion of the main site is no longer present. The remainder of the southern half of the site has remained unchanged.</p> <p>The ‘Drym Colliery’ is now marked as the ‘Dulais Colliery’ and has grown considerably with multiple structures located to the north of the Neath and Brecon Railway. The majority of the washery portion of the site has remained unchanged.</p>
1945 Aerial Photographs	<p>Extensive earthworks and stockpiles are shown to be surrounding the collieries along the northern boundary of the site (Abercrave, International, Gwaunclawdd and Glynllech).</p> <p>Two distinct areas containing a number of depressions in the ground surface are shown on the aerial photograph in the southern portion of the site. These areas are in the same location as the coal levels and air shafts identified on the 1876/77 historical mapping sets. The frequency of the depressions is indicative of ‘bell pitting’ extraction methods refer to Figure 12 Extract from 1945 aerial photography showing potential ‘bell pitting’</p> <p>2 within Section 9.3.</p> <p>The washery portion of the site is shown to have been developed with numerous rail tracks spurring from the Onllwyn Station in an easterly direction. The tramway identified on earlier historical sources is still present. A number of large stockpiles/spoil heaps are shown to be present within the washery portion of the site and to the west of the Onllwyn Colliery.</p>
1948 Historical Maps	<p>The Glynllech Colliery is still shown however the tramway linking the colliery to the Neath and Brecon Railway (Junction Line) is no longer present; this suggests that the colliery is no longer operational. The Abercrave and International Colliery footprints have reduced in size and much of the interlinking rail tracks and tramways are no longer shown. The Gwaunclawdd Colliery is no longer shown.</p> <p>No changes noted within the southern portion of the main site.</p> <p>The Dulais Colliery is now labelled as disused and all the coal mining related infrastructure associated with the colliery that was previously shown is no longer present. The Onllwyn Colliery is still present. A ‘Brickworks’ is shown to be present within the washery portion of the site. The brickworks is located to the south of the existing rail tracks and assumed ‘Washery’ infrastructure. An ‘aerial ropeway’ is shown within the site and is believed to be associated with the spoil heaps shown to be present within the washery portion of the site.</p>
1951 Aerial Photographs	<p>The Abercrave and International Collieries are shown to be present and the area of land previously occupied by the Gwaunclawdd Colliery has been completely cleared of coal mining infrastructure; the only evidence of the colliery that remains are the earthworks located immediately to the south. The Glynllech Colliery is no longer shown.</p>

Source	Notable features and alterations
	<p>The first evidence of opencast coal mining activity is shown to be present within the southern half of the main portion of the site. These workings appear to have been recently filled are anticipated to be the original Onllwyn opencast site. The workings are shown to intersect the “Old Tramway” identified on the 1876/77 historical mapping; two sections of cuttings along the tramway alignment appear to have been filled with spoil which anticipated to have arisen from two of the opencast sites shown. The Onllwyn opencast sites shown appear to coincide with the locations of the “dimpling” noted from the 1945 photography; as a result, the “dimpling” (possible bell pitting extraction) is no longer shown on the 1951 photography.</p>
<p>1965 Historical Maps</p>	<p>The Abercrave Colliery is still shown on the map, however many of the levels and drifts are labelled as ‘disused’ and the majority of rail and tramway infrastructure is no longer present.</p> <p>The infrastructure within the washery portion of the site has increased in size and the plan extent of the stockpiles/spoil heaps in the east has grown.</p>
<p>1975 Aerial Photographs</p>	<p>The land previously occupied by the numerous collieries located along the northern boundary of the site appears to have been completely reprofiled with no evidence of the collieries, or the worked land immediately to the south of the collieries, present. This is believed to be the result of the Abercrave/Gwaunton opencast coal mine (refer to Section 9.5).</p> <p>Evidence of earthworks associated with the construction of the A4221 are shown to be located along the north-eastern boundary of the main portion of the site.</p>
<p>1977 Aerial Photographs</p>	<p>A large opencast coal mine is shown to be present in the eastern half of the main portion of the site. This opencast site is anticipated to be the second Onllwyn opencast site and covers a much greater plan area than the original workings. The land to the southwest of the opencast site is covered with numerous stockpiles/spoil heaps. The A4221 is shown to have completed construction and borders the north-eastern boundary of the site.</p> <p>The Onllwyn Colliery is no longer shown to be present. A large stockpile is now shown to occupy the original colliery site. The Neath and Brecon Railway line is still present and links to an extensive network of sidings which spur eastwards into the washery portion of the site. The washery has increased in size and the numerous pond features, shown on the most recent aerial imagery, are now present. The area of land to the east of the washery appears to be in the process of being filled with numerous stockpiles/spoil heaps present.</p>
<p>1985 Aerial Photographs (Colour)</p>	<p>A distinct area of darker land is shown along the northern boundary of the site. This is anticipated to be associated with the backfilling of the Abercrave/Gwaunton opencast site; extensive forestry planting operations appear to have taken place within the areas which have been backfilled.</p> <p>The larger Onllwyn opencast site is shown to have been backfilled with numerous man-made drainage features shown to be present across the surface.</p>
<p>1987 / 1988 Historical Maps</p>	<p>The northern half of the main portion of the site is shown to be covered with forestry. A collection of disused levels and drifts are shown to be present. These are likely to</p>

Source	Notable features and alterations
	<p>have been associated with the Glynllech Colliery. The Onllwyn opencast site is labelled as disused workings.</p> <p>No other major observable changes are shown with regards to the south of the main portion of the site or within the washery portion of the site.</p>
1989 Aerial Photographs	<p>The main site compound is shown to be present centrally located within the main portion of the site. The first evidence of the Nant Helen opencast workings are shown to be present immediately to the west of the site compound. To the west of the opencast workings the “layer cake” overburden storage area is being formed; it is likely that the layer cake was formed with arisings from the original Nant Helen opencast workings.</p> <p>Numerous pond features are present along the southern face of the overburden storage area and along the eastern and western edges of the Nant Helen opencast excavation. From review of the Site Context figure provided by Celtic Energy, see Appendix H, these pond features are labelled as water treatment areas.</p>
1995 Aerial Photographs (Colour)	<p>The Nant Helen opencast excavation has progressed northwards with the existing void having been backfilled. The large overburden storage area, now located to the southwest of the opencast workings, is shown to have been completed to its present extent.</p>
2006 Aerial Photograph (Colour)	<p>The Nant Helen Extension opencast coal mine is shown to extend westwards from the Nant Helen opencast coal mine identified in the 1989 and 1995 aerial photographs. The original Nant Helen opencast void appears to have been filled and the surface is now covered with numerous stockpiles. An access track runs westward through the stockpiles from the site compound to the Nant Helen Extension workings in the west.</p> <p>The site of the original Nant Helen opencast appears to have been restored with a collection of small pond features and areas of vegetation present</p>
2009 Aerial Photograph (Colour)	<p>The Nant Helen Extension opencast coal mine has grown westwards and the original extent has now been partially backfilled with what appears to be site-won material. No other major changes are noted between the 2006 and 2009 aerial photographs.</p>
2019 Online Aerial Imagery	<p>The Nant Helen Extension opencast is shown to have reached its maximum extent. The extent of excavation shown on the 2006 aerial photograph has been backfilled and the majority of the 2009 extent has been partially filled with batter slopes falling westward into the open excavation.</p> <p>The ‘washery’ portion of the site is shown to contain a varied array of coal processing infrastructure with a limited network of rail lines running along an east to west alignment towards the north of the site. The land to the north and east appears to be artificially raised industrial scrubland with minimal vegetation cover. The land to the south of the washery has a higher degree of vegetation.</p>

## 4.1 Summary

Although certain areas, particularly the area close to southern boundary of site, have been left relatively undeveloped, the majority of the site is shown to have been impacted by extensive coal mining activity. These activities include both



surface and sub-surface workings and have been identified from the earliest historical mapping to the present day.

Several historical collieries have been identified along the northern and southern boundaries of the site. 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 and the last evidence of the collieries disappeared following the absence of the Onllwyn Colliery on the 1977 aerial photography (refer to Section 9.4 for greater detail regarding underground mining).

The first evidence of opencast workings was identified on the 1951 aerial photography which showed workings believed to be associated with the first Onllwyn opencast site. The subsequent aerial photographs show evidence of the second Onllwyn, the Abercrave/Gwaunton, the Nant Helen and the Nant Helen Extension opencast sites. The depth and extent of the opencast sites appears to have increased from the shallow workings associated with the first Onllwyn opencast site to the deepest workings associated with the Nant Helen Extension works which are shown on the present day online aerial imagery.

Various rail tracks and tramways are shown to have crossed through and run along the boundaries of the site. The earliest of which was marked as an ‘Old Tramway’ on the historical mapping from 1876/77; from a review of information presented on the Transport Trust [19] and Forest Ffawr online sources [20], this tramway is believed to have formed part of the “Brecon Forest Tramroad”. The section that passes through the site was known as “Claypon’s extension” and was constructed circa 1827. The tramroad is a historically significant site and is a scheduled ancient monument alternatively known as “Tramroad at Ystradgynlais”.

A selection of other short tramways are shown to have been present within the site linking collieries like the Glynllech Colliery to the Neath and Brecon Railway (Junction Line).

The washery portion of the site has contained rail tracks/sidings and tramways since the earliest historical mapping and as the opencast coal mining activity increased towards the end of the 20<sup>th</sup> century the extent of coal mining washery infrastructure and stockpile/spoil heaps also increased.

## 5 Published Geology

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The geology beneath the site has been interpreted through a review of published geological sources. These sources include the BGS 1:10,560 geological mapping (sheet SN 81 SW) [1], the BGS 1:50,000 geological mapping (Sheet 231) [2] and the BGS GeoIndex online viewer [3]. Refer to Figure 5 and Figure 6 throughout.

## 5.1 Made Ground

A region of artificial ground is shown to be present in the north of the site; based on review of documents provided by Celtic Energy, this is anticipated to be made ground associated with the backfilling of the Abercrave/Gwaunton opencast coal mine (refer to Section 9.5 for greater detail).

Although not shown on published geological sources, based on the known extent of opencast coal mining across the site, backfill made ground is anticipated to be encountered beneath much of the proposed track route. Based on observations made during the site walkover the material excavated during mining are generally granular (see Photographs 3, 4, 5 and 6).

## 5.2 Drift (Superficial Deposits)

Geological mapping of superficial deposits at 1:50,000 scale shows that the site is predominantly void of superficial material with only localised areas to the west and south of Devensian Till and an area of peat located centrally within the site. Deposits of Devensian Till and peat are also shown to be present beneath a small section of the washery portion of the site. The Devensian Till is noted to be of glacial origins and is labelled as boulder clay on the 1:10,560 geological map. Glacial till typically comprises a heterogenous mixture of clay, sand and gravel with large cobble and boulder inclusions of various size and shape (diamicton). The 1904 geological memoir for sheet 231 describes the glacial till deposits within the Dulais valley “...*Old Red (sandstone) in a stiff bluish matrix (clay)*” [4]. Peat typically comprises a partially decomposed mass of vegetation that has grown under anaerobic conditions, usually found in bogs or swamps.

It should be noted that the area of glacial till identified to the west of the site coincides with the known extent of the Nant Helen Extension opencast site (refer to Section 9.5). It is therefore likely that these deposits are no longer present and will have been incorporated within the extensive ‘overburden storage areas’ formed from the surplus material excavated during opencast mining activity.

The area of peat shown in the centre of the site is also unlikely to be present due to the fact that the plan extent of the peat coincides with the Nant Helen opencast site. It is not known whether these peat materials were stockpiled on site or disposed of offsite.

Given the location shown, the area of glacial till shown to the south is unlikely to have been impacted by the earthworks associated with opencast activities and is therefore likely to remain present.

The geological map shows glacial till deposits to be present in the eastern end of the washery portion of the site. Peat deposits are shown to encroach into the north of the washery site, but it is considered likely that these materials would have been removed from beneath developed areas.

### 5.3 Solid (Bedrock)

The majority of the site is underlain by solid geology of the South Wales Middle Coal Measures Formation. The remainder of the site is shown to be underlain by South Wales Lower Coal Measures Formation. The South Wales Coal Measures generally 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. According to the geological memoir (Sheet Memoir 231) from 1988, nodular masses of pyrite, up to 0.15m thick, are often present within the Middle and Lower Coal Measures formations [5].

The Middle and Lower Coal Measures reach their maximum thickness of around 900m in the Swansea district and decrease in thickness towards the northeast and east with a thickness of around 425m near Merthyr Tydfil [5]. Based on the location of the site, and assuming a linear reduction in thickness, the thickness of the Middle and Lower Coal Measures Formations beneath the site is anticipated to be to the order of 700m.

Based on review of dip angles presented on the 1:10,560 geological mapping, the solid geology is anticipated to have a regional dip in a west south-westerly direction at angles ranging from between 5° and 15° [1]. The sequence is folded with a syncline and anticline indicated to be present beneath the site and as a result of which the bedding dip angles will vary in these locations. Within the South Wales Coal Measures, there is the potential for instability within rock cuttings as a result of planar failure along bedding plans of weaker beds such as seatearths.

### 5.4 Linear Features

Five faults, three of which are named, have been identified to cross the site from review of published geological mapping. All of the faults are roughly aligned along a NNW to SSE alignment.

Refer to Figure 6 and Figure 11 throughout.

The easternmost fault, the Glyncorrwg Fault, is shown to pass through the washery portion of the site. The cross-mark on the 1:10,560 geological mapping indicates that the fault downthrows to the west [1]; the geological memoir for sheet 231 from 1904 suggests that the Glyncorrwg Fault has a downthrow of “*forty yards*” (~36.6m) [4]. Moving westwards, there is an unnamed fault (potentially associated with the Glyncorrwg Fault) which crosses into the eastern half of the main portion of the site that is also indicated to be downthrown to the west. The Chapel Fault is shown to cross through the eastern half of the site and is indicated to be downthrown to the east; the geological memoir for sheet 231 from 1904 suggests that the Chapel Fault is downthrown “*sixteen yards*” (~14.6m) eastwards [4].

To the west of the Chapel Fault is the Pwllau Bach Fault. The alignment of the Pwllau Bach Fault splits the main portion of the site roughly down the middle and

downthrows to the west. The downthrow is stated to be as much as “*eighty yards*” (~73.2m) within the 1904 geological memoir [4].

The Glyncorrwg, Chapel and Pwllau Bach Faults form part of a horst and graben formation which is shown to be located beneath the eastern half of the site. The final fault shown to cross into the site is also unnamed. The fault crosses into the north-western most corner of the main portion of the site and downthrows to the east.

Numerous coal seams are shown to outcrop within the boundary of the site. A review of the coal resource shown to be present beneath the site and the associated mining activities, both surface and sub-surface, is provided in Section 9 which focuses on mining.

## 6 Ground Conditions

The anticipated ground conditions beneath the site have been interpreted through review of borehole and trial pit logs from previously undertaken ground investigations. The logs have been sourced from information provided by Celtic Energy and BGS borehole scans accessed from the BGS online GeoIndex. The logs reviewed are provided within Appendix C and Appendix D.

The stratigraphy noted on each log is presented in Table 2 below before a summary of the anticipated ground conditions is provided. For the approximate locations of the borehole logs reviewed refer to Figure 5.

Table 2 – Borehole Logs from previous Ground Investigations

Reference	Stratigraphy (m bgl)	Groundwater
Completion plan vertical sections		
Onllwyn <sup>1</sup> (1949)	GL @ 261.2m AOD Base of Nine Feet Seam @ 258.0m AOD – Coal Seam (3.2m bgl) Base of Brass Seam @ 249.3m AOD – Coal Seam (11.9m bgl)	No groundwater remarks noted
Onllwyn <sup>1</sup> (1982)	GL @ 247.4m AOD Base of Upper Peacock @ 242.3m AOD – Coal Seam (5.1m bgl) Base of Peacock @ 232.5m AOD – Coal Seam (14.9m bgl) Base of Bluers @ 198.4m AOD – Coal Seam (49m bgl)	No groundwater remarks noted
Nant Helen Geotechnical Boreholes <sup>2,3</sup>		
BH 2002 (1986)	GL @ 278.2m AOD GL – 0.5: Peat 0.5 – 2: Clay 2 – 3.1: Till 3.1 – 3.4: Mudstone 3.4 – 3.5: Coal 3.5 – 5: Mudstone	No groundwater remarks noted
BH 2005 (1986)	GL @ 280.6m AOD GL – 0.5: Peat 0.5 – 3.6: Till 3.6 – 4.5: Sandstone 4.5 – 4.75: Siltstone 4.75 – 6.8: Mudstone	No groundwater remarks noted
BH 2008 (1986)	GL @ 279.3m AOD GL – 0.5: Peat	No groundwater remarks noted

Reference	Stratigraphy (m bgl)	Groundwater
	0.5 – 1.0: Clay 1.0 – 3.6: Till 3.6 – 5.4: Mudstone	
BH 2009 (1986)	GL @ 282.5m AOD GL – 0.45: Peat 0.45 – 1.45: Clay 1.45 – 3.7: Till 3.7 – 5.7: Mudstone	No groundwater remarks noted
BH 2010 (1986)	GL @ 277.2m AOD GL – 0.2: Peat 0.2 – 1.05: Clay 1.05 – 2.4: Till 2.4 – 4.2: Mudstone 4.2 – 7: Siltstone 7 – 7.5: Sandstone	No groundwater remarks noted
BH 2011 (1986)	GL @ 271.7m AOD GL – 0.2: Peat 0.2 – 1.8: Clay 1.8 – 3: Mudstone 3 – 3.4: Siltstone 3.4 – 6.4: Mudstone	No groundwater remarks noted
BH 2013 (1986)	GL @ 263.4m AOD GL – 0.5: Peat 0.5 – 1.5: Clay 1.5 – 3.5: Till 3.5 – 4.1: Mudstone 4.1 – 4.5: Unknown strata 4.5 – 5.9: Mudstone	No groundwater remarks noted
BH 2018 (1986)	GL @ 253.0m AOD GL – 1.6: Peat 1.6 – 2.6: Clay 2.6 – 3.6: Till 3.6 – 5.7: Mudstone	No groundwater remarks noted
<b>BGS Borehole Scans</b>		
SN81SW30 (1989)	GL @ 236.48m AOD GL – 6: MADE GROUND: Loose to medium dense black sand and gravel mudstone with coal in a black silty clay matrix (colliery waste) 6 – 7: MADE GROUND: Soft grey brown mottled orange and black silty clay with much gravel of weathered sandstone and mudstone 7 – 8.05: Grey highlight to completely weathered silty MUDSTONE very weak laminated and micaceous 8.05 – 8.65: Dark grey IRONSTONE with some SILTSTONE 8.65 – 8.9: Light grey slightly to moderately weathered fine SANDSTONE, strong massive to occasionally cross laminated 8.9 – 9.6: Grey and light grey interlaminated moderately weathered silty MUDSTONE and sandy SILTSTONE, moderately weak occasional grey sandstone bands 9.6 – 11: Grey moderately weathered silty to very silty MUDSTONE, moderately weak 11 – 11.95: Dark grey slightly weathered silty SANDSTONE, weak. Thin sub horizontal laminations 11.95 – 14.2: Dark grey slightly weathered very slightly silty MUDSTONE moderately weak to weak laminated. Becoming very carbonaceous with depth. 14.2 – 15.03: Vitreous COAL 15.03 – 16.08: Dark grey to grey slightly weathered silty MUDSTONE, moderately weak many carbonaceous plant remains	Groundwater level ranging between 3.45m and 7.2m bgl during drilling

Reference	Stratigraphy (m bgl)	Groundwater
	<p>16.08 – 19.7: Light grey slightly weathered clayey SILTSTONE moderately weak with occasional bands of thinly laminated silty mudstone.</p> <p>19.7 – 21.65: Light to dark grey slightly weathered fine and medium SANDSTONE, strong massive with occasional cross bedding</p> <p>21.65 – 22.3: Grey slightly weathered silty fine SANDSTONE moderately weak thin sub horizontal laminations very occasional plant remains and occasional sub vertical joints</p> <p>22.3 – 25: Dark grey/black slightly weathered slightly silty MUDSTONE moderately to very weak. Often highly fragmented, often highly carbonaceous with occasional plant traces and occasional slickenside on joint surfaces</p> <p>25 – 30: Open hole; Dark grey MUDSTONE</p>	
SN81SW36 (1989)	<p>GL @ 237.2m AOD</p> <p>GL – 3.2: MADE GROUND: Medium dense black sands and gravel of carbonaceous silty mudstone and coal with occasional black silty clay matrix</p> <p>3.2 – 3.4: Firm brown organic CLAY with many rootlets and some peat</p> <p>3.4 – 5.8: Firm to stiff grey brown mottled orange and black silty sandy CLAY with much gravel and occasional cobble of sandstone and mudstone and occasional coal fragments</p> <p>5.8 – 6.7: Firm grey brown silty clay with mudstone fragments</p> <p>6.7 – 7.2: Grey brown highly weathered silty micaceous MUDSTONE weak laminated and fragmented some iron staining</p> <p>7.2 – 9: Grey moderately to slightly weathered SILTSTONE moderately weak laminated sub horizontal to massive iron staining on 45° joint planes</p> <p>9 – 11.59: Grey moderately weathered slightly silty MUDSTONE weak often highly fractured</p> <p>11.59 – 12.4: COAL with 45-60° slickensided joint surfaces</p> <p>12.4 – 13: Grey slightly weathered silty MUDSTONE moderately weak massive many carbonaceous plant remains</p> <p>13 – 18: Grey slightly weathered SANDSTONE and MUDSTONE</p> <p>18 – 23: Dark grey slightly weathered SILTSTONE</p>	<p>Seepage of groundwater noted at 3.2m bgl at the base of the made ground</p> <p>Groundwater level ranging between 3.5m and 6.4m bgl during drilling</p>
SN81SE4 (1977)	<p>GL not provided</p> <p>GL – 0.6: MADE GROUND: Stiff grey/brown stony clay with sandstone cobbles</p> <p>0.6 – 3.9: MADE GROUND: Firm dark grey silty clay with coal fragments</p> <p>3.9 – 5: Stiff brown and grey mottled sandy CLAY with mudstone fragments</p>	<p>Groundwater struck at 1.5m bgl which rose to 1.3m bgl after 10 minutes</p>
SN81SE5 (1977)	<p>GL not provided</p> <p>GL – 0.2: Topsoil</p> <p>0.2 – 0.5: MADE GROUND: Clay with coal wood and stones</p> <p>0.5 – 1.5: MADE GROUND: Firm brown and grey mottled silty clay with sandstone and coal fragments</p> <p>1.5 – 2.6: MADE GROUND: Stiff brown mottled silty clay with sandstone and coal fragments</p> <p>2.6 – 3: MADE GROUND: Stiff dark grey shaly clay with coal fragments</p> <p>3 – 4: Very stiff brown grey shaly CLAY with large angular sandstone fragments</p>	<p>Borehole dry</p>
SN81SE6 (1977)	<p>GL not provided</p> <p>GL – 0.1: Topsoil</p> <p>0.1 – 0.7: MADE GROUND: Coal and clay</p> <p>0.7 – 2.5: MADE GROUND: Firm grey/brown sandy stony clay with mudstone fragments and disseminated coal particles</p> <p>2.5 – 4: Stiff grey/brown sandy stony CLAY with mudstone and large sandstone fragments</p>	<p>Groundwater struck at 3.0m bgl. Standing water level was measured at 1.6m bgl.</p>
SN81SW37 (1991)	<p>GL not provided</p> <p>GL – 0.8: Firm orange silty sandy CLAY with some fine and medium angular mudstone gravel and occasional coarse gravel and cobbles of sandstone</p>	<p>Slight groundwater seepage at 1.0m bgl within mudstone</p>

Reference	Stratigraphy (m bgl)	Groundwater
	0.8 – 1.9: Highly weathered grey and orange laminated MUDSTONE, very weak. Generally recovered as angular gravel size fragments in a clay matrix	
SN81SW38 (1991)	<i>GL not provided</i> GL – 0.6: MADE GROUND: Grey shale and coal fragments with occasional brick and clinker 0.6 – 1.1: Firm grey and orange silty sandy CLAY with occasional fine gravel 1.1 – 1.8: Dark grey completely weathered MUDSTONE, recovered as clay with very occasional very weak mudstone lithorelicts 1.8 – 2: Highly weathered grey and orange laminated MUDSTONE, very weak. Generally recovered as angular gravel size fragments in a clay matrix.	Trial pit was dry throughout
SN81SW39 (1991)	<i>GL not provided</i> GL – 0.25: MADE GROUND: Grey shale fragments with occasional gravel 0.25 – 0.45: Stiff orange and grey silty sandy CLAY with occasional fine sandstone gravel and occasional boulder 0.45 – 1.5: Grey and orange highly weathered laminated MUDSTONE, very weak. Recovered as gravel size fragments	Trial pit was dry throughout

### Notes

1. Detailed stratigraphy is not provided on the vertical sections shown on the opencast completion plans. Vertical sections have been reviewed to reveal the depth to coal seams.
2. The level of detail regarding ‘Nant Helen Geotechnical Boreholes’ is as presented on logs, refer to Appendix C. Logs reviewed to ascertain anticipated thicknesses of strata and depth to bedrock rather than for a detailed description of the materials encountered.
3. The boreholes appear to have been progressed in the same location as the large overburden storage area. Given the ground levels provided on the logs reviewed, it has been interpreted that these boreholes were progressed through the land currently underlying the large overburden storage area.

## 6.1 Interpretation

Made ground deposits are anticipated to be encountered beneath the majority of the proposed track route and within the washery portion of the site. The made ground backfill material anticipated to be present within the areas where opencast mining has been undertaken is likely to comprise gravel and cobble sized fragments of mudstone, siltstone and occasional sandstone.

Based on the descriptions provided in the logs reviewed, the made ground material anticipated to be encountered beneath the washery site is likely to comprise a mixture of varied granular backfill material within a cohesive clay matrix. The various gravel inclusions within the made ground were noted to be mudstone, sandstone, coal, clinker and wood. The thickness of this material is anticipated to range between 0.25m and 7m, although locally thicker deposits could be encountered in the locations of any stockpiles/spoil heaps within the washery site.

Natural superficial deposits of peat and glacial till are anticipated to be encountered beneath the southern portion of the site that has avoided opencast

activities and locally beneath the made ground materials anticipated to be encountered beneath the washery portion of the site.

In areas of the site that have not been subject to historical opencasting, peat deposits with thicknesses of circa 1-2m may be encountered. This material is anticipated to be soft/highly compressible and would need to be excavated and replaced with suitable earthworks fill or be subjected to ground improvement/treatment if it is encountered in the locations of proposed track alignment or the associated earthworks.

Glacial till deposits are also anticipated to be encountered in the locations that have not been subject to opencast mining activities within the main body of the site. The thickness of the glacial till material materials is likely to be limited (~3m) and discontinuous. No detailed descriptions of the glacial till material encountered were provided on the logs reviewed. Based on review of the published geological sources, glacial till typically comprises sand, gravel and cobble inclusions within a clay matrix.

Firm to stiff grey/brown clay with various mudstone, siltstone and sandstone gravel inclusions was encountered beneath the made ground deposits within the washery portion of the site. Based on the description and the published geological mapping, these materials are anticipated to be glacial till. 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.

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.

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). For



further detail regarding coal mining activity and the risk of shallow workings being present, reference should be made to Section 9 of this report.

Groundwater remarks were only provided on the logs reviewed within the washery portion of the site. The logs for the two deep boreholes reviewed within the washery portion of the site provided no indication of distinct groundwater strikes; however, the measured standing water level ranged between 3.45m and 7.2m bgl. Slight seepages and groundwater strikes were presented on the other logs within the washery portion of the site with some as shallow as 1.0m bgl. A detailed review of the groundwater beneath the site is provided in Section 8.3.

## 7 Hydrology

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The hydrological features that pass through and surround the site have been identified through review of aerial online imagery and through review of the Groundsure EnviroInsight report (refer to Appendix E for the Groundsure report). The flow direction of the watercourses has been determined through interpretation of contours presented on the OS mapping covering the site area.

Figure 7 shows the location of identified hydrological features.

### 7.1 Watercourses

The site overlaps with three principal river catchments. The northern half of the main portion of the site sits within the Tawe catchment and contains several small unnamed streams which drain in a northerly direction towards the River Tawe. The River Tawe is the largest watercourse within the vicinity of the site and flows roughly from east to west approximately 500m to the north of the site boundary.

The Nant Llech, a tributary of the River Tawe, flows from east to northwest where it feeds into the Tawe and passes within 300m of the north-eastern site boundary. The Nant Llech is also an SSSI (refer to Section 10). A collection of small unnamed stream features to the northeast of the main portion of the site are shown to drain in a north-easterly direction towards the Nant Llech.

The southern half of the site sits within the Dulais catchment. The River Dulais flows roughly from east-northeast to west-southwest and runs through the washery portion of the site and along a portion of the south-eastern boundary of the main site.

The Nant Ystalwyn, a tributary of the Dulais, is shown to be fed by a selection of ponds which are located at the base of the large overburden storage area which is centrally located within the body of the main site. These ponds have been identified as water treatment areas and are fed by the drainage features present on the southern face of the large overburden storage area.

A collection of other tributary streams which originate within the central portion of the site flow in a southerly direction to their respective convergences with the River Dulais.

A small portion of the eastern half of the main portion of the site is shown to sit within the Pyrddin catchment. However, from review of OS mapping contours and the Groundsure EnviroInsight report, the drainage features within this portion of the site are anticipated to contribute to flows within the Dulais and not the Pyrddin (located ~1km to the east of the eastern site boundary). The drainage features identified appear to be man-made and initially flow in an easterly direction. Once they pass beneath Onllwyn Road the direction of flow turns south-westwards and runs parallel to the Onllwyn Road before feeding into a collection of ponds within the washery portion of the site. These ponds are located at the apparent source of the River Dulais and based on contours in the area are likely to feed into the flows within the Dulais.

One unnamed stream is shown to be located to the south of the washery portion of the site. From review of information presented within the Groundsure EnviroInsight report, this stream flows in an easterly direction before being culverted beneath the A4109 that borders the washery site to the south. The stream is then shown to re-emerge within the washery site before passing through another culvert beneath a section of the washery site. The stream eventually converges with the Camnant which in turn is a tributary of the Pyrddin.

As shown on the 'Site Context' figure provided by Celtic Energy (refer to Appendix H), several small pond features are shown to be located within the boundary of the site. Most of these appear to be 'water treatment areas', refer to Figure 7.

Through consultation with Celtic Energy it is understood that the easternmost water treatment area comprises ponds which are lined with a plastic liner. The water treatment areas that lie at the southern base of the large overburden storage area were constructed in 'virgin ground' and are possibly clay lined/sealed; if unlined, it is likely that water is retained within these features due to the cohesive nature of the glacial till likely to be present in the area.

In addition to the water treatment areas, a collection of pond features are shown to be present in the area of 'restored land' above a portion of the Nant Helen opencast workings. It is understood that these ponds are an attempt to re-naturalise and create an ecological habitat post backfilling and are possibly lined with low permeability/cohesive materials.

## 8 Hydrogeology

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This section of the report provides details on the anticipated hydrogeological regime beneath the site. Published hydrogeological sources have been reviewed alongside the Groundsure Report purchased for the site and data provided by Celtic Energy regarding groundwater levels beneath the site.

### 8.1 Hydrogeological Mapping

The information presented below has been based on review of the BGS 1:125,000 Hydrogeological Map of South Wales [6].