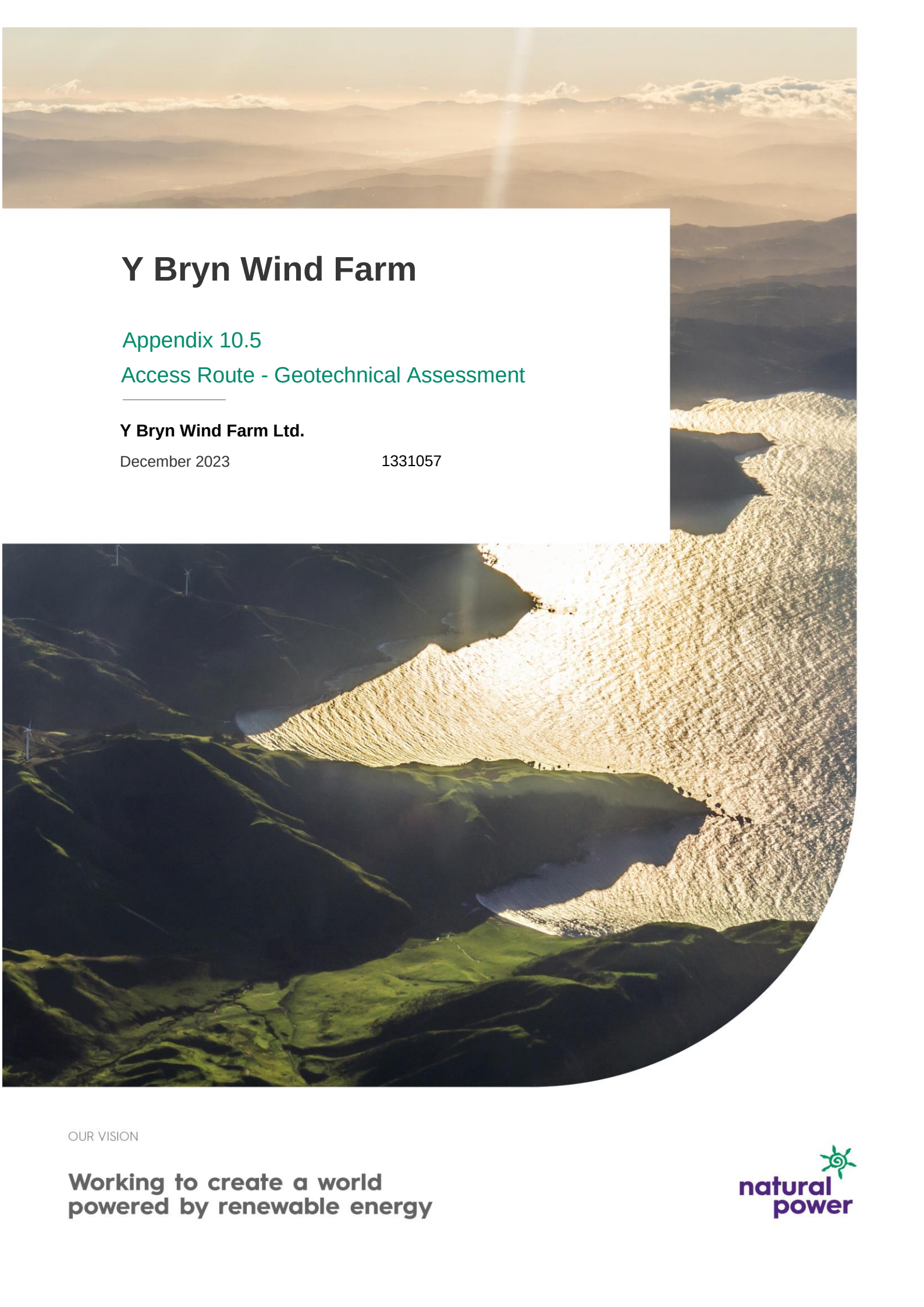




Y Bryn Wind Farm

Appendix 10.5

Access Route - Geotechnical Assessment

Y Bryn Wind Farm Ltd.

December 2023

1331057

OUR VISION

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1. Background

Natural Power was appointed by Y Bryn Wind Farm Ltd. in August-September 2023 to undertake a preliminary geotechnical assessment for the proposed Abnormal Indivisible Load (AIL) access at Y Bryn Wind Farm (the proposed development), South Wales. The main aims of the report are to provide a summary of all published and field-collected information relating to geotechnical risk in line with relevant sections of CD622¹, to assess the initial earthwork engineering designs, and to provide details of potential common mitigation measures.

British Geological Survey information has indicated that landslide deposits are recorded within the AIL access geotechnical study area (the Study Area). Therefore, a preliminary geotechnical study (desk based & walkover) has been undertaken to refine understanding. This report has considered mitigations which are in place, and which may need to be incorporated as part of the planned AIL access route to manage geotechnical risk.

Recommendations for detailed ground investigation at a later stage post consent are also defined.

1.1. Geotechnical Category

In accordance with BS EN 1997 Part 1; the proposed infrastructure for national guidance is currently defined as Geotechnical Category 2. This includes conventional types of structure and foundation with no exceptional risk or difficult soil or loading conditions. Thus, all future structural and foundation design should include quantitative geotechnical data and analysis to ensure design requirements can be satisfied. Routine procedures for field and laboratory testing and for design and execution are expected for this category.

The key focus at this stage of reporting is on geotechnical risk identification and engineering considerations for the AIL access route.

1.2. Report Limitations

Natural Power has made all reasonable effort to obtain relevant information relating to the geotechnical and geo-environmental aspects of the Site (the area within which the proposed development will be located). All primary data sources use the latest information at the published date however Natural Power cannot accept any liability for changes that may have occurred following the published date of information.

1.3. Project Description

The proposed development will comprise of up to x18 wind turbine generators (WTGs). This report examines in detail the proposed new wind farm access route which would access to the Site from off the M4 Motorway at Margam (See Figure F1 in Appendix F for a detailed proposal design for the track). An existing farm access runs adjacent to the proposed AIL access route and has existed along this trajectory since the late 19th Century.

2. Location

The proposed development is located approximately 5km east of Port Talbot in South Wales and is formed of two discrete arrays separated by a minor road (B4282). The development is located within commercial forestry plantation, managed by Natural Resources Wales (NRW). Access is currently possible from the B4282 road running north of the Site (BNG 283708E, 191870N). Figure 2.1 depicts the regional context.

¹ <https://www.standardsforhighways.co.uk/search/ff5ed991-71ed-4ff2-9800-094e18cd1c4c>

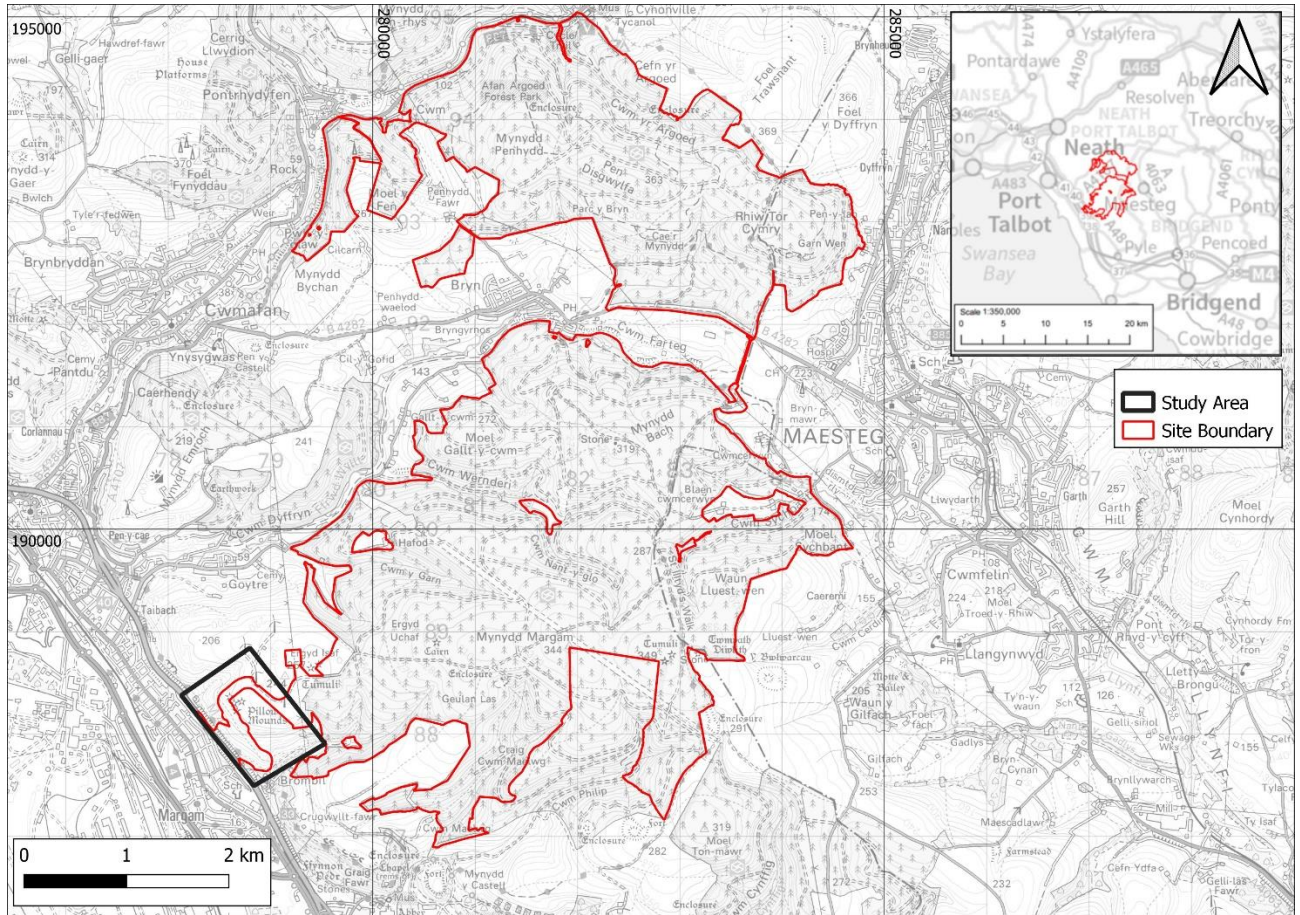


Figure 2.1: Regional context of the proposed development & the Study Area

2.1. Topography and Geomorphology

The Study Area is situated on steep heavily vegetated and grassy upland terrain. There is a steeply incised valley to the northwest (Cwm y Geifr, NGR 278633E,188570N) of the proposed wind farm access route, and a gentler valley form located on the other side of the track to the southeast near Brombil Farm (Cwm y Brombil, 279136E, 187850N).

In the upper parts of the Study Area, where the newly proposed track meets the pre-existing wind farm access (278841E,188487N) the land plateaus and reduces in gradient with grassland dominating. A topographic high of 244m Above Ordnance Datum (AOD) is reached here. The lower (southern) part of the hill on which the access route is situated is densely vegetated with scrub vegetation and trees. Where it interfaces with the M4 motorway, a topographic low of 40m AOD is observed at the base of the Study Area.

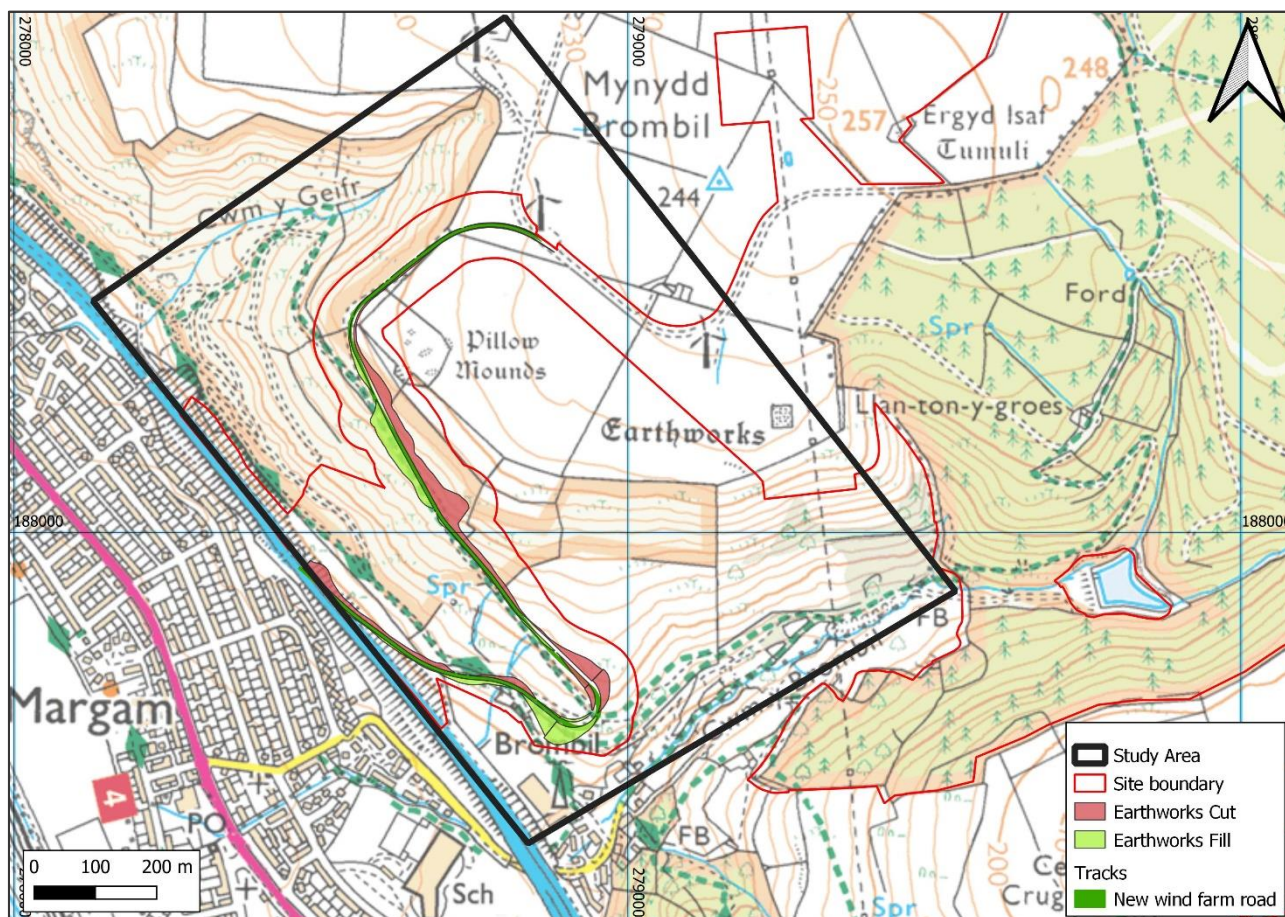


Figure 2.2: Topographic map of the Study Area

2.2. Historical Land Use

Table 2.1. below provides a summary of the land use on the Site and surrounding area using historical maps available through the National Library of Scotland online resource². Historical Map excerpts of the Site and surrounding area are provided in Appendix D.

Table 2.1: Historical Land Use

Site History (on-site)	Surrounding Site History (off-site)
1888-1913	
The south-facing slope of the Site is dominated by moorland which is roughly partitioned by stone walls. A track exists along the alignment of the present day. The track continues along the contours of the hill to the northwest where it intersects with the Cwm y Geifr valley. There are scree deposits on the western sides of this valley which indicates active erosion and possibly past instability. The gentle terrain unit above the slope system is made up of grassland and partitioned by walls. There is a Cairn and a Tumulus (burial ground) on the field on this flat-topped part of the hill. The village of Bronbil (present day Brombil) exists as numerous farm buildings. There is scattered woodland on the lower slopes of the hill (Mynydd Bronbil). Directly to the east of the Site there is a Colliery and Air Shaft presumably used for underground coal mining, these are noted as "Disused" and "Old".	The surrounding area shows similar moorland on the slopes of the hills with walls separating land in places and woodland in the lower slopes of the hills. To the southwest and southeast towards the sea, there is a railway (Great Western Railway), tramway and minor road which travel roughly parallel with the sea. There are numerous collieries and signs of mining activity in the surrounding area (e.g., Morfa Colliery and Margam Copper Works which sit directly on the coast). To the northeast of the Site, by the valley of Cwm y Geifr, there are further old Air Shafts and quarries, and a site of battle (located at Pant Y Cae).
1937-1961	

² <https://maps.nls.uk/>

Site History (on-site)	Surrounding Site History (off-site)
There is no significant change within the Study Area. There are several small building additions around Brombil Farm, directly east of the Study Area.	The suburb of Port Talbot, Margam, shows significant development, southwest of the Site. This includes industrial development related to the mineral extraction and processing, and domestic housing closer to the road nearer the Site.
1960s-2000s	
No significant change within the Study Area. There is further vegetation growth in the ferns and bushes along the hillside.	There is commercial forest development in the surrounding hills. The main road travelling roughly parallel with the coastline has been upgraded to a motorway (M4).
Present Day	
Satellite imagery shows there are several wind turbines and associated access tracks now active on the flat-topped hill above the Study Area (Mynydd Brombil). The old access track (that the proposed new wind farm track will roughly follow) connects with this wind farm via an access gate. There is further vegetation growth, with dense bushes and ferns present along the lower and upper slopes of the Site.	There is more development domestically and industrially around Margam. Updates have been made to existing footpaths with the addition of the "Wales Coast Path" travelling along the lower slopes of the hills above Port Talbot/Margam.

In general, the Study Area shows very little change over the past few hundred years. **The access track which is in part required to be upgraded for the proposed development has existed in the same position from at least the late 1800s.** The surrounding area has shown significant industrialisation during the 1800s-1900s with coal mining and other mineral exploitation bringing the development of railway, tram and road networks and the associated domestic and commercial growth. Directly adjacent to the Study Area, beside Brombil Farm, there are signs of previous mining activity with disused collieries and mining shafts evident from the historic maps. More recently (late 20th century) the surrounding area has seen the development of commercial forestry and the modern-day area shows a wind farm on the hills above the coast. The historical map data has not provided any clear evidence for recent or active large-scale landslide across this area.

2.3. Hydrology and Drainage

Several unnamed watercourses intersect the access track are mapped on the Ordnance Survey mapping shown to originate on the steep terrain near Brombil Farm (278776E, 187904N and 278838E, 187818N). A spring is shown on the map as the source for one of these watercourses. Another unnamed watercourse flows towards the sea in the southwest along the incised valley, Cwm y Geifr to the northwest, and a further watercourse flows along the Cwm y Brombil valley from the Brombil Reservoir in the northeast. The Watercourse Crossing Assessment at Appendix A10.1 of the Environmental Statement assesses one of these as 'Crossing WX1.

2.4. Flooding Risk

The Natural Resources Wales interactive map for flood risk³ shows that there is generally a very low flood risk from rivers and the sea across the Site and surrounding area (See Figure 2.3). There is a single watercourse (mapped on the 1:25K OS map) which shows a low risk of flooding from small watercourses in the map. The other two watercourses found in the valleys adjacent to the Study Area, also illustrated on the 1:25K OS map), show a range of low to high flood risk but this is currently confined to the limits of the watercourses.

³ <https://flood-risk-maps.naturalresources.wales/>

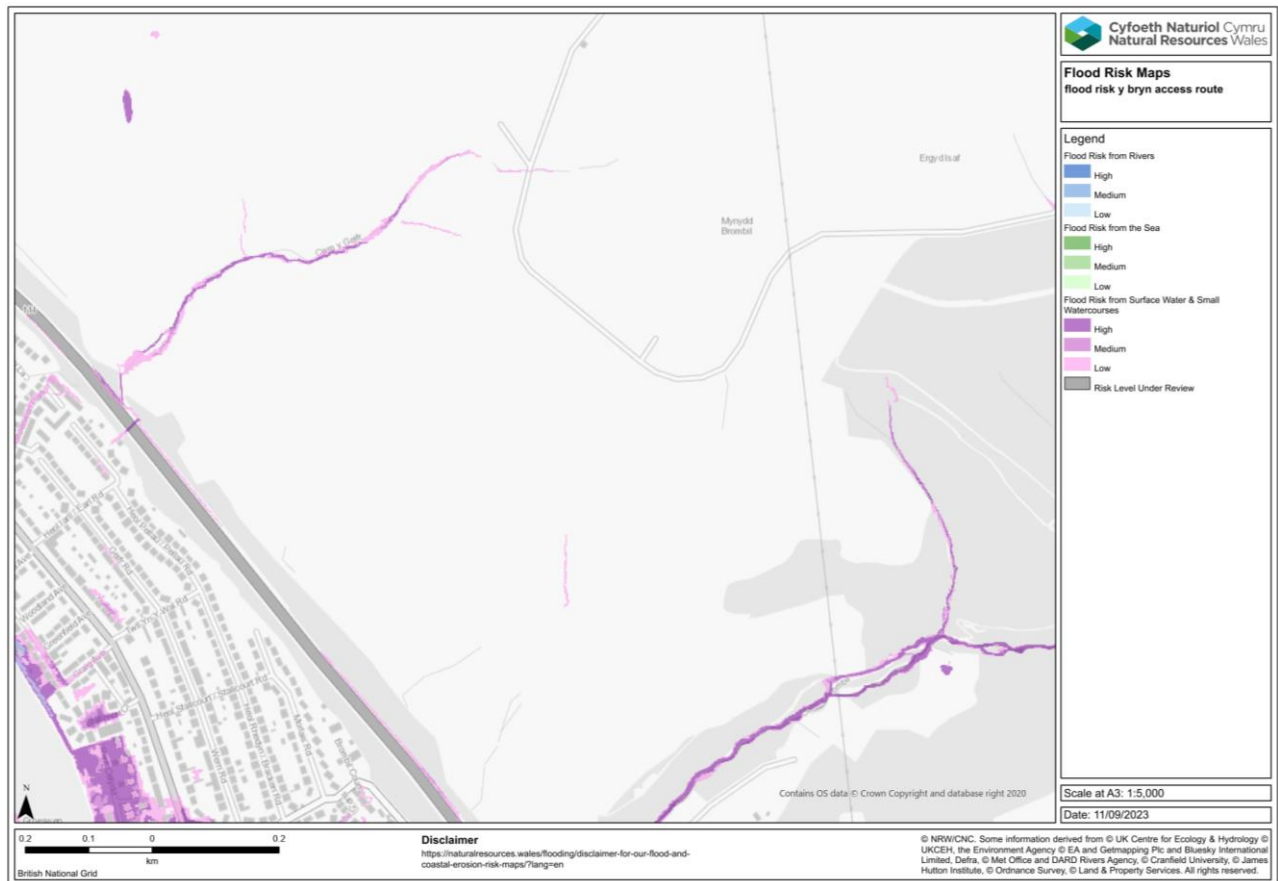


Figure 2.3: Flood Risk Map courtesy of Natural Resources Wales interactive online database

2.5. Geology

2.5.1. Superficial Soils

The British Geological survey⁴, depicts no superficial deposits along the proposed new access track alignment. This could be resultant from a lack of detailed field mapping in the area but more probably due to the presence of the steep slopes and shallow bedrock profile, as was noted during the site walkover.

Across the wider area: the Site contains peat, located north and northeast of the proposed access track in upland terrain closer to the centre of the Site.

All other superficial deposits are mapped outside the Site but near the proposed access route where it intersects with the M4 motorway. Glaciofluvial Ice Contact Deposits (Devensian, Sand and Gravel), Tidal Flat Deposits (Clay, Silt and Sand) and Alluvial Fan Deposits (Sand and Gravel) are present to the west of the Site. All these superficial deposits run in a northwest to southeast orientation and intersect at the very northeast section of the map. The superficial deposits of Till (Devensian, Diamicton) are located west and northwest of the Glaciofluvial Ice Contact Deposits. The other superficial deposit consists of Alluvium (Clay, Silt, Sand and Gravel) with a small section located outside the Site in the southeast section of the surrounding area.

The BGS 1:1M Superficial Engineering Geology online map does not show any information directly on the Site, show Coarse Soil and Fine Soil directly to the southwest of the Site. The BGS provides the following Engineering Geology information for this:

⁴ GeoIndex - British Geological Survey (bgs.ac.uk)

Coarse Soil

Description: Loose to dense fine to coarse-grained Sand or Sand and Gravel with some cobbles. Sandy clay and silt, sometimes laminated, occur locally, especially within terrace deposits which may also contain peat. High to very high permeability flow is through matrix. Includes glaciofluvial sand and gravel, river terrace deposits, blown sand, coarse marine, coarse alluvium, head and talus deposits.

Foundations: Generally good foundation conditions. Frost susceptibility of near-surface silt and fine sand lithologies should be considered in design of shallow foundations. Blown sand may prove unsuitable for conventional pad and strip foundations and may require rafts or piling.

Excavation: Easy digging, occasionally hard digging. Immediate support required. Groundwater control measures will be necessary where deposits are below the water table.

Engineered Fill: May be suitable as selected granular fill if composition is appropriate or with separation of desired grades otherwise suitable as general granular fill.

Site Investigation: Important to determine lithological variation and deposit geometry, particularly the presence and dimensions of buried channels and characteristics of infilling deposits.

Fine Soil

Description: Very soft to very stiff sometimes sandy clay or silt. Desiccation of top few metres may result in firm to stiff material overlying soft to very soft deposits at depth. Generally very low to moderate permeability flow dominantly through fissures. Includes lacustrine deposits, glaciolacustrine deposits, fine marine deposits, estuarine alluvium and lowland river alluvium (any of which may contain peat beds or lenses) and loess/loessic soils.

Foundations: Variable foundation conditions, dependant on shear strength and consolidation characteristics. Settlement rates usually slow but with potentially high total settlements. Possible foundation design considerations may include the potential risk of severe differential settlements in soft, highly compressible zones the potential for sudden collapse of loessic deposits when saturated under engineering loads potentially high sulphide contents of some estuarine alluvium and frost-susceptibility of near surface silty and fine sandy lithologies.

Excavation: Easy digging. Excavations usually require immediate support but stiff clays may be stable in short-term where groundwater ingress is controlled or absent. Running conditions may occur in silts and sands below the water table presence of water-bearing sand/silt layers will require groundwater control measures.

Engineered Fill: May be suitable as selected cohesive fill depending on grading, plasticity, water content and sulphate/sulphide contents where buried concrete and steel are likely to be used otherwise suitable as general cohesive fill. Generally, should be placed as soon as possible after excavation and subject to minimum construction traffic when wet. Material containing a significant proportion of organics, such as some alluvium, are unsuitable as fill.

Site Investigation: Important to determine lithological variability and the presence, depth and extent of any soft compressible zones (and depth to sound strata). Assessment of shrink-swell potential and sulphate/sulphide contents in clay deposits and the potential for rapid collapse settlement in loessic deposits is advisable. In situ loading tests advisable to assess bearing strength at selected sites.

A superficial geology map of the Site and surrounding area is shown below in Figure 2.4.

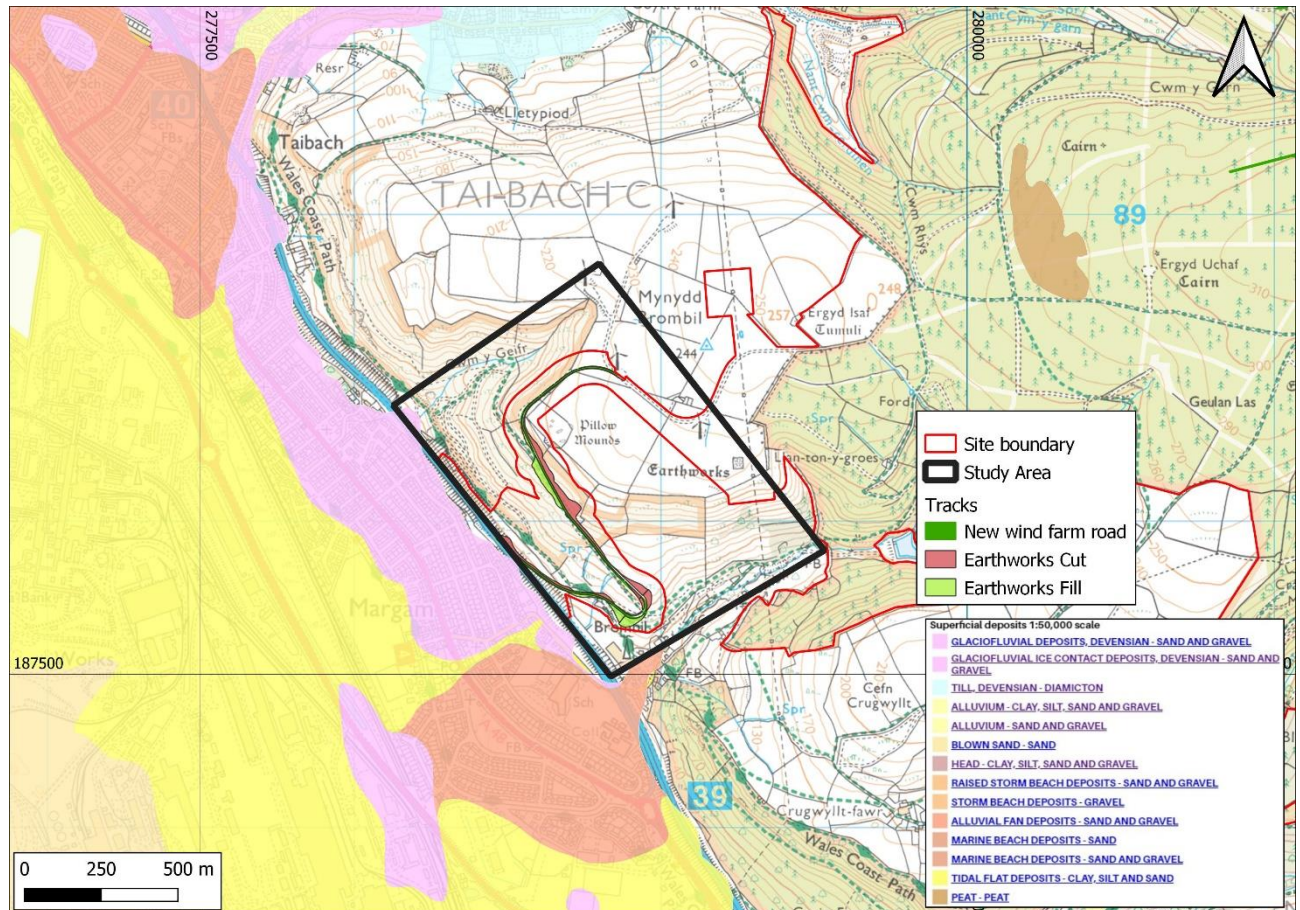


Figure 2.4: Superficial Map of the Site and surrounding area.

2.5.2. Landslide Deposits

The BGS maps show Landslide Deposits near the Site access track and in the surrounding area. Available literature records (Waters et al., 2006) provides additional information on these deposits near to Port Talbot and Margam –

“Following deglaciation, valley sides over steepened by glacial erosion were widely subject to landslide in the region...all are shallow translational slide/debris flows (Conway et al., 1980) and are in argillaceous horizons and/or superficial deposits, with failure caused by seepages at the bases of Pennant Sandstone scarps, or along fault planes”.

Figure 2.5 below shows where landslide deposits have been mapped previously by the BGS in the Site and surrounding area.

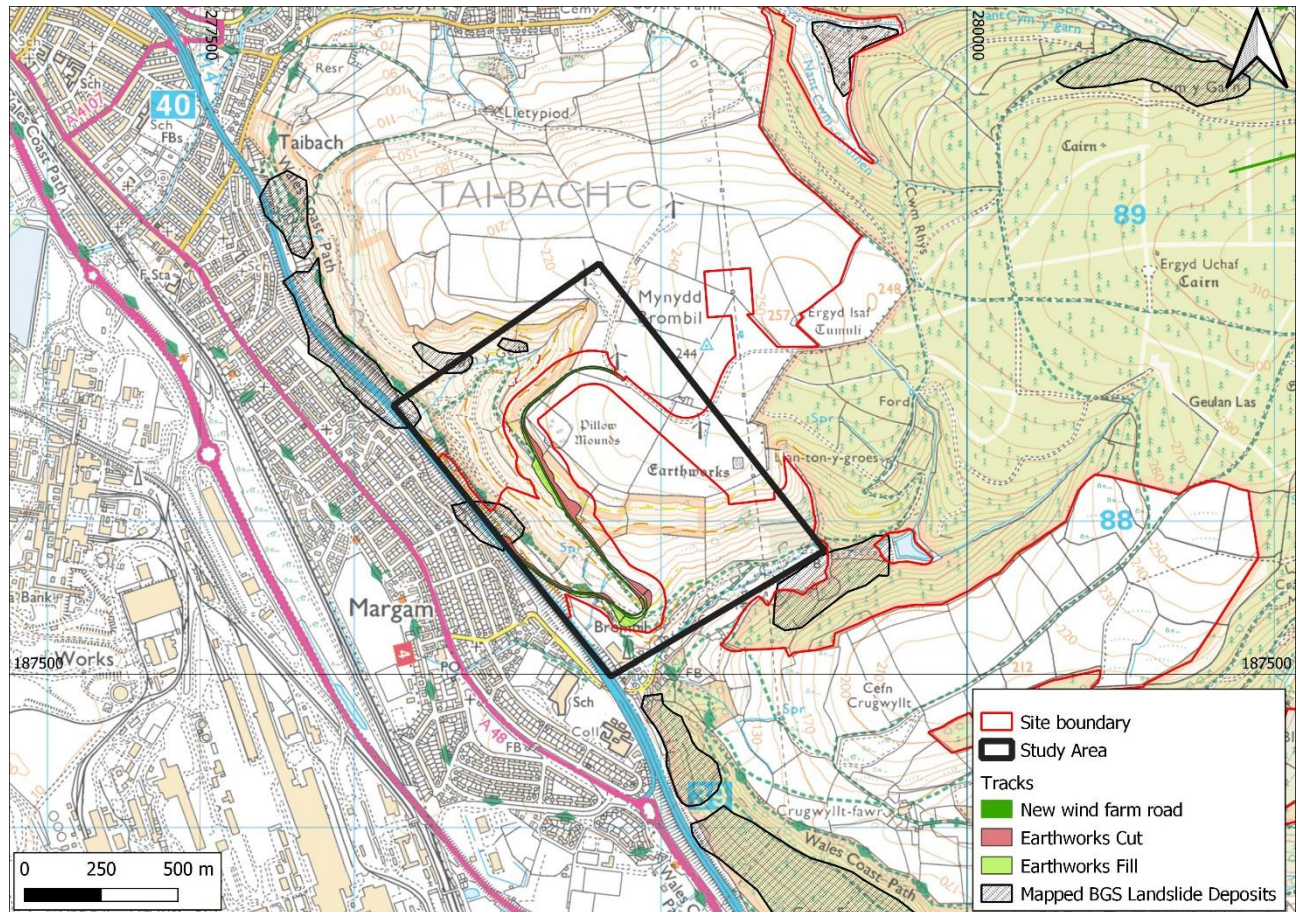


Figure 2.5: BGS-mapped Landslide Deposits on and near to the Site

2.5.3. Solid Geology

According to the British Geological Survey (BGS)⁵, the Site is underlain by the Rhondda Member (Sandstone) and also shows the Rhondda Member (Sandstone, Siltstone, Mudstone) and various inferred Coal seams. The Rhondda member (Sandstone) lies on the Rhondda Member (Sandstone, Siltstone, Mudstone) along a discontinuity trending southwest-northeast, on the western fringes of the Site boundary.

Outside the Site boundary, the South Wales Middle Coal Measures Formation (Mudstone, Siltstone and Sandstone) conformably underlays the South Wales Upper Coal Measures Formation (Mudstone, Siltstone and Sandstone) in a northwest to southeast orientation. The South Wales Upper Coal Measures Formation (Sandstone) constituent is also recorded on the map by the BGS and is in a similar orientation to the other coal-bearing formations. Both Rhondda members are deposited above coal measures along with Llynfi (Mudstone, Siltstone and Mudstone). The Upper and Middle Coal measures along with the Rhondda members discontinuity trends are southwest-northeast and south-north respectively.

A number of faults (of unknown displacement) are recorded by the BGS mapping. These are roughly orientated northwest-southeast and intersect the access tracks within the Site boundary where they can be seen to displace the Rhondda Member (Mudstone, Siltstone and Sandstone). Similarly orientated faults are shown further into the Y Brywn Wind Farm development boundary to the northeast within the Rhondda Member (Sandstone).

Figure 2.6 depicts the geology and faulting of the Site and surrounding area using data provided from the BGS Onshore Geoindex viewer.

The BGS 1:1M Bedrock Engineering Geology online map⁵ shows Mudstone and Strong Sandstone (Coal-bearing) 2:1 on the Site and provides the following engineering geology information for this:

Description: Medium strong to extremely strong medium to widely jointed thinly to thickly bedded fine to coarse-grained Sandstone may contain Slate or Mudstone and Siltstone beds. Weathers to a loose to very dense sand, gravel or silty/clayey sand. Low to high permeability flow is through matrix and discontinuities. Includes Greywackes.

Foundations: Usually very good foundation conditions, depending on nature and thickness of the weathered zone.

Excavation: Highly weathered rock may be excavatable by hard digging. In fresher material ripping or blasting is required depending on joint/bedding spacing and orientation. Where fresh to slightly weathered excavated slopes may maintain long-term stability.

Engineered Fill: Suitable as selected granular fill if care is taken in selection and abstraction.

Site Investigation: Important to determine intact rock strength, spacing, orientation and nature of discontinuities (including water flows) and nature/depth of weathered zone materials.

Source: BGS Geoindex Onshore Map Viewer

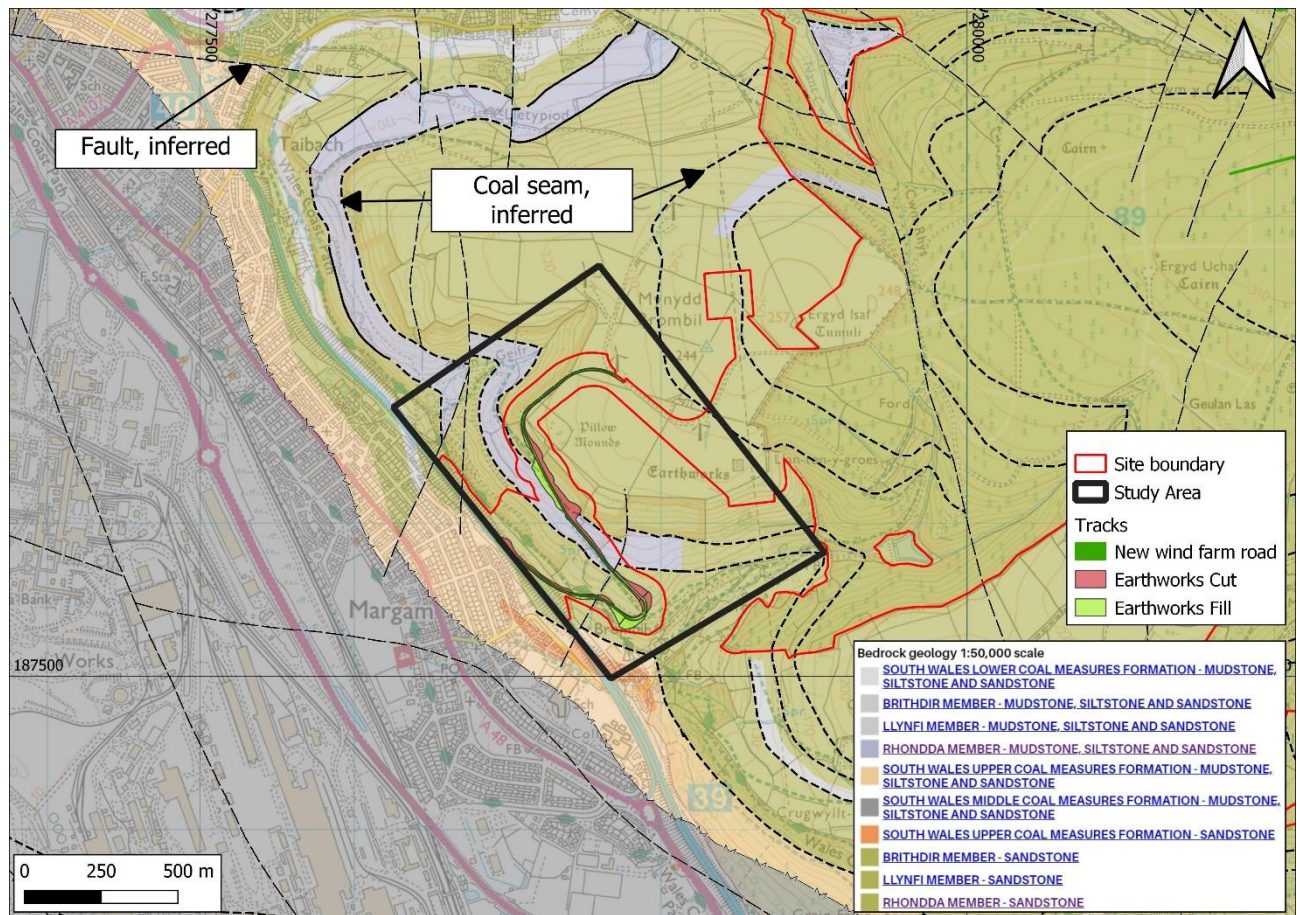


Figure 2.6: Solid Geology of the Study Area and surrounding area

Hydrogeology

The BGS 1:625,000 Hydrogeology map indicates the development is placed South Wales Upper Coal Measures Group. This is characterised by a moderately productive aquifer and summarised by a regional, cyclic multi-layered aquifer with moderate yields from sandstones and springs. The quality of mine water is poor but elsewhere is reasonable.

⁵ <https://www.bgs.ac.uk/map-viewers/geoindex-onshore/>

Waters et al. (2006) provide information on the aquifer properties of the parent unit of the Rhondda Member (Pennant Sandstone Formation) as follows: “Early cementation led to a marked reduction of the initially high intrinsic inter-granular permeability coarse sands to low permeability sandstones, notably within the Pennant Sandstone Formation. The jointed bedrock sandstones, siltstones and coal seams have secondary fracture permeabilities of 0.1-0.2 m/d⁻¹, while interbedded carbonaceous mudstones form aquicludes. Higher zones of secondary permeability (0.08 - 2.678 m/d⁻¹) occur in linear fracture zones, especially along the Tawe Fault and Neath Disturbance. Groundwater discharges, from springs, issues and seepages along coal seam outcrops and fault-controlled valleys, are typically iron oxide rich (Strahan, 1907). Additional secondary permeability developed within zones of water table oscillation associated with sea level and river base flow shifts following the last glacial maximum. These shallow horizons of weathered, iron stained and fractured sandstones form thin zones of groundwater flow.”

3. Site Reconnaissance

During September 2023, a geotechnical site reconnaissance was carried out to assess the potential landslide deposits that are mapped by the BGS and provide an overview of the geological and geomorphological features of the Study Area. This was undertaken to provide further detailed assessment of the development of the AIL proposed access track from the M4 motorway at Margam to the proposed development in the northeast.

During the site walkover, the weather was warm and sunny and followed a relatively humid period, water was not observed to be flowing through the minor watercourses mapped on the OS 1:25,000 map, and very little surface water was observed elsewhere around the Study Area.

The BGS mapped landslide deposits along the interface with the M4 motorway were not clearly identifiable on the Site during the walkover due to dense vegetation cover. However, a significant relic landslide feature with a horizontal extent of about 180 m can be observed from Google Earth Imagery (2021) approximately 600m southwest of the access route (277993E, 188669N, Figure E2 in Appendix E). In closer proximity to the access track, a localised landslide feature was identified (Figure B1 in Appendix B) on the western side of the current access track. The landslide head scarps typically measure 5 to 10 m in width, and the debris was found between 2 to 20 m below this. A clear example of a previous slide, along the western side of the access track/eastern flank of the Cwm y Geifr valley) can be seen using historic satellite imagery from 2013 (Figure E1, Appendix E).

Noted landslide deposits were composed of angular to sub-angular blocks of Sandstone of the Rhondda Member. The size of these blocks ranged from cobble sized (64 to 256 mm diameter) up to boulder sized (up to 1000mm diameter). The deposits were dry, showing no dampness in or along fracture surfaces. The Sandstone blocks were typically separated by an orange to light brown silty sandy soil. This showed poor organic content and was also very dry. Commonly rootlets were observed within the soil, and grasses and ferns were seen to be growing on top and on the sides of the soil profile which suggests a level of soil re-establishment and stabilisation has taken place since the slide occurred.

The field description for the Sandstone is as follows: Medium Strong to Strong orange-yellow medium to coarse Sandstone. Grains range from sub-rounded to sub-angular. There were also interbeds of 10-50 mm thick interbeds composed of Siltstone or fine Sandstone of the Rhondda Member observed between the Sandstone beds. These observations are consistent with the geology map shown on the 1:50,000 BGS Bedrock Geology map. The Sandstone beds exhibit thickly laminated to thinly bedded, with top surfaces showing ripple marks. Jointing is common in the outcrop, they are irregular and closely to widely spaced, showing multiple orientations. Fractures are also present as medium to widely spaced irregular and open aperture, roughly orientated vertically, or along bedding planes. Some of the Sandstone blocks also exhibit iron-oxide mineralisation (orange colour) on their surfaces.

A number of features were identified along the existing access track and proposed new access alignment that suggest ground instability is a recent and contemporary hazard of the Study Area:

- Natural terracing of the slope possibly from relict movement
- Track-side soil erosion and soil slips (both up and downslope of track)

- Previous landslide activity in the form of scarp and associated debris
- Loose blocks of Sandstone outcrop across the side profile of current track and above the track
- Faulting mapped by the BGS coinciding with position of minor watercourses (potential areas of weakness)

Photos of these features from the site walkover can be viewed in Appendix A of this report.

4. Landslide Risk Assessment

4.1. Methodology

Natural Power applied the following assessment workflow for the Y Bryn Wind Farm Landslide Study:

Stage 1: Initial desk-based assessment spread across the slope system. The desk study included updated review of primary data sources across this area including:

- Historical Land Use information
- Hydrology and Hydrogeology data
- Basic flood data including Flood Zones, and groundwater information
- Detailed BGS Geo-sure Ground Stability data ⁶– 1:10,000 scale landslide and collapsible deposits and shrink-swell data
- Detailed BGS data – 1:10,000 and 1:50,000 scale geology
- BGS non-coal mining hazards data
- BGS borehole records, hyperlinked to online BGS scans.

In addition, online archival news searches for local or regional landslip events were undertaken.

Wide scale analysis of high-resolution aerial imagery data was also carried out including three-dimensional visualisation of slope system and terrain units using Google Earth Professional with imaging from 2021.

A terrain slope angle map was created based on a digital terrain model (DTM) elevation data obtained from the Welsh Government Database (Data Map Wales⁷). Elevation terrain data has provided a terrain model across the Study Area to aid in identification of terrain units which may be associated with historic instability. The terrain slope angle was analysed based on a 50m elevation grid.

The use of the BGS Geosure Ground Stability data shows that deposits with potential to collapse when loaded and saturated are not believed to be present across the Site. The data package also provides information on clay shrinkage or swelling. The maps suggest ground conditions where the current track/newly proposed track climbs the hillside on the Rhondda Member are predominantly low plasticity. The BGS hazard rating places this as 'B'⁸, meaning that there are no actions required to avoid problems due to shrink-swell clays. Overall, these additional pieces of information do not increase the level of risk associated with the construction of the access track.

Online archival news searches found that a small landslide occurred on Cwmavon Road approximately 3.5 km from the Site in 2017⁹ following a sustained period of heavy rainfall and wind. A landslide also occurred in 2018¹⁰ on Cymmer Road in Glynccorwg approximately 13 km from the Site, where similar adverse weather conditions led to a slide and local damage to infrastructure. These relatively recent events, although not directly on the Site, show that ground instability in the region is an ongoing issue.

⁶ <https://www.bgs.ac.uk/datasets/geosure/>

⁷ <https://datamap.gov.wales/maps/new#/>

⁸ <https://www.bgs.ac.uk/datasets/bgs-geosure-shrink-swell/shrink-swell-property-hazard-information/>

⁹ <https://www.bbc.co.uk/news/uk-wales-south-west-wales-42529173>

¹⁰ <https://www.bbc.co.uk/news/uk-wales-south-west-wales-43981345>

Stage 2: Site reconnaissance and geomorphological mapping. Carried out across the defined Study Area, providing opportunity for Natural Power geotechnical engineers to visualise the terrain, access geological and soil exposures, examine wider slope systems, terrain geometry, vegetation cover and identify hydrological features which may be impacting stability.

The culmination of the field survey and desk-based review was the production of a geomorphological map (Appendix B). Figure B1 depicts all major geomorphological features within the Study Area and contributed to the formulation of a qualitative preliminary landslide risk map.

Stage 3: Landslide Risk Mapping.

Natural Power has undertaken a qualitative risk mapping exercise and formulated a preliminary landslide risk zonation plan. Key inputs to the risk map (Figure C1 in Appendix C) include interpretation of the field mapping findings, geomorphological elements combined with the digital terrain model (DTM) and terrain slope datasets.

The Study Area has been categorised into four risk zones. This is based on engineering judgement and assessment of key contributory factors to landslip. These include:

- Terrain Slope Angle subjective and correlated with terrain unit changes and underlying geology.
- Presence of surface hydrological features. Ranging from groundwater springs, natural watercourses, artificial drains etc.
- Evidence of previous or active instability. Visual field mapping and DTM analysis used to define the risk areas. Large relict landslip areas only detectable via remote sensed DTM data (beyond the resolution of the model used in this preliminary study) however recent and ongoing failures have been detected during field mapping.

The preliminary risk map provides a current overview of risk and highlights key areas for avoidance and potential further investigation. This offers a wider view of risk across the slope system and should provide additional value for any future consideration of re-routing or slope remediation planning.

Table 4.4.1 below provides a summary of each risk category depicted on Figure C1 in Appendix C.

Table 4.4.1: Risk Rank Category

Risk Rank	Required Control Measures
High	Avoid project development at these locations. (e.g., all factors below present along with current and active signs of instability / ground movement)
Medium	Project should not proceed unless risk can be avoided or mitigated at these locations, without significant impact, to reduce risk ranking to low or negligible.(e.g., multiple contributory factors to potential future instability: sloped (>10 degrees), Watercourse or spring fed surface water flows coupled with presence of possible historic / relict signs of movement)
Low	Project may proceed pending further investigation to refine risk assessment and mitigate hazard through relocation or re-design at these locations. (e.g., Increasing slope angle (4-10deg), single contributory factor to potential instability present, e.g., watercourse / spring, faulting present on BGS map. No signs of past or current failure)
Negligible	Project should proceed with monitoring and mitigation of landslide hazards at these locations as appropriate. (e.g., shallow slope angle (<4deg), no signs of previous instability, no other signs / contributory factors to instability)

Source: Natural Power

Stage 4: Track Earthworks Design and Mitigation

The proposed access track route (Appendix F) closely follows the long-standing farm track but for the most part is positioned further up the slope where the gradient is less severe. This new route generally avoids the areas of increased risk shown on the risk map (Figure C1). The earthworks design for the proposed new access track

indicates either cutting or filling would be necessary to construct the track. Confirmation of the exact cut and fill designs would follow a detailed ground investigation. The implementation of a moderate 2:1 slope ratio for all cut and fill operations would be used to ensure a stable and safe surface and optimum drainage for vehicle and plant use along the entire proposed track. The cut-and-fill plans appended to this report display the maximum lateral limits in the extent of cut that will be necessary – it is likely that stable bedrock is encountered at a shorter distance than these limits. This would reduce the extent of cut required laterally. Cutting operations for the new route are planned below existing ground level directly onto expected shallow bedrock. This would mean that the build-up of superficial deposits would be minimal, and the chance of their mass-movement would be highly unlikely.

However, table 4.2 below highlights select zones of ground stability risk from construction of the new access track and provides potential mitigation measures. These specific points of risk are shown in Figure C1 (labelled A to E) in Appendix C. In all cases shown in the table, appropriate mitigation measures would allow areas of 'Medium' risk to be reduced to 'Low'. Outline geotechnical Risk Mitigation for the earthworks & access track construction are given in Section 5 of this report.

Figures G1 to G3 in Appendix G illustrate examples of slope stabilisation methods. However, it is important to note that these images serve only as examples of slope stabilisation methods and are not approved design or construction proposals.

Table 4.2: Earthworks Risk and Mitigation Measures

Risk Map (Figure C1 and F1) Reference	Hazard	Risk Rank Before Mitigation	Mitigation	Residual Risk
A (CH20-80m**)	Cutting into steep (15 – 18°) slope* where landslide deposits are mapped, possibility for destabilisation of slope with rock & soil debris near to live motorway	Low	Removal of any loose debris, re-compaction of slope to increase ground stabilisation. Consider catch netting at base of slope.	Low
B (CH440-560m)	Filling material on track corner radius, increased load on pre-existing slope which is located upslope of several domestic buildings	Medium	Pressure berms and benching at toe of slope to increase stability, suitable drainage measures to reduce pore pressure build-up. Barriers or ditches at base of slope to ensure any debris caught to protect sensitive receptors downslope	Low
C (CH560-700m)	Cutting into steep (15 – 20°) ground* where convex break in slope exists, slope destabilisation	Medium	Flattening of the overburden slope to reduce the gradient and likelihood of future failure, use of berms and/or benching to increase base of slope stability.	Low
D (CH960-1240m)	Cutting up to 40 m laterally* into bedrock at very steep (25 - 30°) slope, potential for	Medium	Reinforcement of slope (e.g., meshing) if excavation reveals	Low

Risk Map (Figure C1 and F1) Reference	Hazard	Risk Rank Before Mitigation	Mitigation	Residual Risk
	destabilisation due to undercutting of slope		significant amounts of rocky debris and removal of debris where suitable and re-profiling.	
E (CH1020-1180m)	Filling material on steep (25 to 30°) slope, increasing load on pre-existing slope	Medium	Gabion retainment and/or soil nailing to reinforce fill on slope and ensure optimum drainage, pressure berms and benching at toe of slope if necessary	Low

*A moderate 2:1 slope ratio or other stable angle of repose would be developed during all cut and fill operations to ensure gradual incline that allows for a stable blend with surrounding topography, ensuring efficient drainage and safe access.

** CH refers to the chainage profile illustrated on Figures F1 to F7

Source: Natural Power

5. Conclusions and Recommendations

Conceptual Geotechnical Ground Model

Based on the available desk study data and data collected during the walkover, the following generalised conceptual geotechnical ground model has been developed for the Site:

- The Study Area has no superficial deposits mapped by the BGS Onshore Geoindex directly on it. In the surrounding area, Peat is found as sparse deposits in the undulating upland terrain, and Alluvial Fan Deposits, Glaciofluvial Ice Contact Deposits, Till and Tidal Flat Deposits are found towards the coastline around Margam.
- The Study Area is represented by the Rhondda Member (Sandstone) with a secondary component of the Rhondda Member (Mudstone, Siltstone and Sandstone). Bedrock of the Rhondda Member (Sandstone) was identified on the Site during the walkover. Coal seams are also inferred in the area, running approximately northwest-southeast. Faulting is evident on the BGS maps, displacing the Rhondda Member (Mudstone, Siltstone, Sandstone) in a roughly northwest-southeast orientation. Where faulting is present on the Site, there may be zones of weakness and increasing ground instability.
- Landslide deposits mapped by the BGS were not clearly identified during the site walkover due to dense vegetation, however other smaller and unmapped landslide deposits were identified along the west and southwest side of the existing access track and surrounding slope system. These deposits are understood to comprise poorly sorted debris of soil and bedrock material which may be in a state of poor consolidation.
- Field work has identified evidence of ground instability in close proximity to the newly proposed access track alignment such as relic landslide deposits, soil erosion and slippage, terracing of the upper grass-covered slopes and unstable Sandstone (rock mass) outcrops along the current access track.
- The landslide deposits identified on the Site are best described as translational slides, where the mass movement of rock and soil occurred along a roughly planar surface of weakness. The original cause of these landslides is likely a result of over-steepening of the valley sides by glacial erosion and subsequent seasonal freeze/thaw weathering. Geological weaknesses such as adversely orientated discontinuities (e.g. faulting) could have also been a factor in weakening the slope.

- The proposed alignment of the AILaccess track crosses areas of elevated geotechnical risk, but has reduced the risk in many areas by ensuring earthworks can be adequately set back from the slope with space to consider additional slope stabilisation measures.

Recommendations

Natural Power recommends the following steps during the pre-construction phase of development:

- Consider scope of additional ground investigation along the existing Brombil Farm access track and AIL access alignment. This should include trial excavation to characterise the shallow soil and landslide deposits. Deep borehole investigations should be implemented across areas of higher risk to fully characterise the rock mass and geotechnical slope model. There should be emphasis on, soil and rock unit boundaries, and identification of any deeper-seated slip planes. Material classification, in-situ strength, and effective shear strength testing and groundwater regime. Any future ground investigation should be conducted in accordance with BS5930:2015+A1:2020
- Detailed topographic survey of the Study Area to provide a high-resolution digital terrain model for the Study Area and provide a baseline for any future ground movement monitoring campaign.
- Outline slope stabilisation measures specific to the new track are detailed in Section 4 and Table 4.2, the design stage will need to consider a variety of ground stabilisation methods. Current earthworks plans are considered a worst case and may be optimised with land take reduced further through detailed design. The encountering of favourable ground conditions which may become evident during the pre-construction phase may allow for cut slopes to be reduced or profiled to minimise disturbance. This will be particularly the case where good quality rock mass is encountered at shallow depths:
 - construction of targeted reinforcement support and protection measures e.g., retaining, and stabilising structures such as gabion retainment, crib walls and soil/rock nailing. Measures will likely need to be focused on the main areas of cut & fill earthworks to increase slope stability.
 - All earthworks will be required to be designed in accordance with BS EN 1997-1:2004 (Eurocode 7) - Geotechnical Design and BS 6031:2009 Code of Practice for Earthworks.
 - Slope stability analysis should be undertaken to confirm long term slope stability. Depending on ground conditions it may be necessary to reduce slope gradients of cuttings, implement drainage measures on cut faces to ensure stability. Material won from excavation in cuttings will require suitable selection, processing, and classification prior to re-use.
 - Engineered fill used to construct embankments should be selected to ensure long term stability and performance in accordance with design standards.
 - Where embankments are placed directly onto bedrock strata, settlement is likely to be relatively low and within generally acceptable limits. Where embankments are placed directly onto superficial deposits, settlements may be much larger and include long term creep. This should be considered within the earthworks design. The potential for differential settlement of embankments and structures should also be considered. Ground improvement may be necessary to reduce settlements of the soils beneath embankments.
 - It may be necessary to include a granular starter layer at the base of embankments to help reduce the ingress of groundwater/surface water into the base.
 - Where possible, re-planting of grasses and shrubs following construction would help long-term soil stability and reduce erosion. Consideration for 'green' or 'live' retaining structures may also be beneficial to long term stability. In particular vegetation and geogrid supported crib and gabion retaining structures can ensure structures blend into the natural surroundings whilst offering long term protection against erosion.
 - Installing suitable drainage measures to ensure surface and groundwater does not focus onto areas of existing instability or have potential to cause deterioration in the track structure.
 - Re-evaluate fence at base of slope/interface with M4 motorway and reinforce/upgrade if necessary for potential rockfall protection.

- Ensure all downslope receptors including residences are considered with respect of landslip protection.
- Slope monitoring measures such as periodic study by an experienced Geotechnical Engineer or the use of sensors in the post-construction phase to ensure any slope failure warning signs are identified.

6. References

BS5930:2015+A1:2020 Code of practice for ground investigations.

BS EN 1997-1:2004 (Eurocode 7) - Geotechnical Design.

BS 6031:2009 Code of Practice for Earthworks.

CD 622 - Managing geotechnical risk.

Gariano, S.L and Guzzetti, F. (2016) Landslides in a changing climate. *Earth-Science Reviews* (162), 227-252.

Waters, C.N., Price, S.J., Hawkins, M.P., Marchant, A.P., Fiorini, E., Brown, S.E., Tye, A.M., Fleming, C., Davies, J., Schofield, D.I., Barclay, W.J and Garcia-Bajo, M. In: (2006) A background to Urban Geoscience studies in Swansea-Port Talbot area. British Geological Survey Internal Report.

Appendix

A. Site Walkover Photographs



Figure A1: A small-scale translational landslide deposit (annotated) now covered in vegetation located on the eastern side of the Cwm y Geifr valley (west of the hill on which the access track runs).



Figure A2: Sandstone (Rhondda Member) block part of a landslide deposit found west of access track alignment.



Figure A3: Signs of ground instability (soil slippage & active erosion) along the side of the current access track towards crest slope system



Figure A4: View southeast: Natural terracing of the slope above the access track at higher elevations above Brombil Farm. This land feature may be accentuated by grazing sheep and the lack of high-growing vegetation.



Figure A5: Steep exposed terrain directly adjacent to the current access track alignment, looking northwest across the Cwm y Geifr valley



Figure A6: Sandstone (Rhondda Member) outcrop along the access track (278583E, 188196N) exhibiting an approximately 45-degree fracture plane (dotted yellow line). This outcrop is located on shallower-dipping ground along the current track compared to where the landslide deposits were observed which may explain why there hasn't been clear rock sliding/ground movement here



Figure A7: Sandstone (Rhondda Member) outcropping steeply beside the access track running northwest-southeast.



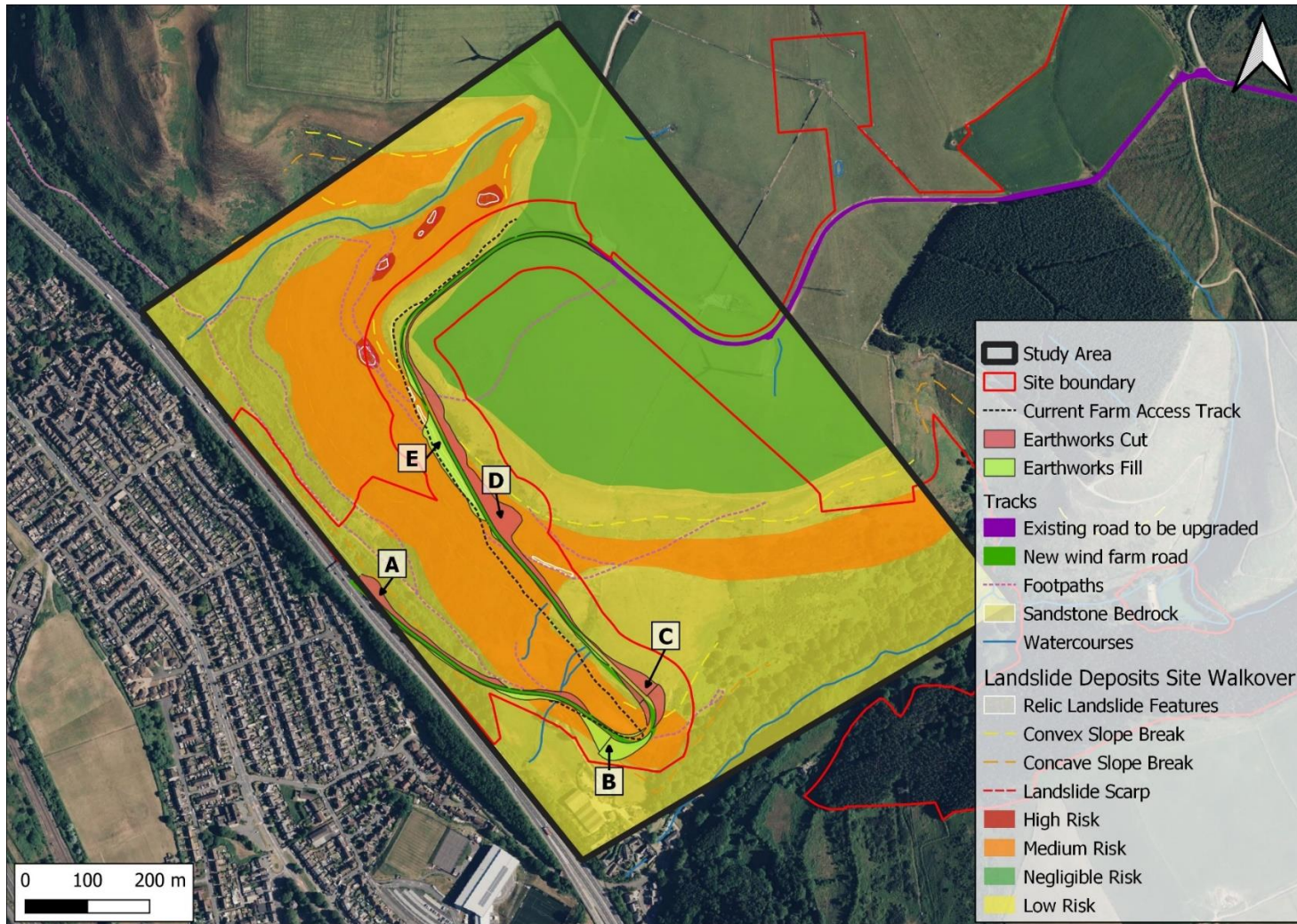
Figure A8: A pre-existing construction install to increase slope stability beside the access track (gabion baskets) located on the lower slopes of the current access track (278672E, 188030N)

B. Geomorphological Map – Figure B1

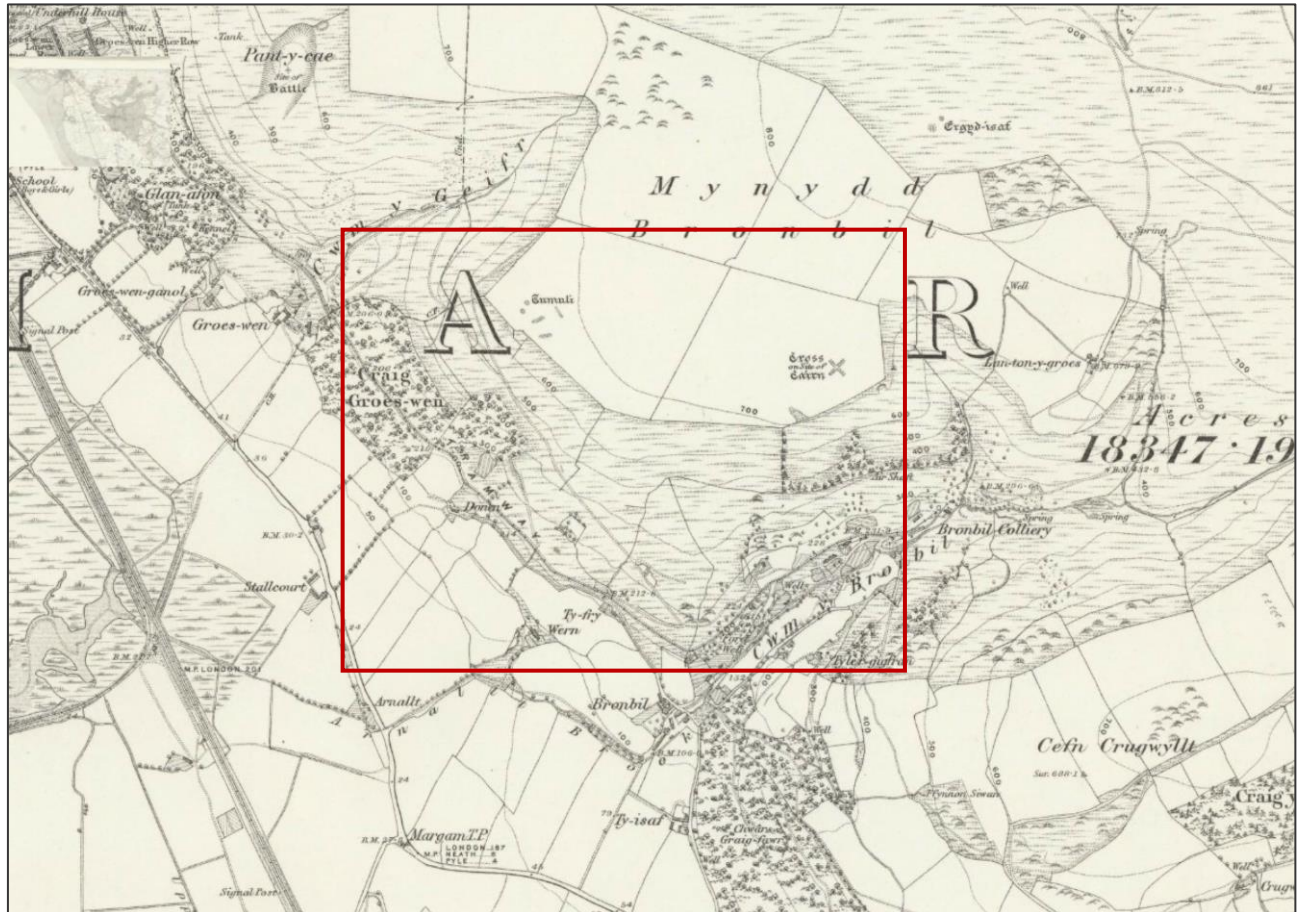


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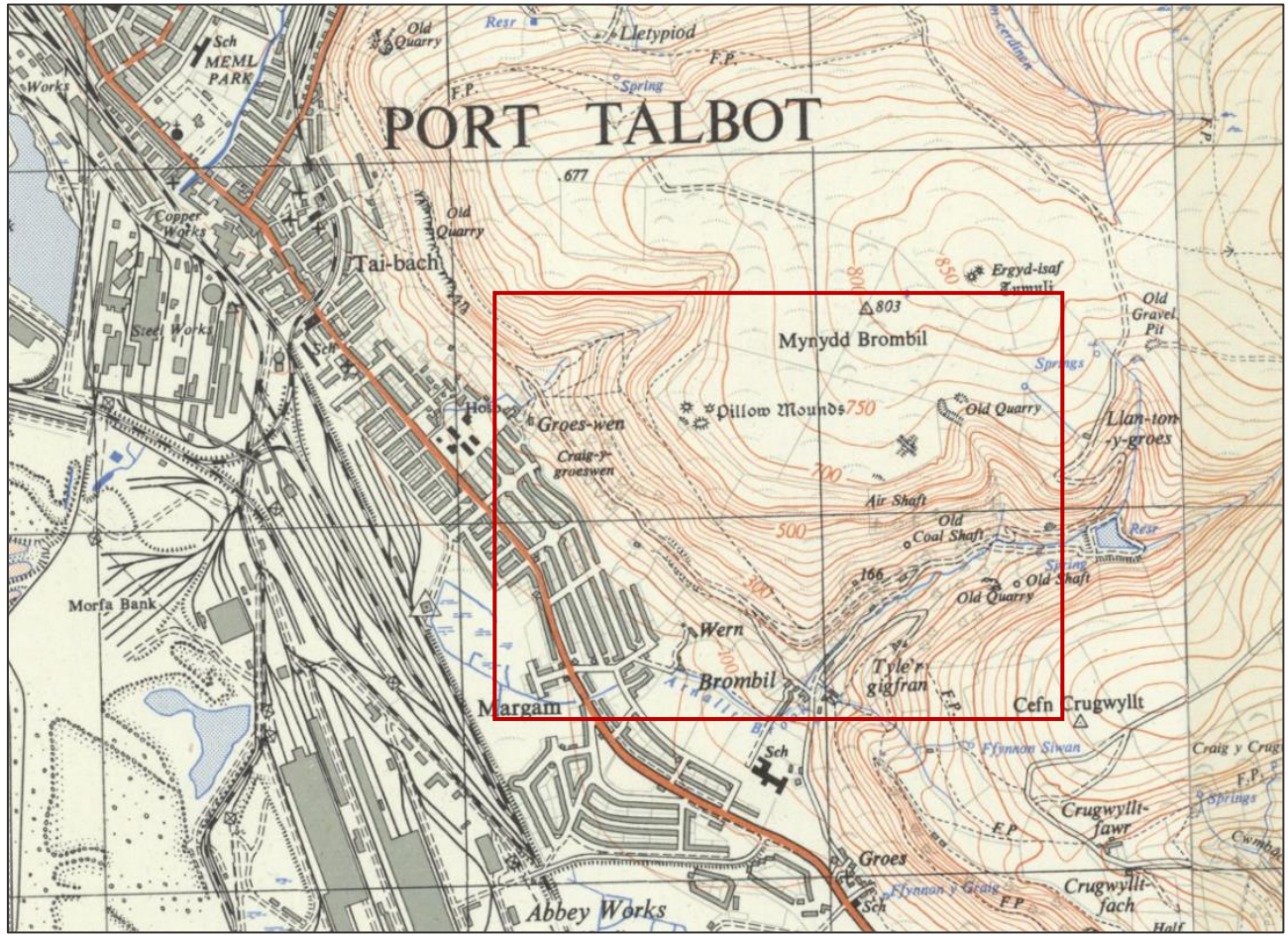
C. Landslide Risk Ranking Map – Figure C1



D. Historical Maps



OS 6 Inch – 1888-1913



OS 1:25,000 – 1937-1961

E. Historic Satellite Imagery



E1: Google Earth Satellite Imagery (2013) with relic landslides circled in red. Image is facing the west side of the existing farm track on the eastern side of the Cwm y Geifr valley.

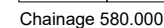
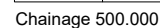
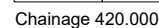
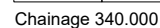
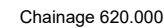
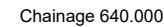


E2: Historic landslide southwest of the proposed development's access route. Google Earth Satellite imagery from 2021

F. New Access Track Design

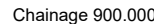
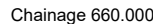
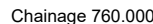
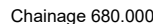
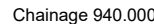
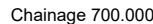
Figure F1: Drawing Y Bryn-X-015, including chainage locations (produced by ESB on behalf of Coriolis Energy)

Figure F2 to F7: Proposed New Track Cross Sections (produced by ESB on behalf of Coriolis Energy)



1. CUT AND FILL BATTER SLOPES TO BE CONFIRMED AFTER GROUND INVESTIGATION HAS BEEN COMPLETED.
2. REFER TO DRG. Y-BRYN 015 FOR CHAINAGE LOCATIONS.

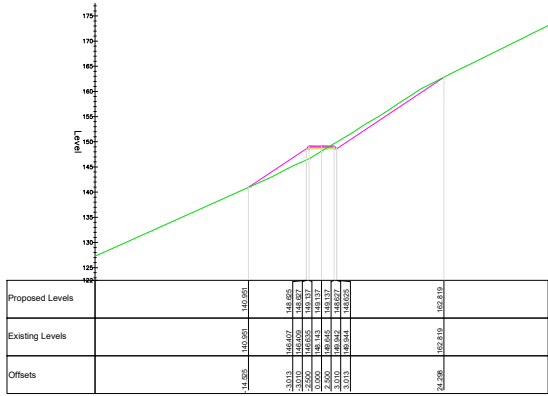
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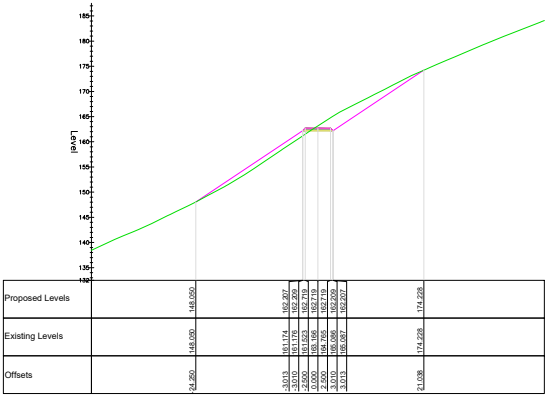
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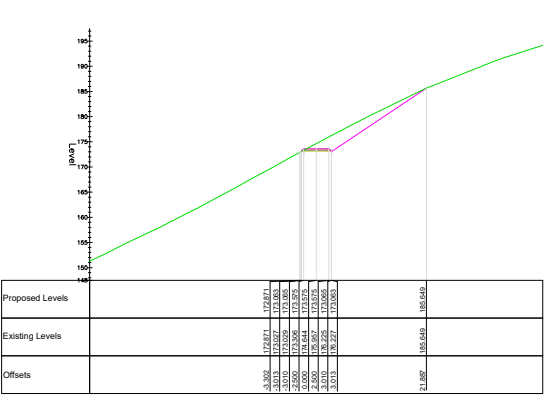
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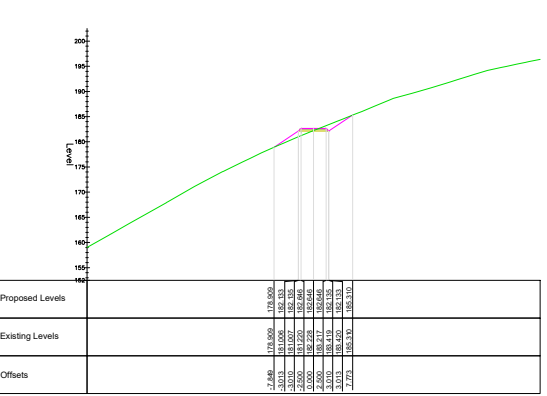
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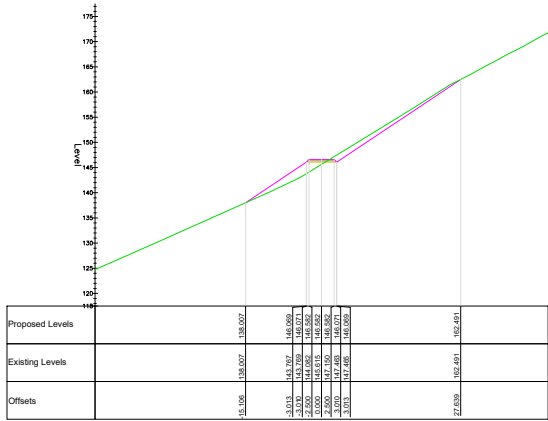
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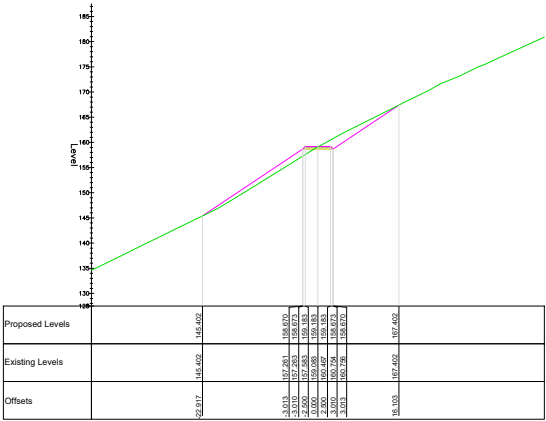
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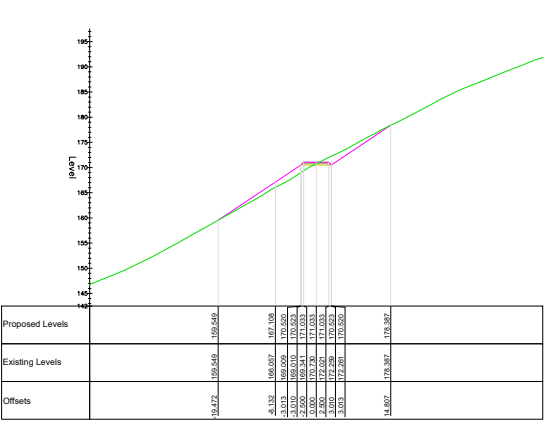
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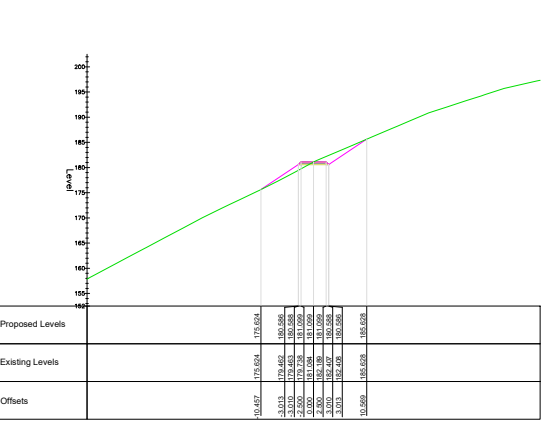
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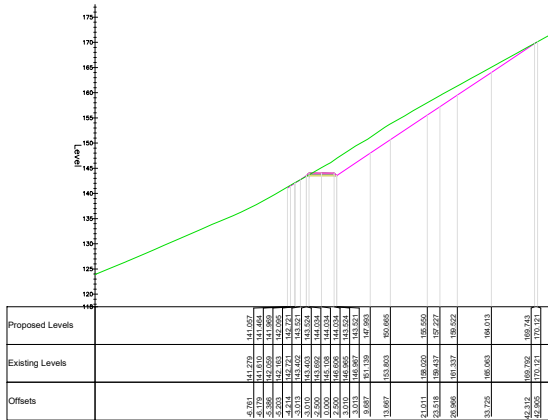
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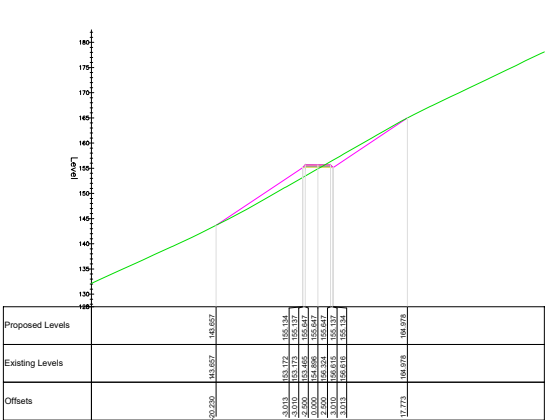
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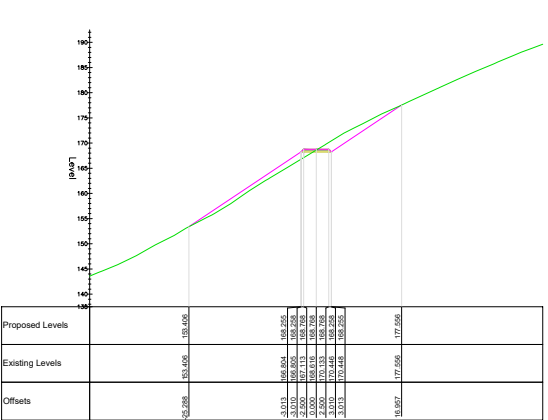
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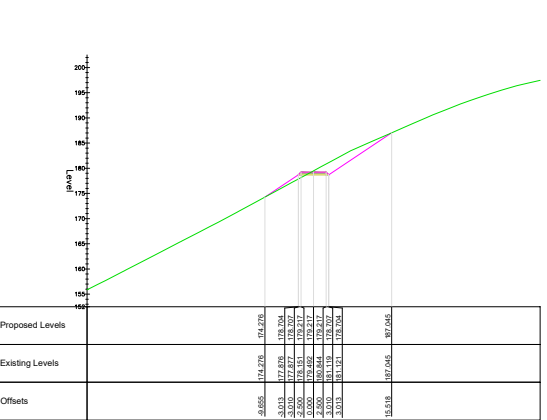
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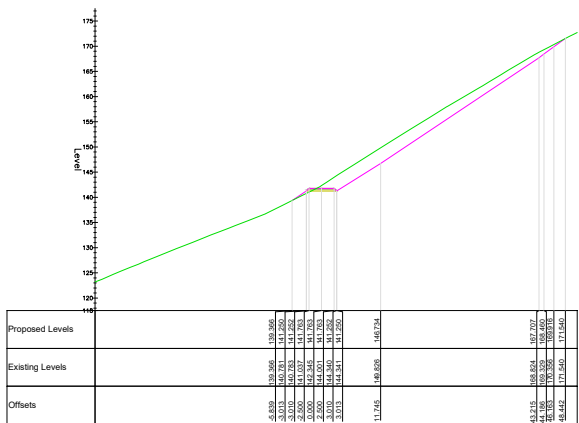
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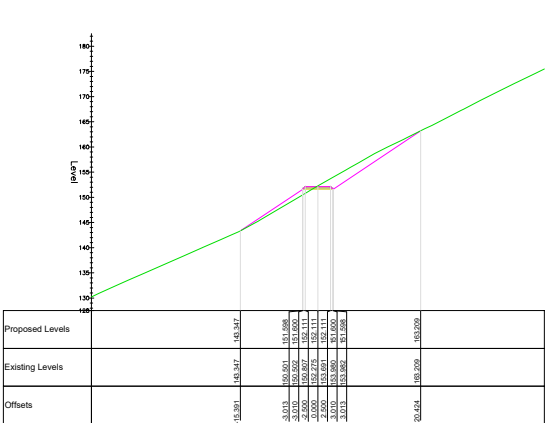
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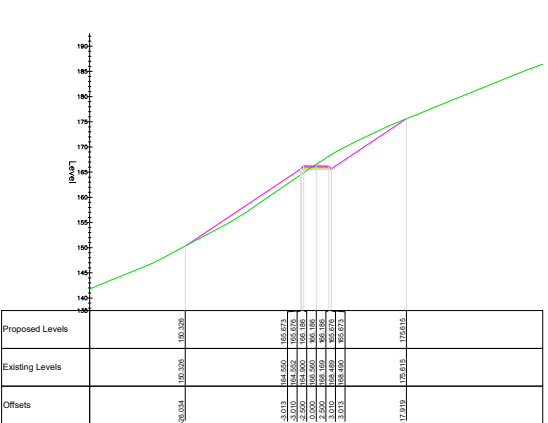
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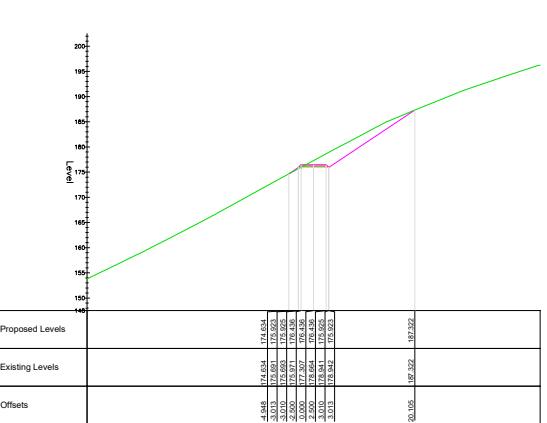
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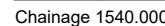
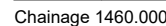
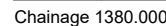
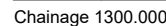
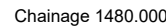
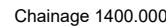
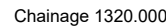
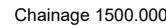
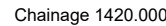
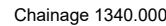
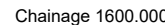
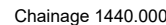
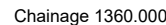


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NOTES

- CUT AND FILL BATTER SLOPES TO BE CONFIRMED AFTER GROUND INVESTIGATION HAS BEEN COMPLETED.
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CONTRACT									
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G. Examples of Slope Stabilisation Methods

Figures G1 to G3: Examples of slope stabilisation methods. Note these are only examples and do not serve as official proposals for planning and construction of the proposed development's AIL access route development.

Figure G1: Example Piled Slope Stabilisation Option – Image Ref Terra Site

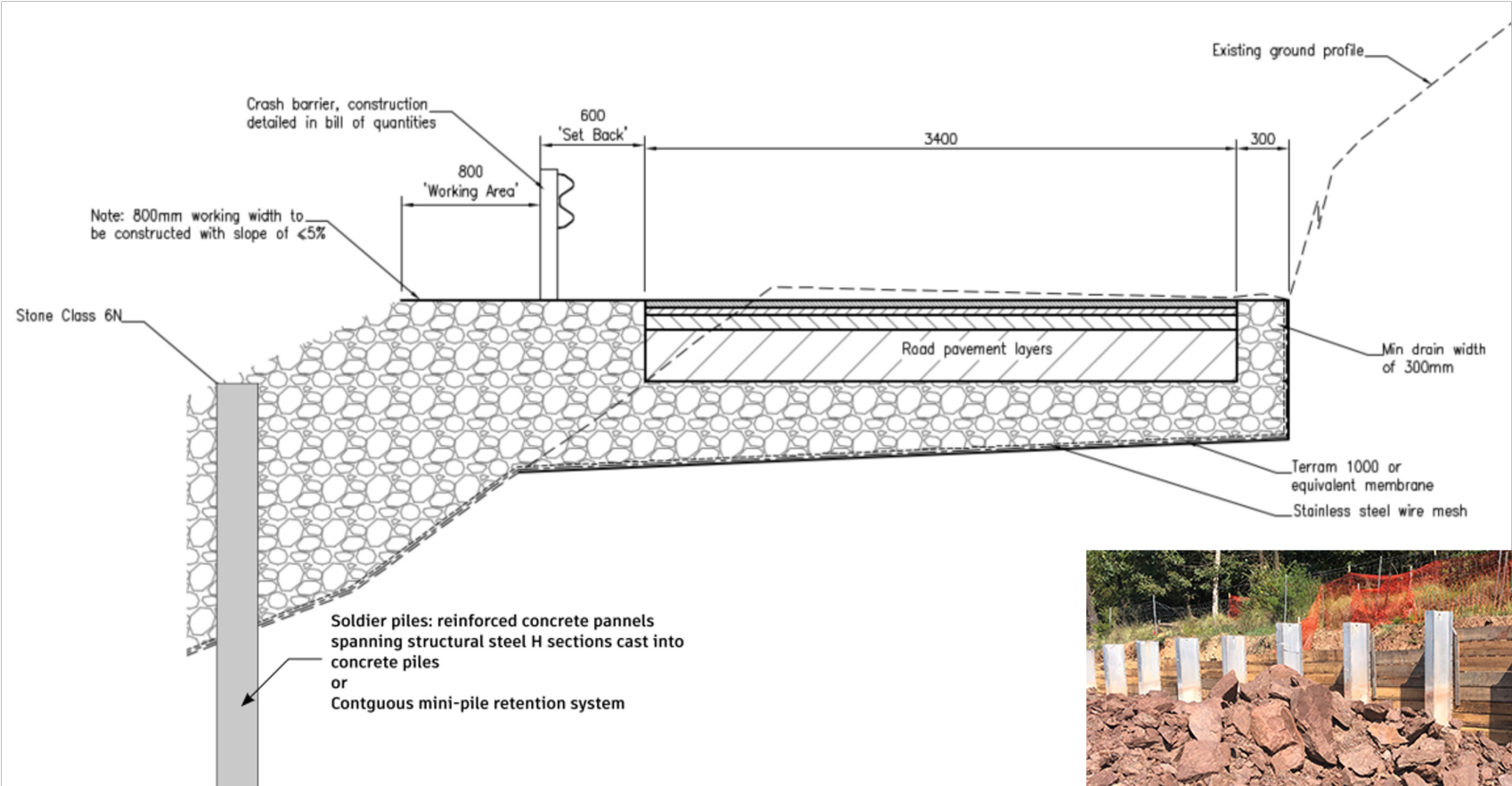


Figure G2: Example Soil Nailing & Retaining Wall Option – image ref CAN Geotechnical

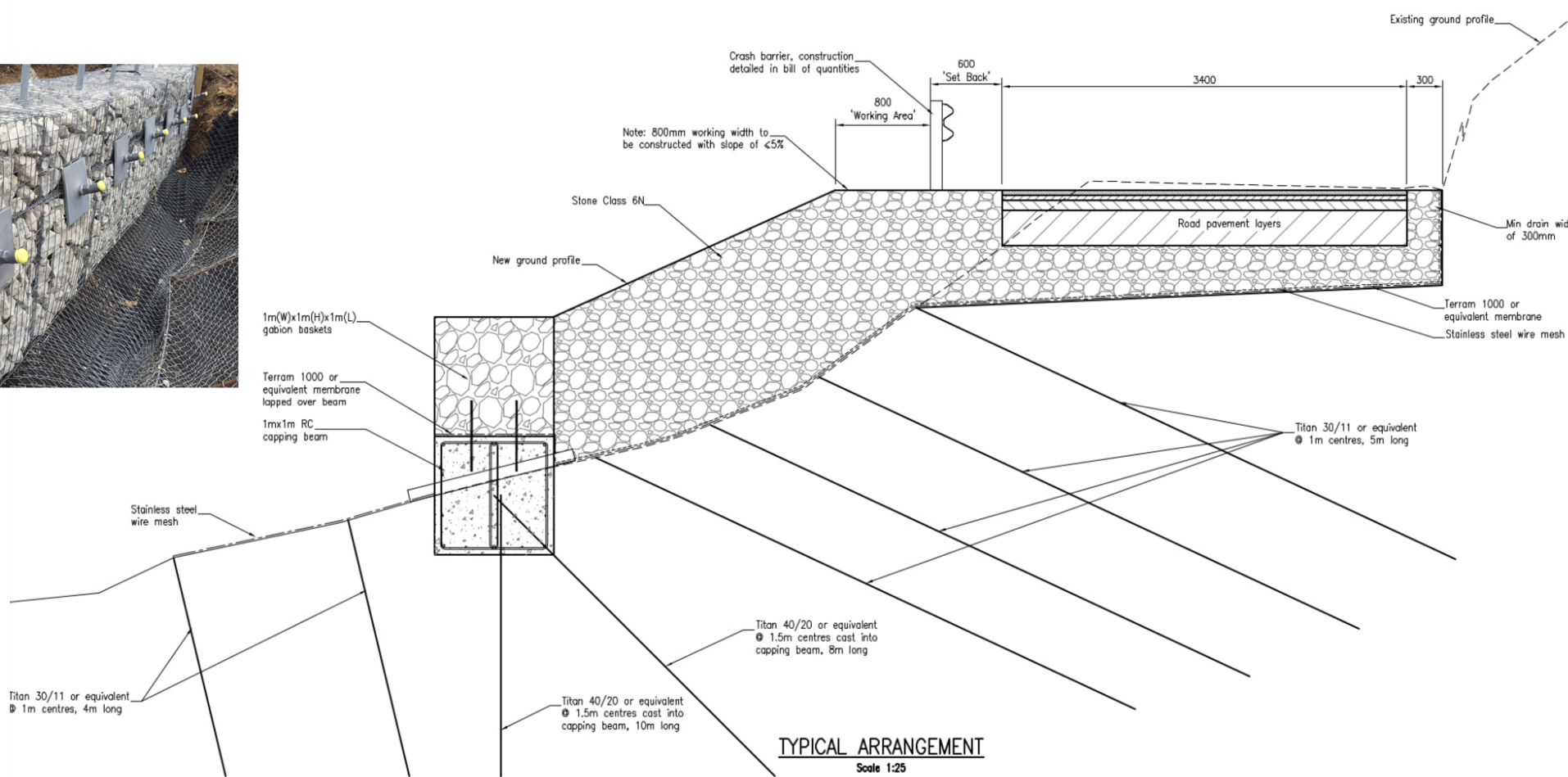
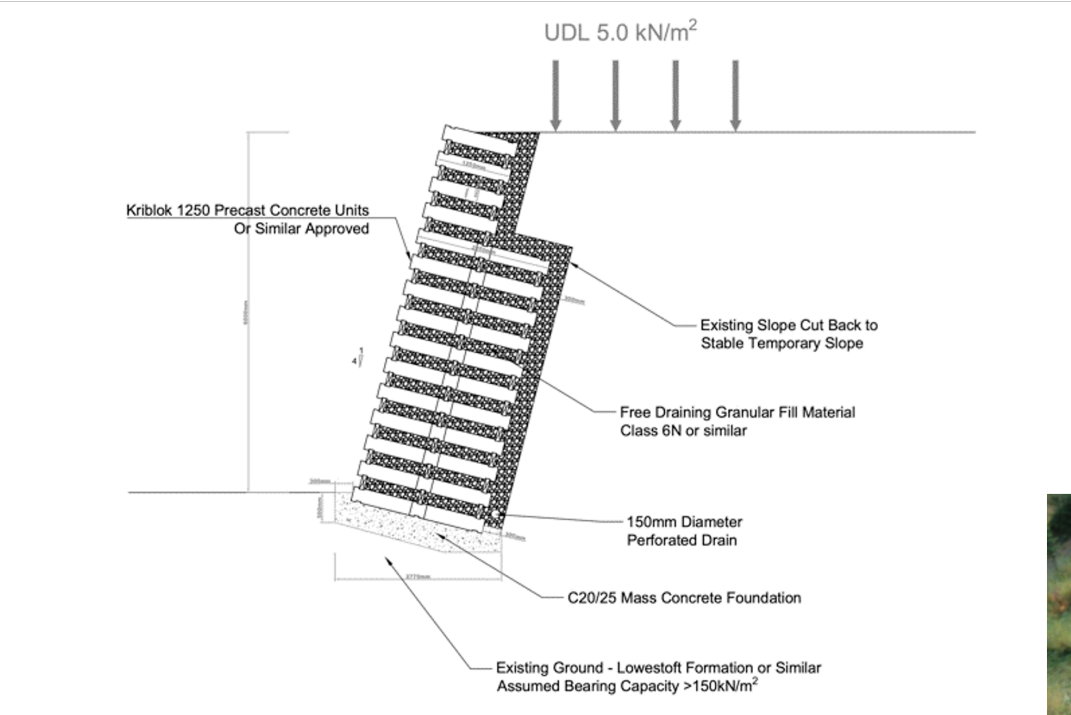


Figure G3: Example Crib Retaining Wall Options (ref: LaRiMIT & Phi Group)





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