Renewable Energy Systems Limited

Upper Ogmore Wind Farm

Ground Investigation report

Project no. 371718-01 (01)

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RSK GENERAL NOTES

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Title: Upper Ogmore Wind Farm Ground Investigation Report

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CONTENTS

FIGURES

APPENDICES

1 INTRODUCTION

RSK Environment Limited (RSK) were commissioned by Renewable Energy Systems Limited (RES) to carry out a ground investigation at three proposed wind turbine locations (T3, T4 and T5) within the proposed wind farm near Upper Ogmore, Nant-y-Moel, at the head of the Ogwr Fawr valley in south Wales.

This report is subject to the RSK service constraints given in **Appendix A**.

1.1 Background

The proposed wind farm site area lies within the South Wales Coalfield and there is known to be extensive historical mining in the area. There are numerous old mine shafts and adits around the site as well as a legacy of post-glaciation ground movement and mining-induced movements in the form of reactivated fault scarps and fissures, which form significant geological hazards.

By way of background, several studies have been previously undertaken for the site, as detailed in the following reports:

- N.A. Brown Engineering Geologist report, "*Upper Ogmore Wind Farm Mining Desk Study Report*", Revision 2, dated August 2015.
- TerraDat report, "*Geophysical Survey Report – Upper Ogmore Wind Farm, Bridgend*", report reference 4565 Version 2, dated October 2015.
- N.A. Brown Engineering Geologist report, "*Upper Ogmore Wind Farm Geophysical Ground Investigation Report",* dated October 2015.
- Ruddleston Geotechnical report, "*Ground Investigation Report for Upper Ogmore Wind Farm*", report no. JF/SR/15725/GIR, dated 30th March 2016.
- N.A. Brown Engineering Geologist report, "*Upper Ogmore Wind Farm Ground Investigation Report",* dated March 2016.

1.2 Objective

Since issue of the above reports, it has become necessary, due to a number of constraints, for RES to consider alternative locations for turbines T3, T4 and T5. Revised turbine locations are given in Turbine Layout No. PWALuog033, given in RES Turbine Layout Drawing No. 02959D0001-08, which is reproduced as **Figure 2** of this report. The objective of the current work is to review the existing information and to conduct ground investigations at Layout No. PWALuog033 T3, T4 and T5 turbine locations to assess the level of risk from potential geological hazards.

1.3 Scope

The project was carried out to an agreed brief as set out in RSK's proposal (ref. 371718-T01 (01), dated 14th May 2018). The scope of works for the assessment was:

- Preliminary sources study:
    - Review of documents and drawings provided to RSK by RES.
- Site works:
    - A walkover survey to identify any visible geotechnical hazards that could potentially affect the three newly proposed turbine locations and surface mapping of any identified features.
    - Trial trenches.
    - Deep rotary open-hole boreholes.
    - Down-borehole geophysical logging.
    - Peat probing.

1.4 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work, the results of tests made in the field and the findings of the previous site studies. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and, therefore, could not be taken into account.

2 REVIEW OF EXISTING INFORMATION

2.1 Introduction

The purpose of the preliminary sources study is to develop an outline conceptual model of the site as a whole and specifically at the three new proposed turbine locations, identifying the geological and geomorphological setting and associated potential hazards to establish whether potentially unacceptable risks are present.

The information has been collated from the reports referenced in **Section 1.1**.

2.2 Site location and description

The wind farm site lies approximately 1.5km to the northwest of Nant-y-Moel in the Ogwr valley and 1.5km to the northeast of Blaengarw in the Garw valley. The location of the site is shown on **Figure 1**.

The topography of the site consists of a moorland plateau with steep slopes and deeply incised stream and river valleys. It forms the northern part of the hill Mynydd Llangeinwyr, which forms a long north-south ridge between the valleys of Cwm Garw to the west and Cwm Ogwr Fawr to the east. The topographic high point is Werfa in the northern part of the site at an elevation of 568m above Ordnance Datum (AOD) and the topographic low is in the southern part at around 440mAOD. There are a number of streams that rise on the site, flowing to the southwest to the Garw valley, southeast to the Ogwr Fawr and north to the Afan valley.

Ground cover consist of a mix of grazing land with closely cropped grass and occasional clumps of soft rush to tussocky moorland grass and heather with some soft peaty areas. A bound track leads up from the A4107 to a communications mast and associated buildings located on higher ground (Werfa) in the centre of the site.

The proposed T3 turbine location is located east of the communications mast on the eastern slope of Mynydd Llangeinwyr and the proposed T4 and T5 turbine locations are in the east of the site on the prominent ridge of Braich yr Hydd. Turbine Layout No. PWALuog033, given in RES Turbine Layout Drawing No. 02959D0001-08, is reproduced as **Figure 2**.

Previous investigations at the site have revealed that extensive historic deep level coal mining beneath the site has created a legacy of large fissures and re-activated fault scarps, which are present in a broad zone running NW to SE through the site. There are several existing landslides around the edge of the high plateau and some of these show indications of recent movement.

2.3 Geology

The bedrock geology of the site area is formed from the Carboniferous Lower Pennant Measures/Upper Coal Measures, which mainly comprise sandstones with interbedded mudstones and siltstones. There are also a number of coal seams interbedded within the sequence. Many of the seams are of economic importance and have been worked

extensively in the past. Some of these seams lie at relatively shallow depth and outcrop close to the site boundary. These include the No. 1 Rhondda Rider, No. 1 Rhondda, No. 2 Rhondda and No. 3 Rhondda seams (**Illustration 1**).

Illustration 1: Geological map extract and geological Section 2 through the site showing the topography, named coal seams and approximate Layout No. PWALuog033 T3, T4 and T5 turbine locations (after N.A. Brown).

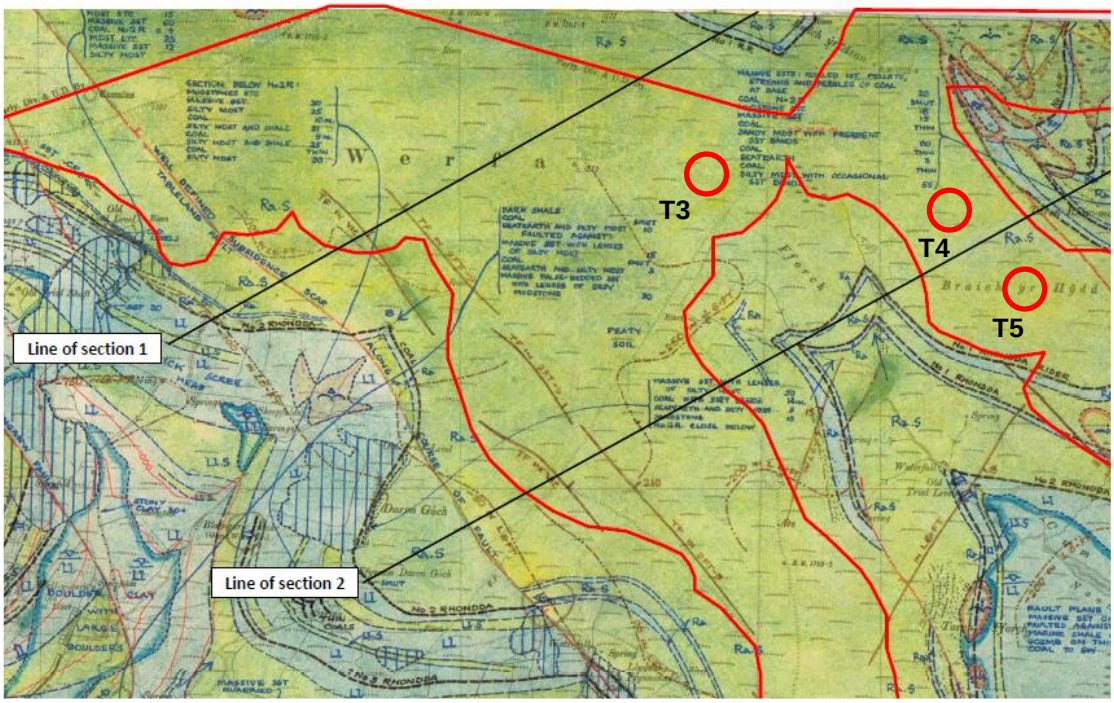
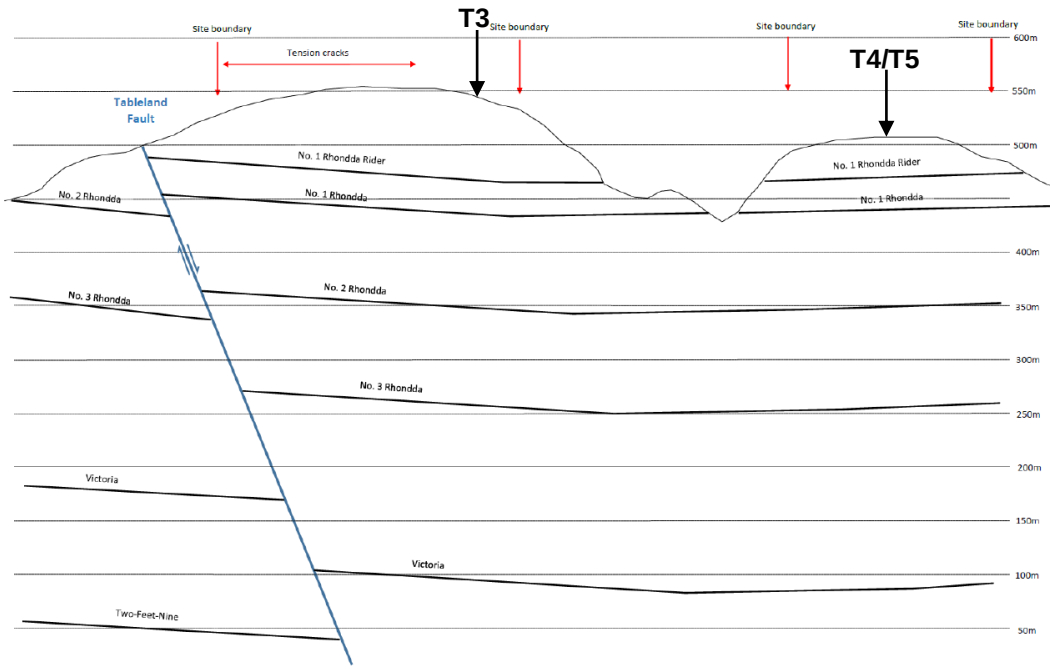


FIGURE 5 - SCHEMATIC GEOLOGICAL CROSS-SECTION, LINE 2 (1:5000 H, 1:2500V)



The superficial geology consists of occasional areas of Glacial Till and peaty soil. Generally, the topography suggests that superficial deposits are likely to be thin, particularly on the steeper sections of the site.

The geological structure consists of shallow, northeasterly dipping strata with a number of major geological faults running generally northwest to southeast. Some of the more prominent faults (e.g. the Tableland Fault) have become reactivated, resulting in topographic 'subsidence scars'.

There are a number of landslips on the steep slopes around the site. Many of the landslides occur below the main sandstone strata outcrop, close to the crop of the No. 2 Rhondda, probably as a result of water issues at the base of the sandstone unit. The landslides appear to be shallow debris slides with toppling failure from the steep rock face at the head of the slide.

2.3.1 Coal mining

There are limited areas where coal seams outcrop within the site boundaries. The seams that are present are generally the No. 1 Rhondda Rider and No. 1 Rhondda, both of which are thin and not extensively worked. The No. 2 Rhondda is the shallowest economic seam below the site and it crops close to the site boundary, on the steep slopes below the plateau.

Historic and geological mapping indicates that several of the coal seams have been worked at their crop positions around the site, including the No. 2 and No. 3 Rhondda seams. The No. 2 Rhondda seam has been worked quite extensively below the southern part of the site.

The available mine abandonment plans indicate that mining has taken place extensively beneath the site. The mining is thought to have taken place between the 1870's and 1970's with extensive working in the 1930's and 1940's. Mining beneath the site ceased in around 1972. The shallowest seams worked appear to be the No. 2 Rhondda, No. 3 Rhondda, Victoria and Two-Feet-Nine seams. The workings were by post and stall and also by longwall methods. The depth of workings is between approximately 200m and 750m below surface. The available plans suggest that the workings are at a depth that should not be affected by void migration from collapse of the workings.

There appears to be only limited mining of the shallowest coal seams beneath the site. The Coal Authority do not hold any records of formal working of the shallower seams but crop working has been noted on BGS plans and during the walk-over close to, but not within, the boundary of the site. The workings are likely to be limited to a small area close to the crop of the seam. As most lie on the steep scarp slope below the high plateau, the workings appear to be at such a depth (greater than 10 times the workings height) that they should not affect stability.

There do not appear to be any shafts or adits present within the site boundary.

2.3.2 Faulting and fissuring

The deeper level mining in the site area has left a significant legacy, in the form of re-activated fault scarps and an extensive zone of deep fissures running in a band through the central part of the site. It is likely that the initiation of the movement on these

structures occurred during the last Ice Age when glaciers, having carved the deep, steep sided valleys, melted. The loss of the horizontal restraining forces and increase in pore water pressure on the steep valley sides resulted in landslides and large scale block movements, some of which have occurred along pre-existing fault planes.

The cumulative effect of valley side movement and mining on multiple seams has resulted in the fissures forming. As the cracks are just the surface expression of a zone of fractures and fissures, there is the possibility that fractured and broken rock exists just below surface. There is also the possibility that the zone of broken rock extends well outside the mapped zone of surface fissures.

2.3.3 Risk assessment

In order to provide an indication of the level of risks to the development associated with mining, faulting/fissuring and landslides, an assessment was undertaken based on the criteria shown in **Table 1** below (after N.A. Brown).

Table 1: Risk Assessment criteria for risk zonation

Hazard Zone	Assigned Risk	Criteria (one or both)		Mitigation measures/options
		Shallow mining/shafts/adits	Fault lines/ fissures /landslides	
1	High	50 – 100% possibility of being under-mined at shallow depth (less than 10 times seam/workings height). Possible or suspected mine shaft or adit within 20m	Within 50 metres of mapped fissure, re-activated fault scarp or landslide, or on projected alignment of above features	Consider re-plan to take proposed development outside of this hazard zone. Alternatively undertake detailed ground investigation to confirm ground stability and provide design data for any stabilisation works.
2	Moderate	5 to 50% possibility of being under-mined or at shallow depth (between 10 and 20 times seam/workings height). Possible or suspected mine shaft or adit within 50m	Outside of 50m of mapped fissure, re-activated fault scarp or landslide but in zone where these features have the potential to be present.	Carry out detailed ground investigation at turbine locations and access tracks to check for subsidence features and confirm ground conditions.
3	Low	Very low possibility of mining at shallow depth (greater than 20 times seam/workings height). No suspected shaft, adit within 50m	Outside of zone where these features have the potential to be present.	Carry out limited ground investigation at turbine locations to confirm ground conditions, carry out basic checks for unusual features during construction of access tracks (soft/loose/broken ground, presence of fill, increased topsoil/subsoil thicknesses, unusual groundwater flows etc.)

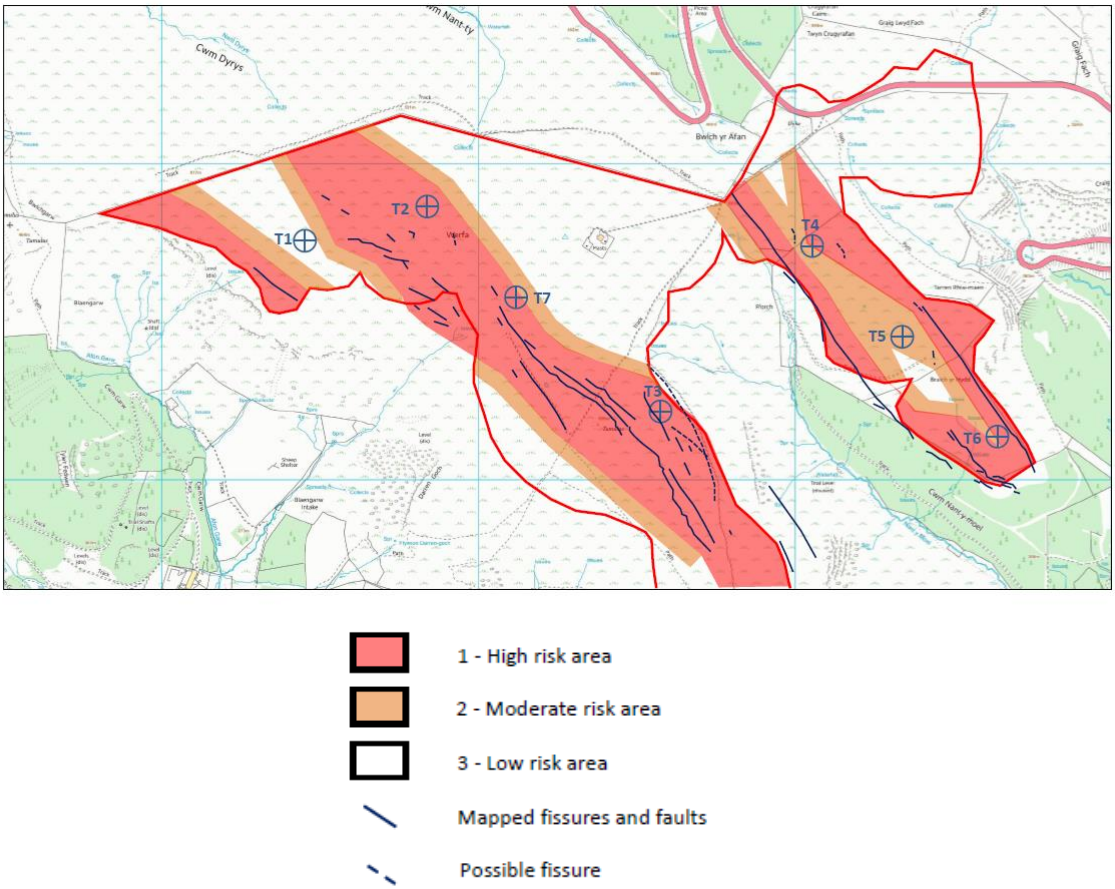
The high risk zones include areas where fissures and re-activated fault scarps are present. The moderate risk zones are areas where they have not been observed but have potential to be present. The low risk zones are areas where no features have been observed and may be a sufficient distance away from the edge of the upland plateau to reduce the potential for these features to occur. There were no identified hazards from shallow mine workings or mine shafts.

In refining the risk assessment, a geophysical investigation of four selected turbine location areas was carried out between August and September 2015 by Terradat Ltd,

producing resistivity and ground penetrating radar (GPR) data. During these site-works, a detailed walk-over of the four areas was also undertaken, recording fissures, fault scarps and any other mining related hazards.

These investigations confirmed the presence of discontinuities as well as a number of other anomalies that could have formed hazards to the then proposed development, as shown in **Illustration 2**.

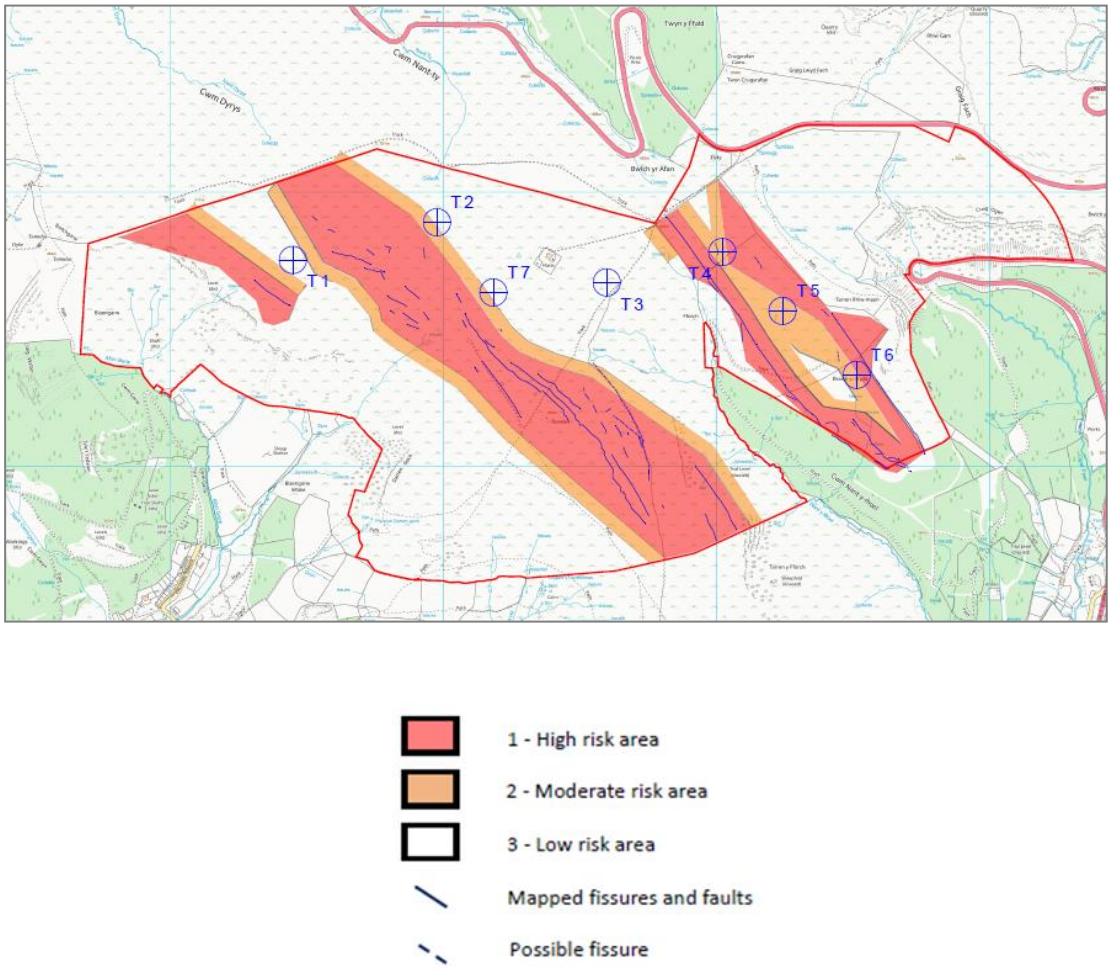
Illustration 2: Risk zones based on the criteria in Table 1 with 2015 turbine layout (after N.A. Brown).



As a result of the findings of the geophysics investigation, the location of several proposed turbines (T2, T3 and T7) were amended to place them in a 'low' risk zone. Three of the turbines, T4, T5 and T6 remained in the 'moderate' risk zone and an intrusive ground investigation was subsequently undertaken at these locations comprising trial trenches and inclined boreholes with down-hole geophysical logging. The ground investigation did not find any features that could be related to re-activated faults, fissures or shallow coal mining. Geophysical logging broadly concurred with the rotary open-hole borehole logs and no obvious evidence of fissures was noted. The risk categorisation for Turbines 4, 5 and 6, which were originally within the moderate risk zone, were, therefore, re-categorized as low risk.

Since issue of the above reports, it has become necessary, due to a number of constraints, for RES to consider alternative locations for turbines T3, T4 and T5 and amend the site boundary. Revised turbine locations are given in Turbine Layout No. PWALuog033, given in RES Turbine Layout Drawing No. 02959D0001-08, shown as **Figure 2**. The risk zone image presented in **Illustration 2** is updated in **Illustration 3** to include the current PWALuog033 turbine layout and amended site boundary.

Illustration 3: Risk zones based on the criteria in Table 1 (after N.A. Brown) with turbine layout PWALuog033 and amended site boundary.



The remainder of this report documents investigations at the Turbine Layout No. PWALuog033 T3, T4 and T5 turbine locations to assess the level of risk from potential geological hazards.

3 FIELDWORK METHODOLOGY

3.1 Introduction

Turbine locations are given in Turbine Layout No. PWALuog033, given in RES Turbine Layout Drawing No. 02959D0001-08 (**Figure 2**).

The fieldwork was carried out under the supervision of RSK between 4th and 12th June 2018, and comprised the activities summarised below.

The ground investigation element was carried out in accordance with the Site Investigation Steering Group's Specification for Ground Investigation (2012) and the investigation and the rock and soil descriptions were carried out in accordance with BS5930: 2015 - Code of Practice for Ground Investigations.

The locations of the intrusive investigations are shown in **Figure 2** and the setting out points of the exploratory holes are shown in **Figure 3**. The investigation points were located accurately using a Leica Rover GPS system.

3.1.1 Site walkover

A site walkover was undertaken by an RSK principal engineering geologist to identify any visible geotechnical hazards that might have the potential to affect the three new proposed turbine locations, e.g. slopes, fissures, faults, local depressions, etc.

3.1.2 Surface Feature Mapping

A detailed walkover of each turbine base location was undertaken based on a 25m by 25m square centred on each the three new proposed turbine locations, although this area was extended to up to 40m, where necessary. The purpose was to identify and facilitate mapping of any visible surface features (e.g. fissures, faults, local depressions) within the turbine footprint. Any observed features were photographed, described and surveyed using a Leica Rover GPS system.

3.1.3 Trial Trenches

A tracked excavator was used to undertake seven trial trenches, 18m long x 1m wide, to hard strata, which could not be further excavated without breaking. Two trenches were excavated across the footprint of each of the three new proposed turbine locations with the aim of exposing bedrock to check for any indication of fissuring/faulting and also to provide data on superficial deposits, bedrock and groundwater level to inform foundation design (by others). The trial trenches were orientated approximately perpendicular to the alignment of any anticipated fissures/faults. At location T5, a third trench was excavated perpendicular to the previous two to rule out the possibility of an observed fissure encroaching into the turbine base area on that orientation (see **Sections 4.2.3**).

The trial trenches were supervised full time by an RSK engineer and the ground conditions were recorded by annotated sketch and photography of the excavations and the arisings.

3.1.4 Rotary Open-Hole Boreholes

The rotary open-hole drilling was carried out by Apex Drilling Services under the fulltime supervision of an RSK engineer.

Six open-hole rotary boreholes were drilled using a down-hole hammer and air-flush, three each at the locations of T4 and T5. The boreholes were drilled at an inclination of 45^{o} to the horizontal with a drilled length of 40m (vertical depth penetration of 28m). The aim of the inclined boreholes was to check for sub-surface broken rock or voids beneath the proposed turbine locations, which could be indicative of fissuring. This drilling technique enables the identification of broken and disturbed ground, as rapid penetration and loss of air flush encountered during borehole propagation could infer the presence of a fissure at depth. However, this method does not allow a detailed log of the strata to be recorded and this must be inferred from the returns.

On completion, the boreholes were installed with temporary 63mm diameter stop ended plain HDPE pipe to facilitate down-borehole geophysical logging. The pipe was removed after completion of the geophysical logging and each borehole was grouted up.

3.1.5 Down-Borehole Geophysical Logging

The down-hole logging was carried out by European Geophysical Services (EGS). The aim of the geophysics was to provide a detailed strata log and a check for the presence of coal seams, voids or broken ground. The geophysical techniques used were natural gamma and dual density logging. The logging was carried out by lowering a sonde down the borehole at a controlled rate.

3.1.6 Peat Probing

Peat probing was undertaken at the proposed location of turbine T3. The probing was undertaken by an RSK engineer, using a hand-held fibreglass Hisco probe, at 6m centres within a 30m by 30m surveyed grid centred on the proposed turbine location and along a linear array within a 75m by 25m rectangle based on the proposed crane hardstanding and track locations.

4 FIELDWORK RESULTS

4.1 Introduction

The results of the intrusive investigation and fieldwork are detailed below. The descriptions of the strata encountered, field observations, *in-situ* testing and associated details are included on the fieldwork records presented in **Appendices B**, **C** and **D**.

4.2 Site walkover and surface feature mapping

4.2.1 Turbine T3

The T3 location is at an elevation of approximately 545mAOD and comprises relatively shallow sloping, gently undulating ground set within an overall east-southeast-facing slope of around 7º, which descends to the track below the T3 location. To the northwest of T3, the higher ground level steps down via a series of shallow, rounded breaks of slope, but these are gentle and vegetated with no sign of movement. To the northeast (approximately 17m from the turbine centre) a small tussock filled depression, 5m in diameter and 300mm deep, was observed. However, there was no visible evidence that this depression was associated with any linear or other geomorphic features indicative of ground disturbance or fissuring. From the track below T3, the ground dips away more steeply at around 13º into the steep and incised valley slopes of Fforch to the southeast. No slope instability features, linear geomorphic features or evidence of ground disturbance was visible in this area.

4.2.2 Turbine T4

The T4 location is situated on relatively flat, very gently undulating ground towards the northwestern end of the spur of Braich yr Hydd. To the immediate northwest of the T4 location the ground level steps up via a curvilinear, rounded break of slope to an elevation of approximately 520mAOD, but this step is gentle and vegetated with no sign of movement. Although a possible linear feature was previously noted on this raised area, no specific visual feature could be identified on this occasion. The curvilinear form of the slope results in a low point in the ground to the southeast of the T4 location. This depressed area was boggy and soft with grass tussocks, but there was no visible evidence that this depression was associated with any linear or other geomorphic feature. No slope instability features, linear geomorphic features or evidence of ground disturbance was visible in this area.

4.2.3 Turbine T5

To the immediate north of the proposed T5 location, a fenced-off mast compound is present, which was not previously shown on site plans. In agreement with RES's site representative, the more northerly of the intrusive site investigation points (rotary borehole T5-BH3 and trial trench T5-TT1) were relocated slightly south of their design positions to be out with the compound. These revised locations are shown on **Figure 3**.

The T5 location is at an approximate elevation of 510mAOD and comprises relatively shallow sloping, gently undulating ground set within an overall southeast-facing slope of around 3º. To the immediate southwest of T5, a relatively large tussock filled depression is present, which extends west of the turbine location. This depressed area was boggy and soft with standing water locally evident.

No slope instability features, linear geomorphic features or evidence of ground disturbance was visible in the immediate turbine area. However, to the west-southwest, a linear feature was present extending in a west-southwesterly direction, from a position within the boggy depression some 35m to the southwest of the T5 turbine centre. This linear feature runs for approximately 100m west-southwest, terminating against the re-activated fault scarp that forms a low topographic ridge on the southwestern side of Braich yr Hydd.

With reference to historic Google Earth imagery, this feature is not present on imagery up to May 2008, but is seen on imagery from December 2009 onwards (**Illustration 4**).

Illustration 4: Google Earth imagery from December 2009 (linear “fissure” arrowed).

The origin of this feature was not entirely clear during the site walkover, but its form suggested that it could reflect fissure related ground displacement.

This feature is relatively linear and varies in width and depth. Towards its northeastern end in the boggy area, it is narrow, up to 200mm wide, and, at least locally, may extend to depths of 1m with a soft boggy/peaty sediment partial infill. Traced west-southwestwards the width generally broadens and locally reaches a metre or more.

The sides are generally formed from vertical faces, locally up to 300mm to 400mm high, of bare soil, and the base of the feature is generally flat and level and locally contains the same vegetation (grasses and tussocks) as the adjacent ground. No surface features were observed that are indicative of running water (e.g. erosion channels/runnels, washed in materials). The above-described features are illustrated in

the photographs below. The mapped locations of the observed features are shown on **Figure 4** and the co-ordinates given in **Table 2**.

Table 2: Mapping co-ordinates for linear features

Linear Features	
X	Y
292112.079	194498.699
292106.199	194506.901
292101.496	194513.329
292100.708	194518.579
292100.967	194525.827
292093.066	194523.087
292101.731	194528.659
292099.414	194526.076
292114.441	194533.946
292118.955	194535.947
292123.687	194536.661
292132.691	194538.045
292141.018	194539.574
292150.485	194542.927
292161.254	194547.639
292171.420	194552.515
292178.494	194556.182
292180.255	194559.066
292187.102	194560.584
292195.488	194560.918
292201.352	194562.494
292206.495	194559.996

However, subsequent to the fieldwork, RES has been informed by the current landowner that this feature is a man-made channel, dug by himself to drain water from the boggy area and to improve the ground and make it easier to drive over. Further, the landowner has stated that there were no features present along this line before he dug the channel, that the channel doesn't connect any previous ditches or pools, and that the channel is filling in over time as a result of sheep tracking over it.

Notwithstanding the above information provided by the landowner, there are certain visual morphological characteristics associated with this feature that would otherwise be consistent with some form of fracture-related ground displacement, or potentially ground collapse from sub-surface drainage of the peat.

4.3 Trial Trenches

4.3.1 Turbine T3

The geological sequence within trial trenches T3-TT1 and T3-TT2 was recorded as 0.2m thickness of black and dark-brown silty amorphous peat over 0.3m thickness of orangish-brown silty fine to coarse sand. These units were undisturbed and continuous across the trial trenches.

Below this was a 0.3m thick layer of sandstone rubble. These fragments had a black patina and were set in a clayey sand matrix. This unit was also locally affected by downward tapering lenses of reddish-brown peaty soil, which penetrated into the underlying layer. This material appears to reflect soil-forming processes prior to deposition of the overlying layers, with relict weathered material and downwashed organic peaty material.

These layers were cut irregularly into an approximately 1.5m thick layer of grey and brown highly weathered and de-structured sandstone, predominantly comprising cobbles and gravel of grey sandstone with a little sandy and clayey matrix. The lower part of this layer graded into *in situ* sandstone bedrock, in which bedding and jointing were evident, but which could still be removed by excavation.

Very hard *in situ* sandstone strata were recorded from 2.30m below ground level (bgl), below which no further penetration could be achieved. The sandstone layer comprised an irregular, thinly to very thinly bedded and regularly jointed light-grey and brown sandstone.

Solid rock was proved along the entire bases of the trial trenches with no evidence of voiding, infilled fissures, zones of broken rock or any significant steps in rockhead level that could be attributed to faulting and fissuring. In addition, the weathered and superficial deposits overlying the rockhead were undisturbed and laterally consistent, indicating that they have not suffered any significant movements or displacements since their deposits and formation.

No groundwater was encountered in the trial trenches.

T3 trial trench records and photographs are shown in **Appendix B**

4.3.2 Turbine T4

The geological sequence within trial trenches T4-TT1 and T4-TT2 was recorded as 0.3m thickness of black and dark-brown silty amorphous peat over 0.2m thickness of orangish-brown silty fine to coarse sand and a 0.2m thick layer of light-brown sandy clay. These units were undisturbed and continuous across the trial trenches.

These layers rested with an irregular base on a variably thick layer of grey and brown highly weathered and de-structured sandstone, predominantly comprising cobbles and gravel of grey and brown sandstone with a little sandy matrix. The lower part of this layer graded into *in situ* sandstone bedrock, in which bedding and jointing were evident, but which could still be removed by excavation.

Very hard *in situ* sandstone strata, below which no further penetration could be achieved, were recorded at variable depths ranging from 1.5m bgl to 1.8m bgl in the

western end of the trenches, and extending to a depth of 2.20m bgl in the eastern end of T4-TT1. At the extreme eastern end of trial trench T4-TT2, excavations were extended to 3.2m bgl without terminating on hard bedrock. The excavation had to be terminated at this depth because the machine was necessarily sited in an area of very boggy peaty ground, which was causing the machine to slide towards the trench in attempting to dig deeper.

Where encountered, the sandstone layer comprised an irregular, thinly to very thinly bedded and regularly jointed light-grey and brown sandstone. Bedding surfaces were noted to be irregular and curviplanar, reflecting cross-bedded sedimentary structure within the sandstone.

With the exception of the eastern end of trial trench T4-TT2, solid rock was proved along the bases of the trial trenches with no evidence of voiding, infilled fissures, zones of broken that could be attributed to faulting and fissuring. It is considered that the step in rockhead level at the eastern end of T4-TT2 is likely to reflect surface erosion rather than structural displacement because the weathered and superficial deposits overlying the rockhead were undisturbed and laterally consistent, indicating that they have not suffered any significant movements or displacements since their deposition and formation.

No groundwater was encountered in the trial trenches.

T4 trial trench records and photographs are shown in **Appendix B**.

4.3.3 Turbine T5

The geological sequence within trial trenches T5-TT1 and T5-TT2 was recorded as 0.2m to 0.3m thickness of black and dark-brown silty amorphous peat over 0.1m to 0.3m thickness of orangish-brown silty fine to coarse sand. These units were variable in thickness but undisturbed and continuous across the trial trenches.

These layers rested on a variably thick layer of grey and brown highly weathered and de-structured sandstone, predominantly comprising cobbles and gravel of grey and brown sandstone with a little sandy/clayey matrix. The lower part of this layer graded into *in situ* sandstone bedrock, in which bedding and jointing were evident, but which could still be removed by excavation.

Very hard *in situ* sandstone strata, below which no further penetration could be achieved, were recorded at variable depths ranging from 1.5m bgl to 1.6m bgl in the western end of the trenches, and extending to depths of 2.0m to 2.10m bgl in the eastern end of the trenches.

The sandstone layer formed an undulating surface, comprised an irregular, thinly to very thinly bedded and regularly jointed light-grey and brown sandstone.

Solid rock was proved along the entire bases of the trial trenches with no evidence of voiding, infilled fissures, zones of broken rock or any significant steps in rockhead level that could be attributed to faulting and fissuring. In addition, the weathered and superficial deposits overlying the rockhead were undisturbed and laterally consistent, indicating that they have not suffered any significant movements or displacements since their deposits and formation.

Due to the presence of the linear surface depression to the west-southwest of the T5 turbine location, which could potentially be related to fissuring on an alignment with the proposed turbine location (**Section 4.2.3**), a third trial trench (T5-TT3) was constructed perpendicular to the orientation of this feature.

A similar sequence of strata was encountered in this latter trench, with solid rock proved along the base of the trench and no evidence of voiding, infilled fissures, zones of broken rock or any significant steps in rockhead level that could be attributed to faulting and fissuring and no disturbance of the overlying superficial deposits.

No groundwater was encountered in the trial trenches.

T5 trial trench records and photographs are shown in **Appendix B**.

4.4 Rotary Open-Hole Boreholes

4.4.1 Turbine T4

Rotary boreholes T4-BH1 to T4-BH3 recorded “solid” bedrock at drill lengths between 2.7m and 4.6m (corrected vertical depths of between 1.91m and 3.25m). Above this, the superficial deposits and highly weathered bedrock provided “soft drilling” conditions. The predominant rock type encountered was grey sandstone of locally variable density, but also recorded were variable thin mudstone bands with possible thin coal seams between approximately 6.5m to 8.5m drill length, possible thin coals between 12m and 14m and various mudstone beds at 14m to 15m and 18m to 20m drill lengths.

No voids or loss of flush were reported and, although some areas of “soft drilling” were recorded, notably in T4-BH1 at 7.5m to 8.0m and 13.1m to 13.8m drill lengths, these appear to be more related to lithology and the drill lengths correlate well with lithological differences described above, although they may also relate to areas of more fractured rock.

No groundwater was encountered in the boreholes during drilling.

Borehole T4-BH1 to T4-BH3 records are shown in **Appendix C**.

4.4.2 Turbine T5

Rotary boreholes T5-BH1 to T5-BH3 recorded “solid” bedrock at a drill length of 3.0m (corrected vertical depth of 2.12m). Above this, the superficial deposits and highly weathered bedrock provided “soft drilling” conditions.

The predominant rock type encountered was grey sandstone of locally variable density. In T5-BH3, between 3.0m and 6.3m (corrected vertical depth of 2.12m to 4.47m) the sandstone was recorded by the drillers as “soft and broken”.

Also recorded at various levels were thin mudstone bands with possible thin coal seams, principally between approximately 4m and 14m drill length and 27m to 32m drill lengths.

No voids or loss of flush were reported and, although an areas of “soft drilling” was recorded in T5-BH3 at 3.0m to 6.3m, which correlates with a low in the gamma bulk density, there is no evidence that a void is present.

No groundwater was encountered in the boreholes during drilling.

Borehole T5-BH1 to T5-BH3 records are shown in **Appendix C**.

4.5 Down-Borehole Geophysical Logging

4.5.1 Turbine T4

The geophysical logging picked out the superficial and weathered bedrock as low density areas with high natural gamma (clays). Over the majority of its depth, the bulk density of the rock (principally grey sandstone) was relatively uniform although bands of both higher density and lower density were variably recorded. Mudstone bands were picked out by peaks in natural gamma and thin low density bands appear to relate to thin coal seams.

The logs did not record any areas of significant low bulk density that could be interpreted as open or partially infilled voids or significant areas of broken ground.

Geophysical logs are shown on the borehole records in **Appendix C** and the geophysical factual report is given in **Appendix D**.

4.5.2 Turbine T5

The geophysical logging picked out the superficial and weathered bedrock as low density areas with high natural gamma (clays). The area of “soft broken sandstone” recorded in the drilling of T5-BH3, between 3.0m and 6.3m is recorded as a low bulk density zone.

As for T4, over the majority of its depth the bulk density of the rock (principally grey sandstone) was relatively uniform although bands of both higher density and lower density were variably recorded. In particular, a low bulk density spike was recorded in the grey sandstone in T5-BH1 at 25.37m to 26.30m (corrected vertical depth of 17.94m to 18.60m) and T5-BH2 at 26.16m to 28.00m (corrected vertical depth of 18.50m to 19.80m). However, the drilling records over these lengths do not record any evidence of voids or significantly broken rock.

Again, mudstone bands were picked out by peaks in natural gamma and thin low density bands appear to relate to thin coals.

The logs did not record any areas of significant low bulk density that could be interpreted as open or partially infilled voids or significant areas of broken ground.

Geophysical logs are shown on the borehole records in **Appendix C** and the geophysical factual report is given in **Appendix D**.

4.6 T3 Peat Probing

Peat probing was undertaken at the proposed location of turbine T3. The probing was undertaken by an RSK engineer, using a hand-held fibreglass Hisco probe, at 6m centres within a 30m by 30m surveyed grid centred on the proposed turbine location and also along a linear array within a 75m by 25m rectangle based on the proposed crane hardstanding and track locations.

In the area of the proposed T3 turbine, the thickness of peat ranged between 0.1m and 0.42m, but in general was mainly between 0.15m and 0.2m thick.

In the area of the proposed trackway, the thickness of peat ranged between 0.12m and 0.66m, but in general was mainly between 0.15m and 0.25m thick.

The areas probed and thicknesses of peat are shown in **Figure 5** and tabulated in **Table 3**.

Table 3: Peat probe locations and thickness

Turbine T3 Grid			T3 Track peat probing		
X	Y	Peat Depth (m)	X	Y	Peat Depth (m)
291582.000	194686.000	0.18	291660.541	194774.286	0.23
291588.000	194686.000	0.2	291687.194	194744.46	0.31
291594.000	194686.000	0.17	291593.194	194660.46	0.2
291600.000	194686.000	0.19	291566.541	194690.286	0.17
291606.000	194686.000	0.34	291579.961	194675.55	0.17
291612.000	194686.000	0.26	291586.934	194682.78	0.21
291612.000	194680.000	0.29	291593.591	194690.123	0.22
291606.000	194680.000	0.19	291600.272	194697.434	0.24
291600.000	194680.000	0.2	291606.91	194704.887	0.6
291594.000	194680.000	0.19	291613.805	194712.117	0.18
291588.000	194680.000	0.22	291620.928	194719.149	0.16
291582.000	194680.000	0.42	291627.976	194726.236	0.19
291582.000	194674.000	0.12	291635.533	194733.146	0.22
291588.000	194674.000	0.2	291643.064	194739.795	0.16
291594.000	194674.000	0.2	291650.761	194746.442	0.14
291600.000	194674.000	0.37	291658.545	194752.791	0.16
291606.000	194674.000	0.16	291670.548	194762.755	0.16
291612.000	194674.000	0.12	291602.517	194710.432	0.16
291612.000	194668.000	0.17	291601.525	194714.984	0.2
291606.000	194668.000	0.2	291596.368	194719.392	0.15
291600.000	194668.000	0.2	291609.302	194701.536	0.43
291594.000	194668.000	0.2	291611.932	194697.677	0.5
291588.000	194668.000	0.16	291614.589	194693.276	0.25
291582.000	194668.000	0.39	291609.08	194695.4	0.45
291582.000	194662.000	0.15	291616.186	194699.148	0.23
291588.000	194662.000	0.18	291606.058	194698.794	0.66
291594.000	194662.000	0.2	291607.001	194701.914	0.49
291600.000	194662.000	0.2	291610.813	194689.473	0.32
291606.243	194662.000	0.15	291597.326	194685.941	0.4
291612.000	194662.000	0.16	291599.207	194690.175	0.44
291612.000	194656.000	0.1	291618.114	194708.437	0.29
291606.000	194656.000	0.12	291625.134	194730.205	0.13
291600.000	194656.000	0.15	291631.593	194721.378	0.25
291594.000	194656.000	0.18	291647.737	194749.757	0.14
291588.000	194656.000	0.24	291653.434	194743.123	0.12
291582.000	194656.000	0.27	291655.048	194757.366	0.12
			291661.791	194749.049	0.3

5 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

The ground investigation did not find any features related to re-activated faults or fissures at the turbine locations.

However, a linear surface feature on an alignment with the T5 turbine location was identified. Evidence from the current landowner via RES indicates that this a man-made drainage channel. Despite this, the visual morphology of this feature is also reminiscent of other fissure–related ground disturbance as identified on other areas of the site (**see Section 4.2.3**). As the current surface morphology of this feature is not entirely consistent with its origins as a man-made drainage ditch, it is worth considering the possibility, albeit small, that this feature may, at least in part, relate to fissuring, perhaps triggered by drainage along this channel, or to a shallow collapse feature related to subsurface drainage rather than to fissuring. The orientation of this feature, northeast-southwest, is roughly perpendicular to the majority of the identified faults and fissures, which are generally on a northwest-southeast alignment. With reference to the paper by Donnelly, Siddle and Northmore ("*The origin of fault scarps and fissures on moorland plateaux in the vicinity of landslides in the south Wales coalfield, UK*"), it is noted that "*the rock mass is broken by discontinuities, which include faults, fissures, bedding planes and at least two sets of high-angle joints that trend northeast-southwest and northwest-southeast. The latter is associated with the principal orientation of faults across the coalfield*".

There is, therefore, a structural discontinuity with a northeast-southwest alignment (although this is clearly not dominant), if the identified linear feature were to be in some way discontinuity-related. The above mentioned paper further notes that fissure walls display evidence of horizontal, as well as vertical, movements. Oblique movements are, therefore, likely to occur due to lateral spreading that could potentially open up fissures on this alignment. Notwithstanding the above, the landowner has stated that there were no visual surface features evident in this area prior to his construction of a drainage channel.

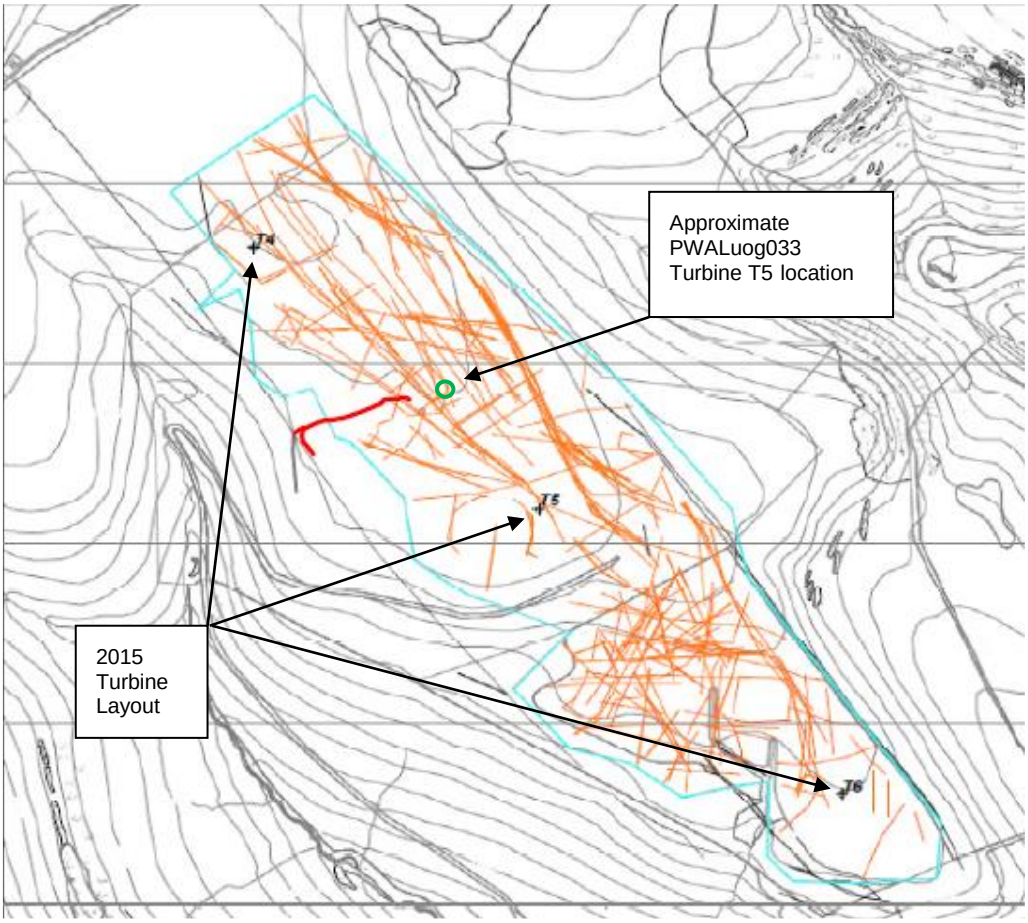
The visible tip of this linear feature is at around 35m from the centre of the T5 turbine location. A trial trench undertaken in line with and perpendicular to the alignment of this linear feature, 24m from the centre of T5 turbine location, did not show any evidence of the shallow ground being affected by a fissure and bedrock was encountered fully across the trial trench with no evidence of any significant breaks or fissures. Nonetheless, there remains the risk, albeit low, that, should this feature prove to be in some way fissure related, it could potentially propagate towards the T5 location over an as yet unquantifiable time period.

To further elucidate the nature of this feature, we have reviewed in detail the geophysical data presented in the 2015 Terradat Ltd report. This report records resistivity and GPR data close to the T5 turbine location in Terradat Ltds "Area 4". The

resistivity lines presented are parallel to the identified feature and do not, therefore, provide any further information. The GPR data, however, gives more global coverage and is presented as a series of maps of GPR response at three depth intervals; 0m to 2m bgl; 2m to 4m bgl; 4m to 6m bgl; and 6m+ bgl.

For the depth intervals 0m to 2m bgl and 2m to 4m bgl, there are several lineaments recorded that have a northeast-southwest, or similar, orientation, although none mapped on the identified feature. These lineaments are particularly evident on the map from the 2m to 4m bgl interval, which is reproduced as **Illustration 5**, below. This also shows the newly mapped feature (red lines). The GPR lineaments are not evident in the data from below 4m bgl.

Illustration 5: GPR lineament map (Terradat Ltd) for 2m to 4m bgl with observed surface linear feature (red line) superimposed.

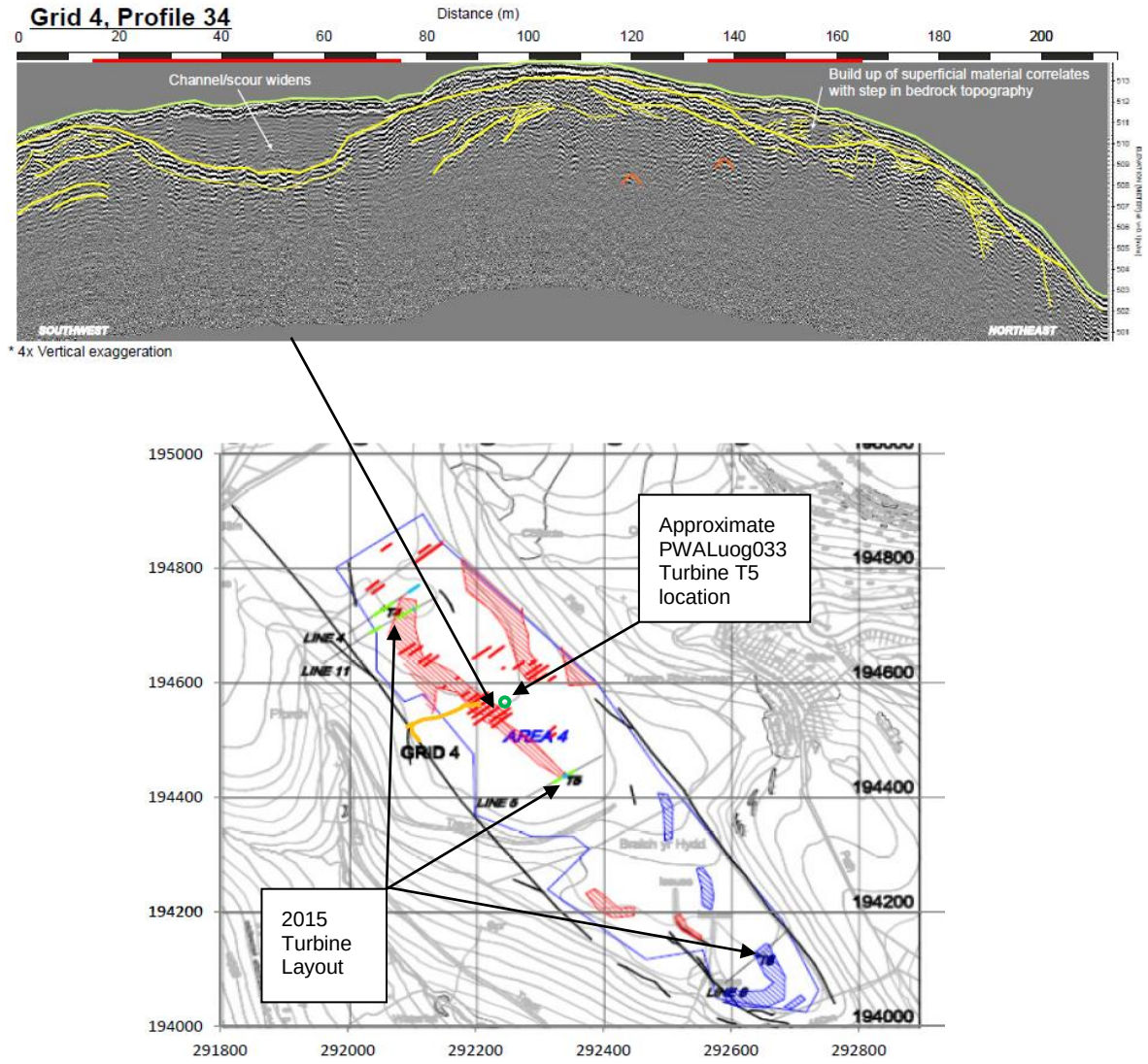


There are no GPR sections presented that are perpendicular to the identified feature. However, some sections parallel to it are presented (Profile 29 to 36), and one of these (Grid 4, Profile 34) is reproduced as **Illustration 6**, below. This profile illustrates that, below part of the newly mapped linear feature, there is a buried channel or scour feature identified within the bedrock, presumably infilled with superficial deposits. This buried channel is aligned northwest-southeast, perpendicular to the identified linear feature and

running through the area of boggy ground that the linear feature appears to have its origin in.

Therefore, whilst there is the possibility that the observed surface linear feature may somehow be related to preferential sub-surface drainage and ground collapse associated with this buried feature, it is not immediately obvious how the observed surface features morphology could have resulted. Equally, the GPR data in **Illustration 5** does not show definitely a deeper lineament upon which the observed surface feature is located.

Illustration 6: GPR section along profile 34 (upper) and GPR section plan (lower) showing the presence of inferred buried channel (red hatched area) and observed surface lineament (orange line).



Given that this feature lies on an alignment with the T5 turbine location and there is a risk, albeit low, that this feature may be in some way related to fissuring (either pre- or post-drainage channel construction) is would be prudent to investigate this feature directly during detailed design to confirm the information provided by the landowner and rule out the risk from fissuring.

5.2 Conclusions

Based on the above and with reference to **Table 1**:

- The risk categorisation for Turbines T3 and T4 locations is assessed as *Low*.
- The risk categorisation for Turbine T5 location is also assessed as *Low,* based on the anecdotal evidence provided by RES that the linear feature on alignment with this turbine is a man-made drainage channel.

For areas of site assessed as having a risk categorisation of *Low*, there remains a low risk to the development as a result of potential ongoing ground movements, which could be triggered by: -

- Further collapse of old coal workings deep below the site, which could result in subsidence or trigger fault-reactivation and fissuring.
- Ground movements, such as landslides on the steep slopes surrounding the site that could reduce lateral restraint and trigger further fissuring.
- Changes to surface water flow patterns and ground water levels as a result of global warming or groundwater rebound following cessation of mining operations.

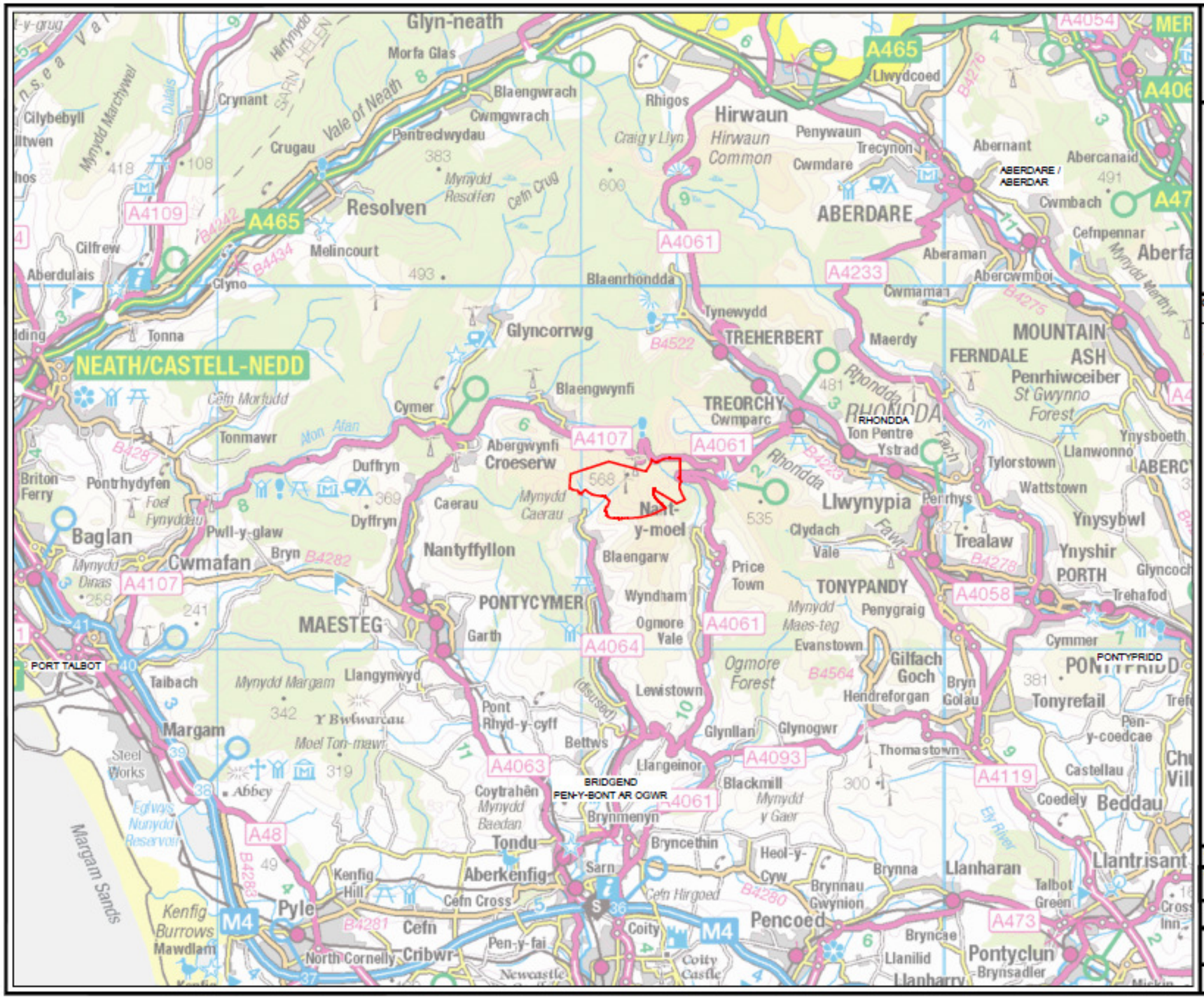
These above identified residual risks apply to the entire site area due to the known geological and coal mining history of this area. Although there is no evidence to suggest that such ground movements are currently affecting any of the proposed turbine locations, the residual low risk comes from the fact that such movements could potentially develop at some unquantifiable time in the future.

5.3 Recommendations

It is recommended that, during detailed design, intrusive trial trenches are undertaken across the alignment of the linear feature to the southwest of the T5 turbine location to expose the bedrock to check for any indication of fissuring/faulting and to inspect the exposed superficial deposits.

In the event that the trial trenches indicate evidence of faulting or fissuring in the bedrock, the risk of propagation can be considered and, if necessary, the turbine mico-sited to avoid the feature alignment altogether.

FIGURES



UPPER OGMORE WIND FARM

FIGURE 1

SITE LOCATION PLAN

KEY:

SITE LOCATION

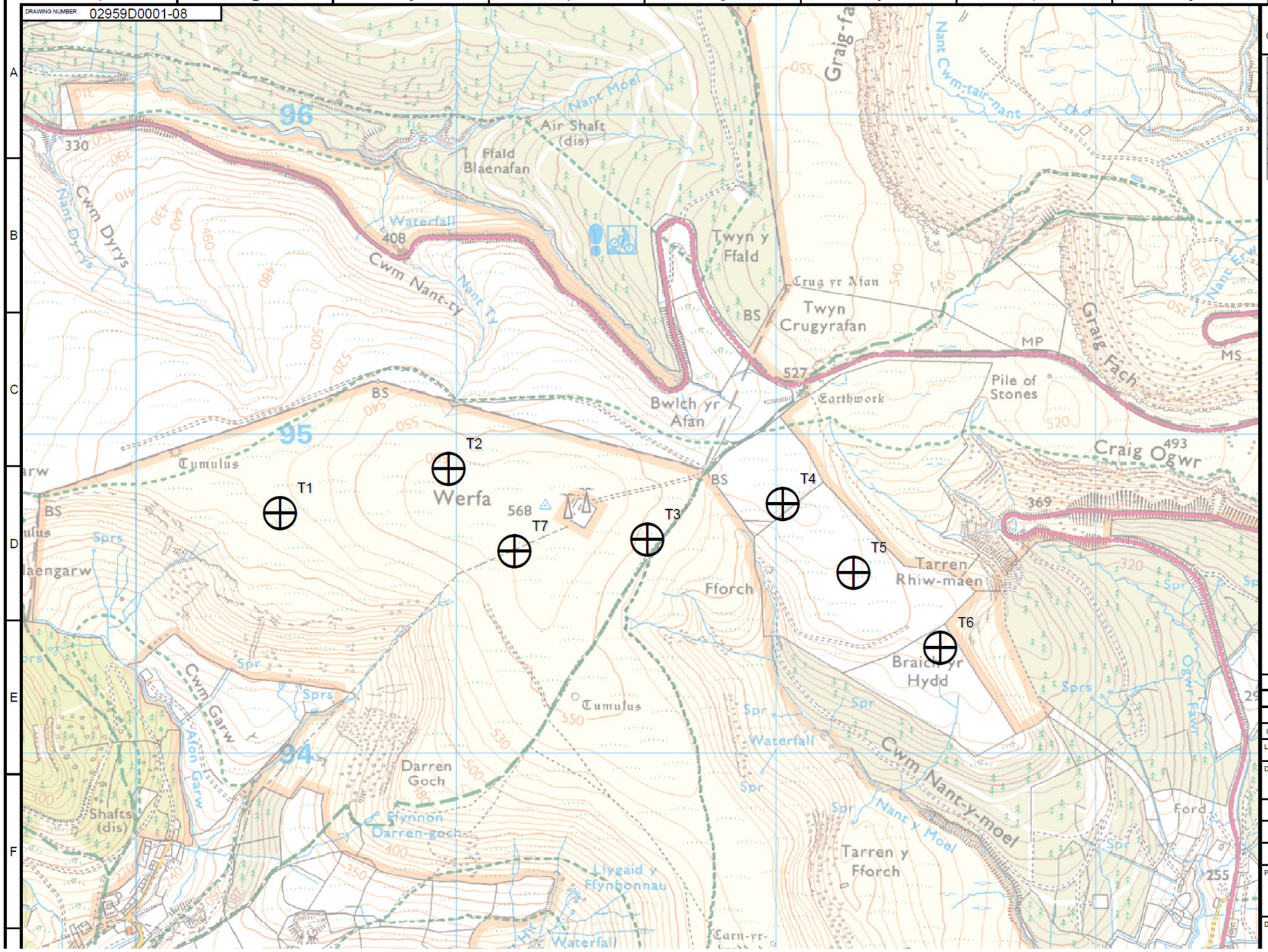
N/A | N/A

02959D2206-03

SCALE - 1:100,000 @ A3

RSK	**Site Location Plan**	**Client:**	RES Ltd	**Figure No:**	1
		Site:	Upper Ormore Wind Farm	**Job No:**	371718-01 (00)
		Scale:	NTS	**Source:**	Client

DRAWING NUMBER 02959D0001-08



Turbine ID	Diameter (m)	Hub Height (m)	EASTING	NORTHING
T1	105	77.50	290447	194753
T2	105	77.50	290975	194891
T3	105	97.40	291597	194671
T4	105	97.40	292020	194782
T5	105	97.40	292241	194567
T6	105	77.50	292513	194333
T7	105	97.40	291182	194634

Layout has been exported as a shapefile suitable for CAD import:

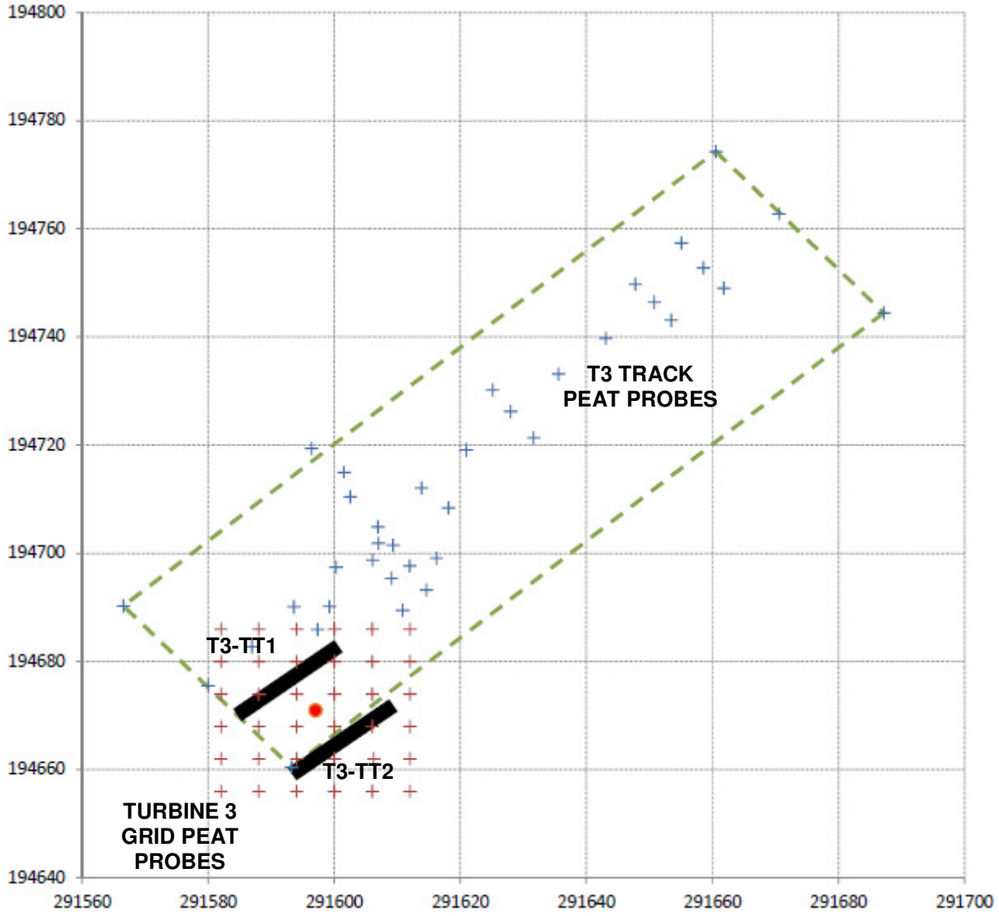
\\kl-fs-003\GIS_Storage\Projects\ONSHORE_WIND\WAL\uog\Outbox\00 EXPORTEDLAYOUTS\

8	NC	240518	AR	240518	T4 MOVED
7	NC	230418	AR	230418	T8 DROPPED; T6 RETURNED
1	DRAWN	DATE	APPD	DATE	FIRST ISSUE
ISSUE	DRAWN	DATE	APPD	DATE	REVISION NOTES

LAYOUT DWG	N/A	LAYOUT NO.	PWALuog033
DRAWING NUMBER	02959D0001-08		
COORDS	British National Grid		
PURPOSE	PRELIMINARY		
SCALE	1:12,500	ORIGINAL PLOT SIZE	A3
PROJECT TITLE	UPPER OGMORE WIND FARM		
DRAWING TITLE	TURBINE LAYOUT		

Turbine Layout No. PWALuog033

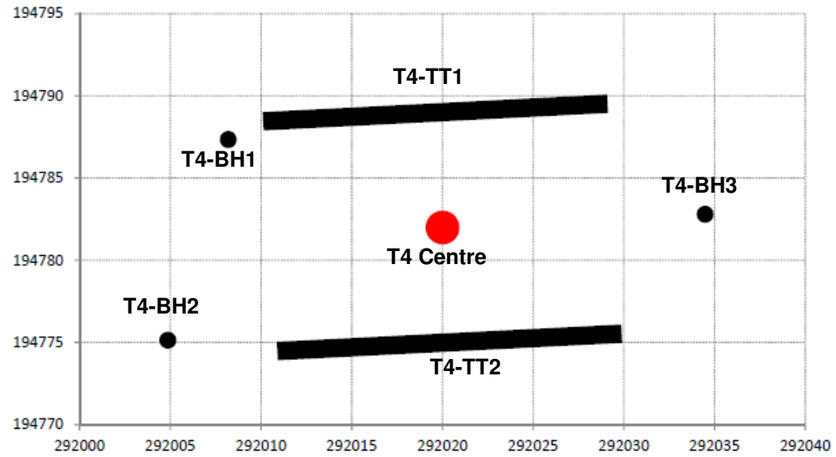
Client:	RES Ltd	**Figure No:**	2
Site:	Upper Ormore Wind Farm	**Job No:**	371718-01 (00)
Scale:	NTS	**Source:**	



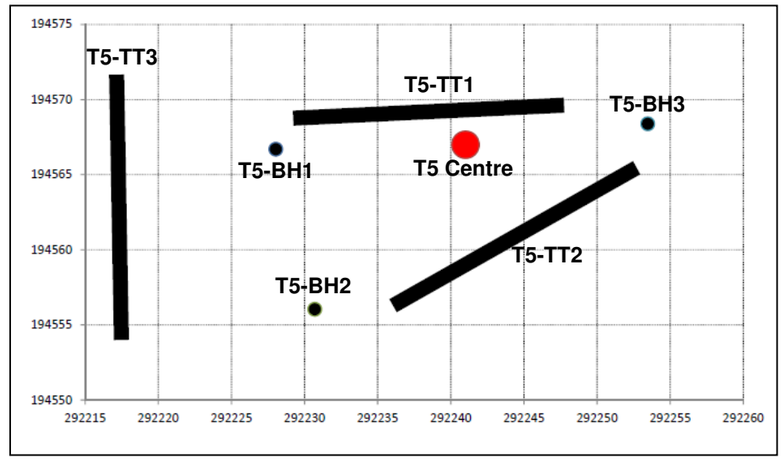
Turbine 3 Grid	
X	Y
291582.000	194686.000
291588.000	194686.000
291594.000	194686.000
291600.000	194686.000
291606.000	194686.000
291612.000	194686.000
291612.000	194680.000
291606.000	194680.000
291600.000	194680.000
291594.000	194680.000
291588.000	194680.000
291582.000	194680.000
291582.000	194674.000
291588.000	194674.000
291594.000	194674.000
291600.000	194674.000
291606.000	194674.000
291612.000	194674.000
291612.000	194668.000
291606.000	194668.000
291600.000	194668.000
291594.000	194668.000
291588.000	194668.000
291582.000	194668.000
291582.000	194662.000
291588.000	194662.000
291594.000	194662.000
291600.000	194662.000
291606.243	194662.000
291612.000	194662.000
291612.000	194656.000
291606.000	194656.000
291600.000	194656.000
291594.000	194656.000
291588.000	194656.000
291582.000	194656.000

Turbine T3				
Exploratory Hole	X	Y	Cardinal bearing	Comment
T3-TT1 (1)	291585.599	194670.883	51.536	
T3-TT1 (2)	291599.693	194682.079		
T3-TT2 (1)	291594.307	194659.921		
T3-TT2 (2)	291608.401	194671.117		

T3 Track	
X	Y
291660.541	194774.286
291687.194	194744.460
291593.194	194660.460
291566.541	194690.286



Turbine T4				
Exploratory Hole	X	Y	Cardinal bearing	Comment
T4-BH1	292008.185	194787.352	116	
T4-BH2	292004.857	194775.149	070	
T4-BH3	292034.478	194782.805	280	
T4-TT1 (1)	292010.625	194788.49		
T4-TT1 (2)	292028.597	194789.489		
T4-TT2 (1)	292011.403	194774.511		
T4-TT2 (2)	292029.375	194775.51		

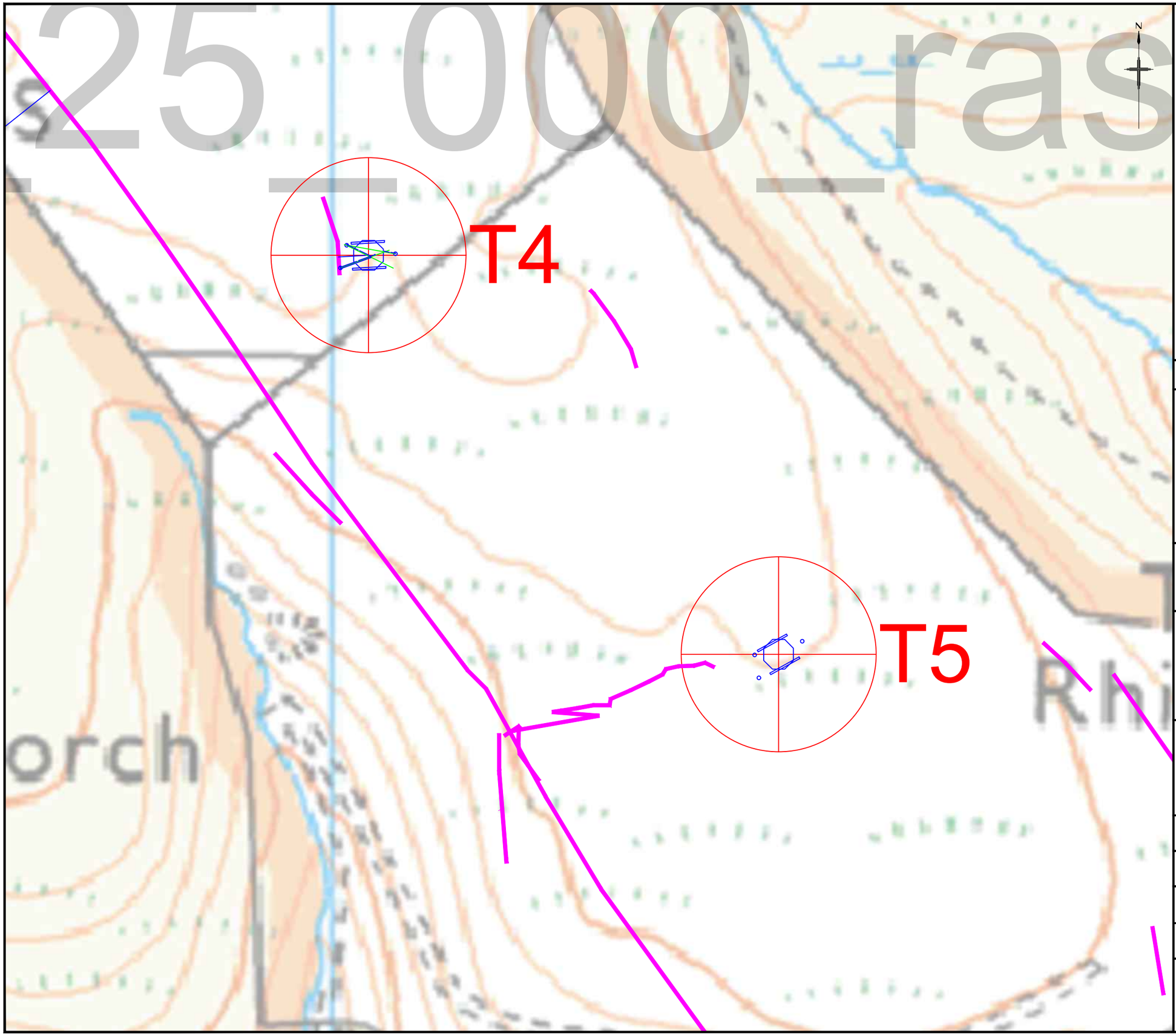


Turbine T5				
Exploratory Hole	X	Y	Cardinal bearing	Comment
T5-BH1	292228.032	194566.696	083	
T5-BH2	292230.693	194556.047	048	Moved slightly north out of the marshy area
T5-BH3	292253.466	194568.388	260	Moved south out of mast compound
T5-TT1 (1)	292229.738	194568.78		
T5-TT1 (2)	292247.234	194569.608		Moved south out of mast compound
T5-TT2 (1)	292236.503	194556.523		
T5-TT2 (2)	292252.262	194565.22		
T5-TT3 (1)	292217.16	194571.153		
T5-TT3 (2)	292217.469	194554.507		

RSK

EXPLORATORY HOLE SETTING OUT AND CO-ORDINATES

Client:	RES LIMITED	**Figure No:**	3
Site:	UPPER OGMORE WIND FARM	**Job No:**	371700-01 (00)
Scale:	NTS	**Source:**	RSK



LEGEND

Mapped Linear Features

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

RSK

18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT
United Kingdom

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Fax: +44 (0) 1442 437550
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

T4/T5
EXPLORATORY HOLE
LOCATION PLAN

Drawn	Date	Checked	Date	Approved	Date
ASC	09.07.18	MM	09.07.18	MM	09.07.18

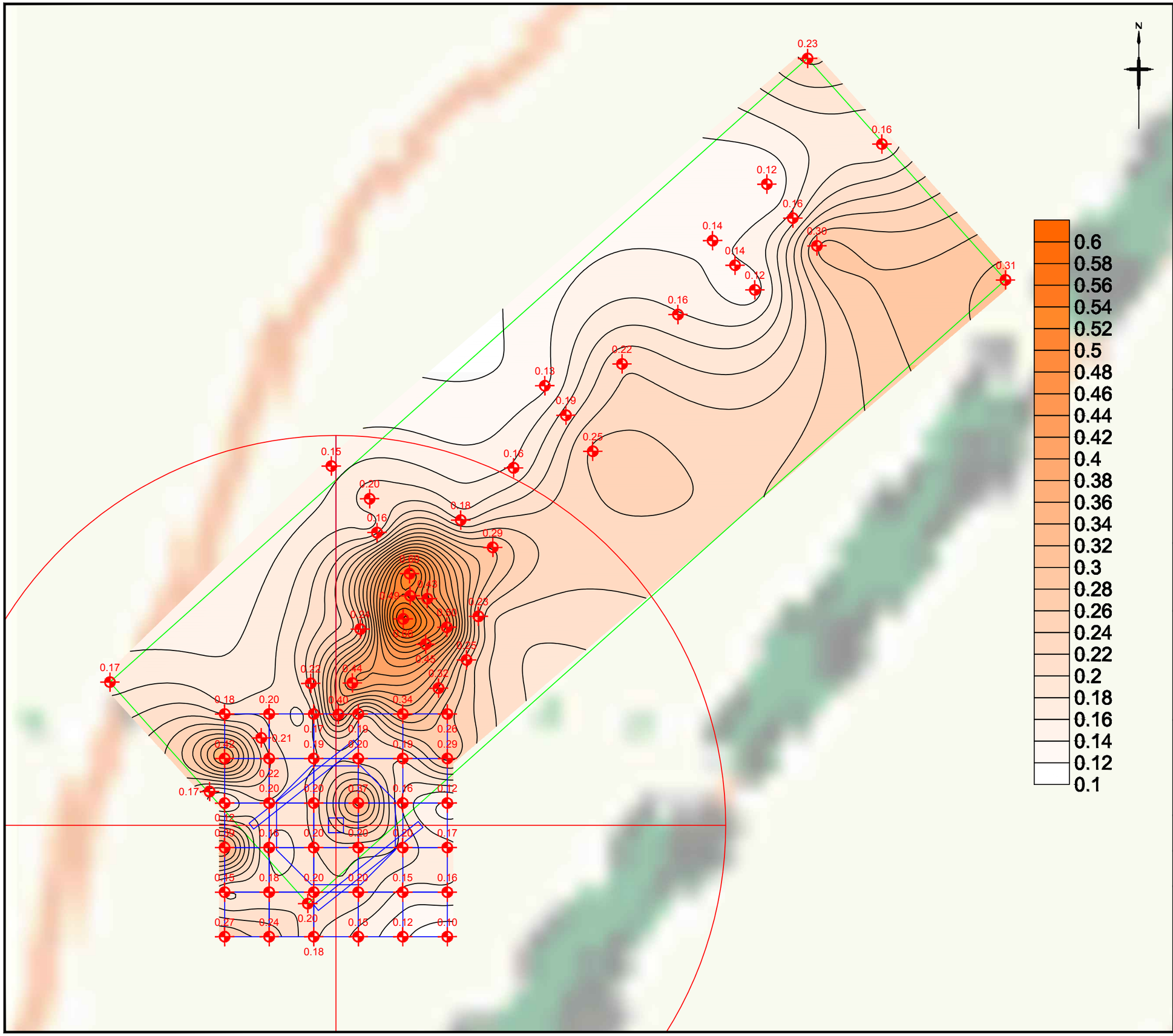
Scale	Orig Size	Dimensions
1:2000	A3	m

Project No.	Drawing File
371718	371718 (R01-00) Fig 2.dwg

Drawing No.	Rev.
FIGURE 2	P1

Scale 1 : 2,000

0 20 40 60 80 100m



LEGEND

- Peat Probing Location
- 0.16 Depth of Peat Encountered *(mbgl)*

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

RSK

18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT
United Kingdom

Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

T3
PEAT PROBING
CONTOUR PLOT

Drawn	Date	Checked	Date	Approved	Date
ASC	09.07.18	MM	09.07.18	MM	09.07.18

Scale	Orig Size	Dimensions
1:500	A3	m

Project No.	Drawing File
371718	371718 (R01-00) Fig 3.dwg

Drawing No.	Rev.
FIGURE 5	P1

Scale 1 : 1000

0 10 20 30 40 50m

APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for RES Limited (the "client") in accordance with the terms of a contract between RSK and the "client". The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.

2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.

3. Unless otherwise agreed in writing the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**

4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

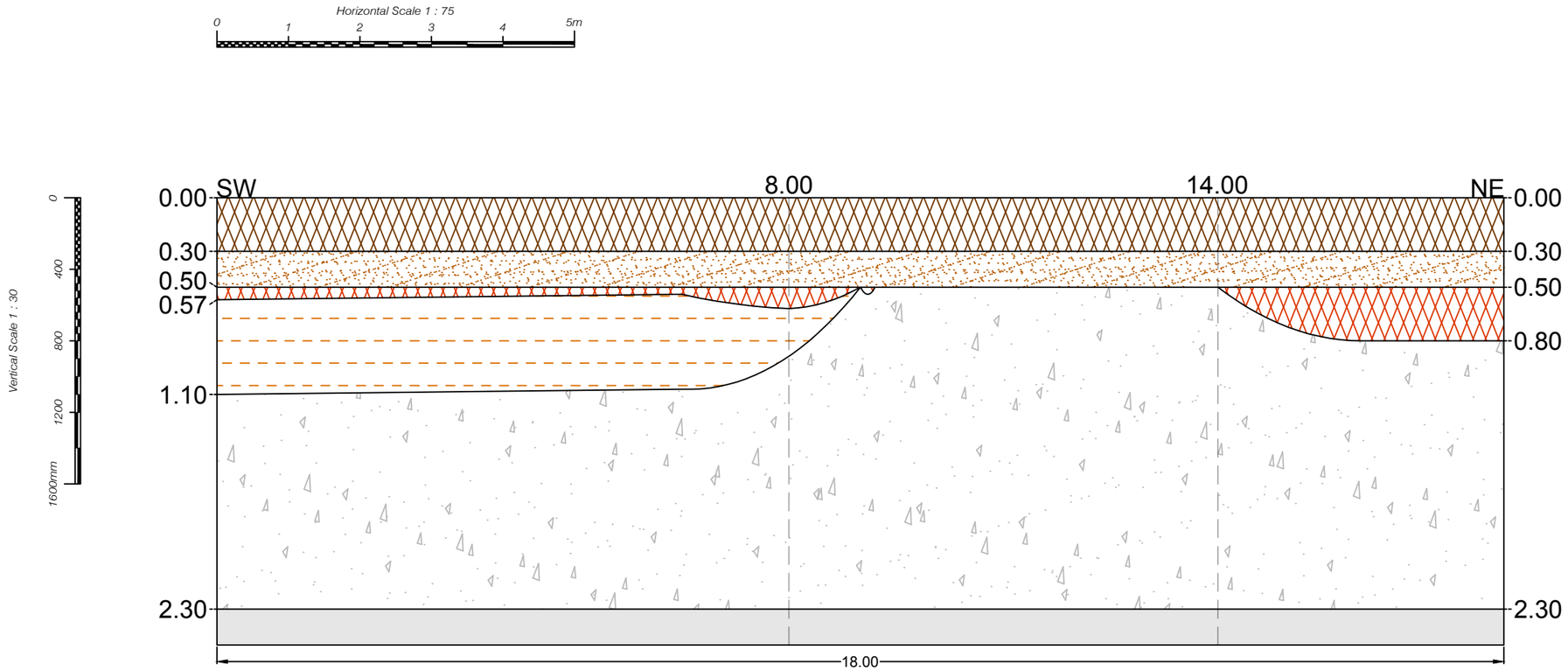
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (boreholes, trial pits etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B
TRIAL TRENCH RECORDS



LEGEND

- Topsoil: Dark brown silty amorphous PEAT.
- Sand: Orangish brown silty fine to coarse SAND.
- Peaty Topsoil: Reddish brown peaty topsoil.
- Clay: Brown sandy clay. Sand is fine to coarse.
- Sandy Gravel: Greyish brown sandy gravel and cobbles. Sand is fine to coarse. Gravel is fine to coarse subangular to angular sandstone (Weathered Sandstone).
- Sandstone: Off whitish greyish brown sandstone.

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

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HP3 9RT
United Kingdom
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Fax: +44 (0) 1442 437550
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client
RES

Project Title
UPPER OGMORE
WIND FARM

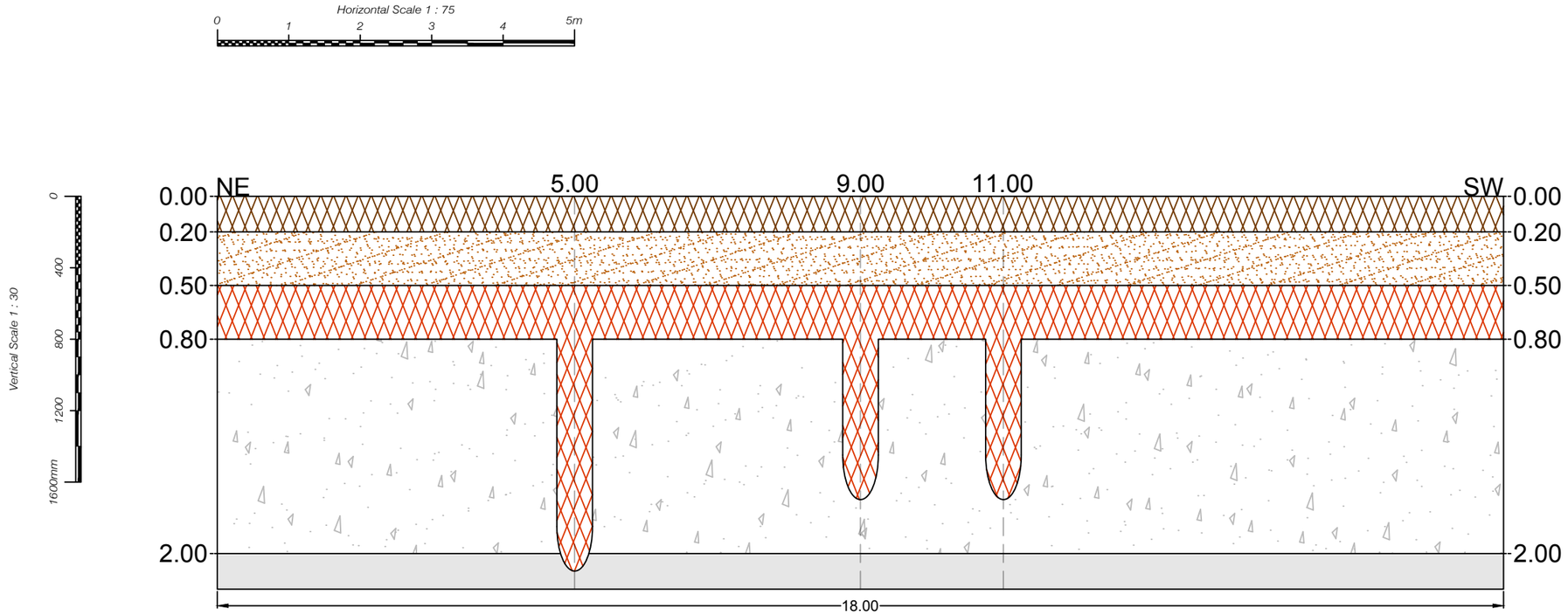
Drawing Title
TRIAL PIT
DIAGRAM
T3-TT1

Drawn	Date	Checked	Date	Approved	Date
ASC	20.06.18	NH	20.06.18	NH	20.06.18

Scale	Orig Size	Dimensions
As Shown	A3	m

Project No.	Drawing File
371718	371718 (R01-00) TP.dwg

Drawing No.	Rev.
T3-TT1	P1



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Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

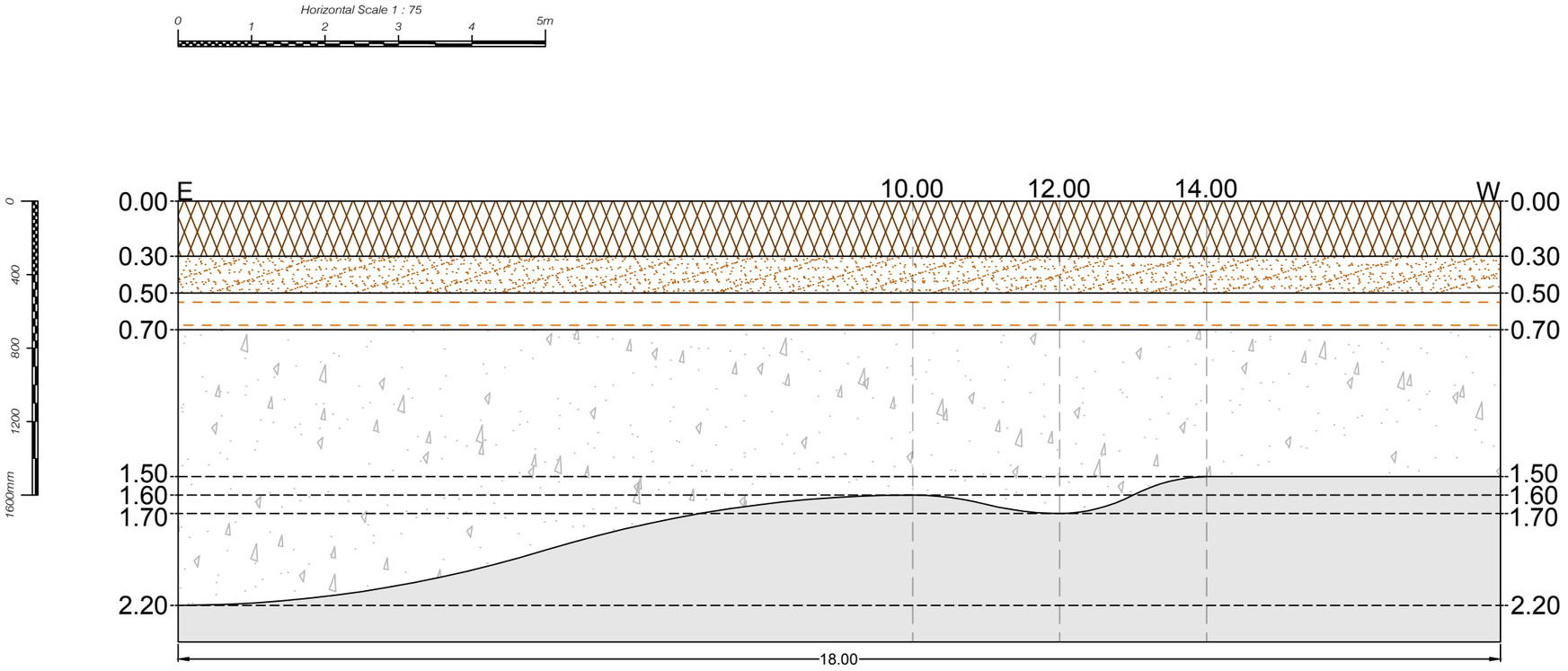
TRIAL PIT
DIAGRAM
T3-TT2

Drawn	Date	Checked	Date	Approved	Date
ASC	20.06.18	NH	20.06.18	NH	20.06.18

Scale	Orig Size	Dimensions
As Shown	A3	m

Project No.	Drawing File
371718	371718 (R01-00) TP.dwg

Drawing No.	Rev.
T3-TT2	P1



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Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

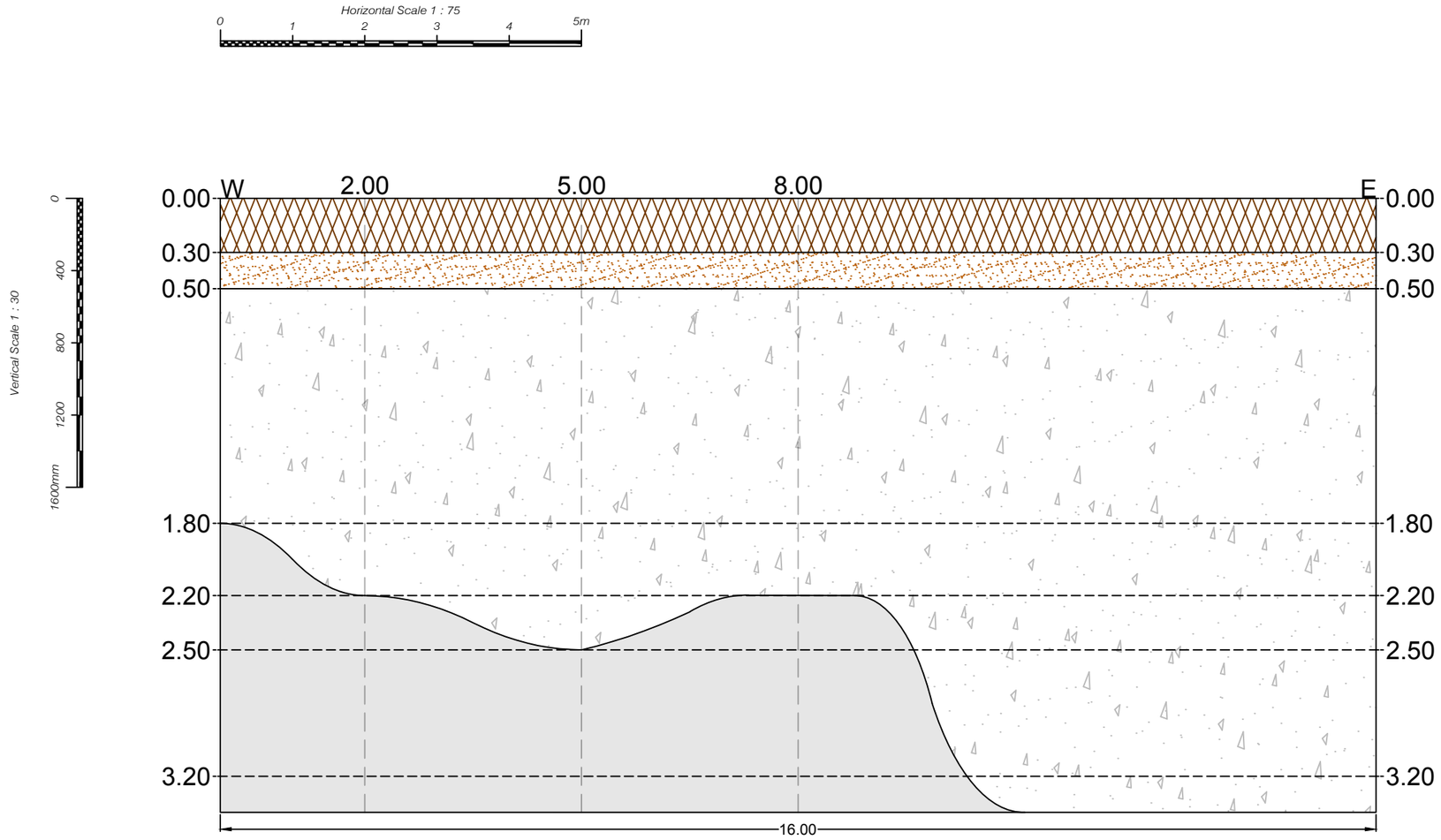
TRIAL PIT
DIAGRAM
T4-TT1

Drawn	Date	Checked	Date	Approved	Date
ASC	28.06.18	NH	28.06.18	NH	28.06.18

Scale	Orig Size	Dimensions
As Shown	A3	m

Project No.	Drawing File
371718	371718 (R01-00) TP.dwg

Drawing No.	Rev.
T4-TT1	P1



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Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

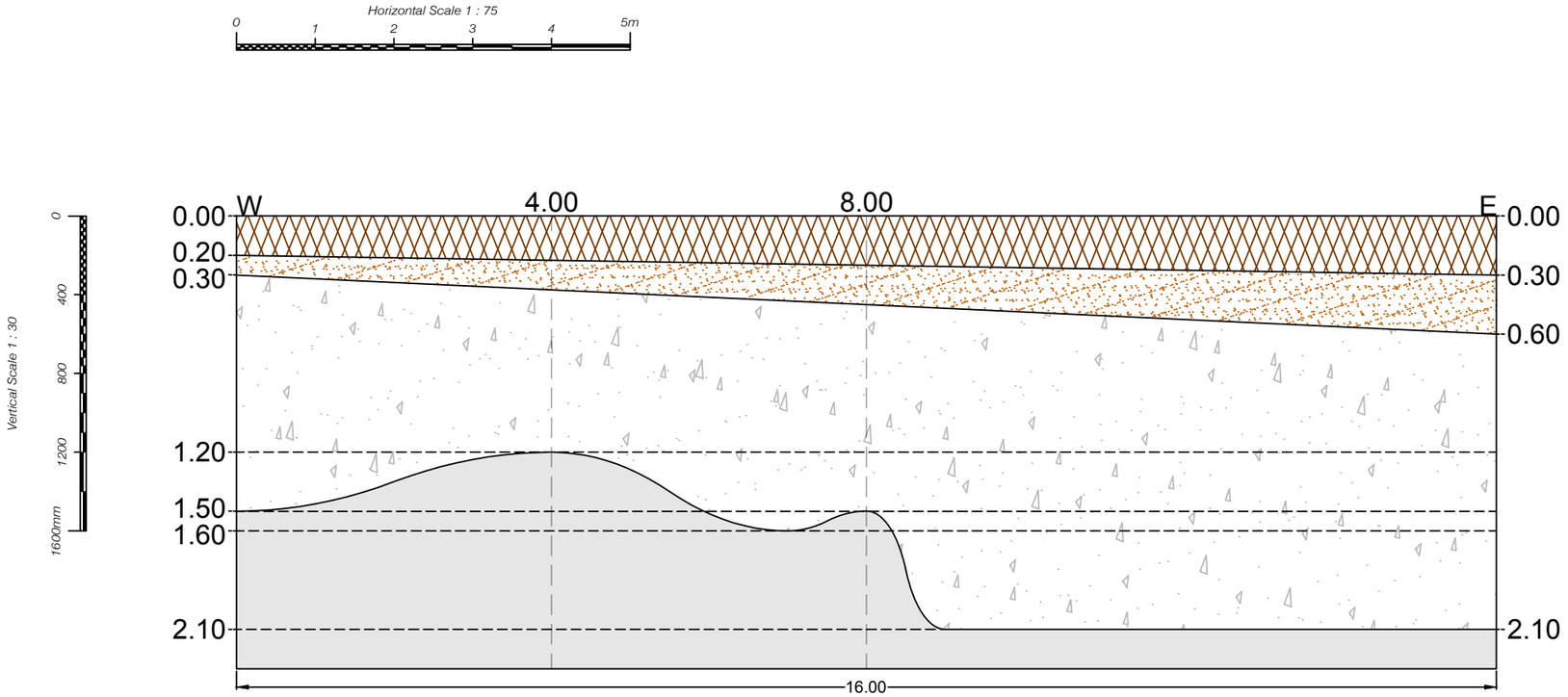
TRIAL PIT
DIAGRAM
T4-TT2

Drawn	Date	Checked	Date	Approved	Date
ASC	28.06.18	NH	28.06.18	NH	28.06.18

Scale	Orig Size	Dimensions
As Shown	A3	m

Project No.	Drawing File
371718	371718 (R01-00) TP.dwg

Drawing No.	Rev.
T4-TT2	P1



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Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

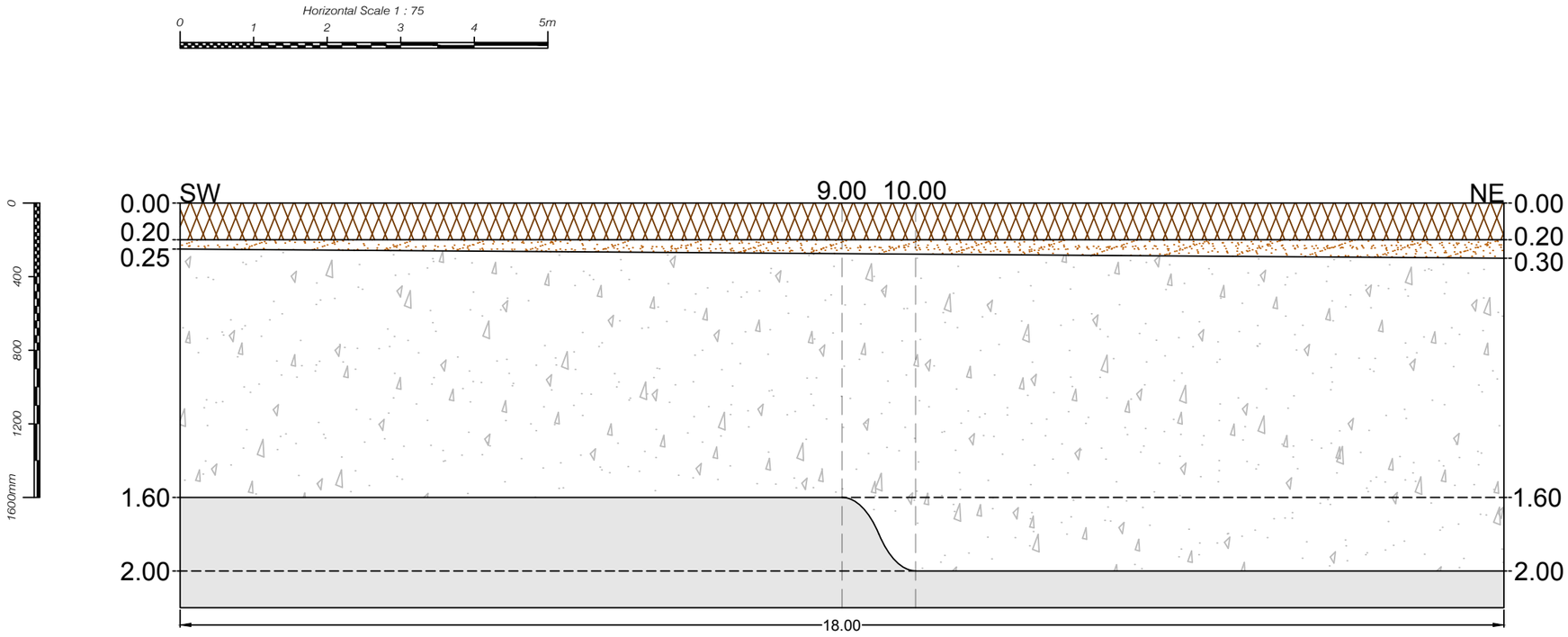
TRIAL PIT
DIAGRAM
T5-TT1

Drawn	Date	Checked	Date	Approved	Date
ASC	28.06.18	NH	28.06.18	NH	28.06.18

Scale	Orig Size	Dimensions
As Shown	A3	m

Project No.	Drawing File
371718	371718 (R01-00) TP.dwg

Drawing No.	Rev.
T5-TT1	P1



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Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

TRIAL PIT
DIAGRAM
T5-TT2

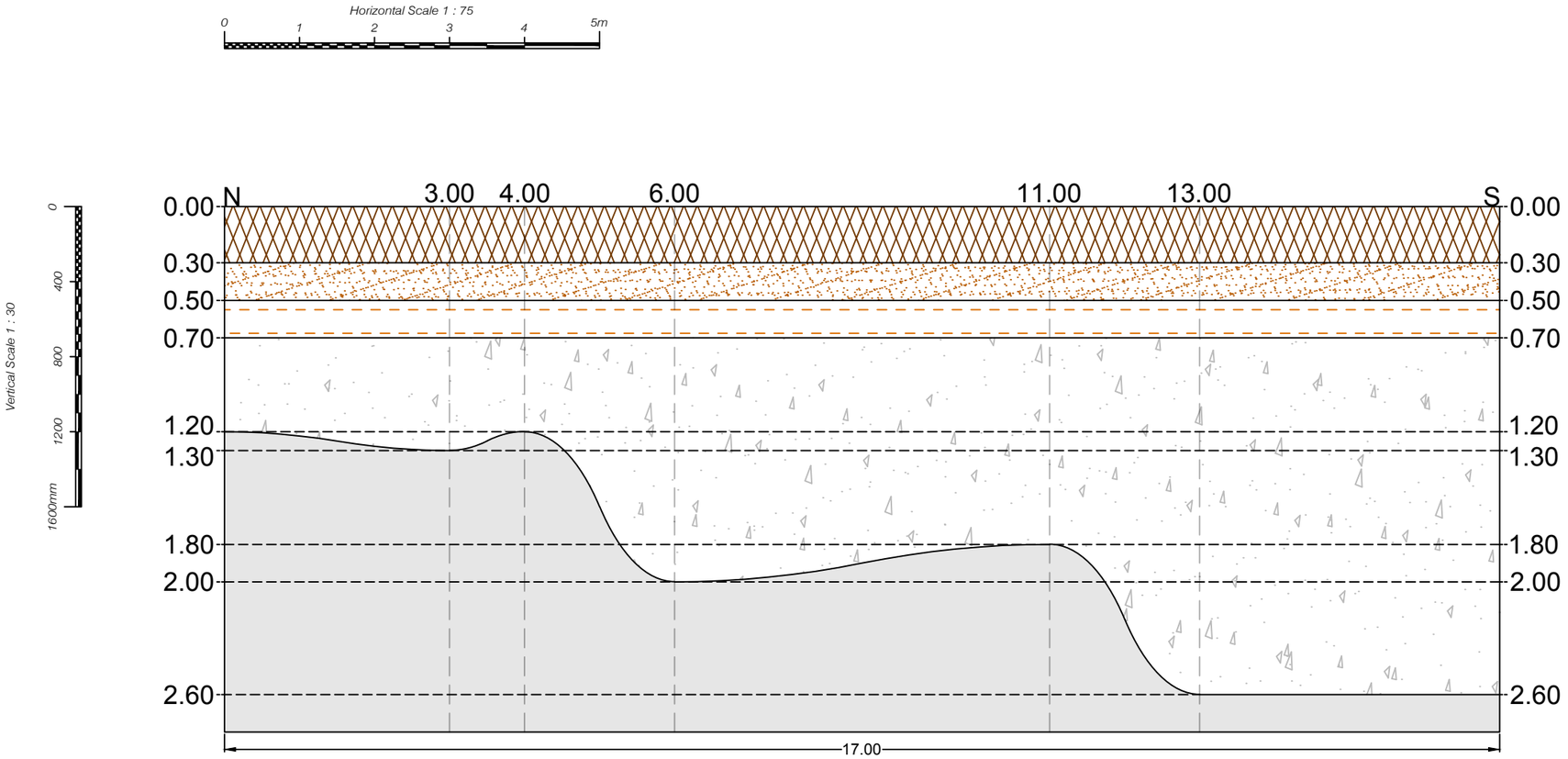
Drawn	Date	Checked	Date	Approved	Date
ASC	28.06.18	NH	28.06.18	NH	28.06.18

Scale	Orig Size	Dimensions
As Shown	A3	m

Project No.	Drawing File
371718	371718 (R01-00) TP.dwg

Drawing No.	Rev.
T5-TT2	P1

Scale 1 : 75
0 1 2 3 4 5m



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Client

RES

Project Title

UPPER OGMORE
WIND FARM

Drawing Title

TRIAL PIT
DIAGRAM
T5-TT3

Drawn	Date	Checked	Date	Approved	Date
ASC	28.06.18	NH	28.06.18	NH	28.06.18

Scale	Orig Size	Dimensions
As Shown	A3	m

Project No.	Drawing File
371718	371718 (R01-00) TP.dwg

Drawing No.	Rev.
T5-TT3	P1

Scale 1 : 60
0
800
1600
2400
3200
4000mm

PHOTOGRAPHIC LOG

Photo no. **1**	**Date:** 05/06/18
Direction photo taken: Looking southwest	
Description: **T3-TT1**	

Photo No. **2**	**Date:** **05/06/18**
Direction photo taken: **Looking southwest**	
Description: **T3-TT2**	

Photo No. 3	Date: 06/06/18	
Direction Photo Taken: east		
Description: **T4-TT1**		

Photo No. 4	Date: 06/06/18	
Direction Photo Taken: west		
Description: **T4-TT2**		

Photo No. 5	Date: 05/06/18	
Direction Photo Taken: west		
Description: **T5-TT1**		

Photo No. 6	Date: 05/06/18	
Direction Photo Taken: southeast		
Description: **T5-TT2**		

Photo No.	Date:	
7	06/06/18	
Direction Photo Taken: south		
Description: **T5-TT3**		

APPENDIX C
ROTARY BOREHOLE RECORDS

ROTARY BOREHOLE RECORD

Job Number: 371799

Project	Upper Ogmore Wind Farm	**Client**	RES Limited	**Date**	04/06/2018
Location	292008, 194787	**Drilling Contractor**	Apex Drilling	**Logged By**	CG
				Borehole Number:	T4-BH1

Drilling Rate		Observations											
		Drilling		Hammer			Returns			Colour			
Depth (m)	Seconds/0.5m	Steady	Unsteady	Regular	Irregular	None	Good Dust	No Dust	Water	Brown	Grey	Black	
0.0			X		X			X		X			
0.5			X		X			X		X			
1.0			X		X			X		X			
1.5			X		X			X		X			
2.0			X		X			X		X			
2.5			X		X			X		X			
3.0	19	X		X			X			X	X		
3.5	22	X		X			X			X	X		
4.0	27	X		X			X			X	X		
4.5	26	X		X			X			X	X		
5.0	22	X		X			X			X	X		
5.5	26	X		X			X			X	X		
6.0	29	X		X			X			X	X		
6.5	30	X		X			X			X	X		
7.0	28	X		X			X			X	X		
7.5	20	X		X				X		X	X		
8.0	25	X		X			X			X	X		
8.5	32	X		X			X			X	X		
9.0	53	X		X			X			X	X		
9.5	53	X		X			X			X	X		
10.0	53	X		X			X			X	X		
10.5	45	X		X			X			X	X		
11.0	45	X		X			X			X	X		
11.5	45	X		X			X			X	X		
12.0	45	X		X			X			X	X		
12.5	45	X		X			X			X	X		
13.0	45	X		X			X			X	X		
13.5	10	X		X			X			X	X		
14.0	40	X		X			X			X	X		
14.5	40	X		X			X			X	X		
15.0	40	X		X			X			X	X		
15.5	40	X		X			X			X	X		
16.0	40	X		X			X			X	X		
16.5	52	X		X			X			X	X		
17.0	52	X		X			X			X	X		
17.5	52	X		X			X			X	X		
18.0	52	X		X			X			X	X		
18.5	52	X		X			X			X	X		
19.0	52	X		X			X			X	X		
19.5	58	X		X			X			X	X		
20.0	58	X		X			X			X	X		
20.5	58	X		X			X			X	X		
21.0	58	X		X			X			X	X		
21.5	58	X		X			X			X	X		
22.0	58	X		X			X			X	X		
22.5	53	X		X			X			X	X		
23.0	53	X		X			X			X	X		
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29.5	47	X		X			X			X	X		
30.0	47	X		X			X			X	X		
30.5	47	X		X			X			X	X		
31.0	47	X		X			X			X	X		
31.5	42	X		X			X			X	X		
32.0	42	X		X			X			X	X		
32.5	42	X		X			X			X	X		
33.0	42	X		X			X			X	X		
33.5	42	X		X			X			X	X		
34.0	42	X		X			X			X	X		
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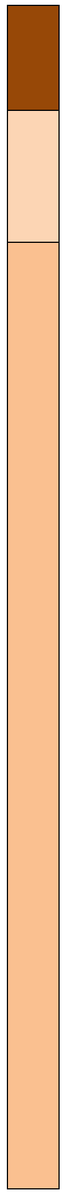
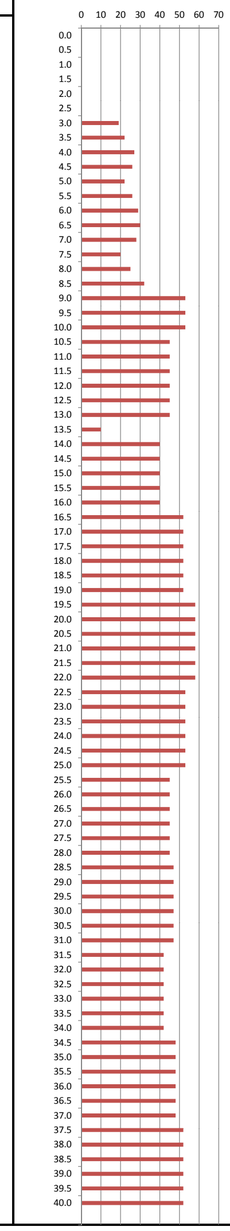
36.0	48	X		X			X			X	X		
36.5	48	X		X			X			X	X		
37.0	48	X		X			X			X	X		
37.5	52	X		X			X			X	X		
38.0	52	X		X			X			X	X		
38.5	52	X		X			X			X	X		
39.0	52	X		X			X			X	X		
39.5	52	X		X			X			X	X		
40.0	52	X		X			X			X	X		

Rock Quality Log



Plot of drilling penetration rate against inclined drill length



Description of Returns

Inclined drill length (m)		Corrected vertical depth (m bgl)		Vertical thickness (m)	Description
From	To	From	To		
0.00	2.70	0.00	1.91	1.91	Peat, sand and clay over highly weathered sandstone
2.70	4.00	1.91	2.83	0.92	Grey sandstone
4.00	4.70	2.83	3.32	0.49	Grey sandstone - low density band
4.70	6.70	3.32	4.74	1.41	Grey sandstone
6.70	8.50	4.74	6.01	1.27	Low density band - probable 0.5m thick mudstone bands between 6.7m & 7.2m and 7.7m & 8.2m and possible thin coal seam
8.50	12.50	6.01	8.84	2.83	Grey sandstone
12.50	13.70	8.84	9.69	0.85	Grey sandstone - low density bands (possible thin coal seams)
13.70	14.00	9.69	9.90	0.21	Grey sandstone
14.00	15.00	9.90	10.61	0.71	Mudstone
15.00	15.50	10.61	10.96	0.35	Grey sandstone - high density bands
15.50	17.36	10.96	12.28	1.32	Grey sandstone
17.36	18.58	12.28	13.14	0.86	Mudstone
18.58	40.00	13.14	28.28	15.15	Grey sandstone

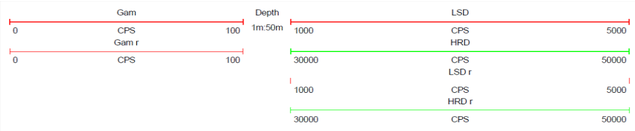
Key to Rock Quality Log

- Superficial Deposits and highly weathered rock
- Void/Fissure
- Poor Quality Rock
- Moderate Quality Rock
- Good Quality Rock

Key to Graphic Log

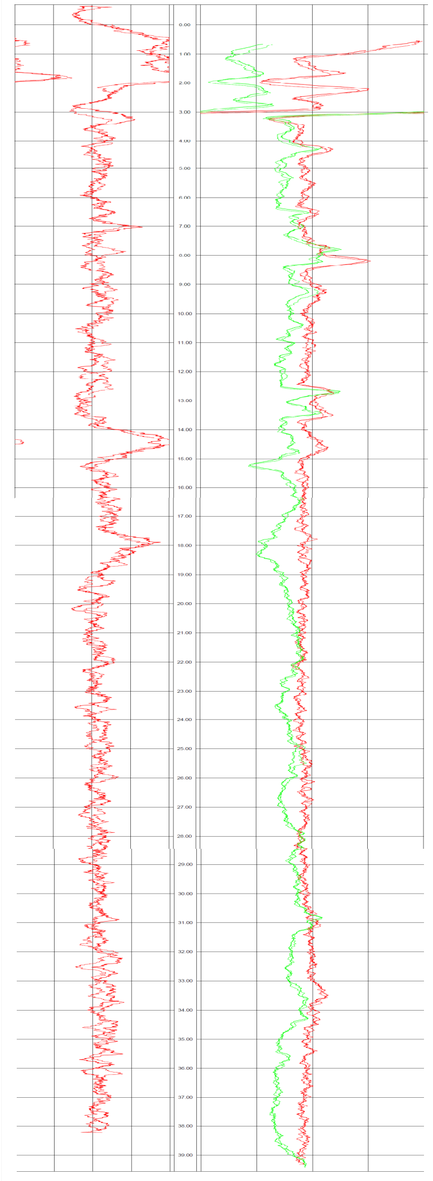
- Superficial Deposits and highly weathered rock
- Grey Sandstone
- Mudstone
- Coal

Key to Geophysical Log



Graphic Log

Geophysical Log



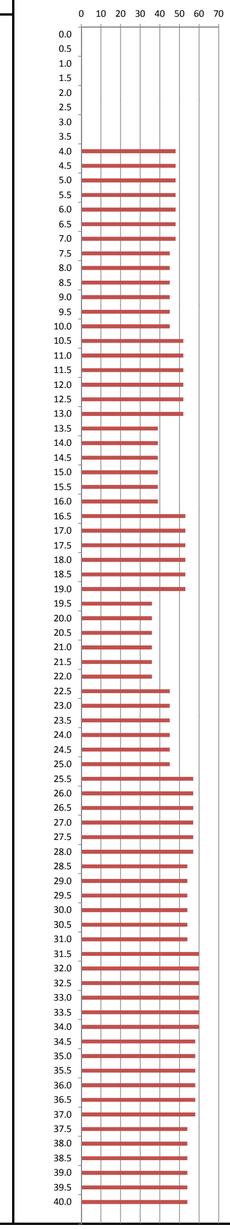
ROTARY BOREHOLE RECORD

Job Number: 371799

Project	Upper Ogmore Wind Farm	**Client**	RES Limited
Location	292004, 194775	**Drilling Contractor**	Apex Drilling
Date	05/06/2018	**Logged By**	CG
Borehole Number:	T4-BH2		

Drilling Rate		Observations											
		Drilling		Hammer			Returns			Colour			
Depth (m)	Seconds/0.5m	Steady	Unsteady	Regular	Irregular	None	Good Dust	No Dust	Water	Brown	Grey	Black	Rock Quality Log
0.0			X		X			X		X			
0.5			X		X			X		X			
1.0			X		X			X		X			
1.5			X		X			X		X			
2.0			X		X			X		X			
2.5			X		X			X		X			
3.0			X		X			X		X			
3.5			X		X			X		X			
4.0	48	X		X			X			X	X		
4.5	48	X		X			X			X	X		
5.0	48	X		X			X			X	X		
5.5	48	X		X			X			X	X		
6.0	48	X		X			X			X	X		
6.5	48	X		X			X			X	X		
7.0	48	X		X			X			X	X		
7.5	45	X		X			X			X	X		
8.0	45	X		X			X			X	X		
8.5	45	X		X			X			X	X		
9.0	45	X		X			X			X	X		
9.5	45	X		X			X			X	X		
10.0	45	X		X			X			X	X		
10.5	52	X		X			X			X	X		
11.0	52	X		X			X			X	X		
11.5	52	X		X			X			X	X		
12.0	52	X		X			X			X	X		
12.5	52	X		X			X			X	X		
13.0	52	X		X			X			X	X		
13.5	39	X		X			X			X	X		
14.0	39	X		X			X			X	X		
14.5	39	X		X			X			X	X		
15.0	39	X		X			X			X	X		
15.5	39	X		X			X			X	X		
16.0	39	X		X			X			X	X		
16.5	53	X		X			X			X	X		
17.0	53	X		X			X			X	X		
17.5	53	X		X			X			X	X		
18.0	53	X		X			X			X	X		
18.5	53	X		X			X			X	X		
19.0	53	X		X			X			X	X		
19.5	36	X		X			X			X	X		
20.0	36	X		X			X			X	X		
20.5	36	X		X			X			X	X		
21.0	36	X		X			X			X	X		
21.5	36	X		X			X			X	X		
22.0	36	X		X			X			X	X		
22.5	45	X		X			X			X	X		
23.0	45	X		X			X			X	X		
23.5	45	X		X			X			X	X		
24.0	45	X		X			X			X	X		
24.5	45	X		X			X			X	X		
25.0	45	X		X			X			X	X		
25.5	57	X		X			X			X	X		
26.0	57	X		X			X			X	X		
26.5	57	X		X			X			X	X		
27.0	57	X		X			X			X	X		
27.5	57	X		X			X			X	X		
28.0	57	X		X			X			X	X		
28.5	54	X		X			X			X	X		
29.0	54	X		X			X			X	X		
29.5	54	X		X			X			X	X		
30.0	54	X		X			X			X	X		
30.5	54	X		X			X			X	X		
31.0	54	X		X			X			X	X		
31.5	60	X		X			X			X	X		
32.0	60	X		X			X			X	X		
32.5	60	X		X			X			X	X		
33.0	60	X		X			X			X	X		
33.5	60	X		X			X			X	X		
34.0	60	X		X			X			X	X		
34.5	58	X		X			X			X	X		
35.0	58	X		X			X			X	X		
35.5	58	X		X			X			X	X		
36.0	58	X		X			X			X	X		
36.5	58	X		X			X			X	X		
37.0	58	X		X			X			X	X		
37.5	54	X		X			X			X	X		
38.0	54	X		X			X			X	X		
38.5	54	X		X			X			X	X		
39.0	54	X		X			X			X	X		
39.5	54	X		X			X			X	X		
40.0	54	X		X			X			X	X		

Plot of drilling penetration rate against inclined drill length



Description of Returns

Inclined drill length (m)		Corrected vertical depth (m bgl)		Vertical thickness (m)	Description
From	To	From	To		
0.00	3.70	0.00	2.62	2.62	Peat, sand and clay over highly weathered sandstone
3.70	5.00	2.62	3.54	0.92	Grey sandstone
5.00	7.00	3.54	4.95	1.41	Probable mudstone bands interbedded with sandstone
7.00	7.40	4.95	5.23	0.28	Grey sandstone
7.40	7.60	5.23	5.37	0.14	Probable coal
7.60	13.40	5.37	9.48	4.10	Grey sandstone
13.40	14.20	9.48	10.04	0.57	Grey sandstone - low density bands (possible thin coal seams)
14.20	15.30	10.04	10.82	0.78	Grey sandstone
15.30	16.70	10.82	11.81	0.99	Mudstone
16.70	17.00	11.81	12.02	0.21	Grey sandstone - high density band
17.00	19.20	12.02	13.58	1.56	Grey sandstone
19.20	20.75	13.58	14.67	1.10	Mudstone
20.75	25.80	14.67	18.24	3.57	Grey sandstone
25.80	26.20	18.24	18.53	0.28	Grey sandstone - low density band (possible thin coal seam)
26.20	40.00	18.53	28.28	9.76	Grey sandstone

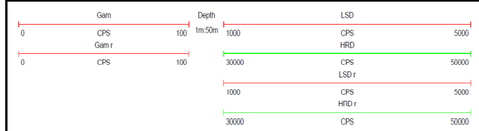
Key to Rock Quality Log

- Superficial Deposits and highly weathered rock
- Void/Fissure
- Poor Quality Rock
- Moderate Quality Rock
- Good Quality Rock

Key to Graphic Log

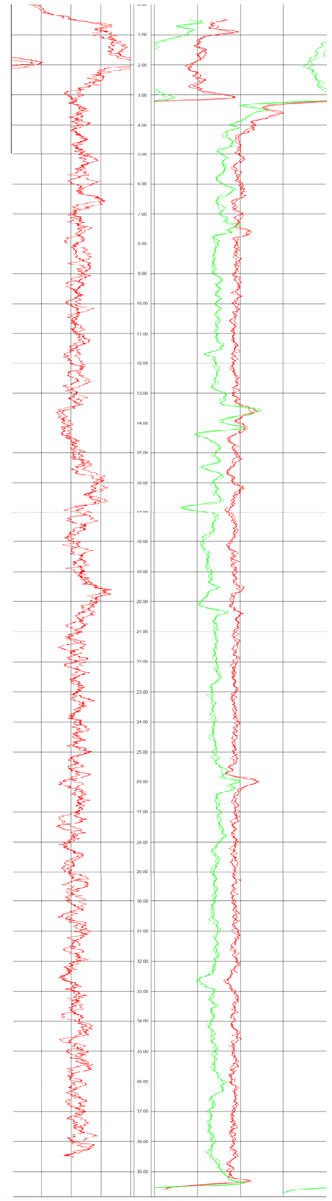
- Superficial Deposits and highly weathered rock
- Grey Sandstone
- Mudstone
- Coal

Key to Geophysical Log



Graphic Log

Geophysical Log



ROTARY BOREHOLE RECORD

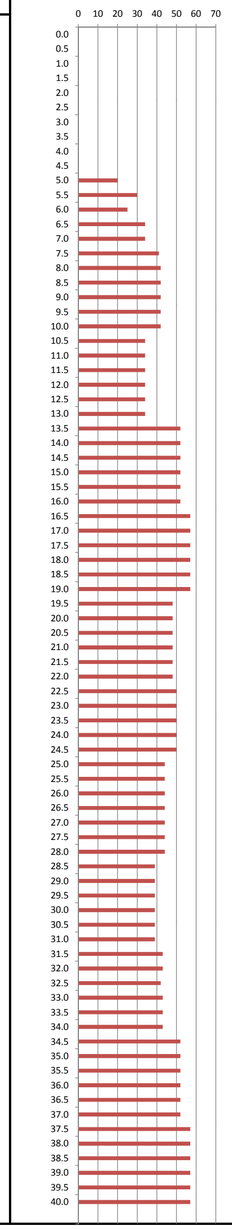
Project	Upper Ogmore Wind Farm	**Client**	RES Limited	**Date**	06/06/2018
Location	292034, 194782	**Drilling Contractor**	Apex Drilling	**Logged By**	CG

Job Number: 371799

Borehole Number: T4-BH3

Drilling Rate		Observations											
		Drilling		Hammer			Returns			Colour			
Depth (m)	Seconds/0.5m	Steady	Unsteady	Regular	Irregular	None	Good Dust	No Dust	Water	Brown	Grey	Black	Rock Quality Log
0.0			X		X			X		X			
0.5			X		X			X		X			
1.0			X		X			X		X			
1.5			X		X			X		X			
2.0			X		X			X		X			
2.5			X		X			X		X			
3.0			X		X			X		X			
3.5			X		X			X		X			
4.0			X		X			X		X			
4.5			X		X			X		X			
5.0	20	X		X			X			X	X		
5.5	30	X		X			X			X	X		
6.0	25	X		X			X			X	X		
6.5	34	X		X			X			X	X		
7.0	34	X		X			X			X	X		
7.5	41	X		X			X			X	X		
8.0	42	X		X			X			X	X		
8.5	42	X		X			X			X	X		
9.0	42	X		X			X			X	X		
9.5	42	X		X			X			X	X		
10.0	42	X		X			X			X	X		
10.5	34	X		X			X			X	X		
11.0	34	X		X			X			X	X		
11.5	34	X		X			X			X	X		
12.0	34	X		X			X			X	X		
12.5	34	X		X			X			X	X		
13.0	34	X		X			X			X	X		
13.5	52	X		X			X			X	X		
14.0	52	X		X			X			X	X		
14.5	52	X		X			X			X	X		
15.0	52	X		X			X			X	X		
15.5	52	X		X			X			X	X		
16.0	52	X		X			X			X	X		
16.5	57	X		X			X			X	X		
17.0	57	X		X			X			X	X		
17.5	57	X		X			X			X	X		
18.0	57	X		X			X			X	X		
18.5	57	X		X			X			X	X		
19.0	57	X		X			X			X	X		
19.5	48	X		X			X			X	X		
20.0	48	X		X			X			X	X		
20.5	48	X		X			X			X	X		
21.0	48	X		X			X			X	X		
21.5	48	X		X			X			X	X		
22.0	48	X		X			X			X	X		
22.5	50	X		X			X			X	X		
23.0	50	X		X			X			X	X		
23.5	50	X		X			X			X	X		
24.0	50	X		X			X			X	X		
24.5	50	X		X			X			X	X		
25.0	44	X		X			X			X	X		
25.5	44	X		X			X			X	X		
26.0	44	X		X			X			X	X		
26.5	44	X		X			X			X	X		
27.0	44	X		X			X			X	X		
27.5	44	X		X			X			X	X		
28.0	44	X		X			X			X	X		
28.5	39	X		X			X			X	X		
29.0	39	X		X			X			X	X		
29.5	39	X		X			X			X	X		
30.0	39	X		X			X			X	X		
30.5	39	X		X			X			X	X		
31.0	39	X		X			X			X	X		
31.5	43	X		X			X			X	X		
32.0	43	X		X			X			X	X		
32.5	42	X		X			X			X	X		
33.0	43	X		X			X			X	X		
33.5	43	X		X			X			X	X		
34.0	43	X		X			X			X	X		
34.5	52	X		X			X			X	X		
35.0	52	X		X			X			X	X		
35.5	52	X		X			X			X	X		
36.0	52	X		X			X			X	X		
36.5	52	X		X			X			X	X		
37.0	52	X		X			X			X	X		
37.5	57	X		X			X			X	X		
38.0	57	X		X			X			X	X		
38.5	57	X		X			X			X	X		
39.0	57	X		X			X			X	X		
39.5	57	X		X			X			X	X		
40.0	57	X		X			X			X	X		

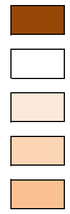
Plot of drilling penetration rate against inclined drill length



Description of Returns

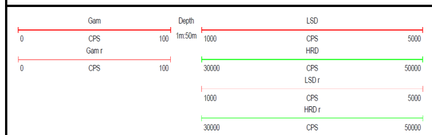
Inclined drill length (m)		Corrected vertical depth (m bgl)		Vertical thickness (m)	Description
From	To	From	To		
0.00	4.60	0.00	3.25	3.25	Peat, sand and clay over highly weathered sandstone
4.60	6.00	3.25	4.24	0.99	Grey sandstone
6.00	8.00	4.24	5.66	1.41	Probable mudstone bands interbedded with sandstone
8.00	12.26	5.66	8.67	3.01	Grey sandstone
12.26	12.90	8.67	9.12	0.45	Grey sandstone - low density bands (probable coal seam)
12.90	14.00	9.12	9.90	0.78	Grey sandstone
14.00	17.00	9.90	12.02	2.12	Grey sandstone - high density band
17.00	18.00	12.02	12.73	0.71	Mudstone
18.00	27.60	12.73	19.52	6.79	Grey sandstone
27.60	27.60	19.52	19.52	0.00	Water level
27.60	40.00	19.52	28.28	8.77	Grey sandstone

Key to Rock Quality Log

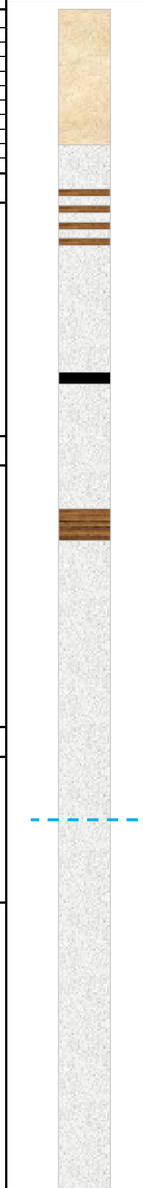


Key to Graphic Log

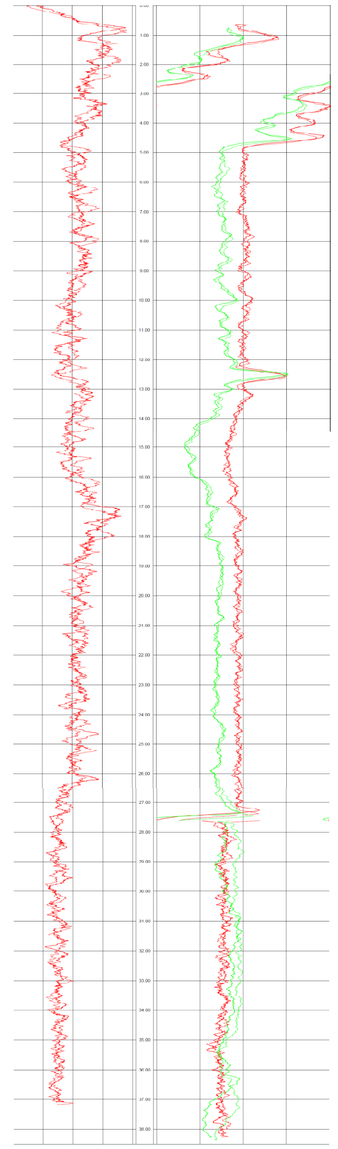
Key to Geophysical Log



Graphic Log



Geophysical Log



ROTARY BOREHOLE RECORD

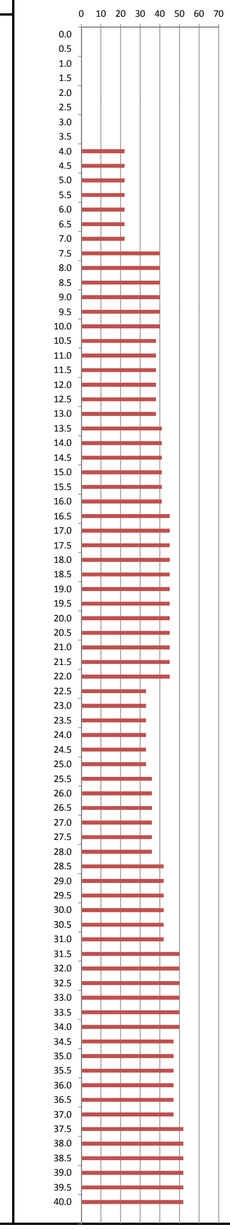
Job Number: 371799

Project	Upper Ogmore Wind Farm	**Client**	RES Limited	**Date**	06/06/2018
Location	292228, 194566	**Drilling Contractor**	Apex Drilling	**Logged By**	CG

Borehole Number: T5-BH1

Drilling Rate		Observations											
		Drilling		Hammer			Returns			Colour			
Depth (m)	Seconds/0.5m	Steady	Unsteady	Regular	Irregular	None	Good Dust	No Dust	Water	Brown	Grey	Black	Rock Quality Log
0.0			X		X			X		X			
0.5			X		X			X		X			
1.0			X		X			X		X			
1.5			X		X			X		X			
2.0			X		X			X		X			
2.5		X		X			X			X	X		
3.0		X		X			X			X	X		
3.5		X		X			X			X	X		
4.0	22	X		X			X			X	X		
4.5	22	X		X			X			X	X		
5.0	22	X		X			X			X	X		
5.5	22	X		X			X			X	X		
6.0	22	X		X			X			X	X		
6.5	22	X		X			X			X	X		
7.0	22	X		X			X			X	X		
7.5	40	X		X			X			X	X		
8.0	40	X		X			X			X	X		
8.5	40	X		X			X			X	X		
9.0	40	X		X			X			X	X		
9.5	40	X		X			X			X	X		
10.0	40	X		X			X			X	X		
10.5	38	X		X			X			X	X		
11.0	38	X		X			X			X	X		
11.5	38	X		X			X			X	X		
12.0	38	X		X			X			X	X		
12.5	38	X		X			X			X	X		
13.0	38	X		X			X			X	X		
13.5	41	X		X			X			X	X		
14.0	41	X		X			X			X	X		
14.5	41	X		X			X			X	X		
15.0	41	X		X			X			X	X		
15.5	41	X		X			X			X	X		
16.0	41	X		X			X			X	X		
16.5	45	X		X			X			X	X		
17.0	45	X		X			X			X	X		
17.5	45	X		X			X			X	X		
18.0	45	X		X			X			X	X		
18.5	45	X		X			X			X	X		
19.0	45	X		X			X			X	X		
19.5	45	X		X			X			X	X		
20.0	45	X		X			X			X	X		
20.5	45	X		X			X			X	X		
21.0	45	X		X			X			X	X		
21.5	45	X		X			X			X	X		
22.0	45	X		X			X			X	X		
22.5	33	X		X			X			X	X		
23.0	33	X		X			X			X	X		
23.5	33	X		X			X			X	X		
24.0	33	X		X			X			X	X		
24.5	33	X		X			X			X	X		
25.0	33	X		X			X			X	X		
25.5	36	X		X			X			X	X		
26.0	36	X		X			X			X	X		
26.5	36	X		X			X			X	X		
27.0	36	X		X			X			X	X		
27.5	36	X		X			X			X	X		
28.0	36	X		X			X			X	X		
28.5	42	X		X			X			X	X		
29.0	42	X		X			X			X	X		
29.5	42	X		X			X			X	X		
30.0	42	X		X			X			X	X		
30.5	42	X		X			X			X	X		
31.0	42	X		X			X			X	X		
31.5	50	X		X			X			X	X		
32.0	50	X		X			X			X	X		
32.5	50	X		X			X			X	X		
33.0	50	X		X			X			X	X		
33.5	50	X		X			X			X	X		
34.0	50	X		X			X			X	X		
34.5	47	X		X			X			X	X		
35.0	47	X		X			X			X	X		
35.5	47	X		X			X			X	X		
36.0	47	X		X			X			X	X		
36.5	47	X		X			X			X	X		
37.0	47	X		X			X			X	X		
37.5	52	X		X			X			X	X		
38.0	52	X		X			X			X	X		
38.5	52	X		X			X			X	X		
39.0	52	X		X			X			X	X		
39.5	52	X		X			X			X	X		
40.0	52	X		X			X			X	X		

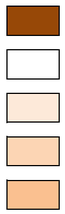
Plot of drilling penetration rate against inclined drill length



Description of Returns

Inclined drill length (m)		Corrected vertical depth (m bgl)		Vertical thickness (m)	Description
From	To	From	To		
0.00	3.00	0.00	2.12	2.12	Peat, sand and clay over highly weathered sandstone
3.00	3.85	2.12	2.72	0.60	Grey sandstone
3.85	4.16	2.72	2.94	0.22	Probable mudstone band
4.16	5.30	2.94	3.75	0.81	Grey sandstone
5.30	6.40	3.75	4.53	0.78	Grey sandstone - low density bands (probable coal seams)
6.40	8.80	4.53	6.22	1.70	Grey sandstone
8.80	9.50	6.22	6.72	0.49	Mudstone
9.50	13.10	6.72	9.26	2.55	Grey sandstone
13.10	13.80	9.26	9.76	0.49	Mudstone
13.80	22.00	9.76	15.56	5.80	Grey sandstone - low density band at 17.7m
22.00	23.30	15.56	16.48	0.92	Grey sandstone - low density bands (probable coal seams)
23.30	25.37	16.48	17.94	1.46	Grey sandstone with high density bands
25.37	26.30	17.94	18.60	0.66	Low density band
26.30	29.30	18.60	20.72	2.12	Grey sandstone with high density bands
29.30	30.60	20.72	21.64	0.92	Mudstone
30.60	31.47	21.64	22.25	0.62	Grey sandstone
31.47	33.00	22.25	23.33	1.08	Probable mudstone bands
33.00	40.00	23.33	28.28	4.95	Grey sandstone with high density bands

Key to Rock Quality Log



Void/Fissure

Poor Quality Rock

Moderate Quality Rock

Good Quality Rock

Key to Graphic Log

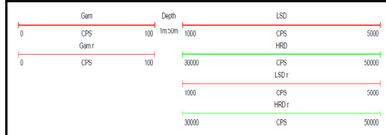
Superficial Deposits and highly weathered rock

Grey Sandstone

Mudstone

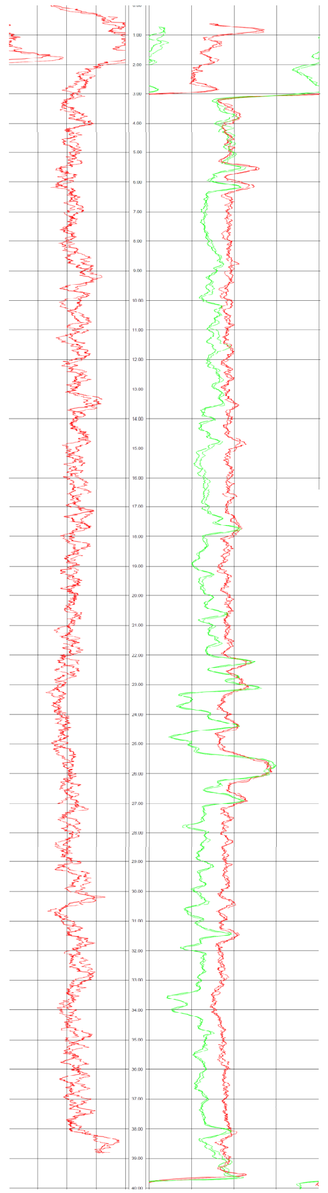
Coal

Key to Geophysical Log



Graphic Log

Geophysical Log



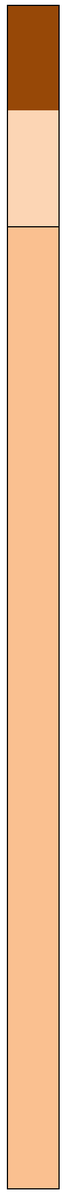
ROTARY BOREHOLE RECORD

Job Number: 371799

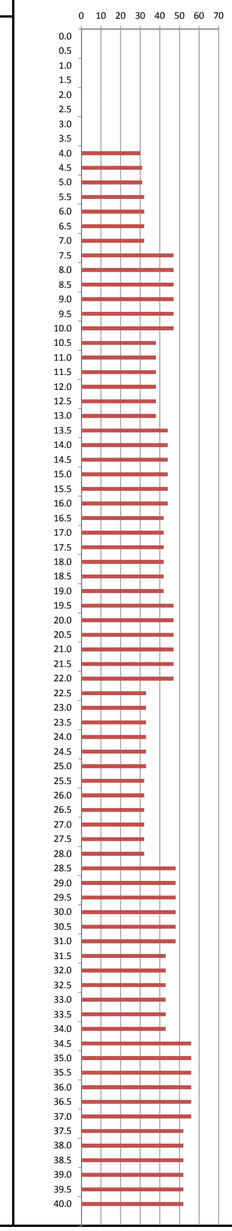
Project	Upper Ogmore Wind Farm	**Client**	RES Limited
Location	292230, 194556	**Drilling Contractor**	Apex Drilling
Date	07/06/2018	**Logged By**	CG
Borehole Number:	T5-BH2		

Drilling Rate		Observations											
		Drilling		Hammer			Returns			Colour			
Depth (m)	Seconds/0.5m	Steady	Unsteady	Regular	Irregular	None	Good Dust	No Dust	Water	Brown	Grey	Black	
0.0			X		X			X		X			
0.5			X		X			X		X			
1.0			X		X			X		X			
1.5			X		X			X		X			
2.0			X		X			X		X			
2.5			X		X			X		X			
3.0			X		X			X		X			
3.5		X		X			X			X	X		
4.0	30	X		X			X			X	X		
4.5	31	X		X			X			X	X		
5.0	31	X		X			X			X	X		
5.5	32	X		X			X			X	X		
6.0	32	X		X			X			X	X		
6.5	32	X		X			X			X	X		
7.0	32	X		X			X			X	X		
7.5	47	X		X			X			X	X		
8.0	47	X		X			X			X	X		
8.5	47	X		X			X			X	X		
9.0	47	X		X			X			X	X		
9.5	47	X		X			X			X	X		
10.0	47	X		X			X			X	X		
10.5	38	X		X			X			X	X		
11.0	38	X		X			X			X	X		
11.5	38	X		X			X			X	X		
12.0	38	X		X			X			X	X		
12.5	38	X		X			X			X	X		
13.0	38	X		X			X			X	X		
13.5	44	X		X			X			X	X		
14.0	44	X		X			X			X	X		
14.5	44	X		X			X			X	X		
15.0	44	X		X			X			X	X		
15.5	44	X		X			X			X	X		
16.0	44	X		X			X			X	X		
16.5	42	X		X			X			X	X		
17.0	42	X		X			X			X	X		
17.5	42	X		X			X			X	X		
18.0	42	X		X			X			X	X		
18.5	42	X		X			X			X	X		
19.0	42	X		X			X			X	X		
19.5	47	X		X			X			X	X		
20.0	47	X		X			X			X	X		
20.5	47	X		X			X			X	X		
21.0	47	X		X			X			X	X		
21.5	47	X		X			X			X	X		
22.0	47	X		X			X			X	X		
22.5	33	X		X			X			X	X		
23.0	33	X		X			X			X	X		
23.5	33	X		X			X			X	X		
24.0	33	X		X			X			X	X		
24.5	33	X		X			X			X	X		
25.0	33	X		X			X			X	X		
25.5	32	X		X			X			X	X		
26.0	32	X		X			X			X	X		
26.5	32	X		X			X			X	X		
27.0	32	X		X			X			X	X		
27.5	32	X		X			X			X	X		
28.0	32	X		X			X			X	X		
28.5	48	X		X			X			X	X		
29.0	48	X		X			X			X	X		
29.5	48	X		X			X			X	X		
30.0	48	X		X			X			X	X		
30.5	48	X		X			X			X	X		
31.0	48	X		X			X			X	X		
31.5	43	X		X			X			X	X		
32.0	43	X		X			X			X	X		
32.5	43	X		X			X			X	X		
33.0	43	X		X			X			X	X		
33.5	43	X		X			X			X	X		
34.0	43	X		X			X			X	X		
34.5	56	X		X			X			X	X		
35.0	56	X		X			X			X	X		
35.5	56	X		X			X			X	X		
36.0	56	X		X			X			X	X		
36.5	56	X		X			X			X	X		
37.0	56	X		X			X			X	X		
37.5	52	X		X			X			X	X		
38.0	52	X		X			X			X	X		
38.5	52	X		X			X			X	X		
39.0	52	X		X			X			X	X		
39.5	52	X		X			X			X	X		
40.0	52	X		X			X			X	X		

Rock Quality Log



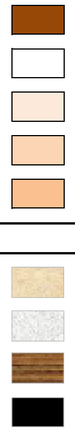
Plot of drilling penetration rate against inclined drill length



Description of Returns

Inclined drill length (m)		Corrected vertical depth (m bgl)		Vertical thickness (m)	Description
From	To	From	To		
0.00	3.00	0.00	2.12	2.12	Peat, sand and clay over highly weathered sandstone
3.00	3.90	2.12	2.76	0.64	Grey sandstone
3.90	4.16	2.76	2.94	0.18	Probable mudstone band(s)
4.16	6.20	2.94	4.38	1.44	Grey sandstone
6.20	7.45	4.38	5.27	0.88	Mudstone
7.45	10.89	5.27	7.70	2.43	Grey sandstone
10.89	12.00	7.70	8.49	0.78	Mudstone bands
12.00	15.50	8.49	10.96	2.47	Grey sandstone
15.50	16.00	10.96	11.31	0.35	Mudstone - low density band (possible coal)
16.00	17.90	11.31	12.66	1.34	Grey sandstone with possible thin mudstone bands
17.90	18.58	12.66	13.14	0.48	Grey sandstone - low density band (possible coal seam)
18.58	22.63	13.14	16.00	2.86	Grey sandstone
22.63	24.32	16.00	17.20	1.20	Grey sandstone - low density bands (probable coal seams)
24.32	26.16	17.20	18.50	1.30	Grey sandstone with high density bands
26.16	28.00	18.50	19.80	1.30	Low density band
28.00	30.47	19.80	21.55	1.75	Grey sandstone
30.47	31.50	21.55	22.27	0.73	Mudstone
31.50	31.89	22.27	22.55	0.28	Grey sandstone
31.89	32.84	22.55	23.22	0.67	Mudstone
32.84	40.00	23.22	28.28	5.06	Grey sandstone with high density bands

Key to Rock Quality Log



Void/Fissure

Poor Quality Rock

Moderate Quality Rock

Good Quality Rock

Key to Graphic Log

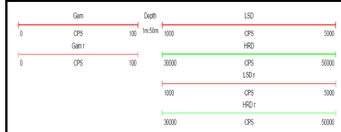
Superficial Deposits and highly weathered rock

Grey Sandstone

Mudstone

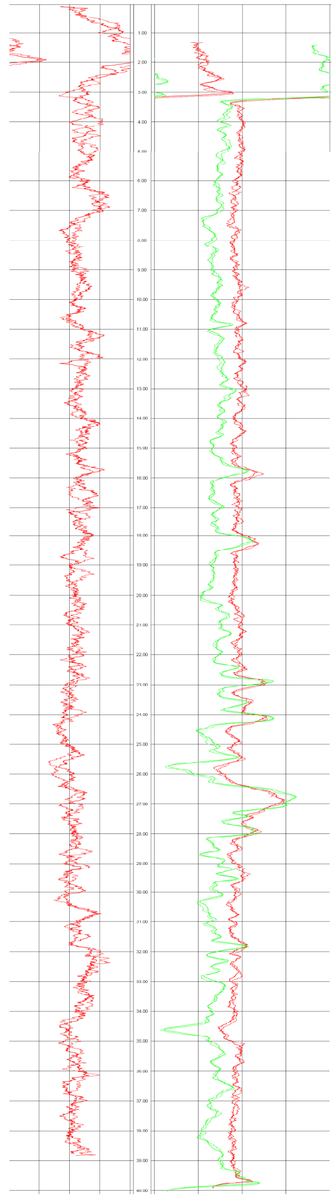
Coal

Key to Geophysical Log



Graphic Log

Geophysical Log



ROTARY BOREHOLE RECORD

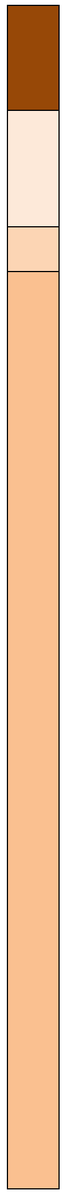
Project	Upper Ogmore Wind Farm	**Client**	RES Limited	**Date**	06/06/2018
Location	292253, 194568	**Drilling Contractor**	Apex Drilling	**Logged By**	CG

Job Number: 371799

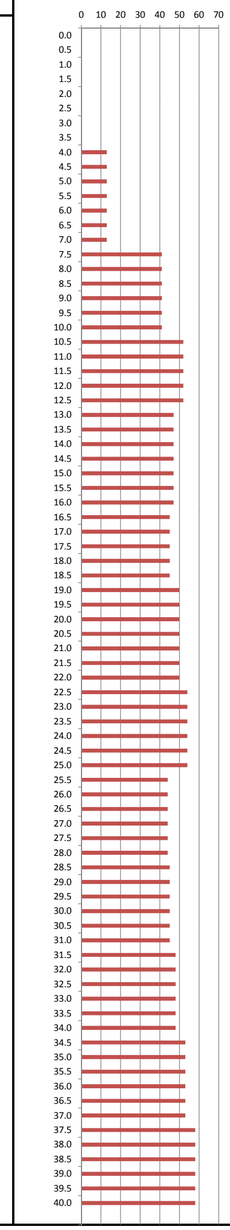
Borehole Number: T5-BH3

Drilling Rate		Observations											
		Drilling		Hammer			Returns			Colour			
Depth (m)	Seconds/0.5m	Steady	Unsteady	Regular	Irregular	None	Good Dust	No Dust	Water	Brown	Grey	Black
0.0			X		X			X		X		
0.5			X		X			X		X		
1.0			X		X			X		X		
1.5			X		X			X		X		
2.0			X		X			X		X		
2.5			X		X			X		X		
3.0			X		X			X		X		
3.5			X		X		X			X	X	
4.0	13	X		X			X			X	X	
4.5	13	X		X			X			X	X	
5.0	13	X		X			X			X	X	
5.5	13	X		X			X			X	X	
6.0	13	X		X			X			X	X	
6.5	13	X		X			X			X	X	
7.0	13	X		X			X			X	X	
7.5	41	X		X			X			X	X	
8.0	41	X		X			X			X	X	
8.5	41	X		X			X			X	X	
9.0	41	X		X			X			X	X	
9.5	41	X		X			X			X	X	
10.0	41	X		X			X			X	X	
10.5	52	X		X			X			X	X	
11.0	52	X		X			X			X	X	
11.5	52	X		X			X			X	X	
12.0	52	X		X			X			X	X	
12.5	52	X		X			X			X	X	
13.0	47	X		X			X			X	X	
13.5	47	X		X			X			X	X	
14.0	47	X		X			X			X	X	
14.5	47	X		X			X			X	X	
15.0	47	X		X			X			X	X	
15.5	47	X		X			X			X	X	
16.0	47	X		X			X			X	X	
16.5	45	X		X			X			X	X	
17.0	45	X		X			X			X	X	
17.5	45	X		X			X			X	X	
18.0	45	X		X			X			X	X	
18.5	45	X		X			X			X	X	
19.0	50	X		X			X			X	X	
19.5	50	X		X			X			X	X	
20.0	50	X		X			X			X	X	
20.5	50	X		X			X			X	X	
21.0	50	X		X			X			X	X	
21.5	50	X		X			X			X	X	
22.0	50	X		X			X			X	X	
22.5	54	X		X			X			X	X	
23.0	54	X		X			X			X	X	
23.5	54	X		X			X			X	X	
24.0	54	X		X			X			X	X	
24.5	54	X		X			X			X	X	
25.0	54	X		X			X			X	X	
25.5	44	X		X			X			X	X	
26.0	44	X		X			X			X	X	
26.5	44	X		X			X			X	X	
27.0	44	X		X			X			X	X	
27.5	44	X		X			X			X	X	
28.0	44	X		X			X			X	X	
28.5	45	X		X			X			X	X	
29.0	45	X		X			X			X	X	
29.5	45	X		X			X			X	X	
30.0	45	X		X			X			X	X	
30.5	45	X		X			X			X	X	
31.0	45	X		X			X			X	X	
31.5	48	X		X			X			X	X	
32.0	48	X		X			X			X	X	
32.5	48	X		X			X			X	X	
33.0	48	X		X			X			X	X	
33.5	48	X		X			X			X	X	
34.0	48	X		X			X			X	X	
34.5	53	X		X			X			X	X	
35.0	53	X		X			X			X	X	
35.5	53	X		X			X			X	X	
36.0	53	X		X			X			X	X	
36.5	53	X		X			X			X	X	
37.0	53	X		X			X			X	X	
37.5	58	X		X			X			X	X	
38.0	58	X		X			X			X	X	
38.5	58	X		X			X			X	X	
39.0	58	X		X			X			X	X	
39.5	58	X		X			X			X	X	
40.0	58	X		X			X			X	X	

Rock Quality Log



Plot of drilling penetration rate against inclined drill length



Description of Returns

Inclined drill length (m)		Corrected vertical depth (m bgl)		Vertical thickness (m)	Description
From	To	From	To		
0.00	3.00	0.00	2.12	2.12	Peat, sand and clay over highly weathered sandstone
3.00	6.32	2.12	4.47	2.35	Low density zone - possible broken rock
6.32	13.00	4.47	9.19	4.72	Grey sandstone
13.00	13.53	9.19	9.57	0.37	Probable Mudstone
13.53	21.79	9.57	15.41	5.84	Grey sandstone
21.79	22.20	15.41	15.70	0.29	Grey sandstone with high density bands
22.20	25.37	15.70	17.94	2.24	Grey sandstone
25.37	25.63	17.94	18.12	0.18	Grey sandstone - low density band (possible coal seam)
25.63	26.79	18.12	18.94	0.82	Grey sandstone with high density band
26.79	27.16	18.94	19.21	0.26	Grey sandstone - low density band (possible coal seam)
27.16	27.80	19.21	19.66	0.45	Mudstone
27.80	29.00	19.66	20.51	0.85	Grey sandstone
29.00	30.50	20.51	21.57	1.06	Mudstone
30.50	31.00	21.57	21.92	0.35	Grey sandstone
31.00	32.00	21.92	22.63	0.71	Mudstone with low density bands (possible coal seams)
32.00	40.00	22.63	28.28	5.66	Grey sandstone

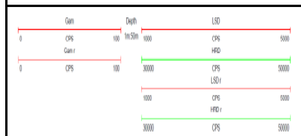
Key to Rock Quality Log

- Void/Fissure
- Poor Quality Rock
- Moderate Quality Rock
- Good Quality Rock

Key to Graphic Log

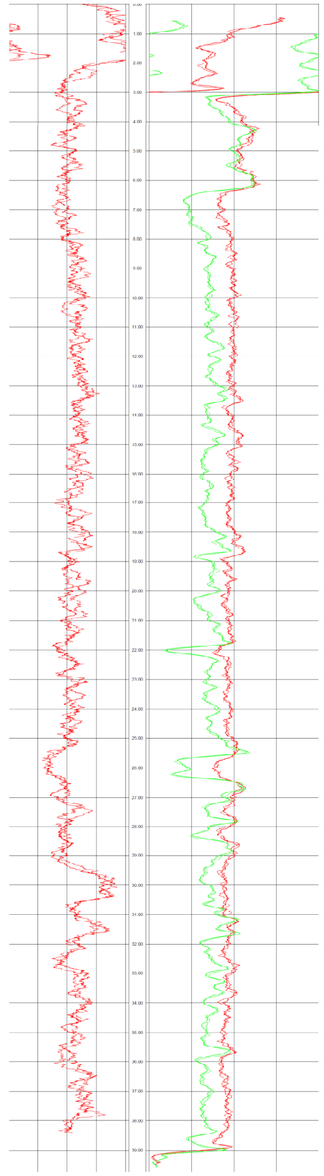
- Superficial Deposits and highly weathered rock
- Grey Sandstone
- Mudstone
- Coal

Key to Geophysical Log



Graphic Log

Geophysical Log



APPENDIX D
GEOPHYSICS REPORT

EUROPEAN GEOPHYSICAL SERVICES

REPORT ON THE

GEOPHYSICAL LOGGING

OF

SIX BOREHOLES

AT

OGMORE WIND FARM

Prepared For:

RSK

18 Frogmore Road,
Hemel Hempstead,
Hertfordshire,
HP3 9RT, UK

JUNE 2018/RSK1801_ rpt/SS99

	Name	Date
Logged by:	R. Powell	06/08.06.18
Report by:	R. Powell	25.06.18
Checked by:	M. Kynaston	25.06.18

European Geophysical Services Ltd
22 The Stables, Sansaw Business Park, Hadnall, Shrewsbury. SY4 4AS
Tel: 01939 210710 | Fax: 01939 210532 E-mail: *eurogeophys@europeangeophysical.com* |
www.europeangeophysical.com

Registered in England and Wales No. 2962962 | VAT No. GB 648 4148 18

CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

At the request of RSK Ltd., geophysical logging was carried out in six boreholes at two turbine locations situated at Ogmore Wind Farm, South Wales.

The work was carried out by European Geophysical Services on the 6th & 8th of June 2018.

The following logs were run:-

BH	Logs	From (m)	To (m)
T4-BH1	Trisonde Density, Natural Gamma	0.9	39.5
T4-BH2	Trisonde Density, Natural Gamma	0.7	39.8
T4-BH3	Trisonde Density, Natural Gamma	1.0	38.4
T5-BH1	Trisonde Density, Natural Gamma	0.9	40.1
T5-BH2	Trisonde Density, Natural Gamma	1.6	40.1
T5-BH3	Trisonde Density, Natural Gamma	0.8	39.7

2.0 THE GEOPHYSICAL LOGGING METHODS

The Equipment and Field Procedure

A fully digital logging system with a 600m capacity motorised winch mounted in a 4x4 van was used.

All logging data was recorded digitally for reprocessing and archiving purposes.

Repeat runs of logs were carried out in all boreholes for quality control purposes.

Gamma - Gamma (GGLS / GGHR)

These logs give qualitative information on the density of the formation and/or the material behind linings where installed. The logs are expressed in counts per second (cps) which are inversely related to density.

The sonde has two detectors at different spacing's from a source of gamma radiation. The logs from each detector respond to the apparent bulk density of the material surrounding the tool at a radius of investigation related to the spacing's. The Long Spaced (LS) has a spacing of 48cm and the High Resolution (HR) has a spacing of 24cm.

Natural Gamma (Gam)

The tool measures the naturally occurring gamma radiation found in rocks and sediments. It is mainly used to detect the clays that contain potassium K^{40}, though the U^{238} and the Th^{232} series of elements present in certain rocks also emit gamma radiation.

The higher the concentration of these clay minerals the greater the responses on the natural gamma log.

3.0 SITE DETAILS

Site
Ogmore Wind Farm

OS Grid Ref: SS 920 950

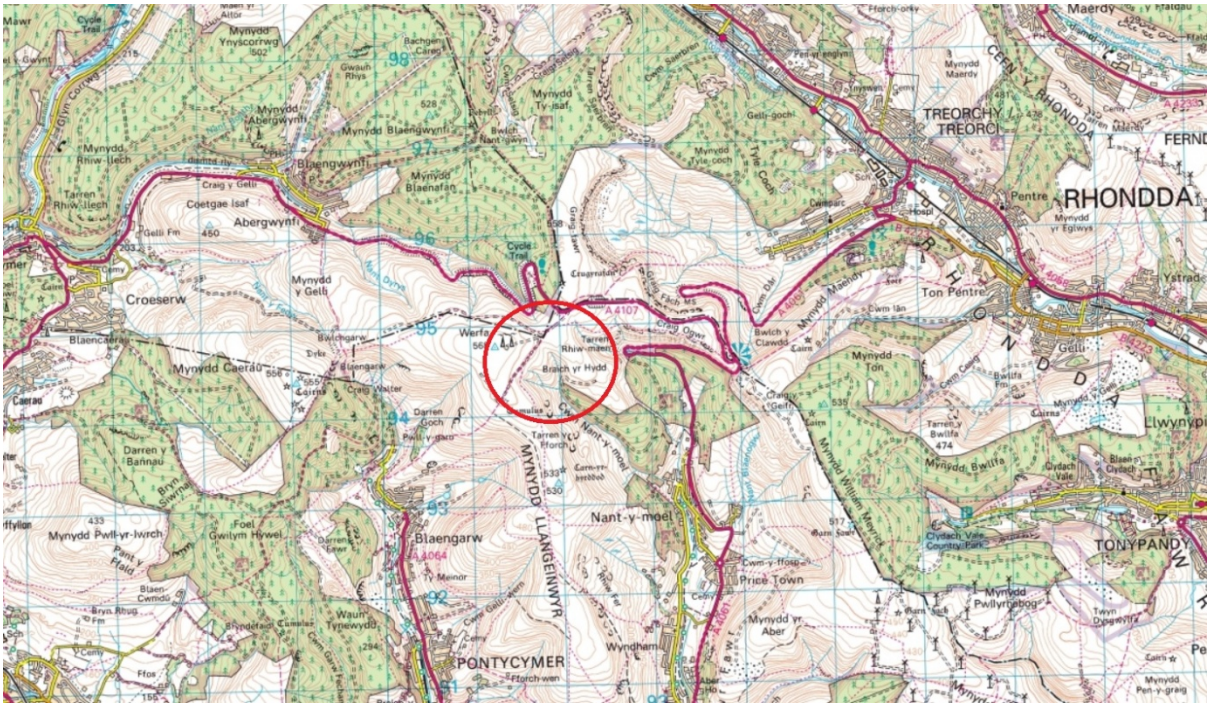


Figure 3.1 Location map showing site location highlighted by red circle. © Crown copyright 2005 OS100057099

Figure 3.2 Aerial image showing approximate turbine positions. © Bing Maps 2018.

4.0 BOREHOLE LOGGING CONSTRAINTS

- **Vehicle access restrictions**
  Off road, 4x4 required.

- **Tool access restrictions**
  None

- **Borehole conditions / risk to equipment**
  Inclined boreholes, lined with 50mm plastic pipe to total depth

- **Lack of fluid filled column / cloudy fluid**
  n/a.

- **Time constraint**
  None

- **Borehole construction / casing**
  ~100mm open-holed to depth, lined with 50mm AW casing on completion.

Figure 4

Geophysical Logs

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **RSK**

Borehole: **T4-BH1**

Log Type: ***Trisonde***

Location: **Ogmore Wind Farm** Area: **South Wales** Grid Ref: Elevation:

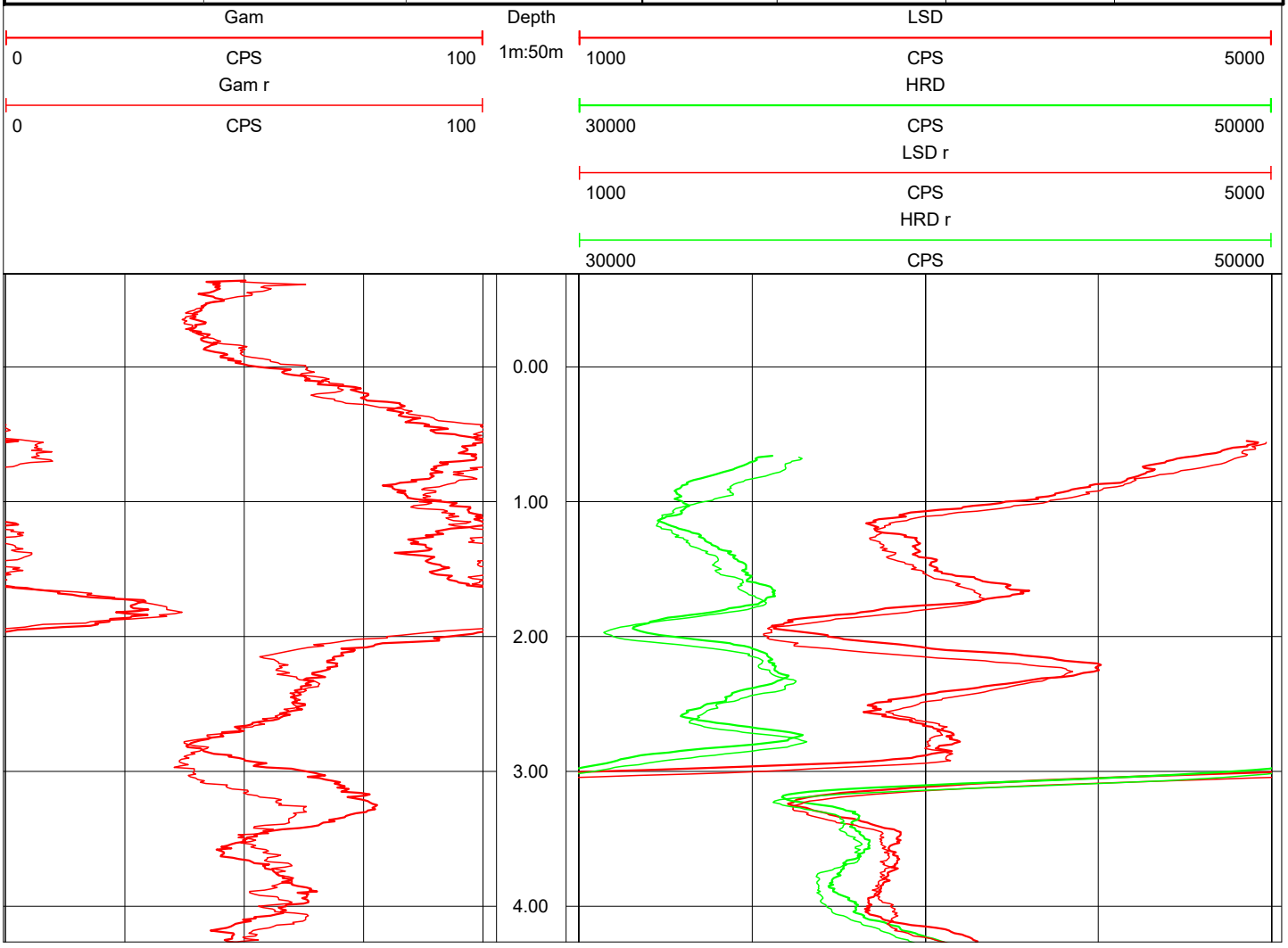
Drilled Depth: (m)	**40.0**	Date:	**06.06.18**
Logged Depth: (m)	**39.5**	Recorded By:	**R. Powell**
Logging Datum:	**Ground Level**	Remarks: Inclined BH	
Logged Interval: (m)	**0.9 - 39.5**		
Fluid Level: (m)		**Ref:**	

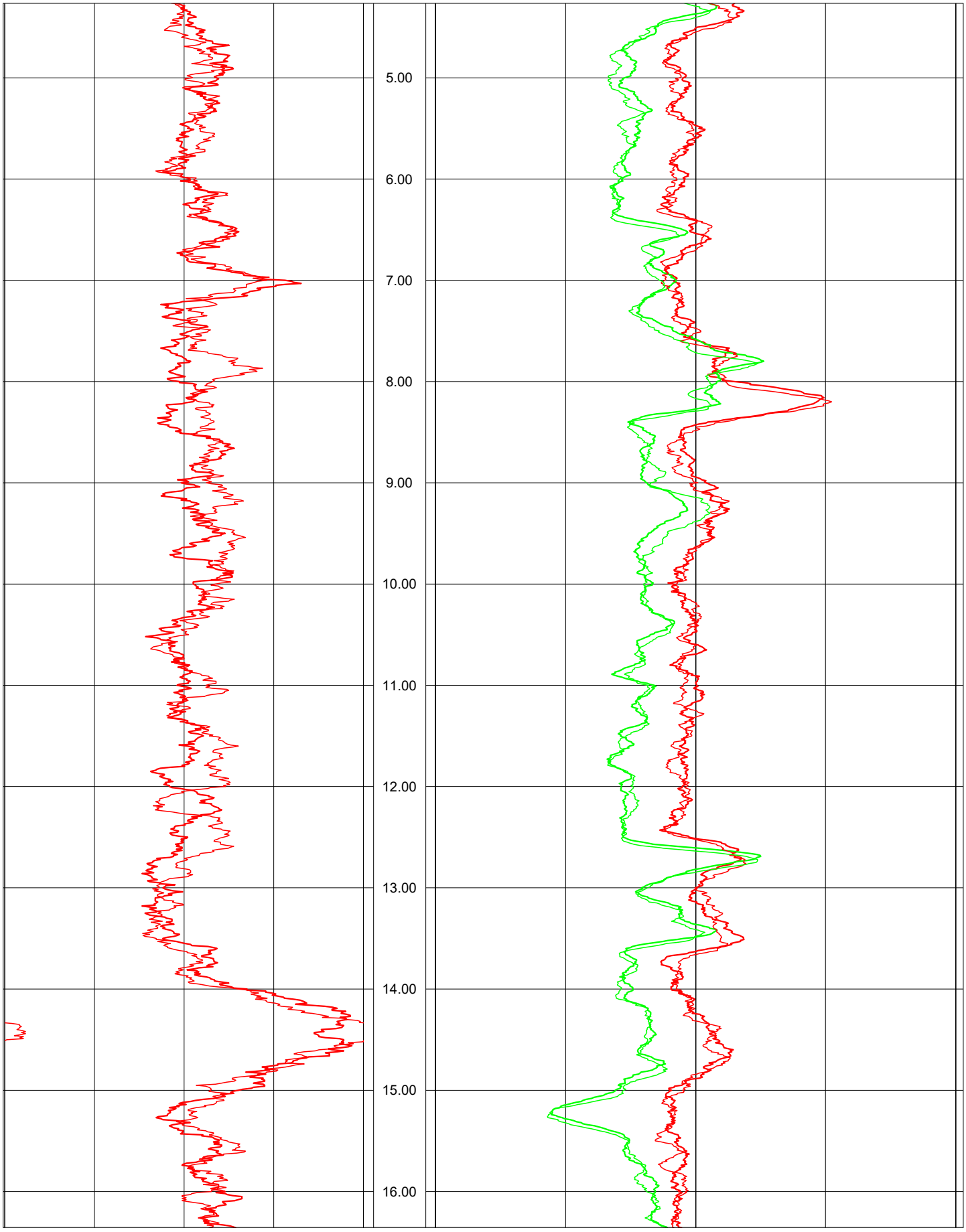
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
PVC	**50**	**0.0**	**40.0**

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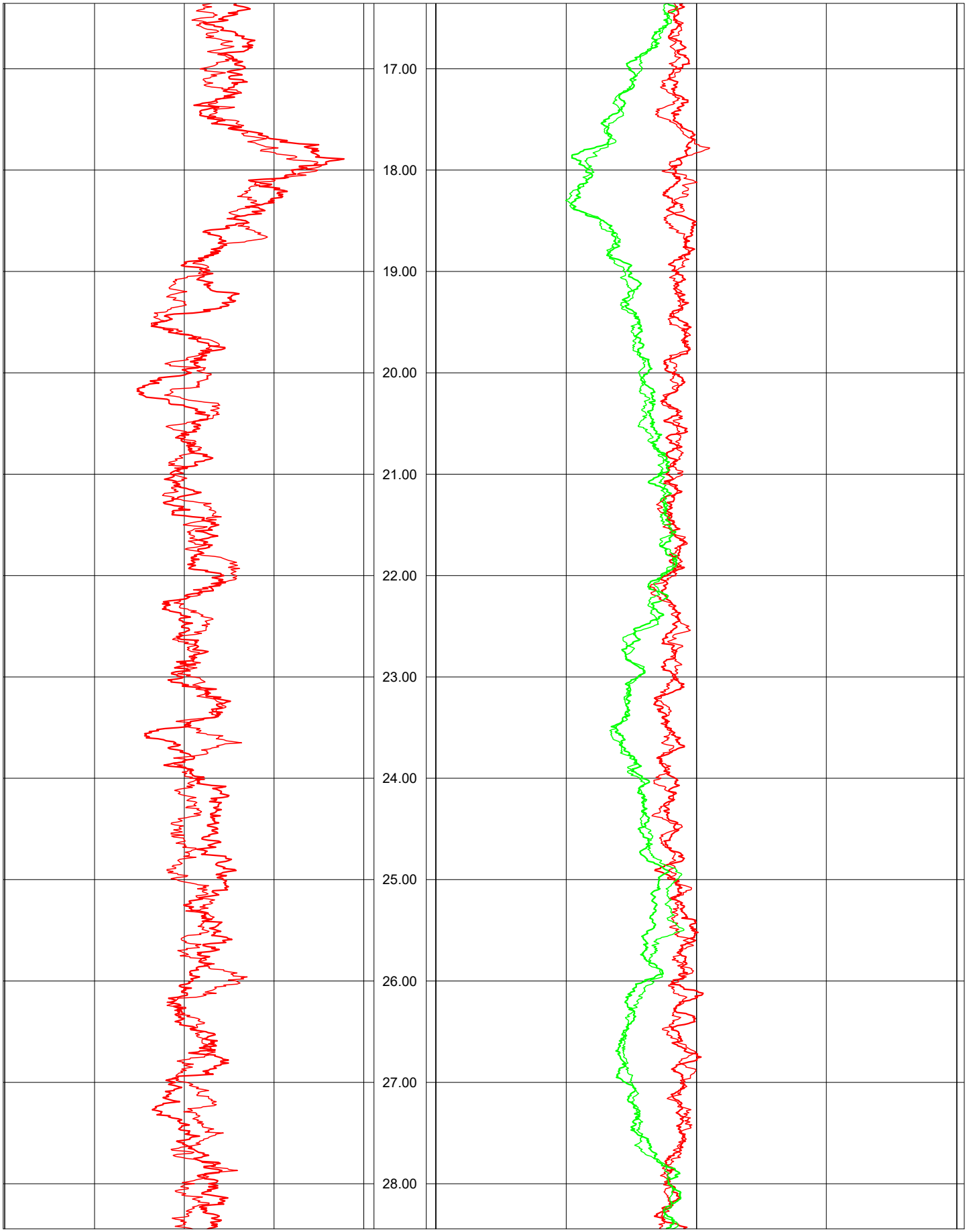
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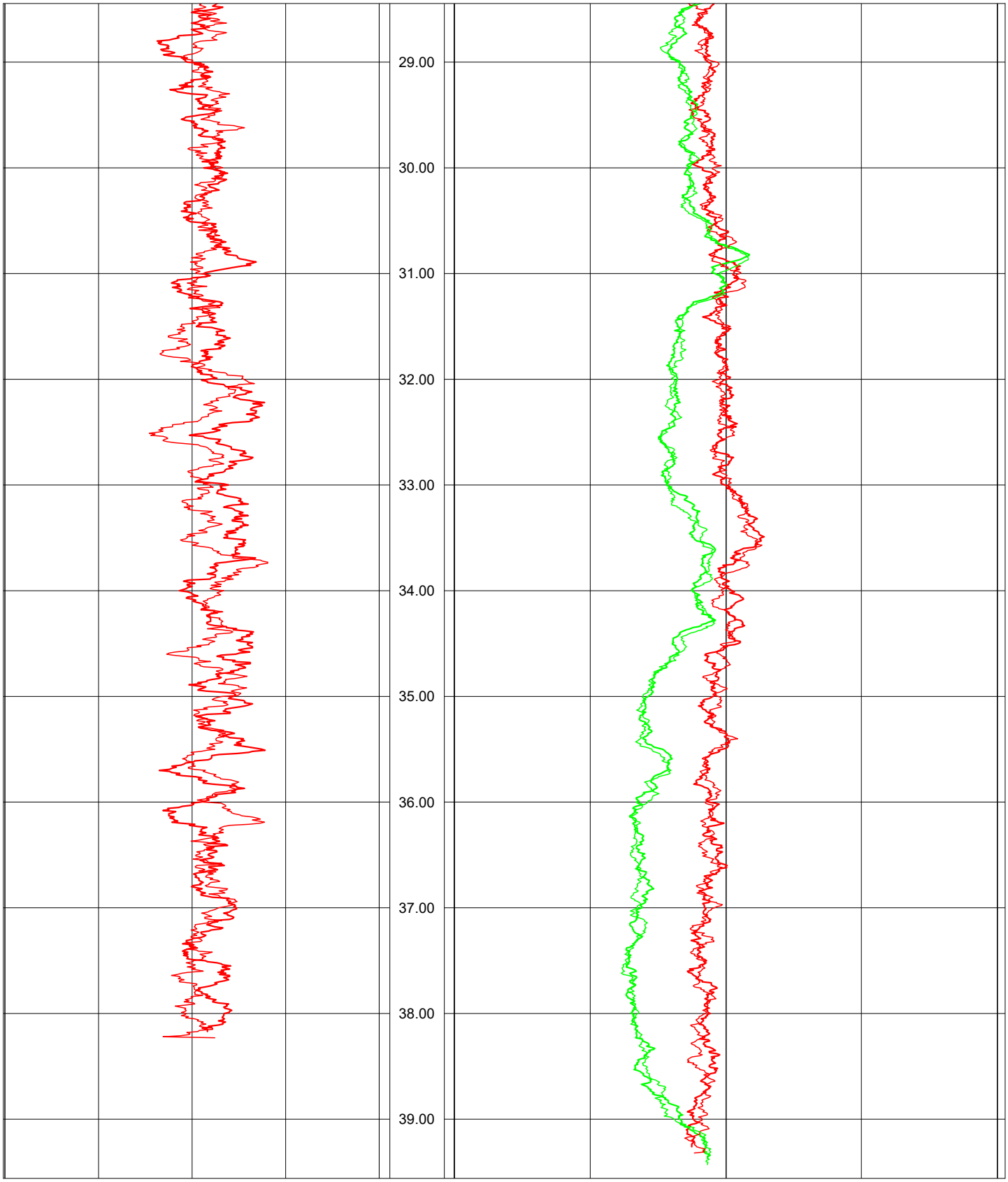
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EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **RSK**

Borehole: **T4-BH2**

Log Type: ***Trisonde***

Location: **Ogmore Wind Farm** Area: **South Wales** Grid Ref: Elevation:

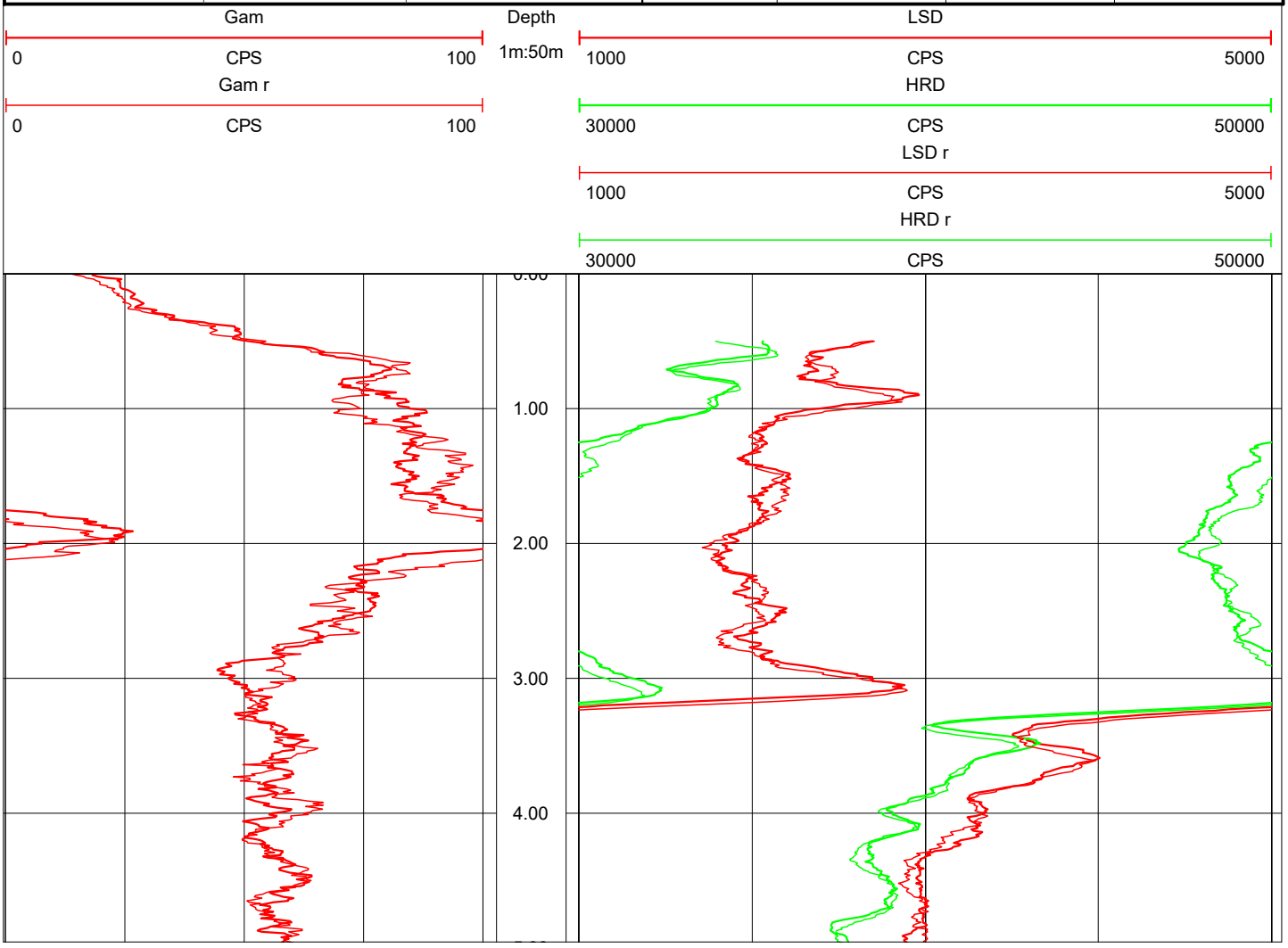
Drilled Depth: (m)	**40.0**	Date:	**06.06.18**
Logged Depth: (m)	**39.8**	Recorded By:	**R. Powell**
Logging Datum:	**Ground Level**	Remarks: Inclined BH	
Logged Interval: (m)	**0.7 - 39.8**		
Fluid Level: (m)		**Ref:**	

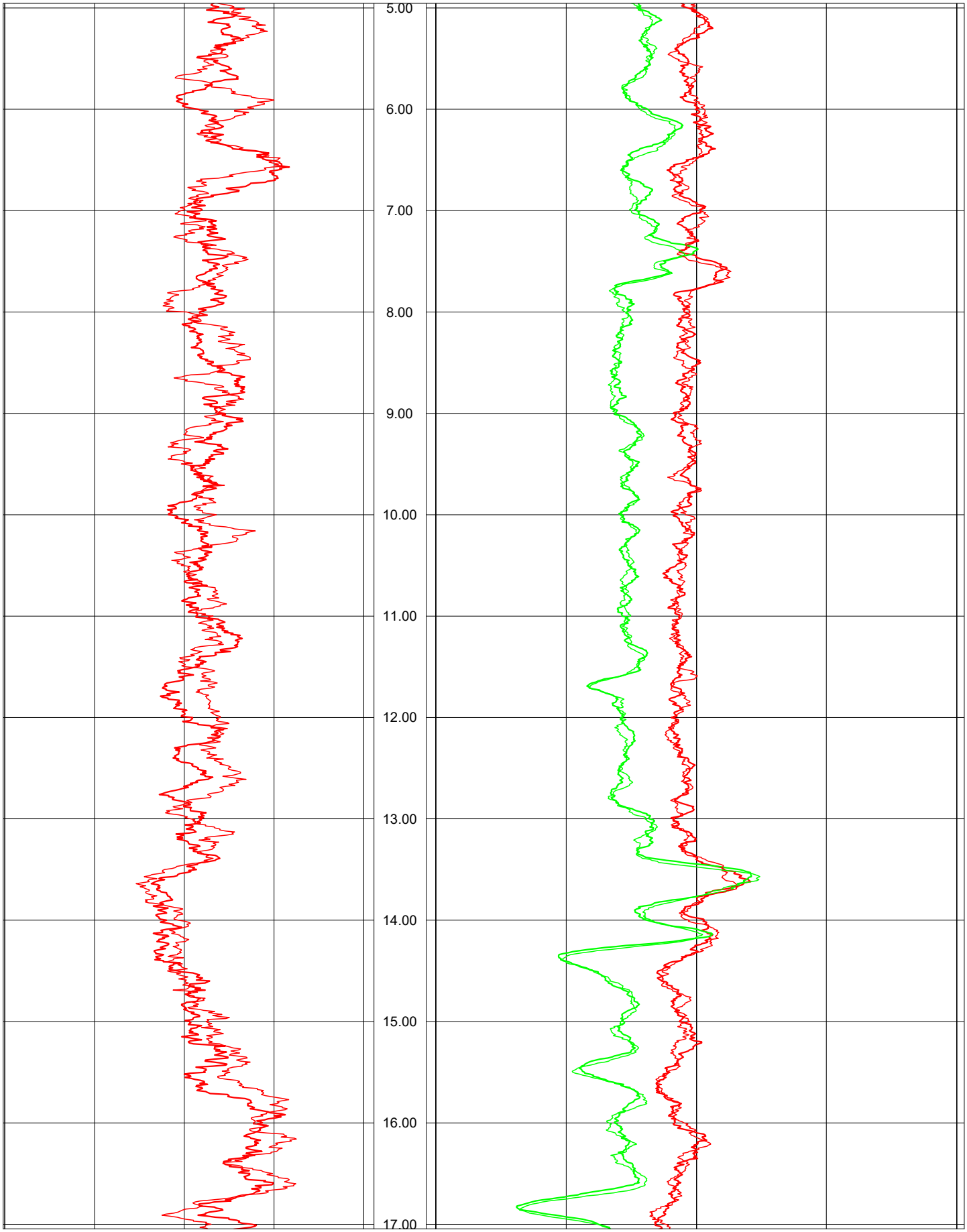
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
PVC	**50**	**0.0**	**40.0**

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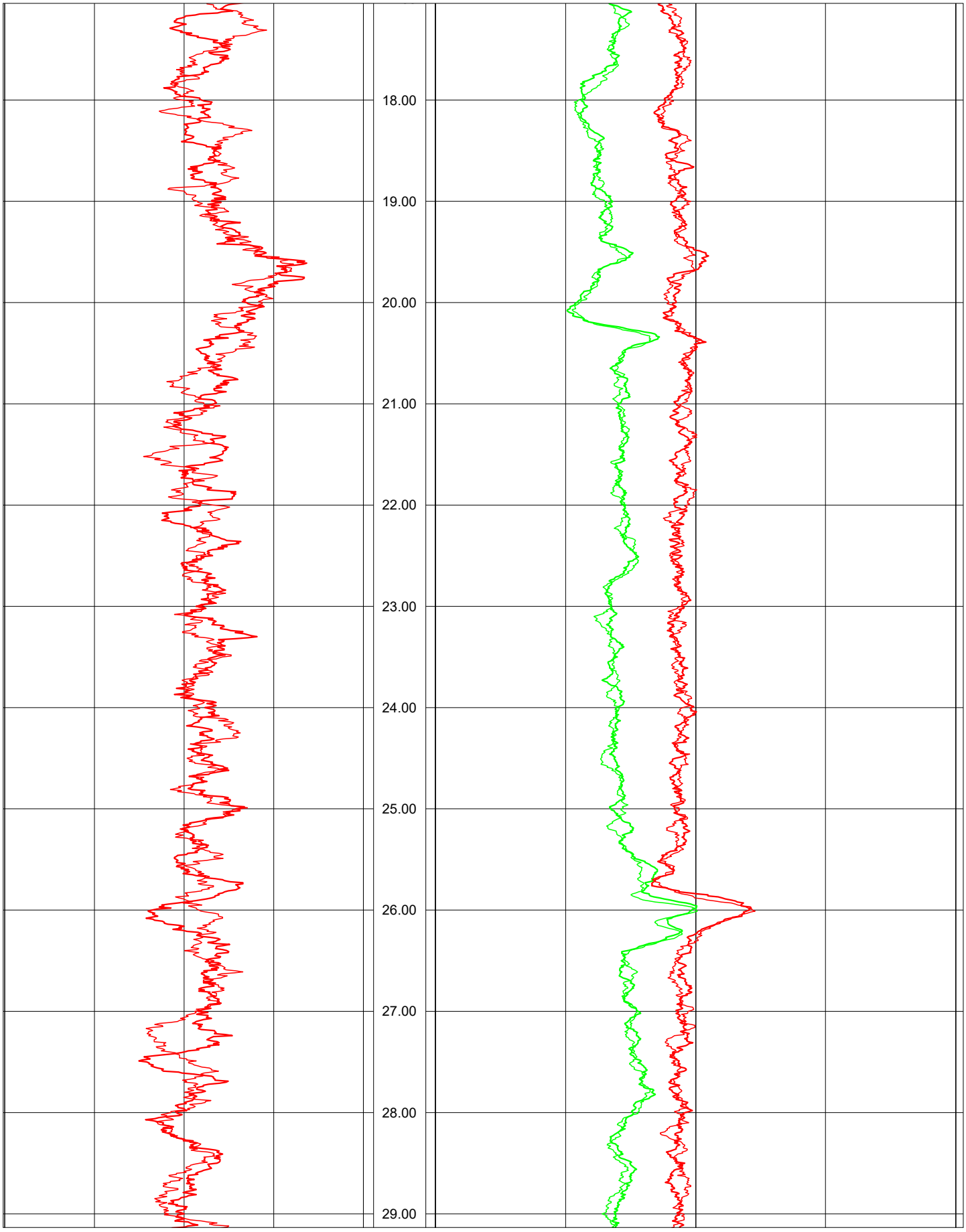
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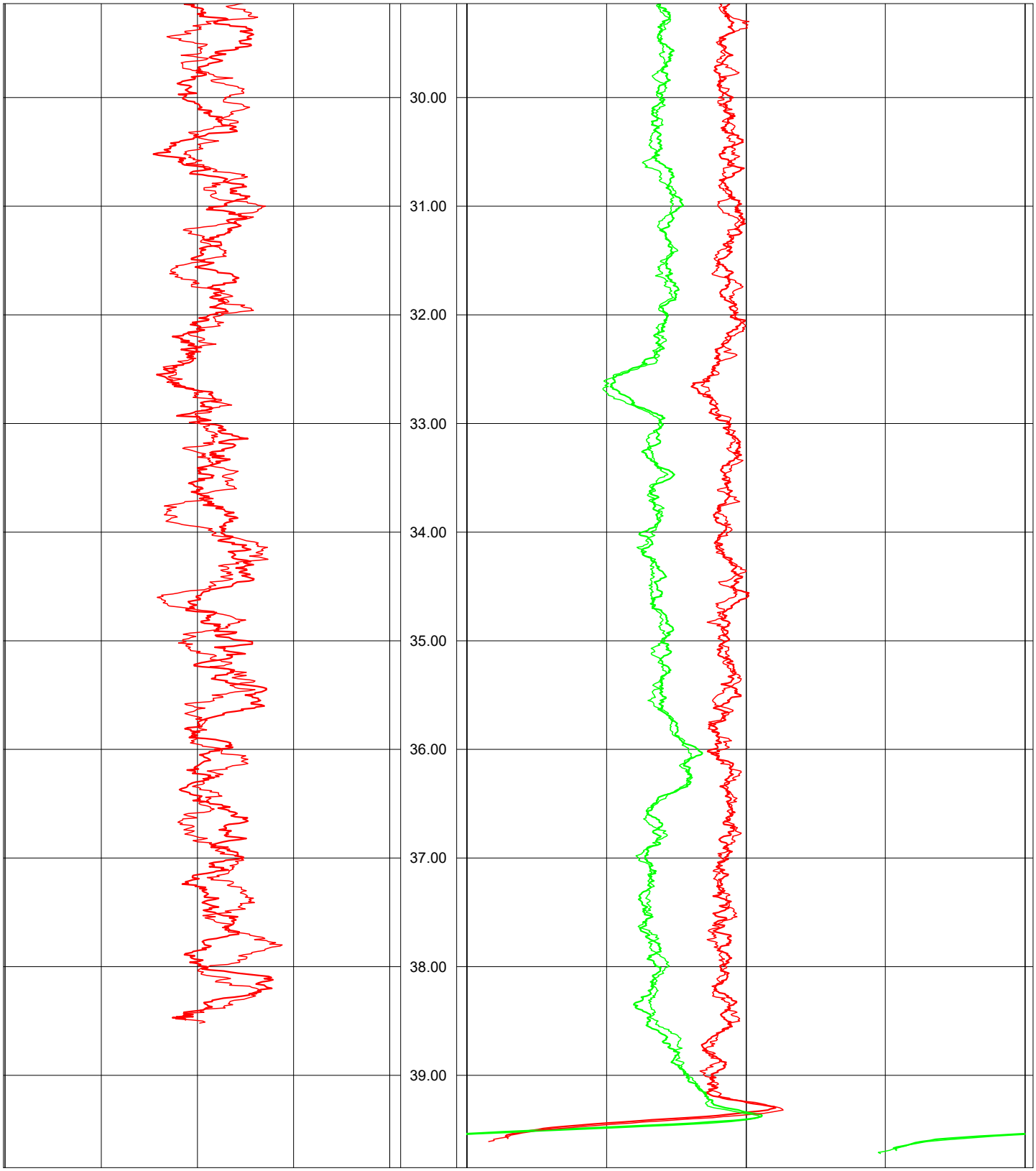
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EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **RSK**

Borehole: **T4-BH3**

Log Type: ***Trisonde***

Location: **Ogmore Wind Farm** Area: **South Wales** Grid Ref: Elevation:

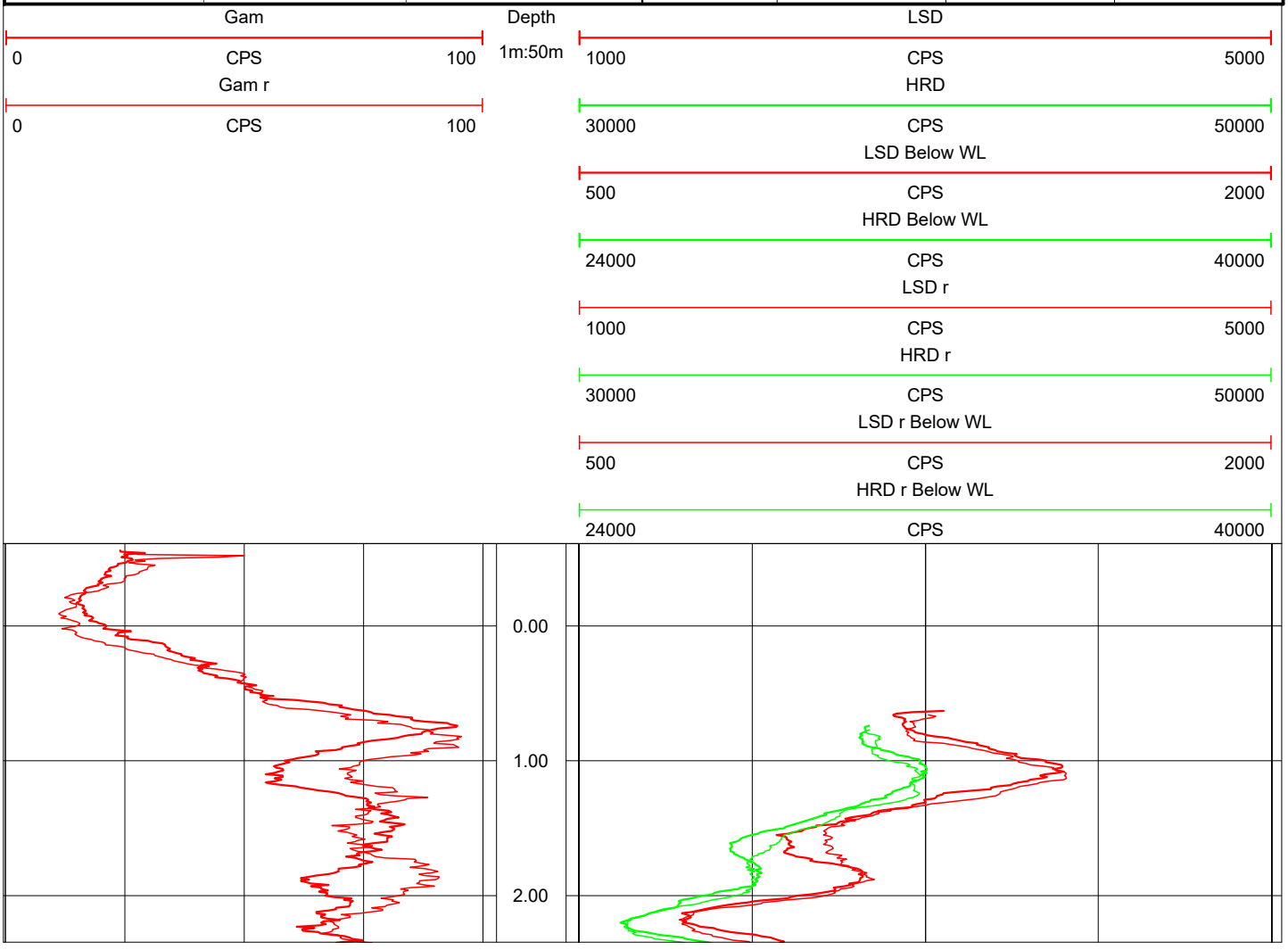
Drilled Depth: (m)	**40.0**	Date:	**06.06.18**
Logged Depth: (m)	**38.4**	Recorded By:	**R. Powell**
Logging Datum:	**Ground Level**	Remarks: Inclined BH	
Logged Interval: (m)	**1.0 - 38.4**		
Fluid Level: (m)	**27.6**	**Ref:**	

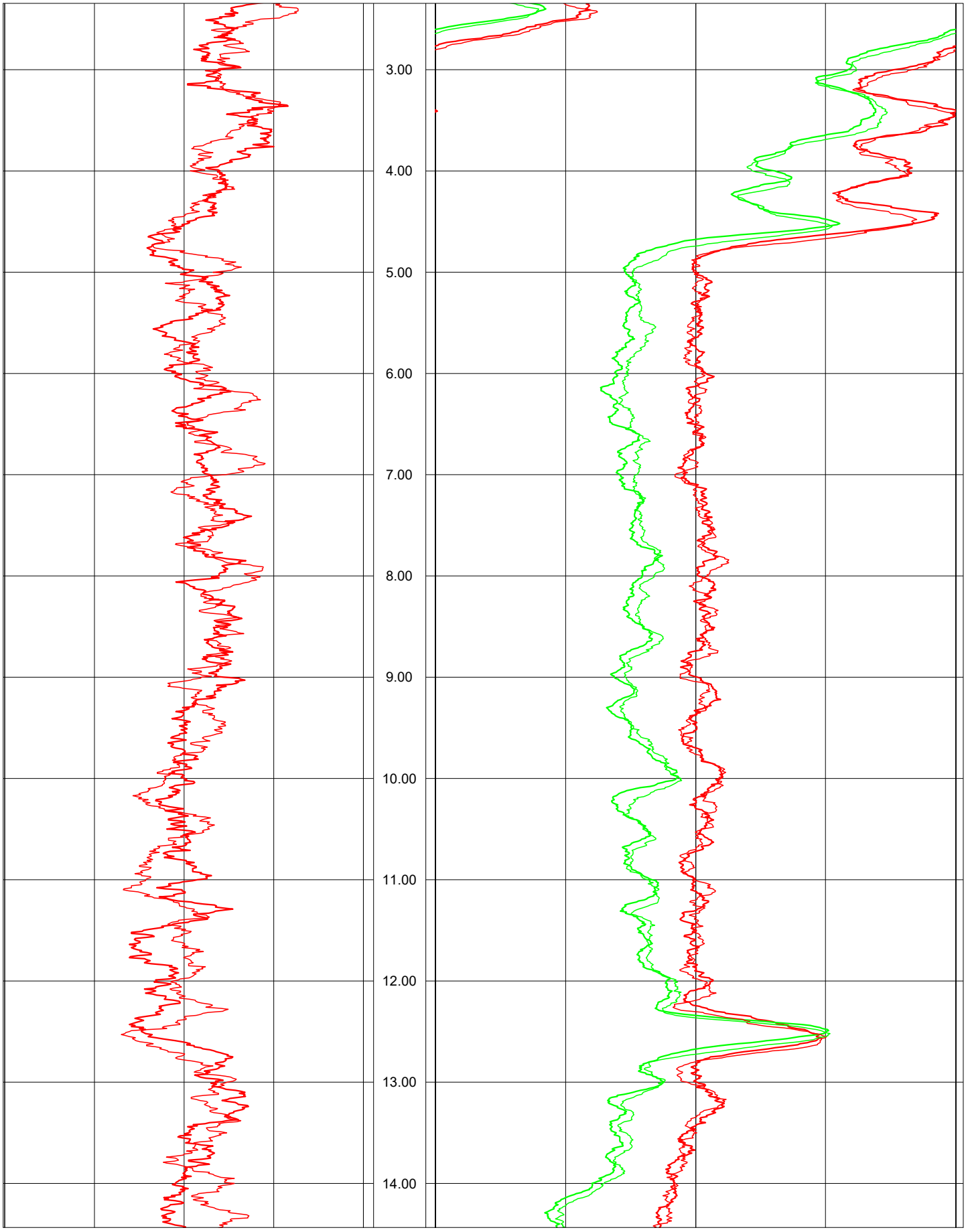
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
PVC	**50**	**0.0**	**40.0**

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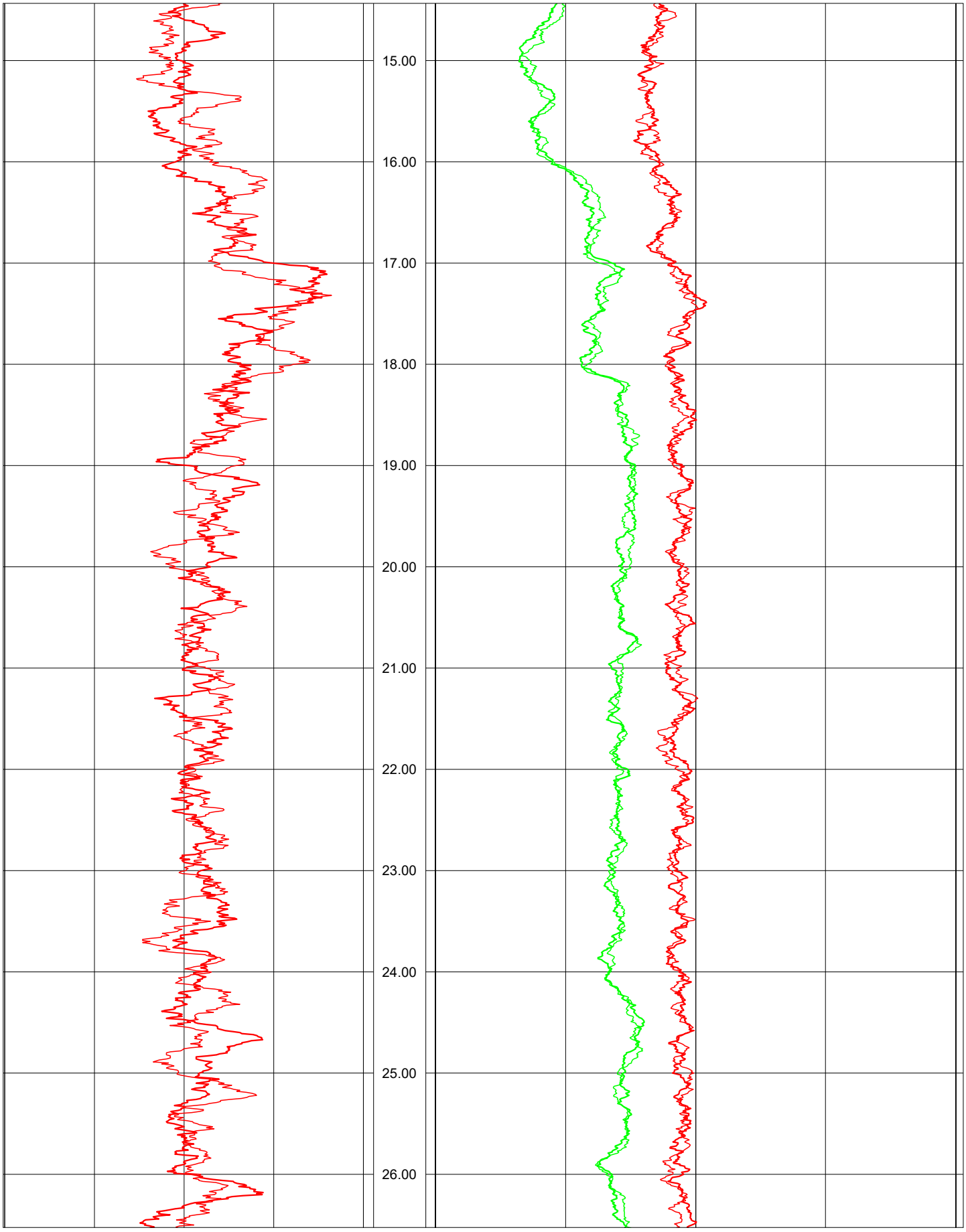
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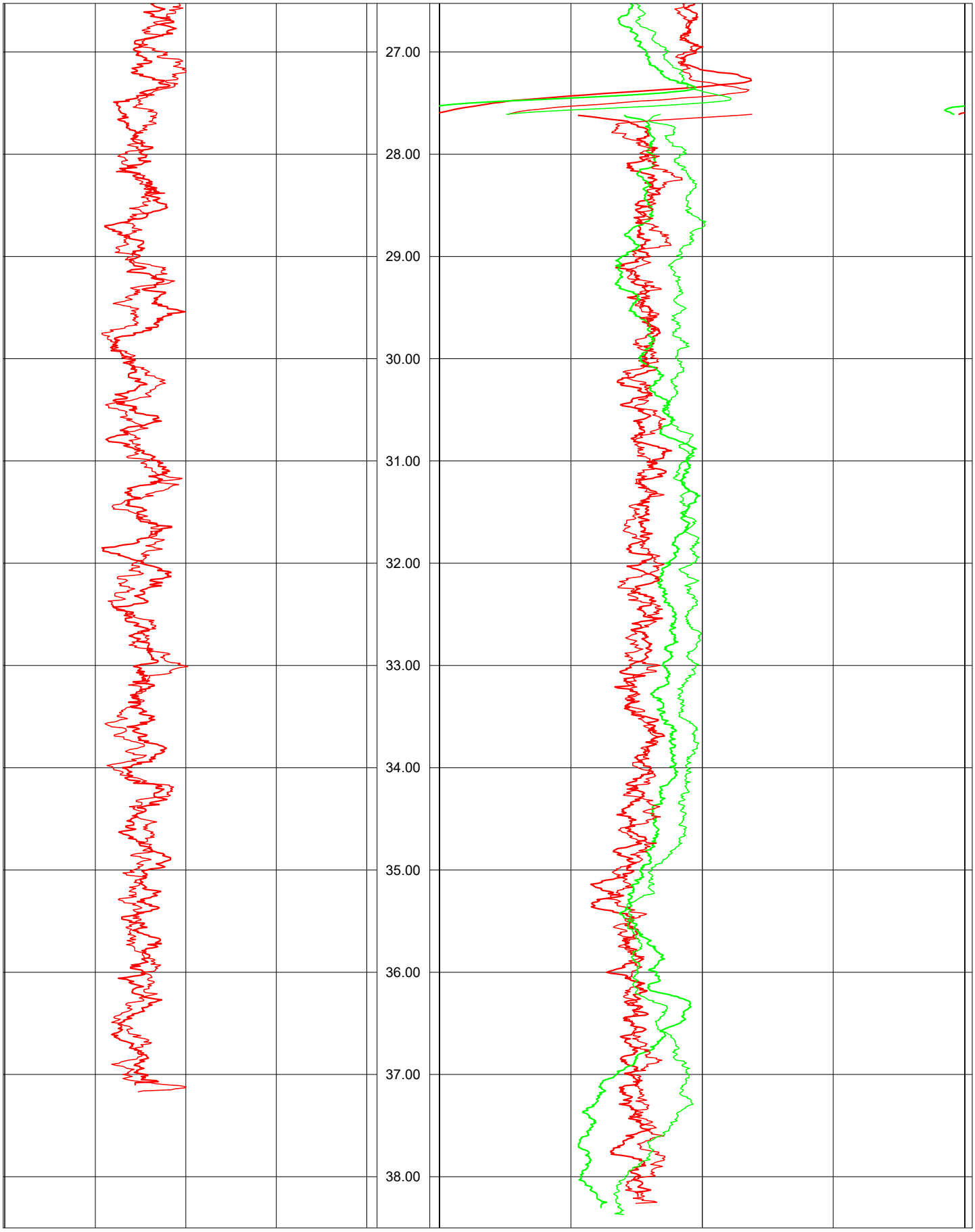
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EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **RSK**

Borehole: **T5-BH1**

Log Type: ***Trisonde***

Location: **Ogmore Wind Farm** Area: **South Wales** Grid Ref: Elevation:

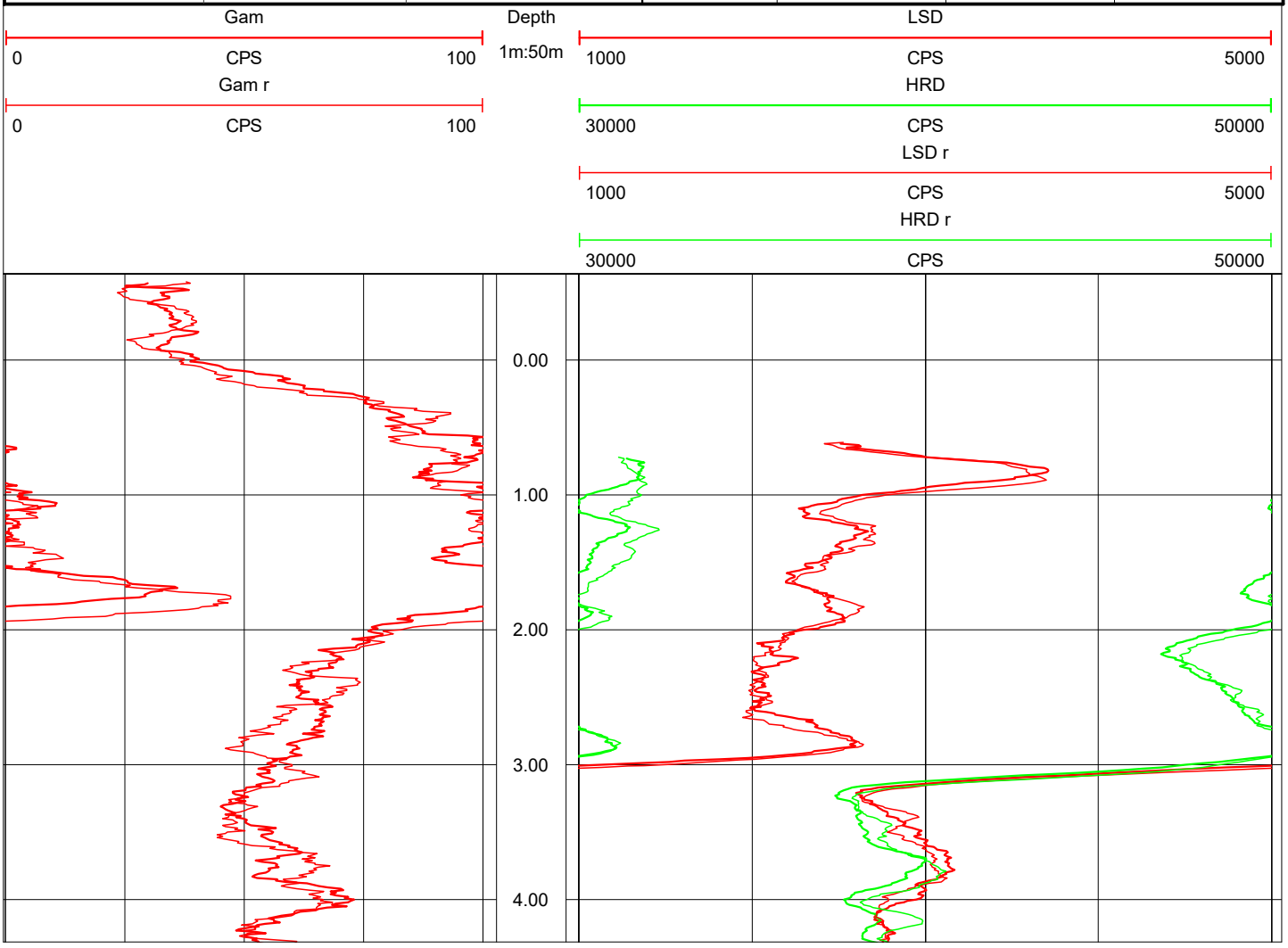
Drilled Depth: (m)	**40.1**	Date:	**08.06.18**
Logged Depth: (m)	**40.1**	Recorded By:	**R. Powell**
Logging Datum:	**Ground Level**	Remarks: Inclined BH	
Logged Interval: (m)	**0.9 - 40.1**		
Fluid Level: (m)		**Ref:**	

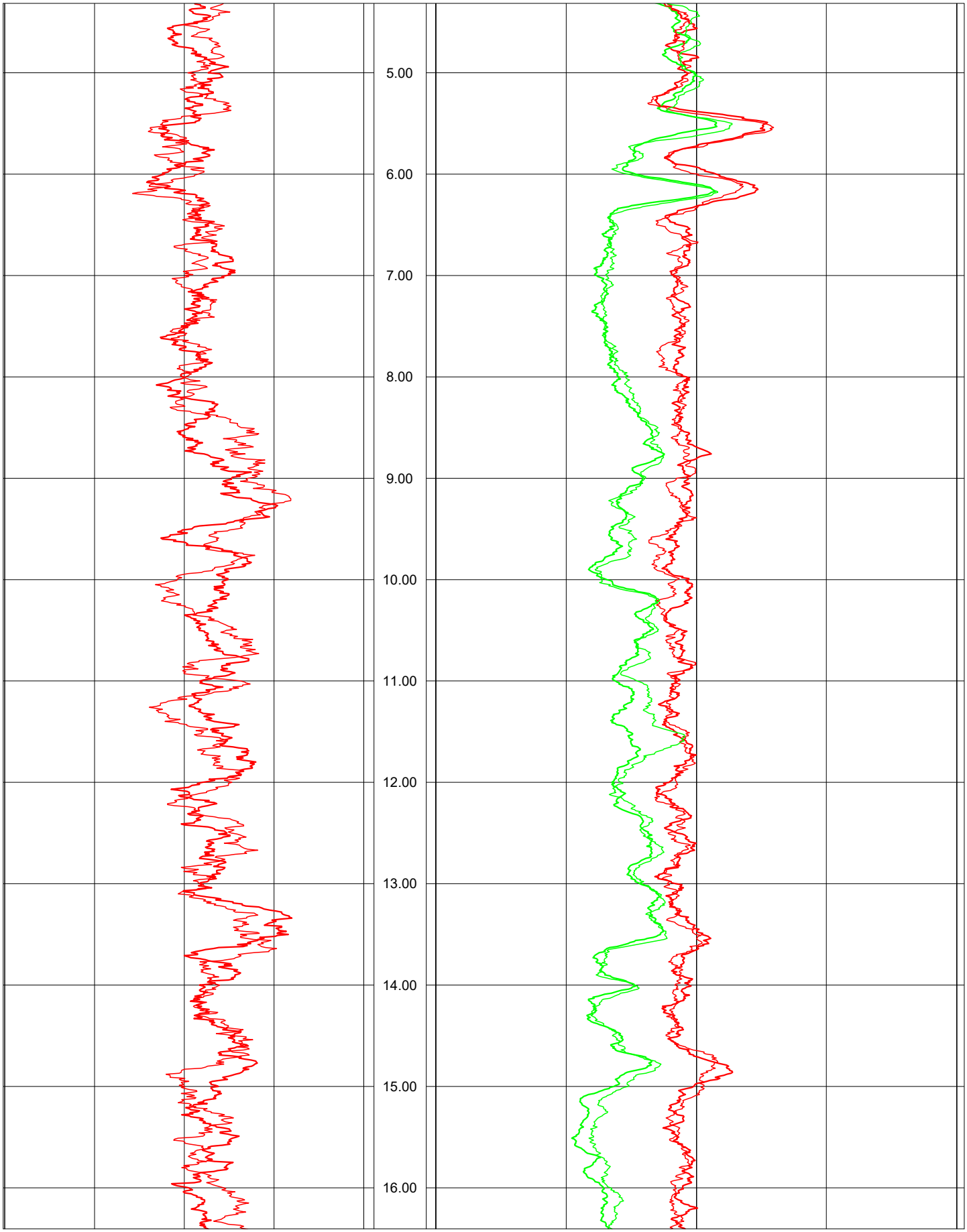
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
PVC	**50**	**0.0**	**40.1**

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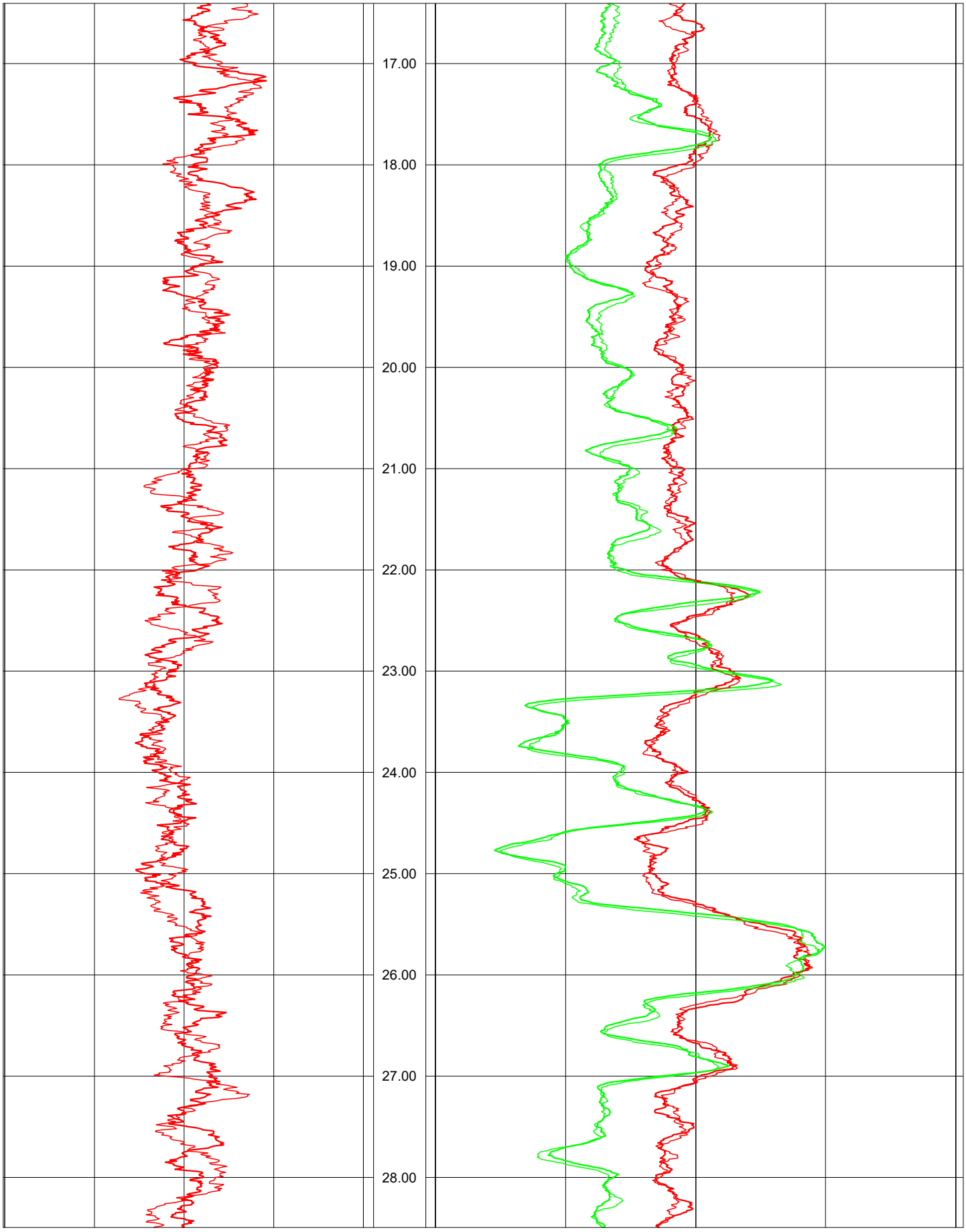
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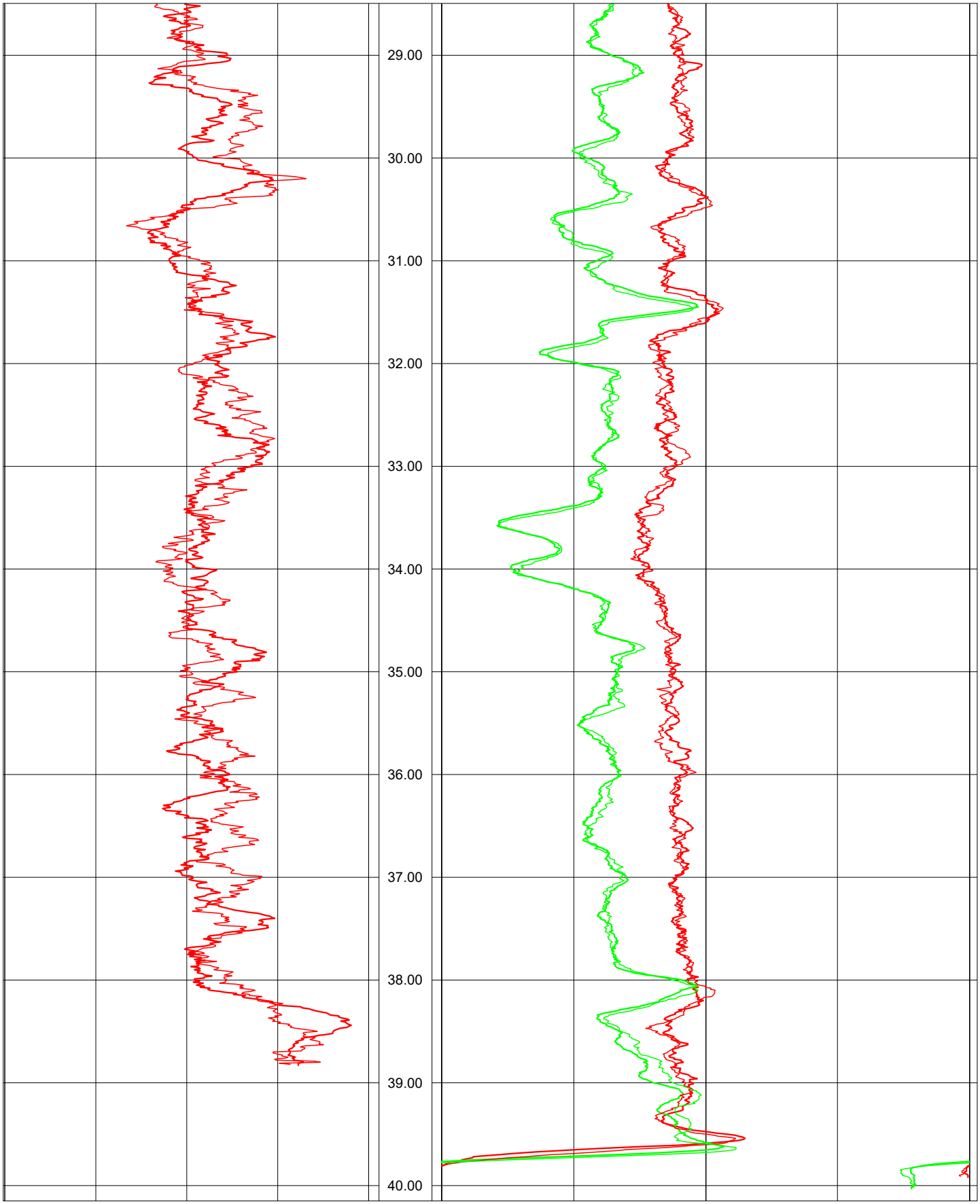
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EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **RSK**

Borehole: **T5-BH2**

Log Type: ***Trisonde***

Location: **Ogmore Wind Farm** Area: **South Wales** Grid Ref: Elevation:

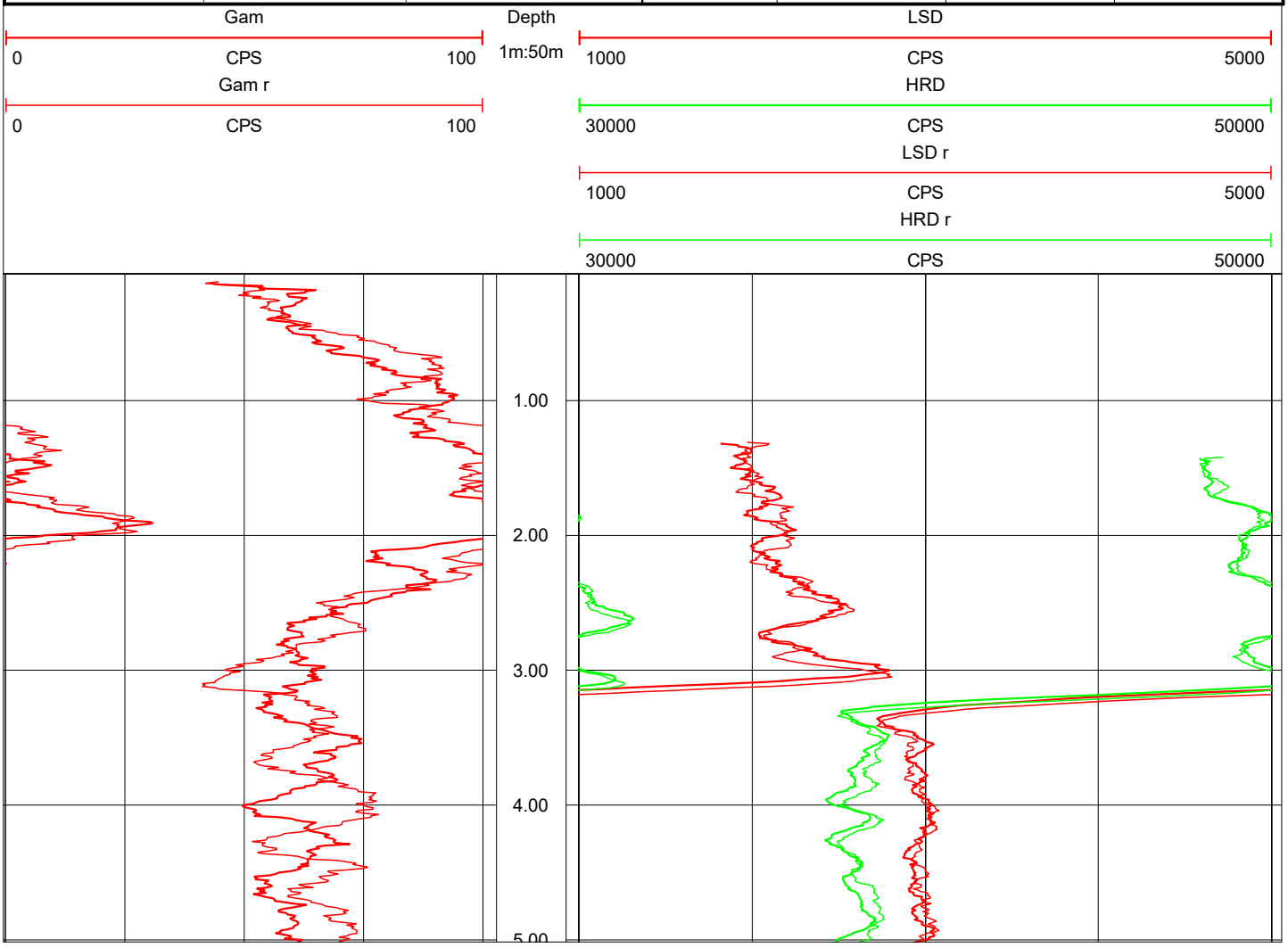
Drilled Depth: (m)	**40.1**	Date:	**08.06.18**
Logged Depth: (m)	**40.1**	Recorded By:	**R. Powell**
Logging Datum:	**Ground Level**	Remarks:	Inclined BH
Logged Interval: (m)	**1.6 - 40.1**		
Fluid Level: (m)		**Ref:**	

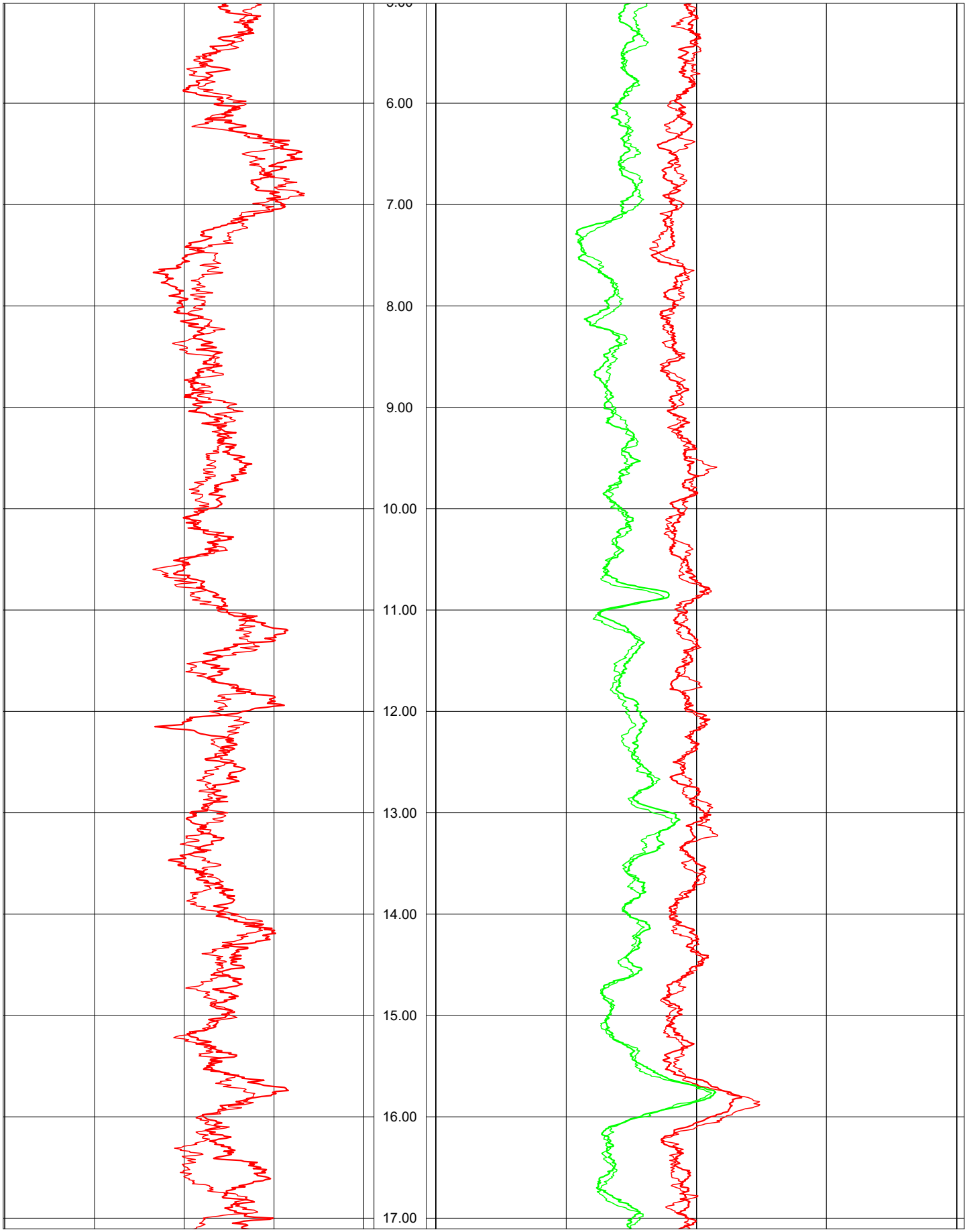
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
PVC	**50**	**0.0**	**40.1**

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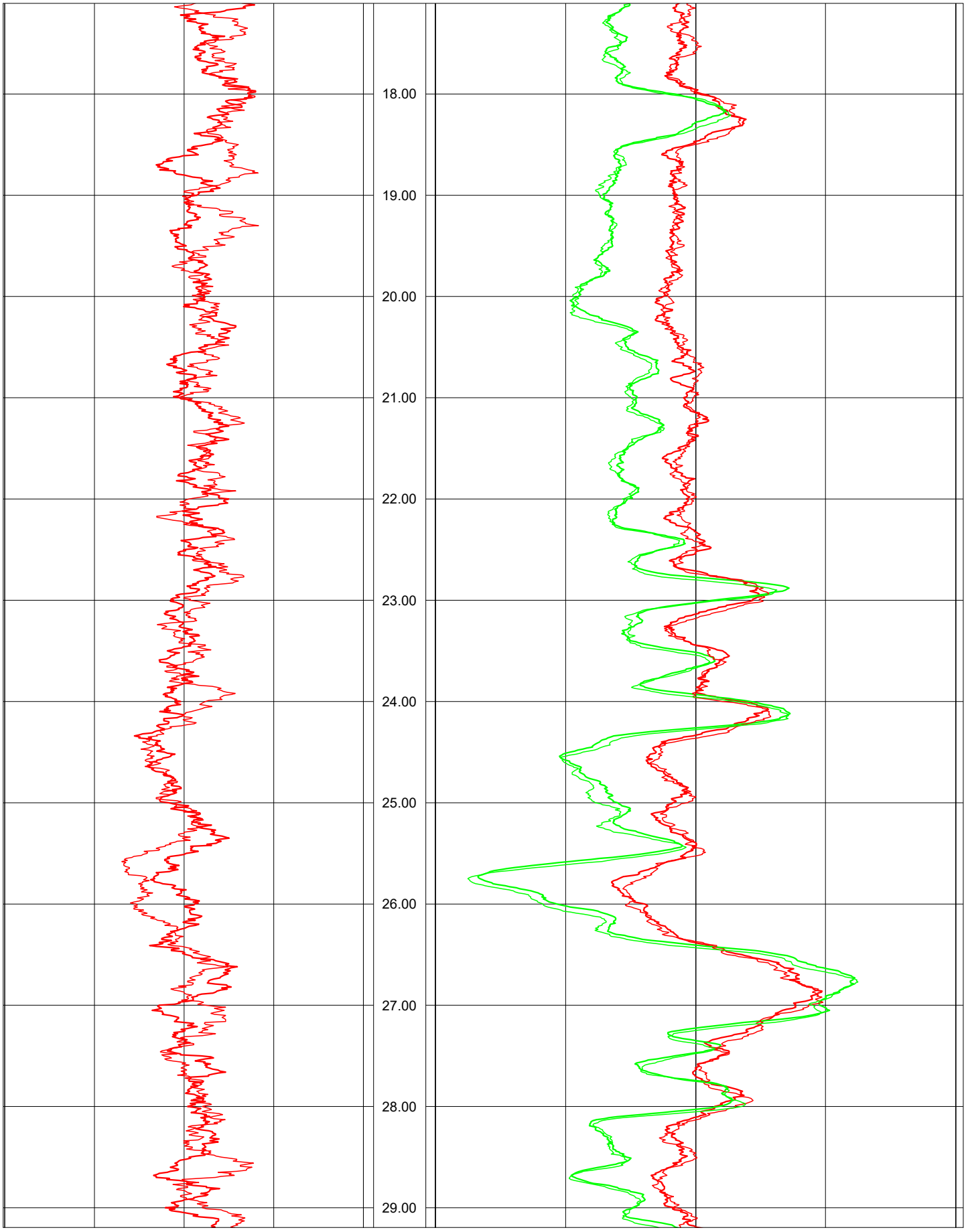
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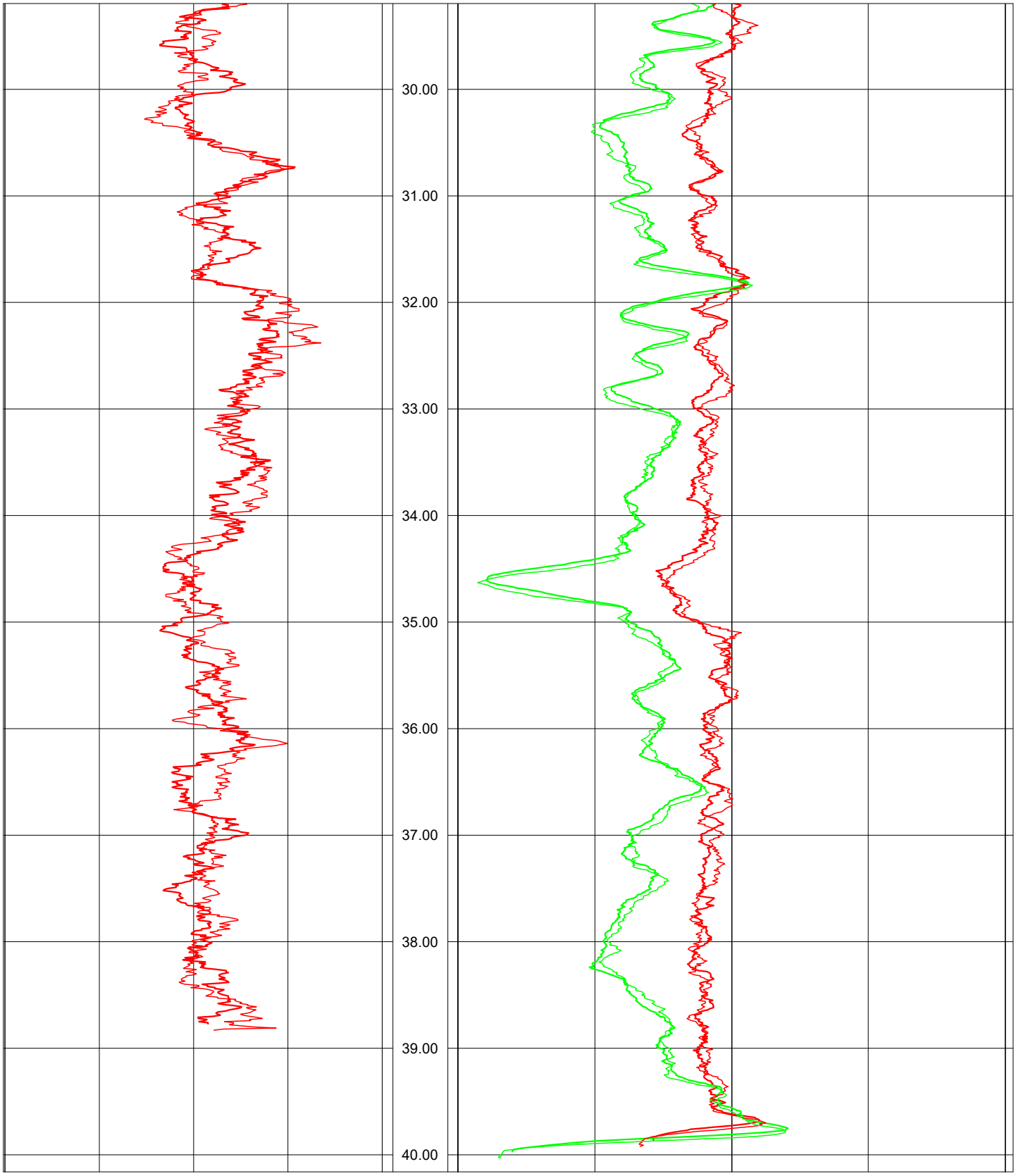
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EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **RSK**

Borehole: **T5-BH3**

Log Type: ***Trisonde***

Location: **Ogmore Wind Farm** Area: **South Wales** Grid Ref: Elevation:

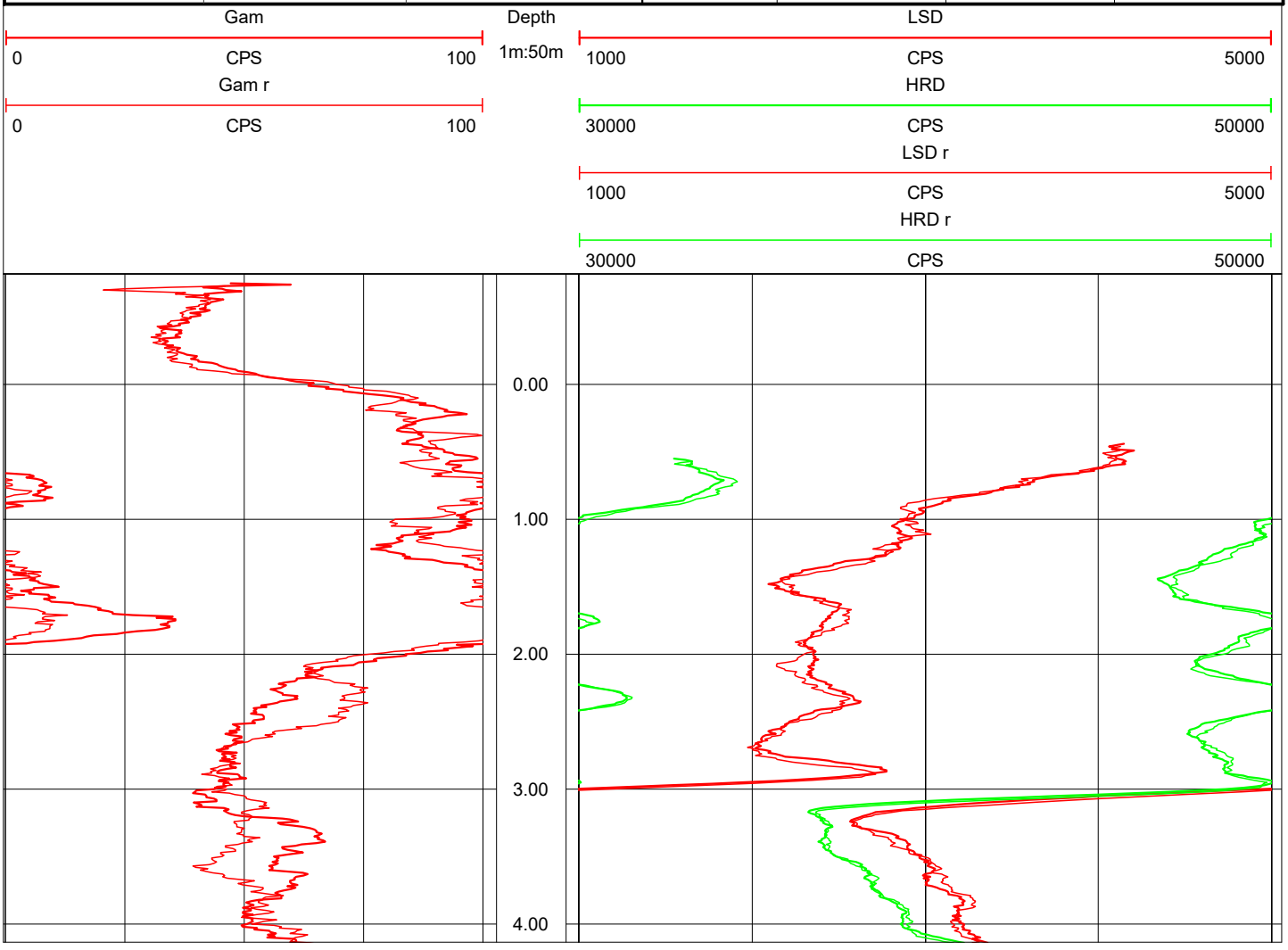
Drilled Depth: (m)	**40.0**	Date:	**08.06.18**
Logged Depth: (m)	**39.7**	Recorded By:	**R. Powell**
Logging Datum:	**Ground Level**	Remarks: Inclined BH	
Logged Interval: (m)	**0.8 - 39.7**		
Fluid Level: (m)		**Ref:**	

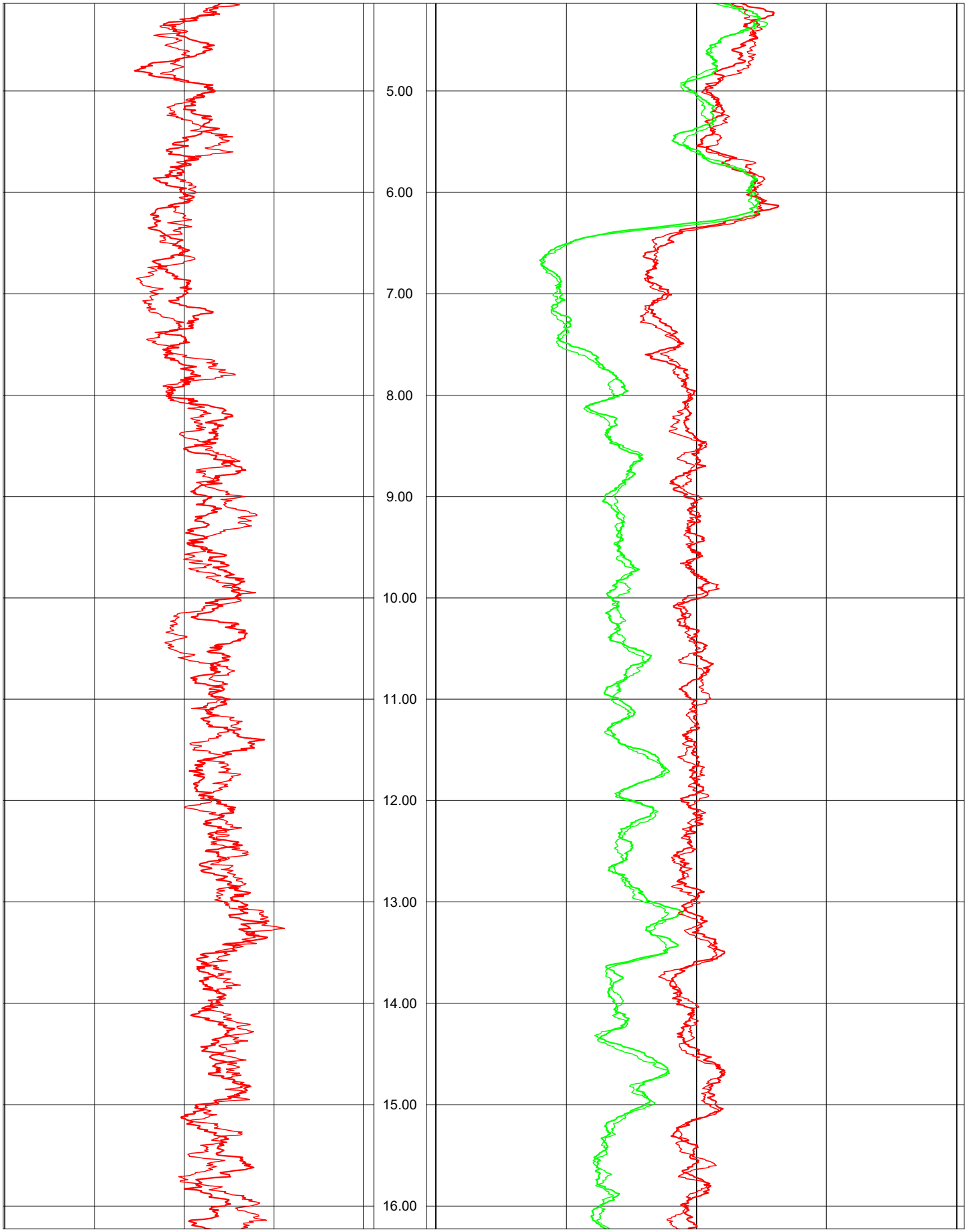
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
PVC	**50**	**0.0**	**40.0**

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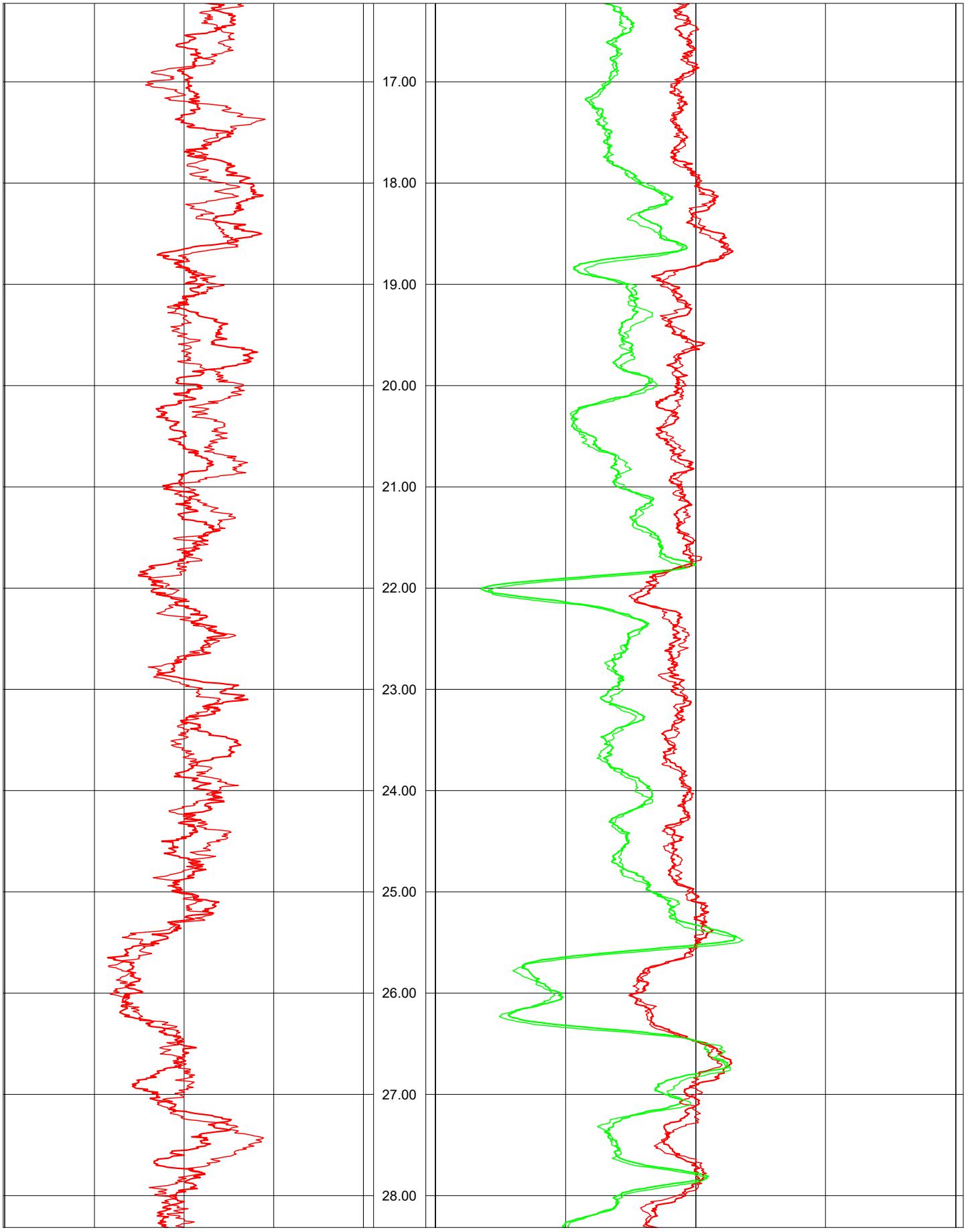
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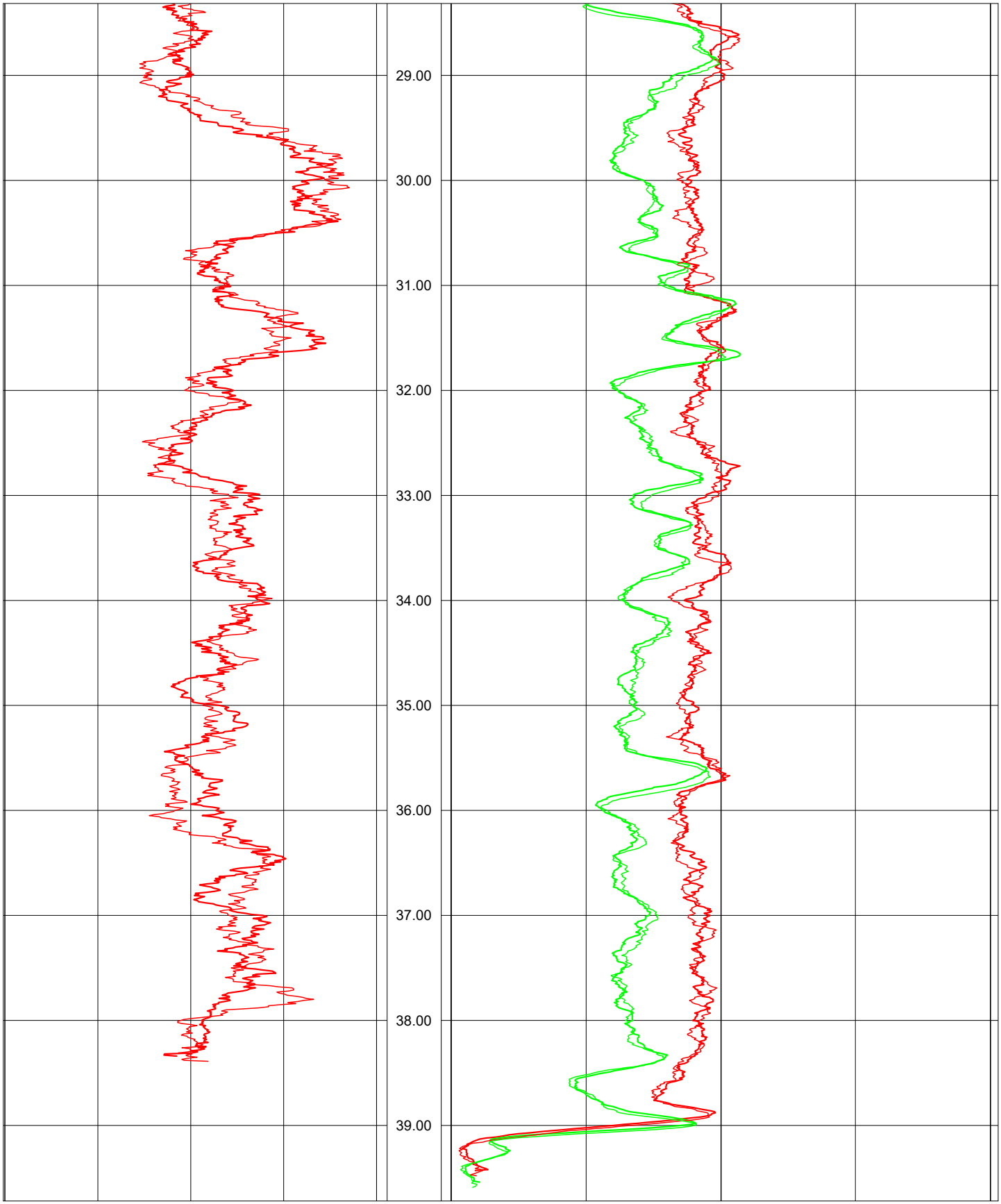
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