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BREEDON TRADING LIMITED

TAFFS WELL QUARRY

HYDROGEOLOGICAL IMPACT APPRAISAL

MARCH 2025

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HYDROGEOLOGICAL IMPACT APPRAISAL

MARCH 2025

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APPENDICES

1 INTRODUCTION

1.1 Context

1.1.1 Wardell Armstrong LLP (WA) submitted an application for a transfer abstraction licence to Natural Resources Wales (NRW) on behalf of Breedon Trading Limited (the Client) in January 2025. The intention is to vary consumptive abstraction licence (Licence No. 21/57/25/0047/V006) to increase the abstraction rates and vary the means and purpose set out in the original licence. The abstracted water will be transferred directly to the River Taff or, if settlement is required, transferred to the River Taff via a settlement lagoon. Abstracted water will be discharged to the River Taff under the current discharge consent (Consent No. AN0222302).

1.1.2 NRW issued an 'Invalid Application' letter on 07 March 2025 outlining additional information required to make the application valid. This letter outlined the requirement for a Hydrogeological Impact Appraisal (HIA), including Water Features Survey. The following presents a HIA for the proposed abstraction in line with the Environment Agency (EA) guidance for preparing a Hydrogeological Impact Assessment[1].

2 STEP 1: ESTABLISH THE WATER RESOURCE STATUS

2.1 Catchment Abstraction Management Strategy (CAMS)

2.1.1 The Site is located within the South East Valleys Catchment Abstraction Management Strategy (CAMS) area which shows 'no water available for licencing' at Q95, 'restricted water available for licencing' at Q70, and 'water available for licensing' at Q50 and Q30[2].

2.2 Water Framework Directive (WFD) Status

2.2.1 The Site is located within the South East Valleys Carboniferous Limestone Groundwater Body (ID: GB40901G203600)[3]. NRW have classified the groundwater body as having Good quantitative and chemical status, with an overall status of Good.

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[1] Environment Agency (2025) Guidance: Preparing a hydrogeological impact assessment [online] Available at: Preparing a hydrogeological impact assessment - GOV.UK

[2] Natural Resources Wales (2017) South East Valleys Abstraction Licensing Strategy

[3] Natural Resource Wales (2025) DataMapWales [online] https://datamap.gov.wales/maps/new?layergroup=geonode:nrw_wfd_cycle_3_classifications#/ (Accessed: March 2025)

3 STEP 2: PURPOSE OF THE PROPOSED GROUNDWATER ABSTRACTION

3.1.1 The purpose of the new Transfer Abstraction Licence is to dewater the old mine workings both prior to and during quarrying works, with a maximum abstraction rate not exceeding 1,330m^3 per day. The details of the new Transfer Abstraction Licence compared with the existing abstraction licence are outlined in Table 3.1.

Table 3.1 Variation to Existing Licence

Item	Existing Licence (Ref. 21/57/25/0047)	Transfer Abstraction Licence
Source of Supply	Underground strata, old mine workings in Pentyrch, Cardiff	No change
Point of abstraction	National Grid Reference (NGR) ST 1184 8235	No change
Means of abstraction	A pump with maximum output not exceeding 45.46m^3 per hour (10 hours operation)	A pump with maximum output not exceeding 56m^3 per hour (24 hour operation)
Purpose of abstraction	Industrial: aggregate washing, cooling water in crushers, and dust suppression / washing lorries	Dewatering from old mine workings (no consumptive use)
Period of abstraction	All year	No change
Maximum quantity of water to be abstracted during the specified period	454.5m^3/day 136,380m^3/year	1,330m^3 per day

3.1.2 The Site is not currently abstracting water from the old mine workings under Abstraction Licence Number 21/57/25/0047. Abstraction from mine workings used to be via a pipeline through the Little Pit. Gunn[4] estimated the surface area of the underground reservoir as 1,850 m^2 with a total volume (down to 25 mAOD) of 120,000 m^3. There has been no adverse impact on water levels in the mine pit as a result of stopping abstraction.

3.1.3 In 1926, the underground 'lakes' in the mines were pumped dry over 18 months at a rate of 273 m^3 per hour[5] (6,552 m^3/d).

[4] Gunn Engineering & Environmental Consultancy (2002). Survey of Underground Workings at Garth Iron Mine, Taffs Well Quarry, Nr Cardiff

[5] Wardell Armstrong, October 2020. Hydrogeological Impact Assessment (Report Reference: ST18210/002/V2.0/FINAL)

3.1.4 Breedon would like to ensure that the groundwater levels in the old mine workings are controlled during the proposed quarrying works. Taking into consideration the mine water abstraction history, a rate of 56 m^3 per hour is considered to be sufficient to control the groundwater levels throughout the quarrying works.

3.1.5 The abstracted water will be discharged to the River Taff under the current downstream discharge consent (Consent Number: AN0222302) located at NGR ST 12720 82270. The upstream discharge consent (Consent Number: AN0222301), located at NGR ST 12600 82800, is currently not used. The discharge consents do not have a maximum discharge volume.

4 STEP 3: DEVELOP A CONCEPTUAL MODEL

4.1.1 The Site setting and hydrogeological conceptual site model is detailed in Report No. ST19539-001 (included in Appendix 1), and is summarised as follows.

- Precipitation falling onto the Site, or in the quarry void, will either be captured by the water management system or will infiltrate to recharge the underlying aquifer. In the absence of superficial deposits on site, recharge is likely to be direct to the bedrock aquifer, Black Rock Limestone.
- Groundwater levels recorded in the boreholes installed within the quarry floor range from 32.28 mAOD to 61.03 mAOD and are monitoring the main aquifer within the limestone. Groundwater levels in the north/north west of the quarry are consistently higher than those observed in other boreholes and are considered to monitor a perched aquifer system associated with the former iron-ore workings. Groundwater levels recorded to the south-east of the quarry show similar levels to the River Taff.
- Groundwater flow will predominantly be via secondary porosity including fracture flow and historic mine workings, and will be controlled by interconnectivity of the features. Large groundwater level fluctuations will occur within the perched and main aquifer in response to water entering and leaving the system as a result of the fractured nature and low storativity of the limestone.
- Groundwater flow is towards the River Taff to the east of the quarry void.
- Groundwater flow is anticipated to reduce with depth due to pressure of the overlying rock reducing fracture density and aperture size. Greater flow will occur in the vicinity of the mine as a result of blasting creating localised fissures and fractures.

- Inflows to the quarry void will locally lower the groundwater table, creating a cone of depression (Radius of Influence (ROI)) around the quarry. Due to the fractured nature of the limestone, the extent and direction of the ROI will be controlled by the connectivity and aperture of the fractures and fissures.
- Currently water levels within the void are maintained by abstracting water from the quarry sump and discharging to the River Taff.
- Current plans to deepen the quarry void will likely also result in greater inflows to the quarry void as the depth increases and a greater portion of the saturated aquifer is intercepted, and a gradual increase in the ROI as the depth of the quarry increases.

5 STEP 4: WATER FEATURES SURVEY

5.1.1 A desk-based review of water features within 2km of the proposed abstraction is summarised in Appendix 2. The conceptual model outlined in Appendix 1 considers water features within 2km of the Site.

5.1.2 Appendix 2 summarises whether each water feature has been carried forwards for further assessment, based on the hydrogeological conceptualisation of the Site and the surrounding area.

6 STEP 5: ASSESS IMPACTS TO WATER FEATURES

6.1.1 The assessment of impacts to water features brought forwards from Step 4 is included within Appendix 3.

6.1.2 A Radius of Influence of 504m has been calculated for the proposed transfer abstraction licence. Within the ROI, the only potential receptors identified are the limestone groundwater body and the spring (S1) to Cwmrhyddgoed. The River Taff is also considered as the proposed transfer abstraction licence is located within this waterbody.

7 STEP 6: RISK ASSESSMENT OF GROUNDWATER ABSTRACTION

7.1.1 The following section assesses the risks to each of the water features identified within the Radius of Influence, and the River Taff.

7.1.2 The drawdown within the Carboniferous Limestone principal aquifer will be localised around the mine workings. Any impact will be minimal in comparison to the size of the aquifer. The overall balance of the groundwater in the aquifer will be unaffected as the abstracted water will be returned to the River Taff, which is in hydraulic connection with the groundwater. As such, the magnitude of impact is considered to be low. The probability of the impact is high, and the timing of the impact will be primarily during abstraction. The significance of the risk is considered to be low.

7.1.3 The spring to Cwmrhyddgoed is located up hydraulic gradient of the quarry, coincides with a fault and geological boundary and is likely to be supported by preferential flow pathways along the fault (north-south trending). Due to the fractured nature of the limestone, there is still the potential of an impact on the spring however this is anticipated to be low. As such the overall magnitude of the impact is considered to be moderate, however the probability is considered to be low. The significance of the risk is therefore considered to be low.

7.1.4 The River Taff is outside of the Radius of Influence for the proposed transfer abstraction licence, however as the Abstraction Point is located within the water body has been included. Appendix 4 assesses potential impacts to the River Taff and outlined monitoring and mitigation measures.

8 STEP 7: MITIGATION MEASURES

8.1.1 No mitigation measures are proposed for the Carboniferous Limestone principal aquifer, or the spring to Cwmrhyddgoed.

8.1.2 Potential impacts to the River Taff will be mitigated through the discharge of abstracted water directly to the River, or via a settlement lagoon where necessary. These are further discussed in Appendix 4.

9 CONCLUSIONS

9.1.1 A Hydrogeological Impact Appraisal has been undertaken, through development of a Hydrogeological Conceptual Site Model, desk based Water Features Survey, and assessment of impacts to identified water features.

9.1.2 The significance of risk to the Carboniferous Limestone principal aquifer and the spring to Cwmrhyddgoed is considered to be low. Risks to the River Taff will be mitigated through the discharge of abstracted water to the River.

APPENDICES

APPENDIX 1

Hydrogeological Impact Assessment for Planning Application

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OCTOBER 2023

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TAFFS WELL QUARRY

HYDROGEOLOGICIAL IMPACT ASSESSMENT

OCTOBER 2023

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1 INTRODUCTION

1.1.1 Wardell Armstrong LLP (hereafter referred to as WA) has been appointed by Breedon Trading Ltd (the Client) for the preparation of a Hydrogeological Impact Assessment (HIA) for the proposed further development of Taffs Well Quarry (the Site). The HIA is to feed into an Environmental Impact Assessment (EIA) being submitted in support of the planning application for deepening the quarry from 30metres above ordnance datum (AOD) to 6meters below ordnance datum (OD).

1.2 Background

1.2.1 In October 2020, WA updated and produced both an HIA and a Flood Consequence Assessment (FCA) (referred to in this document as "the 2020 HIA" and "the 2020 FCA" respectively) following the divestment of assets from CEMEX UK Operations Ltd (CEMEX) to Breedon Trading Ltd. At the time of the 2020 HIA, Taffs Well Quarry operated under Pinnacle Construction Materials (PCM), prior to being incorporated into Breedon Trading Ltd.

1.3 Scope of works

1.3.1 This HIA will be an updated and revised version of the 2020 HIA to reflect the latest data and quarry design, and ensure associated impacts have been assessed and any necessary mitigation proposed.

1.3.2 The following scope of works will be performed to update the 2020 HIA.

- A review and update of baseline data, including obtaining and reporting the latest licensed abstraction and private water supply data from Natural Resources Wales (NRW) and the relevant Local Authorities.
- Review, and the subsequent graphical representation, of the latest groundwater monitoring data obtained from 2020 to the present. The graphs presented in the 2020 HIA will be updated to include the latest groundwater level data and rainfall data.
- The Site conceptualisation will be updated to reflect the latest baseline data, up to data monitoring data, and the quarry design for the new proposed depth of 6m below OD.
- A description of the proposed quarry development and phases, and calculation of groundwater inflow rates will be undertaken using analytical solutions.

- The HIA report will review potential drawdown at identified receptors, provide an assessment of potential impacts to these receptors, and propose necessary mitigation.

1.4 Sources of Information

1.4.1 A number of earlier reports have included an appraisal of the hydrogeology around the Site and have been used in this assessment. These include the following.

- Geoffrey Walton, July 1986. Report on a Hydrogeological and Geotechnical Study at a Limestone Quarry for the Department of the Environment.
- Scott Wilson Kirkpatrick, March 1989. Taffs Well Access Tunnel, Feasibility Report.
- Polytechnic of Wales, June 1990. An appraisal of the proposed quarry extension at Taffs Well on the existing water table levels.
- Wardell Armstrong, August 1990. Proof of Evidence (Vols 1-4).
- Steetley Quarry Products Limited, October 1990. Environmental Statement.
- Wardell Armstrong, May 1991, Interim Report on the Hydrogeology of Taffs Well Quarry.
- MJ Carter, March 1994, An assessment of the Hydrogeology of Taffs Well Quarry.
- Geoffrey Walton, June 1997, Assessment of the Stability of the current and proposed Eastern faces at Taffs Well Quarry.
- MJ Carter Associates, Nov 1998, Water Features Survey.

1.4.2 In addition, the following have been reviewed.

- Garth Iron Mine, edited by Keith Jones (collection of extracts, dates unknown).
- The Mine Pits Project, 1991 (record of diving exploration of mines).
- Iron in the Soul, June 1993 edition, by John Tyler.
- MJ Carter, Environmental Liabilities, April 1999.
- Wyn Thomas Gordon Lewis, July 2001. Environmental Statement for the proposed extension, deepening and Restoration of Ton Mawr Quarry. Volumes 1 – 4.
- Gunn Engineering & Environmental Consultancy, February 2002. Survey of Underground Workings at Garth Iron Mine, Taffs Well Quarry, Nr Cardiff.
- Terradat (UK) Ltd, November 2005. Geophysical Surveys To Investigate the Depth to Rockhead and Characterise Bedrock Materials.

- SRK Consulting Ltd, November 2005 (Draft). Taffs Well Structural Assessment.
- British Geological Survey 1:50,000 scale sheet 249, Newport and 263 Cardiff and 1:10,000 sheet ST 18SW.
- 1:625,000 Hydrogeological Maps of England and Wales, British Geological Survey, 1977.
- Groundwater Vulnerability Map of Gwent, South and Mid Glamorgan, Sheet 36. Environment Agency, Policy and Practice for the protection of Groundwater, 1996.
- Tythe, first, second and third edition Ordinance Survey Maps.
- Quarry Design, September 2017. Taffs Well Quarry Analysis of Underground – Surface Interaction.
- Quarry Design, June 2020. Taffs Well Quarry Stability Analysis for North West Extension.
- Cotswold Archaeology, September 2020. Taffs Well Quarry Outline Archaeological Mitigation Strategy.
- Taffs Well Deepening Models and Restoration Plans 2023.

1.4.3 Further information regarding water abstractions, discharges and River Taff flow data has been obtained from NRW.

1.4.4 For the production of the 2020 HIA, a search for further information was made at Taffs Well by CEMEX (prior to the transfer of Taffs Well to PCM) and at Aberdare and Pontypridd local libraries. Rhondda Cynon Taff CBC provided data on private water supplies close to the quarry.

1.4.5 For the production of this updated HIA, information on private water supplies has been obtained from the two relevant councils for this area - Vale of Glamorgan Council and Rhondda Cynon Taff council.

2 BASELINE CONDITIONS

2.1 Site Setting

2.1.1 Breedon Trading Ltd operate Taffs Well Quarry, located to the north of Cardiff, see Figure ST19539-001.

2.1.2 The quarry exploits Black Rock Limestone of Lower Carboniferous age. The Site is located on the northern edge of Cardiff, less than a mile to the north of the M4 motorway, and to the west of the A470 dual carriageway. Access is from B4262, through the disused Ty Nant Quarry and via a tunnel to the south-east corner of the Site.

2.1.3 The quarry has been developed in a limestone plateau that was presumably once covered by Garth Wood, the substantial remnants of which still clothe the surrounding hillsides. On the northern side of the excavation lie the extensive opencast and underground workings of Garth Mine, which exploited haematitic iron ore deposits from Roman times until the middle of the last century. To the north-west of the quarry is the smaller and relatively shallow Ton Mawr Quarry which has planning permission to extend southwards towards the western boundary of Taffs Well Quarry. The current Site layout and quarry profiles are shown on Figure ST19539-003 and ST19539-004 respectively.

2.1.4 Surrounding the quarry void, the ground elevation ranges from 120mAOD in the south, to 175mAOD in the north. The current permission is for extraction to 30mAOD and the current void is approximately 720m from west to east, and 620m from north to south at its widest points.

2.2 Geology

Geological Sequence

2.2.1 BGS mapping shows that the Site is largely absent of superficial deposits, which have been removed during quarrying activities however, Till and Glaciofluvial Deposits are mapped along the southern boundary of the Site (Figure ST19539-005).

2.2.2 Beyond the Site boundary, Till is widespread however is typically absent from higher topographical elevations. Alluvium, River Terrace Deposits and Glaciofluvial Deposits are located to the east of the Site associated with the River Taff. A large deposit of Glaciofluvial Deposits is located to the south-east of the Site.

2.2.3 Taffs Well Quarry is located on a dominant east-west trending ridge of dolomitised limestone known as the Little Garth. The limestone exposed in the quarry belongs to the Black Rock Limestone of Lower Carboniferous (Dinantian) age. These overlie the Lower Limestone Shales and, at depth, the Devonian sandstones and mudstones. The stratigraphic succession, with approximate thicknesses of the Carboniferous strata within and in the vicinity of the quarry has been taken from the BGS 1:50 000 scale geological map sheet 263, is summarised in Table 2.1.

Table 2.1: Stratigraphic succession of Carboniferous strata within the vicinity of the quarry

Horizon	Approximate Thickness	Description
High Tor Limestone	up to 65m	Dark grey, partly red stained fine- to medium-grained crinoidal dolomite
Caswell Bay Mudstone	3 to 7m	Pale and dark grey dolomite, partially laminated (0.1 - 0.4m thick beds) with dark grey dolomitic shale partings
Gully Oolite	19 to 30m	Grey, medium-grained dolomite
Friars Point Limestone (Upper section of the Black Rock Limestone)	76 to 83m	Grey packstones and grainstones. Dolomitic in places, passes laterally into lenses up to 1.1m thick of coarse, massive to soft and friable red dolomite, locally mineralised by calcite, haematite and barytes Grey, fine-grained dolomite (~5m) Grey fine-grained dolomite with scattered crinoid debris (~50m)
Brofiscin Oolite (Black Rock Limestone)	12 – 16m	Mainly dolomitised. Thick cross-bedded crinoidal grainstone
Barry Harbour Limestone (Lower section of the Black Rock Limestone)	c. 34m	Thinly bedded crinoidal and shelly packstones with cherts
Cwymyniscoy Mudstone	40 – 53m	Mudstones with thin bioclastic packstones
Castle Coch Limestone	21 – 25m	Cross-bedded oolites and skeletal bioclastic limestone

Geological Structure

2.2.4 The geological structure within the vicinity of the quarry is complicated by faulting and folding. The southeast-northwest trending Tongwynlais Fault is located in the Taff Gorge immediately to the east of the quarry. The east-west trending Castell Coch Anticline and the Tongwynlais Syncline run through the quarry itself, see Figure 2008_C034_TAFF_007.

2.2.5 Geological mapping of the quarry and environs was carried out as part of the 1990 Wardell Armstrong study. Several minor faults and thrusts were identified, some brecciated or fracture zones were noted in some of the eastern benches and both the anticline and syncline were proved to plunge westwards; the former at an angle of 24-46 degrees to the horizontal. A suspected fault zone previously inferred to the north-west of the quarry, between the quarry itself and the old mine workings, was not proven.

2012 and 2022 Site Investigations

2.2.6 CEMEX drilled five groundwater monitoring boreholes (BH1-BH5) in and around the quarry in July 2012. In 2022, Breedon Trading Ltd carried out further site investigation and installed an additional groundwater monitoring borehole (BH6). The groundwater observation boreholes (BH1 – BH6, BHF and BHH) shown on Figure ST19539-006 were strategically positioned with the aim of providing baseline groundwater level data around the quarry. The 2012 site investigations also included downhole geophysical logging using temperature, conductivity and natural gamma probes. The geological and geophysical logs from both investigations are included in Appendix A and the installation details are summarised in Table 2.2. Further information about site investigations can be found in Section 2.3.6.

2.3 Hydrogeology

Aquifer Designations

2.3.1 The Carboniferous Limestone in this area is classified as a Principal Aquifer. The Till is classified as Secondary (undifferentiated) Aquifer and the Alluvium, Glaciofluvial deposits and river terrace deposits are classified as Secondary A Aquifers. The quarry is not located within a Source Protection Zone (SPZ) and there are no SPZs within 3km radius of the Site.

Aquifer Characteristics

2.3.2 Groundwater flow in the Black Rock Limestone strata is typically dominated by the secondary permeability (joints, fissures and other discontinuities) rather than the primary permeability (porosity).

2.3.3 The hydraulic conductivity (k) for a non-karstic limestone is estimated to be between 10^{-5} and 1 m/d (Nonner, 2003). This is consistent with the geometric mean of hydraulic conductivity for Carboniferous Limestone of the Mendips to South Wales as reported in the major aquifers properties manual (Allen et al, 1997). The storage coefficient of fractured limestone is low and reported to be between 4×10^{-4} and 9×10^{-4} (Allen et al, 1997).

2.3.4 Permeabilities measured during the WA 1990 site investigation range from $2x10^{-5}$ to $3.5x10^{-5}$ m/s (1.73 to 3.02m/d) with the permeability range obtained in the 1986 investigation generally within the range 10^{-6} to 10^{-9} m/s (0.09 to 10^{-5}m/d). In some of the slug and bail tests, the extremely low permeability relates to the low primary permeability of the rock mass, whereas in other holes, water level changes were so rapid that interim water levels could not be measured. This is characteristic of the large permeability contrast between rock mass permeability and the secondary permeability of fissure flow. Where they locally fail to intersect many fissures, falling head tests in limestone strata can underestimate the hydraulic conductivity by as much as two orders of magnitude, or more in cases where no fissures are intercepted.

2.3.5 Solution cavities have been observed in the top 30m of the quarry and range in size from a few centimetres to several metres and are often filled with large well-formed calcite crystals. This is confirmed by the results of the 2005 drilling programme where a 1m cavity was encountered in borehole CH-02/05 at around 132mAOD. Solution features have not been encountered below 30m therefore the permeability of limestone is anticipated to be higher in the top 30m, where larger fissures and cavities are present (infill dependent) and is likely to reduce with depth.

Groundwater Investigations

2.3.6 Several sets of groundwater monitoring boreholes have been installed throughout the life of the quarry. The locations of these are shown on Figure ST19539-007 and can be summarised as follows

- Six 36m deep exploratory open holes (GW1 – GW6) drilled into the quarry floor in 1985. Water level measurements were recorded in the open holes on a weekly basis during 1985/86. A further two boreholes (GW101 and GW102) were drilled, and standpipe piezometers installed. Slug and bale tests were carried out in the six open holes, with falling head tests conducted in boreholes GW101 and GW102.
- Eight boreholes (A, B, C, D, E1, E2, F and H) drilled for the hydrogeological study carried out in 1990 by WA. Nine standpipe piezometers (2 in Borehole F) were installed and in-situ falling head tests carried out.
- Two boreholes (J and K) drilled in January 1991 as part of the WA 1991 study. Standpipe piezometers were installed in both boreholes.

- Five boreholes (00/1 – 00/5) drilled by RMC aggregates (South Wales) Ltd in the base of the quarry in February 2000 to depths of 35m (~25mAOD). Standpipe piezometers were installed in all boreholes.
- Three boreholes (00/6, 00/6a and 00/7) drilled in the Ty Nant Quarry to depths of 25m (~25mAOD). Standpipe piezometers were installed in all boreholes.
- Five boreholes (BH1 – BH5) were drilled by CEMEX in and around the quarry in July 2012 to depths below the sea level. These were geophysically logged for natural gamma, electrical conductivity and temperature. Standpipe piezometers were installed in all boreholes.
- One borehole (BH6) was installed by Breedon Trading Ltd in September 2022 to 6m below OD.

Groundwater Monitoring Programme

2.3.7 The current groundwater monitoring programme consisting of eight monitoring boreholes (BH1 - BH6, F (referred to as BHF) and H (referred to as BHH)) as shown on Figure ST19539-006 and summarised in Table 2.2. The programme is intended to monitor the impact of quarrying and dewatering on both local groundwater levels and the baseflow contribution to the River Taff.

2.3.8 Boreholes F and H were drilled and installed in 1990; borehole installation details are not available. These boreholes were monitored on a monthly basis for water level between July 1990 and February 2017. Monitoring was interrupted from 2017; however, three additional data points are available for 2018 and 2019. Monthly monitoring resumed in 2020, and data up to the present has been provided (see Appendix B).

2.3.9 In 2012, five additional monitoring boreholes (BH1 – BH5) were drilled around the quarry. The open holes were geophysically logged using natural gamma, impeller flow and temperature-conductivity probes. In 2022, BH6 was installed. The geological and geophysical logs of the monitoring boreholes are presented in Appendix A with installation details summarised in Table 2.2.

Table 2.2: Borehole Installation Details

Borehole ID	BH1	BH2	BH3	BH4	BH5	BH6	BHF	BHH
Date Drilled	31/7/12	7/8/12	1/8/12	2/8/12	6/8/12	18/10/22	16/8/90	4/7/90
Ground Level (mAOD)	60.3	61.1	62.0	60.3	39.1	44.52	178.9	84.8
Datum (mAOD)	60.9	61.6	62.5	60.8	39.6	44.52	179.9	85.8
Borehole Depth (m below datum)	65.0	65.0	65.0	65.0	50.0	52	131.1	34.0

Table 2.2: Borehole Installation Details								
Borehole ID	**BH1**	**BH2**	**BH3**	**BH4**	**BH5**	**BH6**	**BHF**	**BHH**
Depth of Screen (m below datum)	25.0	25.0	25.0	25.0	20.0	17.5	-	-
Length of Screen (m below datum)	40.0	40.0	40.0	40.0	30.0	34.5	-	-
Borehole Base mAOD	-4.7	-3.9	-3.0	-4.7	-10.9	-7.48	47.8	50.8

Groundwater Levels

2.3.10 Groundwater levels around the quarry are monitored on a monthly basis in the eight observation boreholes. Groundwater level data for these boreholes is available from September 2012 to May 2023. The statistics of recorded monthly groundwater levels are summarised in Table 2.3 and detailed data is presented in Appendix B.

Table 2.3: Groundwater level statistics from monthly monitoring of observation boreholes (September 2012 to May 2023)							
Borehole ID	**Dates of Data Range**	**Ground Elevation (mAOD)**	**Base of Piezometer (mAOD)**	**Water level (mAOD)**			
				Minimum	**Mean**	**Maximum**	**Range (m)**
BH1	2012-2023	60.3	-4.67	32.28	42.78	53.53	21.25
BH2	2012-2023	61.1	-3.91	37.99	45.16	52.49	14.50
BH3	2012-2019	62.0	-2.97	49.63	58.18	61.03	11.40
BH4	2012-2023	60.3	-4.73	36.57	55.98	58.94	22.37
BH5	2012-2023	39.1	-10.88	28.87	31.78	34.42	5.55
BH6	2023	47.27	-7.48	46.37	-	46.47	0.1
BHF	2012-2023	178.9	47.79	100.04	101.78	103.54	3.50
BHH	2012-2023	84.8	50.78	59.13	70.74	74.78	15.65

2.3.11 Groundwater levels vary significantly across the Site, ranging from a maximum of 103.54mAOD (BHF) to the north of the quarry to a minimum of 28.87mAOD (BH5) to the south-east of the quarry between the quarry and the River Taff. Groundwater level range is greatest in BH4 (within the quarry floor) with a maximum water level fluctuation of 22.15m recorded in this borehole. Boreholes BH1, BH2, and BHH also show significant groundwater level fluctuations with recorded ranges of 21.25m, 14.50m, and 15.65m respectively.

2.3.12 Groundwater levels within BH1, BH2, and BH4 show a similar trend, with elevated levels following increased precipitation, and reduced levels following periods of reduced precipitation. Groundwater levels within these boreholes declined between 2021 and 2022 following a prolonged period of reduced precipitation. However, groundwater levels began to recover towards the end of 2022. Groundwater levels within BH5, BHF and BHH are more consistent.

2.3.13 For the currently approved scheme (base of quarry to 30mAOD), groundwater levels are required to be measured on an hourly basis within three boreholes (BH2, BH4 and BH5). In addition, warning and action trigger levels (minimum elevations) for BH2 and BH4 have been agreed with NRW (Appendix C) and are outlined in Table 2.4. Available data demonstrates that neither the warning level nor action level has been breached within either BH2 or BH4.

Table 2.4: Groundwater Trigger Levels

Borehole	BH2	BH4
Warning Level (m AOD)	30.5	30.5
Action Level (m AOD)	30.0	30.0

2.3.14 The low storage coefficient of the limestone results in rapid response to groundwater recharge from rainfall, particularly in the quarry sump and in boreholes BH1, BH2, BH4 and BH6. Groundwater level fluctuations in BH1, BH2 and BH4 show clear seasonal patterns, with generally higher levels recorded in winter and lower levels recorded in summer; see groundwater hydrograph in Appendix B. It is anticipated that BH6 will show a similar response. A similar signature is observed within the remaining boreholes, however at a reduced amplitude. Although borehole BH3 is within the quarry floor, it does not show any correlation with other boreholes within the quarry footprint. In addition, groundwater level in this borehole is quite shallow and does not vary much over time which may indicate a different response zone/fissure system from the other boreholes.

2.3.15 WA (1990) reported that during drilling the majority of boreholes encountered up to 3no water strikes separated by dry strata and that in a number of cases these strikes coincided with hitting water filled cavities. Water strike levels above the phreatic surface are possible perched water tables relating to changes in geology or solution cavities.

2.3.16 WA considered that the phreatic surface within the 1990 quarry area was between 40 and 50mAOD, with that in the area of the former Garth Iron Mine at around 50 to 60mAOD. This is supported by the current groundwater levels in boreholes within the quarry footprint. The WA (1990) report suggested that water levels within Garth Mine are maintained by percolation of rainwater (which is enhanced by the increased permeability of mine walls and roof) and return of abstracted water. It also suggested that settlement of suspended solids from returned water from the quarry resulted in self-sealing of the Garth Iron Mine works.

2.3.17 Large water level fluctuations in response to rainfall recharge are consistent with fissured nature of limestone and the resultant low storage. During periods of high rainfall (e.g. winter) localised ingress of water into the quarry occurs via fissures in quarry faces. These are considered to be as a result of water percolating down from surface and are related to perched water rather than intersection of the phreatic surface.

2.3.18 Groundwater levels in boreholes BHF and BHH are consistently higher than other boreholes. These are considered to monitor a perched system which is associated with the former iron-ore workings and it is likely that these levels are supported by the Caswell Bay Mudstone and hydraulically isolated from the main water table in the limestone.

Flow Direction

2.3.19 As the major influences on the hydrogeological regime are topography, geology and drainage systems, regional groundwater flows are considered to be dominated by the River Taff and the Nant Cwmllywdrew. The approximate water level of the River Taff is 30mAOD, the phreatic surface at the quarry is slightly higher, with a recorded average level of 50mAOD within the quarry floor. However, limestone phreatic surfaces are unlikely to be a continuous plane or body due to secondary permeability which results in groundwater flow via drainage conduits within the rock.

2.3.20 The groundwater level monitoring data indicate that groundwater generally flows from the north-west to the south-east. The local groundwater flow system in this area generally mimics the surface topography which drops from north-west to south-east towards the River Taff. It is most likely that some of the groundwater would discharge to the River Taff where the Carboniferous Limestone aquifer is in direct contact with the river.

Historical Groundwater Ingress into Quarry

2.3.21 As described above, it has been observed that during periods of high rainfall, localised ingress of water into the quarry occurs via fissures in quarry faces. These are considered to be as a result of water percolating down from surface and are related to perched water rather than the true groundwater table within the Carboniferous Limestone aquifer.

2.3.22 In the 1986 Geoffrey Walton study, it was noted that, throughout the quarry life, some areas of the quarry have been wet and from time to time yield water in fairly large quantities. The amount of water arising in this way varies seasonally. Water inflows were observed in the winter of 1982/1983 issuing from joint and shear planes in the northern faces.

2.3.23 The 1991 WA assessment also identified localised water ingress into the quarry via fissures and numerous damp areas on quarry faces relating to perched water and that ingress was more numerous/heavier after rainfall. The assessment also concluded that pumping was required during winter months and there was little or no groundwater ingress during the dry season.

Groundwater Abstractions

2.3.24 NRW provided data for six licensed groundwater abstractions within 3km of the Site, see Appendix D. These abstractions are presented on Figure ST19539-008.

2.3.25 Vale of Glamorgan Council and Rhondda Cynon Taf Council provided information on private water supplies within 3km of the Site. There are 15no private water supplies within 3km of the Site, see Appendix D.

2.4 Hydrology

Surface Water Features

2.4.1 The River Taff is located within the Taff Gorge to the east of the quarry and flows southward towards the sea. At its nearest point, the river is only 150m from the quarry boundary. To the north and south of the quarry, east-west orientated tributaries flow towards the River Taff.

2.4.2 The Nant Cwmllwydrew is a tributary of the River Taff which flows west to east through Garth Wood, approximately 600m north of the quarry, and discharges to the River Taff at National Grid Reference (NGR) ST 12185 83252. The source of water in this tributary is largely from the Millstone Grit, but it also receives flow from at least four Carboniferous Limestone springs on the southern side of the valley (see Figure ST19539-008). However, it is considered that these springs are from groundwater within the limestone above the Caswell Bay Mudstone and, are therefore, isolated from the main limestone at the Site.

2.4.3 The Nant Gwladys watercourse, approximately 1.7km to the west of the quarry (which flows from Pentyrch in a southerly direction), is spring fed at levels between 110 and 75mAOD.

2.4.4 There are also several minor watercourses within the vicinity of the Site and to the east of the River Taff including the Nant y Brynau, the Nant Llywydd and the Nant y Fforest, see Figure ST19539-008. Based on the Site setting and geological nature of the area it is likely these watercourses are either spring fed or have an element of flow from springs. Three of these (Nant Llywydd and Nany y Fforest and tributary) are considered to receive baseflow discharge from the Carboniferous Limestone; the fourth (the Nant y Brynau), from the Carboniferous Coal Measures.

2.4.5 There are also four streams on the east bank of the River Taff, including tributaries of the River Taff and all are considered to be spring fed.

2.4.6 There are two springs with 350m of the Site (see Figure ST19539-008). One spring (S1) is located 250m east at approximately 118mAOD which coincides with a fault and feeds an unnamed watercourse. A second spring (S2) has been identified approximately 350m to the north-west of the quarry at 102mAOD which is coincident with a geological boundary between limestone and overlying boulder clays. Flow appears to directly reflect rainfall and may be a natural drain for shallow groundwater over a wide catchment area.

River Taff Spot Flow Gauging

2.4.7 NRW provided spot flow gauging data carried out on the River Taff during summer of 2001 and 2002 at NGR ST 12450 83040 shown on Figure ST19539-008. The data is summarised in Table 2.5 below.

Table 2.5: Spot flow gauging data for River Taff [NGR: ST 12450 83040]

Date & Time of measurement	Cross section[m^2]	Mean Velocity [m/s]	Flow [m^3/s]	Flow [m^3/d]
23.05.2001 11:23	12.856	0.425	5.468	472,435
31.07.2001 09:57	13.048	0.362	4.72	407,808
26.09.2001 10:13	12.42	0.33	4.096	353,894
28.08.2002 11:27	12.888	0.284	3.664	316,570

Rainfall

2.4.8 Rainfall data was acquired from NRW for Rhiwbina rainfall station (NGR ST 14976 82442) which lies approximately 2.5km to the east of the Site. The rainfall was measured using the tipping bucket method with an automatic recorder. The daily rainfall records presented in the 2020 HIA were updated to include data from 1 September 2021 to 13 March 2023, recorded at 15-minute intervals.

2.4.9 Rainfall over the 12 consecutive months for the period of September 2021 to August 2022 (inclusive) was equal to 1123mm. A maximum annual rainfall of 1591mm/yr was recorded in 2019, and a minimum of 789mm/yr was recorded in 2010. The mean annual rainfall computed for this period was 1136.5mm/yr.

2.4.10 The daily and more recent 15-minute records were totalled for each month. The summary statistics are presented in Table 2.6.

Table 2.6: Rainfall data statistics						
From daily records (2010 to 2020)				**2021***	**2022**	**2023**
Month	**Average (mm)**	**Minimum (mm)**	**Maximum (mm)**	**Total (mm)**	**Total (mm)**	**Total (mm)**
January	138.1	1.8	266.0	-	76.8	215.6
February	111.6	15.4	300.0	-	170.6	40.8
March	88.7	14.2	162.8	-	62.8	-
April	63.1	10	170.6	-	30	
May	80.3	9	161.8	-	50.6	
June	85.2	9.6	194.8	-	69.2	
July	84.1	32.4	154.2	-	30.4	
August	116.7	60.8	183.2	-	51.8	
September	99.0	10.6	262.4	115.4	44.2	
October	122.0	38.8	263.4	14.8	142.4	
November	147.6	80.6	263.4	56.4	257	
December	141.3	8.8	229.0	170	154.2	
TOTAL (mm/yr)	1271.5	789.0	1591.0	-	1139.9	-
* Rainfall data from January – August 2021 not available from NRW						

Surface Water Abstractions

2.4.11 NRW provided data for three licensed surface water abstractions within 3km of the quarry. These are presented on Figure ST19539-008 and summarised in Appendix D.

Water Discharges

2.4.12 Discharge permits within 3km of the Site can be found in Appendix D and shown on Figure ST19539-008.

2.4.13 Breedon Trading Ltd currently hold two discharge permits for the Site which were transferred from PCM. Permit number AN0222301 is for discharge of Trade Effluent/Site drainage and rainfall to River Taff from Taffs Well Quarry. The second discharge permit number AN0222302 is for the discharge to the River Taff of water accumulating within the access tunnel and associated road through the disused Ty Nant Quarry. Presently, water is only discharged under permit number AN0222302. Figure ST19539-009 and Figure ST19539-010, respectively, show the measured pH and suspended solids of this discharge water.

2.5 Ecological Designations

2.5.1 There are eight Sites of Special Scientific Interest (SSSI) within 3km radius of the quarry as summarised in Table 2.7.

Table 2.7: Sites of Special Scientific Interest

Site Name	Reason for classification	Distance from Site (km)
Cwarrau Ton Mawr a Ffynnon Taf – Ton Mawr and Taffs Well Quarries	Exposed mineralisation which is of geological interest.	On site
Garth Wood	Garth Wood is of special interest for its semi-natural broadleaved woodland. The Site is also of special interest for the nationally rare spider Porrhomma rosenhaueri, found within Lesser Garth Cave.	Boarders northern and eastern boundary of the Site
Coed y Bedw	It is an ancient broadleaf woodland, with Alder, Oak, Birch & Ash. Wildlife includes the uncommon Giant Lacewing.	0.5 north-west
Castell Coch Woodlands and Road Section	Extensive beech woodlands thought to be the furthest west that such woods occur. Geologically a sequence of rock bedding is exposed and is of geological interest.	0.55 east
Cauau Blaen-bielly	Large number of grasses, rushes and flowering plants.	1.29 north-west
Fforestganol a Chwm Nofydd	An ancient woodland home to many different species.	1.48 north-east

Table 2.7: Sites of Special Scientific Interest		
Site Name	**Reason for classification**	**Distance from Site (km)**
Glamorgan Canal / Long Wood	Standing water within the canal supports many different species including 2No native newt species.	1.49 south-east
Ty Du Moor	This Site is of special interest for its base-enriched fen-meadow vegetation.	2.5 south-west

2.5.2 In addition to SSSI sites, there is also Cymrhyddgoed Site of Nature Conservation Interest (SNCI) located immediately to the west of the quarry.

3 QUARRY DEVELOPMENT

3.1 Current Development

3.1.1 Breedon Trading Ltd currently have permission for extraction to 30mAOD within the centre of the main void, and the current void is approximately 720m from west to east, and 620m from north to south at its widest points.

3.1.2 The current workings involve pushing the quarry faces laterally to the west. The quarry is worked in 12m high benches, these bench heights were reduced from 15m in line with Quarries Regulations. Limestone is recovered from the working faces by blasting with explosives. The excavated rock is processed on site to produce the required product. Primary blasted material is transported by conveyor to the processing plant. The processed material is fed by conveyor and transported to stockpile bays within the quarry footprint.

3.1.3 The workings have intercepted groundwater levels within the quarry floor and therefore dewatering is undertaken in the form of sump pumping. Groundwater seepage is noted on the northern quarry face associated with perched groundwater which flows after heavy rainfall events. Runoff generated within the Site is collected in the base of the quarry where it is pumped off site in accordance with discharge permit number AN0222302.

Proposed Development

3.1.4 Breedon Trading Ltd propose to deepen the existing void from 30mAOD, by extracting mineral to 6m below OD.

3.1.5 The excavation to 6m below OD would require continuous dewatering throughout the development. Monitoring boreholes within the quarry itself show that dewatering will be required when working mineral below 50mAOD. The average winter groundwater level of 50mAOD was recorded for the four groundwater observation boreholes (BH1, BH2, BH3 and BH4) which are located within the quarry floor.

3.1.6 As a continuation of current operating practice, the extracted mineral will be transported by dumper to the primary crusher, then conveyor to the processing plant positioned in the quarry. The processed aggregates shall be fed on to the conveyor and transported to the stocking bays within the quarry floor.

3.1.7 The quarry waste will continue to be disposed of in the tip on the southern part of the Site until the proposed restoration contours are achieved.

3.2 Site Water Management

3.2.1 Water currently enters the quarry operations via three main routes, which comprise:

- direct rainfall;
- surface runoff from surrounding land;
- groundwater seepage from the quarry faces.

3.2.2 Once water is on the quarry floor it either flows as runoff and collects in the quarry sump or infiltrates into the ground. Some of the water from the sump is used on site for dust suppression and vehicle wheel wash. Excess water from the quarry sump is discharged off site to the River Taff under discharge permit no. AN0222302.

3.2.3 The Site is currently not abstracting water from the Garth Iron Mine workings under abstraction licence number 21/57/25/0047.

3.2.4 Daily rainfall and daily discharge from the quarry between 2015 and 2023 are shown on Figure ST19539-011. Figure ST19539-012 shows monthly discharge and monthly rainfall totals from 2015 to 2023. These graphs show a positive correlation, with higher precipitation resulting in higher volumes of water discharged from the Site.

4 CONCEPTUAL SITE MODEL

4.1 Current Development

4.1.1 The conceptual site model (CSM) for the Site can be summarised as follows and as shown in Figure ST19539-013.

- Precipitation falling on the Site; or in the quarry void; will either be captured by the water management system or will infiltrate to recharge the underlying aquifer. In the absence of superficial deposits on site, recharge is likely to be direct to the bedrock aquifer, Black Rock Limestone.
- Groundwater levels recorded in the boreholes installed within the quarry floor (BH1 to BH4, BH6) range from 32.28mAOD to 61.03mAOD and are monitoring the main aquifer within the limestone. Groundwater levels in boreholes BHF and BHH, to the north/north-west of the quarry, are consistently higher than those observed in other boreholes and are considered to monitor a perched aquifer system associated with the former iron-ore workings. Groundwater levels recorded in BH5, to the south-east of the quarry show similar levels to the River Taff.
- Groundwater flow will predominantly be via secondary porosity including fracture flow and historic mine workings and will be controlled by interconnectivity of the features. Large groundwater level fluctuations will occur within the perched and main aquifer in response to water entering and leaving the system as a result of the fractured nature and low storativity of the limestone.
- Groundwater flow is towards the River Taff to the east of the quarry void.
- Groundwater flow is anticipated to reduce with depth due pressure of the overlying rock reducing fracture density and aperture size. Greater flow will occur in the vicinity of the mine as a result of the blasting creating localised fissures and fractures.
- Inflows to the quarry void will locally lower the groundwater table creating a cone of depression (Radius of Influence (ROI)) around the quarry. Due to the fractured nature of the limestone, the extent and direction of the ROI ‘cone’ will be controlled by the connectivity and aperture of the fractures and fissures.

- Currently, water levels are maintained by abstracting water from the quarry sump and discharging it to the River Taff.

4.2 Proposed Deepening of the Quarry

4.2.1 In addition to the CSM outlined above, deepening of the quarry will likely result in:

- gradual greater inflows to the quarry void as the depth of the quarry increases and a greater proportion of the saturated aquifer is intercepted;
- gradual increase in the ROI as the depth of the quarry increases;
- as the ROI increases, greater proportion of the River Taff could be 'intercepted' resulting in boundary effects causing additional inflows to the quarry void.

5 GROUNDWATER INFLOWS

5.1.1 The rate of inflow to limestone quarries is very difficult to estimate accurately due to the inherent uncertainties regarding the occurrence and nature of the fissures, fractures controlling groundwater flow.

5.2 Quarry Inflows

5.2.1 Groundwater levels from the boreholes indicate that the limestone aquifer is unconfined therefore analytical equations assuming unconfined flow have been used. A conservative, steady state groundwater inflow to the quarry was calculated using analytical solution proposed by Marinelli and Niccoli (2000) and present in the Environment Agency published Tier 1 Groundwater Analytical Equation Tool (2007). Marinelli and Niccoli analytical solutions allow for calculation of flow rates through the pit wall, and the upward flow component through the pit floor.

5.2.2 Groundwater inflows have been calculated for a range of hydraulic conductivities, a non-karstic limestone is estimated to be between 10^{-5} and 1 m/d (Nonner, 2003). In addition, inflows were calculated for the following operational phases: base of quarry at 18mAOD, 12mAOD and 6m below OD. The analytical solutions, numerical input parameters and justifications can be found in Appendix E. Table 5.1 summaries the groundwater inflow results based on Marinelli and Niccoli 2000.

Table 5.1: Groundwater Inflows

	Hydraulic conductivity (m/d)			
	0.001	**0.01**	**0.1**	**1**
Quarry floor at 30m AOD (Current Scenario)				
Radius of influence (m)	355.29	428.1	638.55	1217.37
Groundwater inflow (m^3/d)	31.4	160	1107.9	9443.5
Quarry floor at 18mAOD				
Radius of influence (m)	376	489	809	1,677
Groundwater inflow (m^3/d)	51	263	1,834	15,601
Quarry floor at 12mAOD				
Radius of influence (m)	386	519	890	1,897
Groundwater inflow (m^3/d)	61	317	2,213	18,799
Quarry floor at -6mAOD				
Radius of influence (m)	416	605	1,126	2,533
Groundwater inflow (m^3/d)	92	484	3,405	28,836

5.2.3 The estimated dewatering rates are comparable to those observed at other Carboniferous Limestone quarries (typically 2,000-3,000m^3/d) and are considered to be reasonable estimates for the purposes of this assessment. However, if a significant flow pathway is encountered there is potential for groundwater inflow at greater rates than estimated in the analytical calculations.

5.2.4 The Marinelli and Niccoli 2000 inflow calculations have also been applied to the current scenario (30m AOD) to allow results to be compared to measured dewatering rates. When comparing the calculated inflows to measured dewatering rates between July 2021 and February 2023, assuming a hydraulic conductivity of 1 m/d overestimated inflows into the void. Where the conductivity is assumed as 0.1 m/d the calculations overestimate flow more often than they underestimate flow, and where the conductivity is assumed less than 0.1 m/d the calculations underestimate flow more often than they overestimate flow. Therefore, a hydraulic conductivity value of 0.1 m/d is considered more realistic than assuming 1 m/d. It should be noted that the calculations do not consider direct rainfall into the Site, or runoff from the Site catchment, therefore the groundwater component of the recorded pumping rate, which is considered by the calculations, will be lower than the total pumping rate.

5.3 River Taff Leakage

The River Taff lies approximately 210m to the east of the edge of the quarry at its closest point (measured from centre of the River Taff) and falls within the estimated ROI, see Appendix E. The River Taff is likely to be in hydraulic continuity with the groundwater therefore could create a recharge boundary and effectively 'replace' radial flows from the east of the quarry void. Leakage into the quarry void from the river has been estimated assuming that the river is in direct hydraulic connection with the limestone and that there is a constant head in the river. Calculated inflow rates can be found in Appendix E and summarised in Table 5.2.

Table 5.2: River Taff Leakage

Depth of quarry mAOD	Transmissivity m^2/d		
	4	63	130
18	146	2,297	4,739
12	219	3,445	7,109
-6	437	6,890	14,218

5.4 Rainfall Inflow to the Excavation

5.4.1 Applying the average annual rainfall for nearby Rhiwbina rainfall gauging station of 1,271.5mm/yr over the proposed operational quarry area (phase 6m below OD) of 36 ha equates to rainfall of 1,275m^3/day. The majority of rainfall is likely to be lost via evaporation or intercepted by hardstanding, buildings and eventually enter the Site drainage system.

5.5 Total Inflows

5.5.1 The total dewatering requirement is a summation of direct rainfall into the void (1,275m^3/d), river leakage (mean for phase 6m below OD is 7,182m^3/d) and groundwater ingress. Based on the calculations in Appendix E, the best estimates of combined inflows from groundwater and surface water for phase 6m below OD can be found in Table 5.3. As previously mentioned, the rate of inflow to limestone quarries is very difficult to estimate accurately due to the inherent uncertainties regarding the occurrence and nature of the fissures, fractures controlling groundwater flow therefore the values in Table 5.3 may be considered an over-estimate.

Table 5.3: Total Inflows

Hydraulic conductivity m^3/d	Total inflow	
	m^3/d	l/s
0.001	8,549	99
0.01	8,941	104
0.1	11,862	137
1	37,294	431

6 IMPACT ASSESSMENT

6.1 General Impacts of Proposed Development

6.1.1 The range of potential impacts on the water environment associated with limestone extraction and subsequent restoration of quarry voids is well established. Many of these potential impacts can be avoided by good design and standard mitigation measures. These impacts can be grouped as summarised in Table 6.1.

Table 6.1: General Impacts Associated with Quarry Development	
Types of Impact	**Typical Mitigation Measures**
Extraction Phase	
Impacts from Dewatering Carboniferous Limestone	
Impacts of water levels on spring flows	Re-introduce water back to the aquifer system.
Impacts on habitats (ecological) sensitive to shallow groundwater levels in the vicinity of springs	
Impacts on water quantity on nearby abstractions	
Impacts on baseflow in watercourses sourced from springs draining Carboniferous Limestone	
Impacts from Quarry Operation	
Impacts on groundwater and surface water quality from standard plant operation	Settlement lagoons, standard planning conditions regarding bunding of fuel tanks etc
Impacts from Discharge of Water from Quarrying Operations	
Impacts on receiving water quality	Settlement lagoons, controlled by discharge consent issued by NRW.
Diversion of baseflow from one catchment to another	Relocation of discharge point, discharge of compensation flows down-gradient
Restoration Phase	
Long term impact on groundwater levels (can be either increased or decreased depending on details of restoration scheme)	Appropriate design of restoration, particularly the materials used to restore slopes
Additional loss of water from open water evaporation	Reduce areas of open water in restoration concept

6.1.2 An assessment is made of these potential impacts on the water environment around the Site. The assessment considers the operation and restoration phases separately. The main receptors identified in Section 2 have been summarised in Table 6.2 and screened in/out of the assessment based on the maximum ROI of 2,533m as worst case scenario.

Table 6.2: Receptor Screening		
Receptor	**Potential to receive an impact and therefore carried forward to assessment**	**Justification**
Groundwater body (Principal aquifer)	Y	Groundwater abstracted from aquifer
Secondary A Aquifers	Y	Aquifer in continuity with principal aquifer
Groundwater abstractions (licensed and PrWS)	Y	Five licensed groundwater abstractions within ROI (WA/057/0025/0014, 21/57/25/0023, 21/57/25/0075, 21/57/25/0047, 21/57/25/0080) One PrWS within ROI (289)
River Taff	Y	Within ROI and likely in continuity with the limestone
River Taff tributaries	Y	Within ROI: Nant Cwmllwydrew and Nant gwladys. Several watercourses to the east of the Taff within the ROI
Springs	Y	Within ROI
Surface water abstractions	Y	Three within ROI (21/57/25/0046, WA/057/0025/005, WA/057/0025/009)
Cwarrau Ton Mawr a Ffynnon Taf - Ton Mawr and Taffs Well Quarries	N	Not groundwater dependent
Garth Wood	Y	Seepages in wood have been raised by NRW as a potential concern
Coed y Bedw	N	Not groundwater dependent
Castell Coch Woodlands and Road Section	N	Not groundwater dependent
Cauau Blaen-bielly	N	Not groundwater dependent
Fforestganol a Chwm Nofydd	N	Not groundwater dependent
Glamorgan Canal / Long Wood	Y	Waterbody supporting newts
Ty Du Moor	N	Not groundwater dependent
Cymrhyddgoed Site of Nature Conservation Interest	N	Not groundwater dependent

6.2 Extraction Phase Impact Assessment

Drawdown impacts

6.2.1 Cooper-Jacob analytical solution was used to calculate the drawdown at a given distance from the abstraction. For these calculations it is assumed one dewatering well in the quarry floor at NGR ST 12244 82127. The input values for this equation and the results can be found in Table 6.3 and Appendix F. The analytical solution is based on the following assumptions:

- the aquifer is unconfined;

- the aquifer has infinite areal extent;
- the aquifer is homogeneous, and of uniform thickness;
- flat initial water table;
- the aquifer is pumped at a constant discharge rate;
- the water removed from storage is discharged instantaneously with decline of head;
- the diameter of the well is small, i.e. the storage in the well can be ignored; and
- the pumping well is fully penetrating, therefore receiving water from the entire saturated thickness of the aquifer.

6.2.2 It should be noted that the ROI and the Cooper-Jacob solution assume radial flow in a homogenous aquifer. This is not the case for the limestone whereby groundwater flow is through secondary porosity therefore, the extent and direction of the dewatering impact will be controlled by the interconnected fractures, these calculations are to give an indication only.

Table 6.3: Drawdown at Receptor Impact Assessment							
			Most likely scenario (0.1m3/d -6mAOD) Q= 3,405 m3/d		**Worst case scenario (1m^3/d at -6mAOD) Q= 28,836m3/d**	
		Units	**Input value**	**Drawdown (m)**	**Input value**	**Drawdown (m)**
Transmissivity (T) *Maximum T for limestone in South Wales**		m^2/d	130	-	130	-
Storage coefficient (S) Average S for limestone in South Wales*			0.0007	-	0.0007	-
Time (t) One year of pumping provided in brackets		Days	1	-	1	-
Total discharge from well (Q)		m^3/d	3,405	-	28,836	-
Licensed groundwater abstractions (r)	WA/057/0025/0014	M	1,545	0	1,545	0
	21/57/25/0023	M	1,159	0	1,159	0
	21/57/25/0075	M	827	0	827	0
	21/57/25/0047	M	461	1.4	461	11.9
	21/57/25/0080	M	1,841	0	1,841	0
PrWS (r)	289	M	1,745	0	1,745	0
Surface watercourses (r)	River Taff	M	500	1.1	500	9.1
	Nant Cwmllwydrew	M	1,000	0	1,000	0
	Nant Gwladys	M	2,100	0	2,100	0
	Nant y Brynau and tributary (watercourse east of River Taff)	M	1,672	0	1,672	0

Table 6.3: Drawdown at Receptor Impact Assessment

			Most likely scenario (0.1m3/d -6mAOD) Q= 3,405 m3/d		Worst case scenario (1m^3/d at -6mAOD) Q= 28,836m3/d	
		Units	**Input value**	**Drawdown (m)**	**Input value**	**Drawdown (m)**
	Nant y fforest (watercourse east of River Taff)	M	1,050	0	1,050	0
Springs (r)	Spring S1	M	750	0	750	0
	Spring S2	M	1,027	0	1,027	0
Surface water abstraction (r)	21/57/25/0046	M	1,512	0	1,512	0
	WA/057/0025/005	M	1,550	0	1,550	0
	WA/057/0025/009	M	1,583	0	1,583	0
SSSI	Garth Wood	M	410	1.9	410	16.1
	Glamorgan Canal / Long Wood	M	1,490	0	1,490	0
*from major aquifer properties manual						

Water Quantity

Groundwater body

6.2.3 The limestone aquifer is unlikely to receive an impact from drawdown. Drawdown will be localised around the abstraction well/s, any drawdown will be minimal in comparison to the size of the groundwater body.

Groundwater abstractions

6.2.4 The potential impacts of dewatering on licensed groundwater abstractions and PrWS is considered to be insignificant, as most of these fall outside the ROI. Of the six which fall inside the ROI, one of these was calculated to receive a potential drawdown impact (no. 21/57/25/0047). This licence is held by Breedon Trading Group however, the Site is currently not abstracting water under this licence number. One abstraction licence (no. 21/57/25/0075) held by Tarmac Aggregate Ltd is 82m east of the Site boundary and approximately 830m north-east of the abstraction point. Tarmac abstracts groundwater from the same aquifer as Taffs Well year-round for use a process water. Although the Cooper-Jacob analytical solution did not calculate a drawdown, it should be noted there could potentially be interference effects between the two abstractions leading to greater drawdowns.

Surface Water

6.2.5 The River Taff is located within the ROI and has been calculated to receive a drawdown impact. The impact to the River Taff is likely to be minimised by the discharge of the abstracted groundwater to the River Taff upstream of the quarry and therefore reducing impacts downstream along the River Taff. It should be noted there is the potential to cause a ‘recirculation loop’ when discharging water within the ROI and in close proximity to where the water was abstracted.

6.2.6 Watercourses to the east of the River Taff (Nant y Brynau, Nant Llywydd and Nant y Fforest), although within the ROI, are unlikely to receive an impact from the dewatering. This is due to the River Taff acting as a ‘recharge boundary’ to the groundwater and will effectively prevent the ROI spreading beyond the river.

6.2.7 Nant Cwmllwydrew is hydraulically isolated from the main limestone at the quarry and thus the impact from the proposed deepening of the quarry is unlikely. Nant Gwladys is unlikely to receive an impact due to distance from the quarry and due to it being up hydraulic gradient.

6.2.8 Although Spring 1 (S1) and Spring 2 (S2) are located within the ROI, a drawdown has not been calculated by the Cooper-Jacob analytical solution. The springs are located up hydraulic gradient of the quarry, coincide with a fault and geological boundary and are likely to be supported by preferential pathways along the fault (north-south trending). Due to the fractured nature of the limestone, there is still the potential of an impact on the springs however this is anticipated to be low.

SSSI

6.2.9 The potential impact of the quarry extension on the seepages within Garth Wood SSSI is considered to be low. The seepages which have been raised by NRW as an area of concern are the result of surface water infiltrating into fractures before re-emerging. Therefore the potential impacts of the deepening of the quarry is considered to be low.

6.2.10 Glamorgan Canal/Long Wood will not receive an impact from the dewatering of the quarry as the canal is unlikely to be in hydraulic continuity with the groundwater. In addition, the canal/Long Wood is located to the east of the River Taff which will act as a recharge boundary and prevent the ROI extending beyond it.

Water Quality

6.2.11 There are three mechanisms for potential impacts to occur on groundwater and surface water quality from on site activities:

- impacts from spills from plant operation on site;
- impacts from discharge of sediment laden site runoff to the River Taff;
- impacts from discharge of abstracted groundwater to the River Taff.

Surface Water

6.2.12 The potential for adverse impact arises due to the requirement to discharge water off site. Contaminants, both physical (i.e. suspended solids) and chemical (i.e. oil and grease) from mobile or fixed plant, if inadvertently introduced to adjacent watercourses, could cause pollution.

6.2.13 The two sources of surface water contamination discussed above will continue to be mitigated effectively by standard good working practices. Suspended solids are removed from the water by settlement. The sump within the quarry collects surface water run-off and seepage from quarry faces and provides temporary storage which permits settlement of silt before the water discharged off site. The Site drainage system is inspected on a daily basis to ensure that the there is no visible oil present and there are no reported incidents of spills. A bypass oil interceptor is installed on the discharge line to ensure that no oils are discharged off site. Conditions of a discharge permit issued by NRW are used to regulate the quality of discharge water. Water discharge from to River Taff has been monitored on a monthly basis since 2007 and has always been compliant with permit conditions on suspended solids and pH, see Figures ST19539-009 and ST19539-010.

Groundwater

6.2.14 It is the intention of the applicant to minimise the potential for groundwater contamination. The nature of flow within the limestone (i.e. predominantly fissure flow) is such that in the unlikely event of contaminants entering underlying strata, they could be difficult to contain. The means of mitigating the potential for impact is therefore to ensure that all potential sources of contamination are identified and that measures are in place to reduce the risk of pollution occurring.

6.2.15 The response to incidents conforms to measures given within Guidance on Pollution Prevention (GPP) GPP21: Pollution incident response planning. Measures on site conform to measures described generically within the series of GPPs produced by the Environment Agency/NRW. Specifically:

- GPP1: General guide to the prevention of water pollution;
- GPP2: Above ground storage tanks;
- GPP11: Preventing pollution on industrial sites;
- GPP26: Storage and handling of drums.

6.2.16 The pollution prevention guidelines require:

- all fuels, oil and chemicals to be stored in suitable tanks and containers, sited on an impermeable base and surrounded by an impermeable bund capable of holding at least 110% of the volume of the tank or containers;
- installation of oil receptors at site management areas including the wheel wash facility; and
- provision of oil absorbent materials to deal with any spillage of contaminants.

6.2.17 It is noted that all Pollution Prevention Guidance (PPGs) have been withdrawn by the NRW as the legislative requirements contained within the documents are, in many cases, no longer correct. In Scotland and Northern Ireland, some PPGs have been replaced by Guidance on Pollution Prevention (GPP). The PPGs and GPPs are, however, still considered to be a relevant and effective source of best practice information and are widely used and accepted within industry.

6.2.18 It is thus considered that the potential impacts on water quality will be adequately mitigated by these measures.

6.3 Restoration Phase Impact Assessment

Groundwater Flow Regime

6.3.1 The quarry void will be restored to an open lake. It is expected that the quarry lake will be in hydraulic continuity with groundwater within the adjacent limestone aquifer. The aquifer response time to periods of high rainfall will increase relative to that during the operational phase of the quarry. This is not considered to have a significant impact on the groundwater flow regime due to the relatively small size of the quarry void compared with that of the quarry catchment.

Runoff on Restored Slopes

6.3.2 The quarry waste tip on the south boundary of the Site which forms part of the restoration scheme has the potential to increase surface runoff leading to the erosion of sediments. The eroded sediments could potentially impact on the local water environment. However, the proposed restoration and landscaping would minimise any surface runoff from the waste tip material. The planting of trees on the slope will increase the rate of infiltration and reduce surface runoff on the restored slopes thus minimising any chances of sediment erosion. The quarry has existing restored waste tips and there is no evidence of sediment erosion from the tip either in their exposed form or when planted with trees.

Water Quality

6.3.3 Upon completion of mineral extraction all plant and equipment will be removed from the Site, thereby removing the risk of groundwater contamination from the spillage or leakage of fuels. The material used to restore the Site may partially infill fissures, further reducing the risk of groundwater contamination

7 MONITORING

7.1.1 Monitoring which is currently ongoing as part of the currently approved scheme shall be maintained once dewatering commences, including telemetry flow meter recording daily pumping rates from the sump. Hourly groundwater elevation monitoring will continue within BH2, BH4 and BH5, and equipment will be maintained and replaced where necessary.

7.1.2 Groundwater levels will continue to be reviewed and trigger levels will be revised as part of the application to vary the abstraction licence. Should trigger levels be reached dewatering shall be stopped temporarily allowing groundwater levels to recover before proceeding.

7.1.3 Groundwater level and quality monitoring should be continued during mineral extraction and for a period to be agreed with the regulatory authorities following completion of mineral extraction. In particular, data from BH2, BH4, BH5 and BH6 should be kept up to date.

8 SUMMARY AND RECOMENDATIONS

8.1 Summary

8.1.1 This report presents an assessment of hydrogeological and hydrological impacts of proposed quarry deepening on the water environment at Taffs Well Quarry.

8.1.2 The solid geology within the quarry area is dominated by Little Garth Limestone which belongs to the Black Rock Limestone of Lower Carboniferous age. The geological structure of the area around the quarry is complicated by faulting and folding. The main geological structures are the south-east to north-west trending Tongwynlais fault, east – west trending Castell Coch Anticline and Tongwynlais Syncline which runs through the quarry.

8.1.3 The Carboniferous Limestone is designated as Principal Aquifer. Solution cavities have been observed in the top 30m of the limestone, none has been observed at depth within the quarry. Groundwater levels within the limestone vary significantly across the Site ranging from approximately 61mAOD on the northern edge of the quarry to approximately 30mAOD on the eastern boundary of the quarry. The degree of groundwater level fluctuation is a consequence of the very low storage coefficient of the limestones. The well-developed secondary porosity and lack of superficial cover results in a high proportion of rainfall recharge. Groundwater generally flows from north-west to south-east as it closely mimics the local surface topography. The quarry is not located within a SPZ.

8.1.4 The most significant watercourses in relation to Taffs Well Quarry are the River Taff and River Nant Cwmllwydrew. The River Nant Cwmllwydrew is likely to be hydraulically isolated from the main limestone at the quarry by the Caswell Bay Mudstone and therefore is unlikely to be impacted by dewatering. The base flow component to the River Taff may be reduced due to quarry dewatering. Identified springs are also outside the dewatering zone of influence and are situated at higher elevations than the quarry and therefore unlikely to be affected by the proposed quarry developments.

8.1.5 One groundwater abstraction licence is potentially likely to receive an impact from the dewatering; this licence is within the quarry and is held by Breedon however, the Site is currently not abstracting water under this licence number. Similarly, the conservation sites (SSSI and SINC) around the quarry have been identified to be dependent on a perched water table which is at a much higher elevation than the base of the quarry and therefore unlikely to be affected by quarry deepening.

8.1.6 Water entering the quarry is treated on site and discharged off site to the River Taff under the existing discharge permit. The volume of water discharged off site is expected to increase during quarry deepening, and the discharge consent will be revised accordingly. No additional water will be discharged off site until the relevant permissions are in place with NRW. Treatment facilities shall be increased to cope with additional inflow. It is considered that the adherence to good working practices will effectively mitigates the risk of pollution to water environment.

8.1.7 The conclusions of the impact assessment are as follows.

- Future permitted mineral extraction essentially represents a continuation of the historical quarry operations: the extraction method will not change in the future.
- It is not considered that the quarry workings have, nor will have, an impact on abstractions of surface/groundwater, nor upon designated sites within the vicinity.
- The deepening of the quarry from 30mAOD to 6m below OD will extend the radius of influence. Analytical solutions indicate that drawdown impacts to the Tarmac Aggregate abstraction licence (no. 21/57/25/0075) and springs S1 and S2 will be minimal, and potential drawdown impacts to the River Taff are mitigated by the discharge of abstracted water.
- The risk of pollution of surface and groundwater will be mitigated by continuation of the application of standard good working practices. The existing water management system adequately teats oils and silt content in discharge water to permitted levels.

8.1.8 No significant impacts associated with the proposed restoration of the quarry have been identified.

8.2 Recommendations

8.2.1 Groundwater level and water quality monitoring should be continued at the Site.

8.2.2 It is recommended that the currently implemented industry best practice should be continued to protect groundwater and surface water from possible contamination during the working life of the quarry. These measures should include:

- refuelling on Site in a contained bunded area, and sealed vacuum refuelling of any plant not refuelled within the refuelling area; and
- storage of quarry waste material in a way that minimises the risk of erosion leading to discharge of sediment to surface waters.

APPENDICES

APPENDIX A

Borehole Logs and Geophysics Logs

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH1

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 60.33 m AOD
CO-ORDINATES E 312244.00 N 182127.04
DATE DRILLED START : 31/7/12 FINISH : 1/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
Fractured Limestone	59.03		(1.30) 1.30			1.00	Installed with raised cover
Limestone	58.33		(0.70) 2.00				
Limestone - fractured in some places.	46.43		(11.90) 13.90		13.90		Bentonite seal
Fractured Limestone	45.43		(1.00) 14.90				
Fractured Limestone							

KEY
- B - Bulk distrubed sample
- D - Small distrubed sample
- U - Undistrubed sample
- W - Water sample
- X - Cuttings sample
- c - Coarse grained
- m - Medium grained
- f - Fine grained
- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.883 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES
LOGGED BY Driller
DATE LOGGED
SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH1

SHEET 2 OF 4

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL
60.33 **m AOD**

CO-ORDINATES
E 312244.00 **N** 182127.04

DATE DRILLED
START : 31/7/12
FINISH : 1/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
							25.00
					31.20		Excessive water ingress.
			(45.10)				

KEY
B - Bulk distrubed sample
D - Small distrubed sample
U - Undistrubed sample
W - Water sample
X - Cuttings sample
c - Coarse grained
m - Medium grained
f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.883 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department CEMEX UK Operations Ltd	BOREHOLE No. BH1 SHEET 3 OF 4

SITE NAME **Taffs Well Quarry** **North of Cardiff, South Wales** **SITE REF. ST1282**	**DRILLING CONTRACTOR:** APEX DRILLING SERVICES LTD **EQUIPMENT AND METHOD:** Fraste XL Multidrill		
	GROUND LEVEL 60.33 **m AOD**	**CO-ORDINATES** **E** 312244.00 **N** 182127.04	**DATE DRILLED** **START** : 31/7/12 **FINISH** : 1/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
	0.33		60.00				Gravel pack 50mm uPVC

KEY		NOTES	MONITORING POINT ELEVATION & ID	
B - Bulk distrubed sample D - Small distrubed sample U - Undistrubed sample W - Water sample X - Cuttings sample c - Coarse grained m - Medium grained f - Fine grained	- Water strike 1 - Standing water 1 - Water strike 2 - Standing water 2	Datum level = 60.883 mAOD	Ref. Elev. mAOD	TOTAL DEPTH 65.00 METRES LOGGED BY Driller DATE LOGGED SCALE 1 : 100

SITE NAME **Taffs Well Quarry** **North of Cardiff, South Wales** **SITE REF. ST1282**	**DRILLING CONTRACTOR:** APEX DRILLING SERVICES LTD **EQUIPMENT AND METHOD:** Fraste XL Multidrill **GROUND LEVEL** 60.33 **m AOD** **CO-ORDINATES** **E** 312244.00 **N** 182127.04 **DATE DRILLED** **START** : 31/7/12 **FINISH** : 1/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
Limestone	-4.67		(5.00) 65.00				65.00

KEY B - Bulk distrubed sample D - Small distrubed sample U - Undistrubed sample W - Water sample X - Cuttings sample c - Coarse grained m - Medium grained f - Fine grained - Water strike 1 - Standing water 1 - Water strike 2 - Standing water 2	NOTES Datum level = 60.883 mAOD	MONITORING POINT ELEVATION & ID Ref. Elev. mAOD	TOTAL DEPTH 65.00 METRES LOGGED BY Driller DATE LOGGED SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH2

SHEET 1 OF 4

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL	CO-ORDINATES	DATE DRILLED
61.09 **m AOD**	**E** 312195.09 **N** 182398.39	**START** : 7/8/12 **FINISH** : 8/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION
Weathered Limestone	59.69		(1.40) 1.40			
Limestone	59.09		(0.60) 2.00			
Limestone - fractured in places						

Monitor installation: 0.50 Installed with raised cover

Bentonite seal
50mm plain uPVC

KEY
B - Bulk distrubed sample
D - Small distrubed sample
U - Undistrubed sample
W - Water sample
X - Cuttings sample
c - Coarse grained
m - Medium grained
f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.883 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH2

SHEET 2 OF 4

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 61.09 **m AOD**

CO-ORDINATES **E** 312195.09 **N** 182398.39

DATE DRILLED
START : 7/8/12
FINISH : 8/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
			(63.00)				25.00

KEY
B - Bulk distrubed sample
D - Small distrubed sample
U - Undistrubed sample
W - Water sample
X - Cuttings sample
c - Coarse grained
m - Medium grained
f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.883 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH2

SHEET 3 OF 4

SITE NAME Taffs Well Quarry, North of Cardiff, South Wales	**DRILLING CONTRACTOR:** APEX DRILLING SERVICES LTD **EQUIPMENT AND METHOD:** Fraste XL Multidrill
SITE REF. ST1282	**GROUND LEVEL** 61.09 **m AOD** · **CO-ORDINATES** **E** 312195.09 **N** 182398.39 · **DATE DRILLED** **START** : 7/8/12 **FINISH** : 8/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
							Gravel pack 50mm slotted uPVC

KEY
- B - Bulk distrubed sample
- D - Small distrubed sample
- U - Undistrubed sample
- W - Water sample
- X - Cuttings sample
- c - Coarse grained
- m - Medium grained
- f - Fine grained
- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.883 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department CEMEX UK Operations Ltd	BOREHOLE No. BH2 SHEET 4 OF 4

SITE NAME **Taffs Well Quarry** **North of Cardiff, South Wales** **SITE REF. ST1282**	**DRILLING CONTRACTOR:** APEX DRILLING SERVICES LTD **EQUIPMENT AND METHOD:** Fraste XL Multidrill		
	GROUND LEVEL 61.09 **m AOD**	**CO-ORDINATES** **E** 312195.09 **N** 182398.39	**DATE DRILLED** **START** : 7/8/12 **FINISH** : 8/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
	-3.91		65.00				65.00

KEY	NOTES	MONITORING POINT ELEVATION & ID	
B - Bulk distrubed sample D - Small distrubed sample U - Undistrubed sample W - Water sample X - Cuttings sample c - Coarse grained m - Medium grained f - Fine grained - Water strike 1 - Standing water 1 - Water strike 2 - Standing water 2	Datum level = 60.883 mAOD	Ref. Elev. mAOD	TOTAL DEPTH 65.00 METRES LOGGED BY Driller DATE LOGGED SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH3

SHEET 1 OF 4

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL
52.03 **m AOD**

CO-ORDINATES
E 312255.78 **N** 182496.67

DATE DRILLED
START : 1/8/12
FINISH : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
							0.50 Installed with raised cover
Fractured Limestone	50.73		(1.30) 1.30				
Limestone	50.03		(0.70) 2.00				
Limestone - fractured in places	39.03		(11.00) 13.00				Bentonite seal; 50mm plain PVC; Lost drilling flush
Limestone							

KEY
B - Bulk distrubed sample
D - Small distrubed sample
U - Undistrubed sample
W - Water sample
X - Cuttings sample
c - Coarse grained
m - Medium grained
f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 62.531 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH3

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. **ST1282**

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 52.03 **m AOD**

CO-ORDINATES **E** 312255.78 **N** 182496.67

DATE DRILLED
START : 1/8/12
FINISH : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
							25.00
			(52.00)				

KEY
B - Bulk distrubed sample
D - Small distrubed sample
U - Undistrubed sample
W - Water sample
X - Cuttings sample
c - Coarse grained
m - Medium grained
f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 62.531 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH3

SHEET 3 OF 4

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 52.03 **m AOD**

CO-ORDINATES **E** 312255.78 **N** 182496.67

DATE DRILLED
START : 1/8/12
FINISH : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
							Gravel pack 50mm slotted uPVC

KEY
- B - Bulk distrubed sample
- D - Small distrubed sample
- U - Undistrubed sample
- W - Water sample
- X - Cuttings sample
- c - Coarse grained
- m - Medium grained
- f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 62.531 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH3

SITE NAME Taffs Well Quarry, North of Cardiff, South Wales	**DRILLING CONTRACTOR:** APEX DRILLING SERVICES LTD **EQUIPMENT AND METHOD:** Fraste XL Multidrill
SITE REF. ST1282	**GROUND LEVEL** 52.03 **m AOD** — **CO-ORDINATES** **E** 312255.78 **N** 182496.67 — **DATE DRILLED** **START** : 1/8/12 **FINISH** : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
	-12.97		65.00				65.00

KEY		NOTES	MONITORING POINT ELEVATION & ID	
B - Bulk distrubed sample D - Small distrubed sample U - Undistrubed sample W - Water sample X - Cuttings sample c - Coarse grained m - Medium grained f - Fine grained	- Water strike 1 - Standing water 1 - Water strike 2 - Standing water 2	Datum level = 62.531 mAOD	Ref. Elev. mAOD	TOTAL DEPTH 65.00 METRES LOGGED BY Driller DATE LOGGED SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH4
SHEET 1 OF 4

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 60.27 **m AOD**
CO-ORDINATES **E** 312410.59 **N** 182235.35
DATE DRILLED **START** : 2/8/12 **FINISH** : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
Fractured limestone			(2.90)				0.50 Installed with raised cover
	57.37		2.90				
Limestone	56.77		(0.60) 3.50				
Limestone - fractured in some places							Bentonite seal 50mm plain uPVC

KEY
- B - Bulk distrubed sample
- D - Small distrubed sample
- U - Undistrubed sample
- W - Water sample
- X - Cuttings sample
- c - Coarse grained
- m - Medium grained
- f - Fine grained
- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.827 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH	65.00 METRES
LOGGED BY	Driller
DATE LOGGED	
SCALE	1 : 100

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL	CO-ORDINATES	DATE DRILLED
60.27 **m AOD**	**E** 312410.59 **N** 182235.35	**START** : 2/8/12 **FINISH** : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
			(61.50)			25.00	Lost drilling flush. Standpipes could not go past this zone.

KEY
B - Bulk distrubed sample
D - Small distrubed sample
U - Undistrubed sample
W - Water sample
X - Cuttings sample
c - Coarse grained
m - Medium grained
f - Fine grained
- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.827 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES
LOGGED BY Driller
DATE LOGGED
SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH4

SHEET 3 OF 4

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 60.27 **m AOD**

CO-ORDINATES **E** 312410.59 **N** 182235.35

DATE DRILLED
START : 2/8/12
FINISH : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
							Gravel pack 50mm slotted uPVC

KEY
- B - Bulk distrubed sample
- D - Small distrubed sample
- U - Undistrubed sample
- W - Water sample
- X - Cuttings sample
- c - Coarse grained
- m - Medium grained
- f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 60.827 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 65.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

SITE NAME	DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
Taffs Well Quarry North of Cardiff, South Wales	EQUIPMENT AND METHOD: Fraste XL Multidrill
SITE REF. ST1282	GROUND LEVEL: 60.27 m AOD; CO-ORDINATES: E 312410.59 N 182235.35; DATE DRILLED START : 2/8/12 FINISH : 2/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
	-4.73		65.00				65.00

KEY		NOTES	MONITORING POINT ELEVATION & ID	
B - Bulk distrubed sample D - Small distrubed sample U - Undistrubed sample W - Water sample X - Cuttings sample c - Coarse grained m - Medium grained f - Fine grained	- Water strike 1 - Standing water 1 - Water strike 2 - Standing water 2	Datum level = 60.827 mAOD	Ref. Elev. mAOD	TOTAL DEPTH 65.00 METRES LOGGED BY Driller DATE LOGGED SCALE 1 : 100

Geological Services Department CEMEX UK Operations Ltd	BOREHOLE No. BH5 SHEET 1 OF 3

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 39.12 **m AOD**
CO-ORDINATES **E** 312458.62 **N** 182302.92
DATE DRILLED **START** : 6/8/12 **FINISH** : 6/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
Fractured Limestone	36.32		(2.80) 2.80			0.50	Installed with raised cover
Limestone	35.62		(0.70) 3.50				
Limestone - fractured in some places						20.00	Standpipe could not go through this band; borehole reamed witha 3 inch hammer Bentonite seal 50mm plain uPVC

KEY
- B - Bulk distrubed sample
- D - Small distrubed sample
- U - Undistrubed sample
- W - Water sample
- X - Cuttings sample
- c - Coarse grained
- m - Medium grained
- f - Fine grained
- - Water strike 1
- - Standing water 1
- - Water strike 2
- - Standing water 2

NOTES
Datum level = 39.618 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 50.00 METRES
LOGGED BY Driller
DATE LOGGED
SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH5

SHEET 2 OF 3

SITE NAME
Taffs Well Quarry
North of Cardiff, South Wales

SITE REF. ST1282

DRILLING CONTRACTOR: APEX DRILLING SERVICES LTD
EQUIPMENT AND METHOD: Fraste XL Multidrill

GROUND LEVEL 39.12 **m AOD**

CO-ORDINATES **E** 312458.62 **N** 182302.92

DATE DRILLED
START : 6/8/12
FINISH : 6/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
			(46.50)				Gravel pack 50mm slotted uPVC

KEY
B - Bulk distrubed sample
D - Small distrubed sample
U - Undistrubed sample
W - Water sample
X - Cuttings sample
c - Coarse grained
m - Medium grained
f - Fine grained

- Water strike 1
- Standing water 1
- Water strike 2
- Standing water 2

NOTES
Datum level = 39.618 mAOD

MONITORING POINT ELEVATION & ID
Ref. Elev. mAOD

TOTAL DEPTH 50.00 METRES

LOGGED BY Driller

DATE LOGGED

SCALE 1 : 100

Geological Services Department
CEMEX UK Operations Ltd

BOREHOLE No. BH5

SHEET 3 OF 3

SITE NAME Taffs Well Quarry, North of Cardiff, South Wales	**DRILLING CONTRACTOR:** APEX DRILLING SERVICES LTD **EQUIPMENT AND METHOD:** Fraste XL Multidrill
SITE REF. ST1282	**GROUND LEVEL** 39.12 **m AOD** — **CO-ORDINATES** **E** 312458.62 **N** 182302.92 — **DATE DRILLED** **START** : 6/8/12 **FINISH** : 6/8/12

DESCRIPTION	REDUCED LEVEL (m AOD)	LEGEND	DEPTH & (THICKNESS) (m)	SAMPLE DEPTH (m) & TYPE	WATER STRIKE	MONITOR INSTALL-ATION	
	-10.88		50.00				50.00

KEY		NOTES	MONITORING POINT ELEVATION & ID	
B - Bulk distrubed sample D - Small distrubed sample U - Undistrubed sample W - Water sample X - Cuttings sample c - Coarse grained m - Medium grained f - Fine grained	- Water strike 1 - Standing water 1 - Water strike 2 - Standing water 2	Datum level = 39.618 mAOD	Ref. Elev. mAOD	TOTAL DEPTH 50.00 METRES LOGGED BY Driller DATE LOGGED SCALE 1 : 100

EUROPEAN GEOPHYSICAL SERVICES LTD

Client:	**Cemex / Apex**	Log Type: ***Field Log***
Borehole:	**BH1 - 2012**	

Location: **Taffs Well Quarry** Area: **South Wales** Grid Ref: **ST18** Elevation:

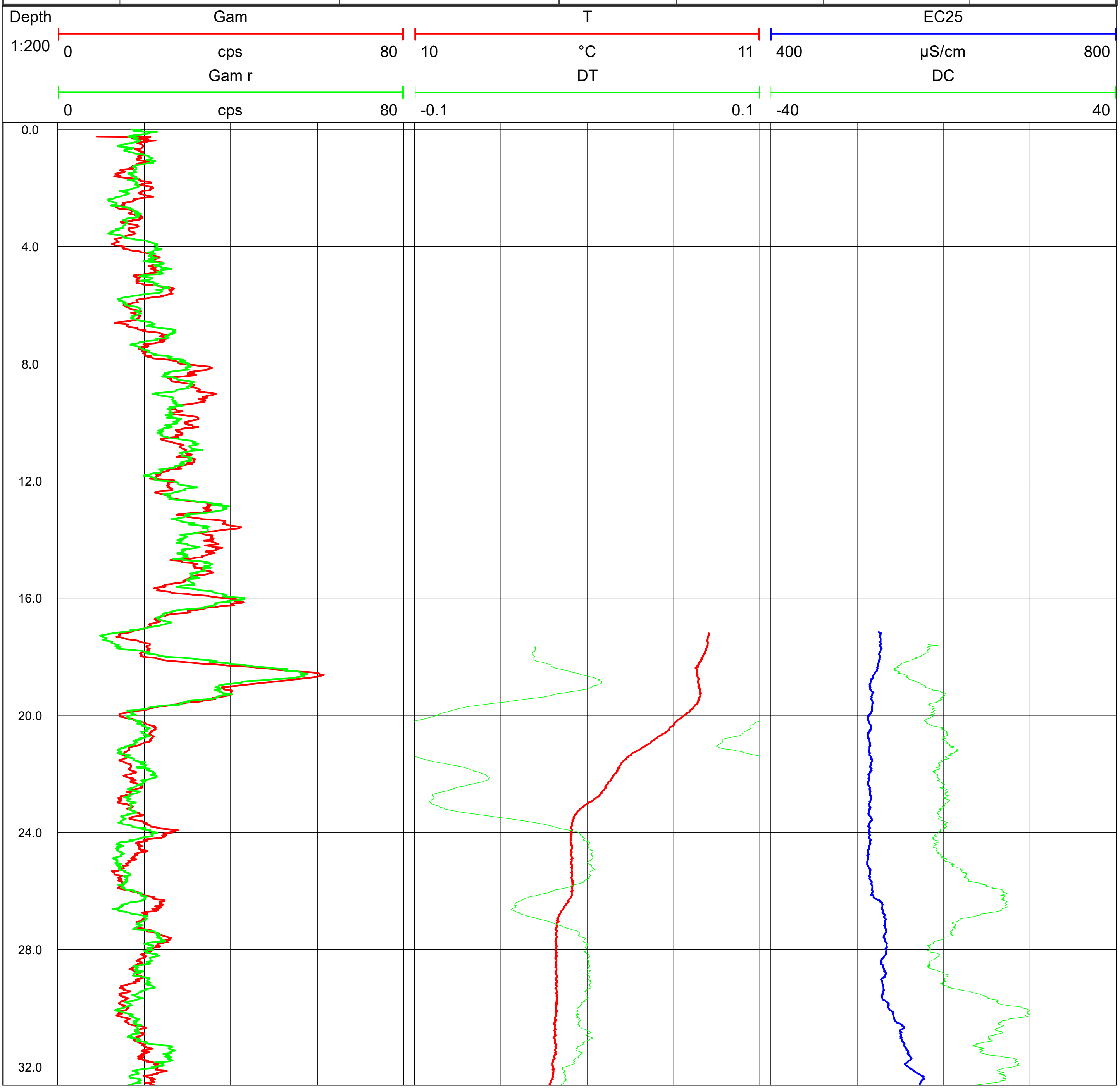
Drilled Depth:	**65m**	Date Logged:	**07.08.12**
Logged Depth:	**64.4m**	Recorded By:	**M. Magill**
Logging Datum:	**Ground Level**	Remarks:	**Lining perforated below ~25m.**
Logged Interval:	**1.32 - 64.4m**		
Fluid Level:	**17.2m**	**Ref:**	**Taffs_quarry_BH1_Field.wcl**

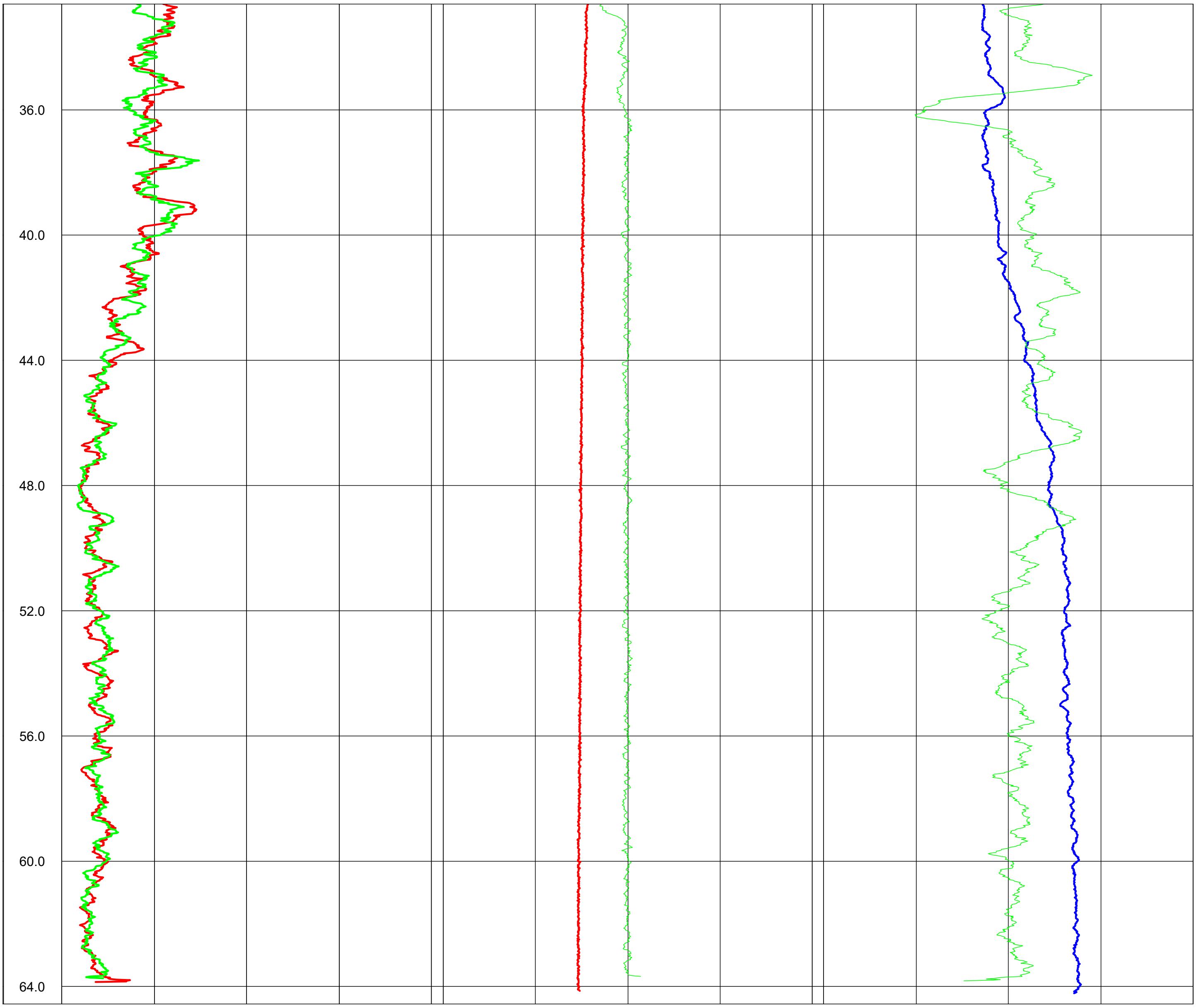
BOREHOLE RECORD

Bit Size:	From:	To:
150mm	**0**	TD

CASING RECORD

Casing Type:	Casing Size:	Casing From:	Casing To:
uPVC	**50mm**	**-0.2m**	**TD**




36.0
40.0
44.0
48.0
52.0
56.0
60.0
64.0

EUROPEAN GEOPHYSICAL SERVICES LTD

Client:	**Cemex / Apex**	Log Type: ***Field Log***
Borehole:	**BH5 - 2012**	

Location: **Taffs Well Quarry** Area: **South Wales** Grid Ref: **ST18** Elevation:

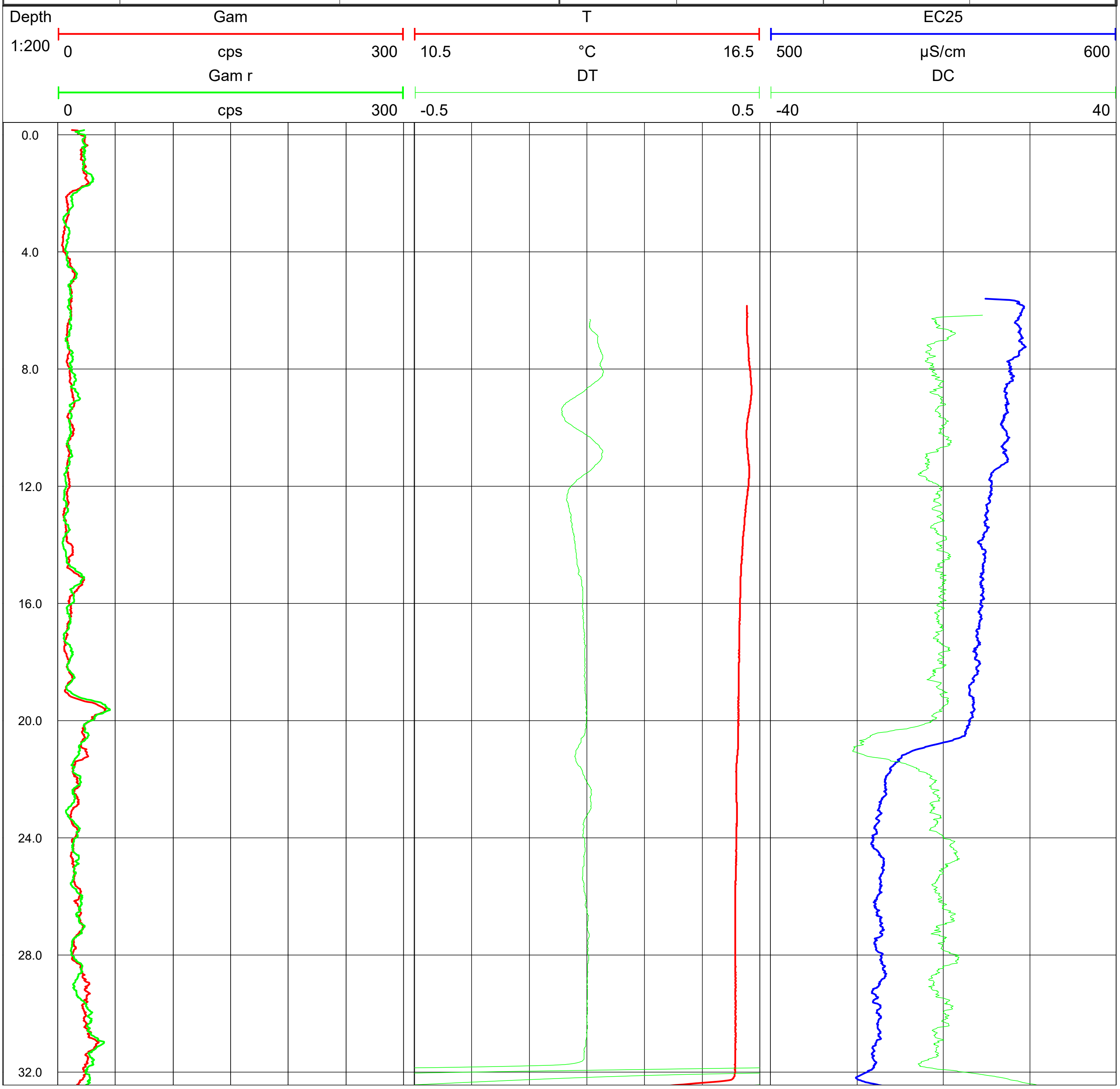
Drilled Depth:	**50.4m**	Date Logged:	**07.08.12**
Logged Depth:	**50.4m**	Recorded By:	**M. Magill**
Logging Datum:	**Ground Level**	Remarks:	**Lining perforated below ~20m.**
Logged Interval:	**0.9 - 50.4m**		
Fluid Level:	**5.8m**	Ref:	**Taffs_quarry_BH5_Field.wcl**

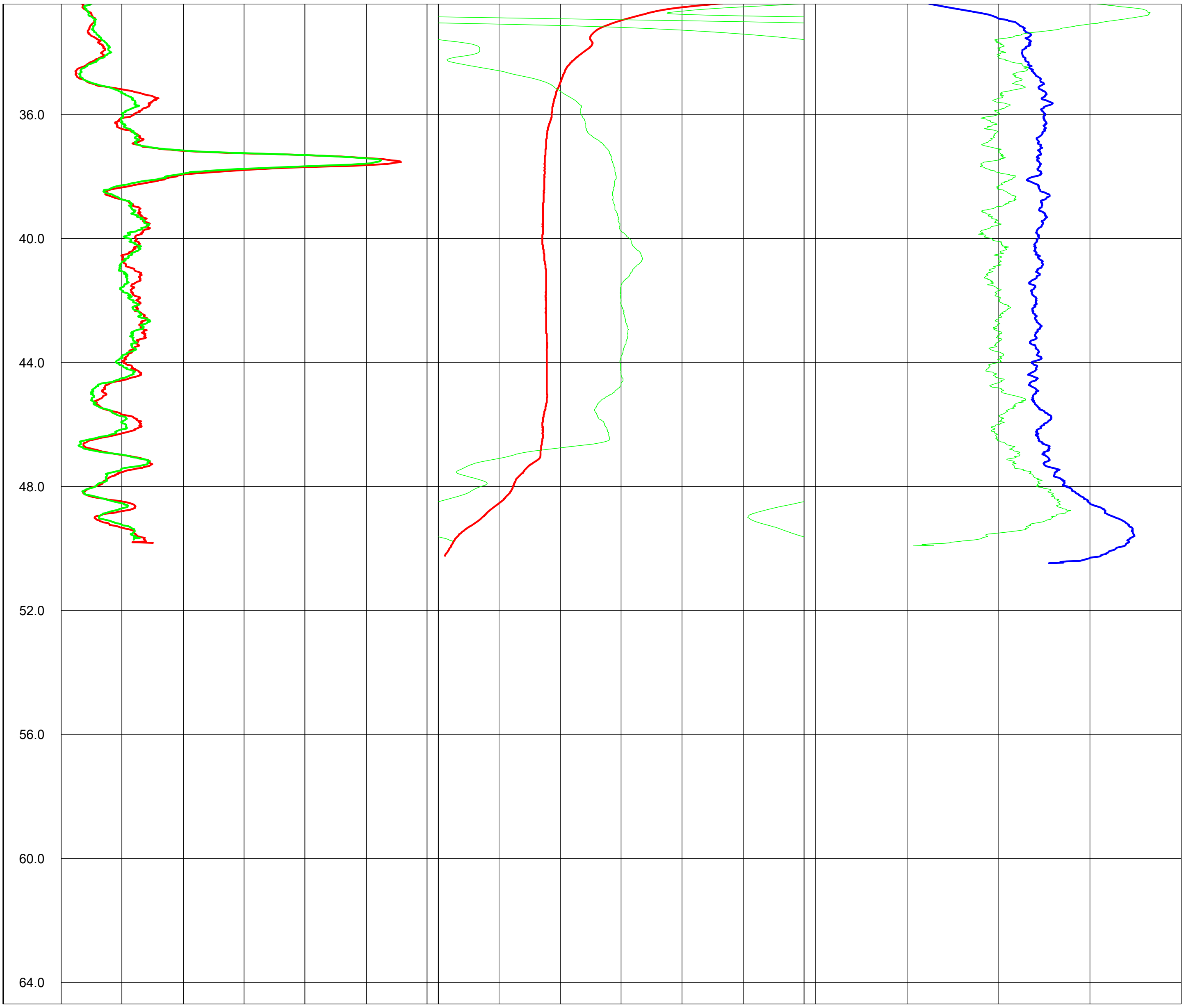
BOREHOLE RECORD

Bit Size:	From:	To:
150mm	**0**	TD

CASING RECORD

Casing Type:	Casing Size:	Casing From:	Casing To:
uPVC	**50mm**	**-0.42m**	**TD**




36.0
40.0
44.0
48.0
52.0
56.0
60.0
64.0

PROJECT:	Taffs Well - Deepening	Borehole No: TW2022-BH6	
DRILLING CONTRACTOR:	Apex Drilling	GRID COORD (E): 3121190.60	GRID COORD (N): 182278.71
DRILLING METHOD:	HQ (62mm) Wireline	DATE STARTED: 20/09/2022	DATE FINISHED: 26/10/2022
DRILLING EQUIPMENT:	Beretta	GROUND LEVEL (mAOD): 46.69	DATUM LEVEL (mAOD): 46.69
CASING:	NR	DEPTH TO FIRST WATER (m):	DEPTH TO FINAL WATER (m):
SAMPLING METHOD:	Cored	LOGGED BY:	S Johnson

DEPTH (m)	Rock Core Data					DESCRIPTION	Thickness (m)	STRATA	LEVEL (mAOD)	DEPTH (m)	INSTALLATION DETAILS AND/OR DRILLING REMARKS
	TCR	Loss (m)	SCR	RQD	Fracture Index						
0–12						Open holed through LST as rock is known to this depth	12		0	0	0.3m raised cover flange set in concrete; Bentonite seal
12–19.3	90	0.10	90	95	9	Extremely strong, partially unweathered, M-C grained, medium bedded, dark grey/black LIMESTONE. Abundant crinoid fragments which characterises the unit. Frequent silica nodules/bands. Frequent calcite mineralisation, minor amounts of red brown clay along SH joints	7.3		-12	12	50mm plain casing with push on top cap
	95	0.05	90	100	8						
	100	0.00	70	100	7				-16	16	
	95	0.05	70	95	11						
	90	0.10	90	85	7						
19.3–27+	90	0.10	90	100	8		35		-20	20	
	90	0.10	40	100	15						
	90	0.10	60	60	31				-24	24	
	95	0.05	75	80	12						
	95	0.05	50	50	19						
	90	0.10	60	60	11						10mm washed gravel filter pack 17.5-50m

PROJECT: Taffs Well - Deepening	Borehole No: TW2022-BH6	
DRILLING CONTRACTOR: Apex Drilling	GRID COORD (E): 3121190.60	GRID COORD (N): 182278.71
DRILLING METHOD: HQ (62mm) Wireline	DATE STARTED: 20/09/2022	DATE FINISHED: 26/10/2022
DRILLING EQUIPMENT: Beretta	GROUND LEVEL (mAOD): 46.69	DATUM LEVEL (mAOD): 46.69
CASING: NR	DEPTH TO FIRST WATER (m):	DEPTH TO FINAL WATER (m):
SAMPLING METHOD: Cored	LOGGED BY: S Johnson	

DEPTH (m)	TCR	Loss (m)	SCR	RQD	Fracture Index	DESCRIPTION	Thickness (m)	LEVEL (mAOD)	DEPTH (m)	INSTALLATION DETAILS AND/OR DRILLING REMARKS
28	100	0.00	80	90	14	Medium strong to strong, distinctly weathered M-C grained, thin to medium bedded, light blue grey LIMESTONE. Fossil fragments are not obvious and mostly absent. Majority of unit is very broken. Red brown soft clay along the majority of joints which penetrate into core in most places. Abundant quartz veining and mineralisation. Core becomes compotent from 51m. Overall much weaker and broken than unit above	35	-28	28	10mm washed gravel filter pack 17.5-50m
30	100	0.00	70	85	25				30	
32	95	0.05	80	75	12			-32	32	
33	95	0.05	60	70	18				33	
35	100	0.00	65	85	16				35	
36	100	0.00	80	85	17			-36	36	
38	95	0.05	85	90	9				38	
39	95	0.05	70	80	14				39	
40	100	0.00	60	85	15			-40	40	
42	90	0.10	50	60	30				42	
43	90	0.10	55	50	35				43	
45	85	0.20	30	40	28			-44	45	50mm slotted screen with filter wrap and end cap
46	90	0.10	70	70	15				46	
48	90	0.10	30	50	11			-48	48	
49	60	0.90	60	60	10				49	
51	100	0.00	85	95	6				51	
52	100	0.00	90	90	16			-52	52	End cap
53	100	0.00	100	100	8				53	
54						EOH			54	
55									55	

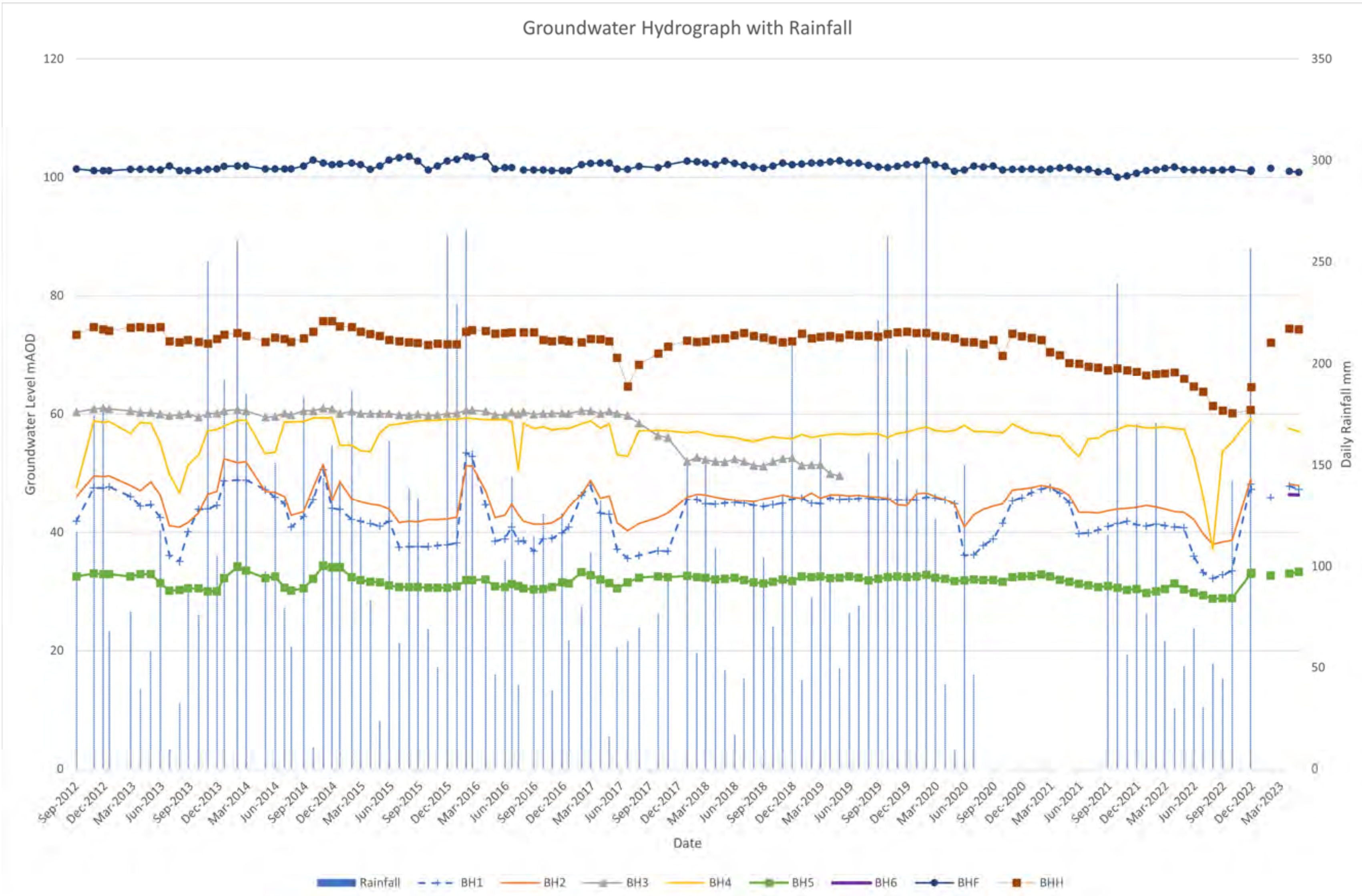
APPENDIX B

Groundwater Level Monitoring Data

Borehole ID	BH1		BH2		BH3		BH4		BH5		BH6		BHF		BHH	
Date drilled	41121		41128		41122		41123		41127		44805		33101		33058	
GL mAOD	60.33		61.086		62.031		60.27		39.118		46.47		178.85		84.78	
Datum mAOD	60.883		61.586		62.531		60.827		39.618				179.94		85.79	
BH Depth m	65		65		65		65		50		60		131.06		34	
BH Base mAOD	-4.67		-3.914		-2.969		-4.73		-10.882		-6		47.79		50.78	

Results	mAOD	mBGL	mAOD	mBGL	mAOD	mBGL	mAOD	mBGL	mAOD	mBGL	mAOD	mBGL	mAOD	mBGL	mAOD	mBGL
Sep-2012	41.883	19	46.086	15.5	60.331	2.2	47.727	13.1	32.618	7	-	-	101.44	78.5	73.49	12.3
Oct-2012	47.583	13.3	49.586	12	60.831	1.7	58.827	2	33.118	6.5	-	-	101.14	78.8	74.79	11
Nov-2012	47.583	13.3	49.486	12.1	61.031	1.5	58.627	2.2	33.018	6.6	-	-	101.14	78.8	74.39	11.4
Dec-2012	47.783	13.1	49.586	12	60.831	1.7	58.727	2.1	33.018	6.6	-	-	101.14	78.8	74.19	11.6
Feb-2013	46.083	14.8	47.986	13.6	60.531	2	56.727	4.1	32.618	7	-	-	101.34	78.6	74.69	11.1
Mar-2013	44.483	16.4	47.086	14.5	60.231	2.3	58.557	2.27	33.018	6.6	-	-	101.34	78.6	74.79	11
Apr-2013	44.683	16.2	48.586	13	60.231	2.3	58.427	2.4	33.018	6.6	-	-	101.34	78.6	74.59	11.2
May-2013	42.483	18.4	46.386	15.2	59.931	2.6	55.127	5.7	31.518	8.1	-	-	101.24	78.7	74.79	11
Jun-2013	36.083	24.8	41.086	20.5	59.731	2.8	49.827	11	30.218	9.4	-	-	101.94	78	72.39	13.4
Jul-2013	35.083	25.8	40.886	20.7	59.831	2.7	46.727	14.1	30.318	9.3	-	-	101.14	78.8	72.19	13.6
Aug-2013	40.083	20.8	41.686	19.9	60.031	2.5	51.427	9.4	30.618	9	-	-	101.14	78.8	72.59	13.2
Sep-2013	43.883	17	43.286	18.3	59.431	3.1	53.127	7.7	30.618	9	-	-	101.14	78.8	72.29	13.5
Oct-2013	43.983	16.9	46.486	15.1	60.031	2.5	57.127	3.7	30.118	9.5	-	-	101.34	78.6	71.99	13.8
Nov-2013	44.583	16.3	46.986	14.6	60.101	2.43	57.397	3.43	30.118	9.5	-	-	101.44	78.5	72.79	13
Dec-2013	48.783	12.1	52.486	9.1	60.531	2	57.927	2.9	32.318	7.3	-	-	101.84	78.1	73.49	12.3
Jan-2014	48.883	12	51.816	9.77	60.731	1.8	58.957	1.87	34.218	5.4	-	-	101.94	78	73.79	12
Feb-2014	48.883	12	51.986	9.6	60.531	2	58.927	1.9	33.618	6	-	-	101.94	78	73.29	12.5
Apr-2014	47.283	13.6	46.986	14.6	59.431	3.1	53.427	7.4	32.318	7.3	-	-	101.44	78.5	72.29	13.5
May-2014	45.983	14.9	46.786	14.8	59.531	3	53.627	7.2	32.618	7	-	-	101.44	78.5	72.99	12.8
Jun-2014	44.883	16	46.086	15.5	60.131	2.4	58.677	2.15	30.718	8.9	-	-	101.44	78.5	72.79	13
Jul-2014	40.883	20	42.886	18.7	59.831	2.7	58.677	2.15	30.218	9.4	-	-	101.44	78.5	72.29	13.5
Aug-2014	42.683	18.2	43.486	18.1	60.531	2	58.727	2.1	30.618	9	-	-	101.94	78	72.89	12.9
Sep-2014	45.583	15.3	47.586	14	60.531	2	59.327	1.5	32.218	7.4	-	-	102.94	77	73.99	11.8
Oct-2014	50.683	10.2	51.586	10	60.931	1.6	59.327	1.5	34.418	5.2	-	-	102.44	77.5	75.79	10
Nov-2014	44.083	16.8	45.386	16.2	60.831	1.7	59.327	1.5	34.118	5.5	-	-	102.14	77.8	75.79	10
Dec-2014	43.883	17	48.586	13	60.031	2.5	54.827	6	34.118	5.5	-	-	102.24	77.7	74.89	10.9
Jan-2015	42.183	18.7	45.686	15.9	60.431	2.1	54.827	6	32.518	7.1	-	-	102.44	77.5	74.79	11
Feb-2015	41.883	19	45.186	16.4	60.031	2.5	53.827	7	32.018	7.6	-	-	102.14	77.8	73.99	11.8
Mar-2015	41.483	19.4	44.786	16.8	60.031	2.5	53.727	7.1	31.718	7.9	-	-	101.34	78.6	73.59	12.2
Apr-2015	41.083	19.8	44.586	17	60.031	2.5	56.827	4	31.618	8	-	-	101.94	78	73.29	12.5
May-2015	41.883	19	43.986	17.6	60.031	2.5	58.127	2.7	31.118	8.5	-	-	102.94	77	72.59	13.2
Jun-2015	37.483	23.4	41.686	19.9	59.831	2.7	58.327	2.5	30.818	8.8	-	-	103.34	76.6	72.39	13.4
Jul-2015	37.583	23.3	41.886	19.7	59.731	2.8	58.627	2.2	30.818	8.8	-	-	103.54	76.4	72.19	13.6
Aug-2015	37.583	23.3	41.786	19.8	59.931	2.6	58.827	2	30.818	8.8	-	-	102.74	77.2	72.09	13.7
Sep-2015	37.583	23.3	42.186	19.4	59.731	2.8	58.877	1.95	30.718	8.9	-	-	101.24	78.7	71.79	14
Oct-2015	37.783	23.1	42.186	19.4	59.831	2.7	58.927	1.9	30.718	8.9	-	-	101.94	78	71.99	13.8
Nov-2015	37.883	23	42.286	19.3	60.031	2.5	59.127	1.7	30.718	8.9	-	-	102.74	77.2	71.89	13.9
Dec-2015	38.183	22.7	42.586	19	60.131	2.4	59.127	1.7	30.918	8.7	-	-	103.04	76.9	71.89	13.9
Jan-2016	53.533	7.35	51.336	10.25	60.631	1.9	59.327	1.5	32.018	7.6	-	-	103.54	76.4	73.99	11.8
Feb-2016	52.883	8	51.286	10.3	60.631	1.9	59.227	1.6	32.018	7.6	-	-	103.34	76.6	74.29	11.5
Mar-2016	44.683	16.2	47.086	14.5	60.431	2.1	59.027	1.8	32.118	7.5	-	-	103.54	76.4	74.09	11.7
Apr-2016	38.483	22.4	42.486	19.1	59.831	2.7	59.027	1.8	30.918	8.7	-	-	101.44	78.5	73.69	12.1
May-2016	38.883	22	42.886	18.7	59.831	2.7	59.027	1.8	30.818	8.8	-	-	101.64	78.3	73.79	12
Jun-2016	40.883	20	44.786	16.8	60.331	2.2	58.727	2.1	31.318	8.3	-	-	101.64	78.3	73.89	11.9
Jul-2016	38.463	22.42	43.036	18.55	59.931	2.6	50.627	10.2	31.018	8.6	-	-	-	-	-	-
Jul-2016	38.583	22.3	41.886	19.7	60.331	2.2	58.427	2.4	30.618	9	-	-	101.24	78.7	73.89	11.9
Aug-2016	36.783	24.1	41.386	20.2	59.931	2.6	57.527	3.3	30.418	9.2	-	-	101.24	78.7	73.89	11.9
Sep-2016	38.883	22	41.386	20.2	60.031	2.5	57.827	3	30.518	9.1	-	-	101.24	78.7	72.59	13.2
Oct-2016	38.983	21.9	41.586	20	60.131	2.4	57.327	3.5	30.818	8.8	-	-	101.14	78.8	72.39	13.4
Nov-2016	39.883	21	42.686	18.9	60.131	2.4	57.527	3.3	31.618	8	-	-	101.14	78.8	72.59	13.2
Dec-2016	40.883	20	44.286	17.3	60.031	2.5	57.527	3.3	31.468	8.15	-	-	101.14	78.8	72.39	13.4
Jan-2017	46.283	14.6	46.486	15.1	60.531	2	58.327	2.5	33.318	6.3	-	-	102.14	77.8	72.19	13.6
Feb-2017	47.983	12.9	48.836	12.75	60.531	2	58.827	2	32.818	6.8	-	-	102.34	77.6	72.79	13
Mar-2017	43.283	17.6	45.786	15.8	60.031	2.5	57.577	3.25	32.118	7.5	-	-	102.44	77.5	72.69	13.1
Apr-2017	43.083	17.8	46.186	15.4	60.431	2.1	58.327	2.5	31.518	8.1	-	-	102.44	77.5	72.39	13.4
May-2017	37.133	23.75	41.596	19.99	60.031	2.5	53.177	7.65	30.618	9	-	-	101.44	78.5	69.59	16.2
Jun-2017	35.583	25.3	40.286	21.3	59.731	2.8	52.977	7.85	31.618	8	-	-	101.34	78.6	64.69	21.1
Aug-2017	36.083	24.8	41.486	20.1	58.431	4.1	57.157	3.67	32.418	7.2	-	-	101.84	78.1	68.39	17.4
Oct-2017	36.883	24	42.486	19.1	56.331	6.2	57.227	3.6	32.618	7	-	-	101.64	78.3	70.29	15.5
Nov-2017	36.783	24.1	43.286	18.3	56.031	6.5	57.127	3.7	32.518	7.1	-	-	102.14	77.8	71.49	14.3
Jan-2018	45.583	15.3	45.986	15.6	52.031	10.5	56.827	4	32.718	6.9	-	-	102.74	77.2	72.49	13.3
Feb-2018	45.583	15.3	46.486	15.1	52.731	9.8	57.027	3.8	32.518	7.1	-	-	102.64	77.3	72.29	13.5
Mar-2018	44.883	16	46.386	15.2	52.331	10.2	56.727	4.1	32.418	7.2	-	-	102.44	77.5	72.39	13.4
Apr-2018	44.783	16.1	45.986	15.6	52.031	10.5	56.327	4.5	32.118	7.5	-	-	102.14	77.8	72.79	13
May-2018	44.983	15.9	45.686	15.9	51.931	10.6	56.227	4.6	32.218	7.4	-	-	102.74	77.2	72.89	12.9
Jun-2018	45.083	15.8	45.386	16.2	52.431	10.1	56.027	4.8	32.418	7.2	-	-	102.34	77.6	73.39	12.4
Jul-2018	44.983	15.9	45.386	16.2	52.031	10.5	55.627	5.2	32.018	7.6	-	-	102.04	77.9	73.79	12
Aug-2018	44.583	16.3	45.186	16.4	51.331	11.2	55.427	5.4	31.618	8	-	-	101.74	78.2	73.29	12.5
Sep-2018	44.383	16.5	45.686	15.9	51.231	11.3	55.827	5	31.418	8.2	-	-	101.54	78.4	72.99	12.8
Oct-2018	44.683	16.2	45.986	15.6	52.031	10.5	56.127	4.7	31.718	7.9	-	-	101.94	78	72.59	13.2
Nov-2018	44.983	15.9	46.386	15.2	52.531	10	55.927	4.9	32.118	7.5	-	-	102.44	77.5	72.19	13.6
Dec-2018	45.683	15.2	45.986	15.6	52.631	9.9	55.827	5	31.818	7.8	-	-	102.14	77.8	72.39	13.4
Jan-2019	45.783	15.1	45.786	15.8	51.331	11.2	56.527	4.3	32.618	7	-	-	102.24	77.7	73.69	12.1
Feb-2019	44.983	15.9	46.686	14.9	51.431	11.1	56.027	4.8	32.518	7.1	-	-	102.44	77.5	72.89	12.9
Mar-2019	44.883	16	45.786	15.8	51.531	11	56.327	4.5	32.618	7	-	-	102.44	77.5	73.09	12.7
Apr-2019	45.883	15	46.386	15.2	49.931	12.6	56.527	4.3	32.318	7.3	-	-	102.64	77.3	73.29	12.5
May-2019	45.583	15.3	46.386	15.2	49.631	12.9	56.627	4.2	32.418	7.2	-	-	102.84	77.1	72.99	12.8
Jun-2019	45.683	15.2	46.186	15.4	-	-	56.527	4.3	32.618	7	-	-	102.44	77.5	73.49	12.3
Jul-2019	45.783	15.1	46.286	15.3	-	-	56.527	4.3	32.418	7.2	-	-	102.44	77.5	73.29	12.5
Aug-2019	45.783	15.1	46.086	15.5	-	-	56.627	4.2	31.918	7.7	-	-	102.04	77.9	73.39	12.4
Sep-2019	45.583	15.3	45.986	15.6	-	-	56.627	4.2	32.218	7.4	-	-	101.74	78.2	73.19	12.6
Oct-2019	45.683	15.2	45.786	15.8	-	-	56.027	4.8	32.518	7.1	-	-	101.64	78.3	73.59	12.2
Nov-2019	45.483	15.4	44.686	16.9	-	-	56.727	4.1	32.618	7	-	-	101.84	78.1	73.89	11.9
Dec-2019	45.483	15.4	44.586	17	-	-	56.927	3.9	32.518	7.1	-	-	102.14	77.8	73.99	11.8
Jan-2020	45.483	15.4	46.586	15	-	-	57.427	3.4	32.618	7	-	-	102.14	77.8	73.79	12
Feb-2020	45.983	14.9	46.686	14.9	-	-	57.827	3	32.918	6.7	-	-	102.84	77.1	73.79	12
Mar-2020	45.883	15	46.086	15.5	-	-	57.227	3.6	32.418	7.2	-	-	102.14	77.8	73.29	12.5
Apr-2020	45.483	15.4	45.586	16	-	-	57.027	3.8	32.218	7.4	-	-	101.84	78.1	73.19	12.6
May-2020	44.883	16	44.786	16.8	-	-	57.227	3.6	31.818	7.8	-	-	101.04	78.9	72.89	12.9
Jun-2020	36.113	24.77	40.916	20.67	-	-	58.077	2.75	31.918	7.7	-	-	101.24	78.7	72.29	13.5
Jul-2020	36.183	24.7	42.986	18.6	-	-	57.027	3.8	32.118	7.5	-	-	101.94	78	72.19	13.6
Aug-2020	37.783	23.1	43.886	17.7	-	-	57.027	3.8	32.018	7.6	-	-	101.74	78.2	71.89	13.9
Sep-2020	38.883	22	44.486	17.1	-	-	56.927	3.9	32.018	7.6	-	-	101.94	78	72.59	13.2
Oct-2020	41.583	19.3	44.836	16.75	-	-	56.827	4	31.718	7.9	-	-	101.24	78.7	69.94	15.85
Nov-2020	45.383	15.5	47.186	14.4	-	-	58.327	2.5	32.518	7.1	-	-	101.34	78.6	73.64	12.15
Dec-2020	45.883	15	47.386	14.2	-	-	57.527	3.3	32.618	7	-	-	101.34	78.6	73.24	12.55
Jan-2021	46.783	14.1	47.586	14	-	-	56.827	4	32.668	6.95	-	-	101.44	78.5	72.94	12.85
Feb-2021	47.383	13.5	47.986	13.6	-	-	56.707	4.12	32.968	6.65	-	-	101.24	78.7	72.59	13.2
Mar-2021	47.643	13.24	47.706	13.88	-	-	56.387	4.44	32.598	7.02	-	-	101.39	78.55	70.55	15.24
Apr-2021	46.663	14.22	47.336	14.25	-	-	56.247	4.58	32.078	7.54	-	-	101.56	78.38	70.02	15.77
May-2021	45.003	15.88	46.316	15.27	-	-	54.577	6.25	31.718	7.9	-	-	101.62	78.32	68.68	17.11
Jun-2021	39.773	21.11	43.396	18.19	-	-	52.907	7.92	31.388	8.23	-	-	101.3	78.64	68.56	17.23
Jul-2021	39.883	21	43.386	18.2	-	-	55.827	5	31.118	8.5	-	-	101.34	78.6	68.09	17.7
Aug-2021	40.383	20.5	43.286	18.3	-	-	55.927	4.9	30.818	8.8	-	-	100.94	79	67.89	17.9
Sep-2021	40.983	19.9	43.686	17.9	-	-	57.027	3.8	31.018	8.6	-	-	101.04	78.9	67.49	18.3
Oct-2021	41.483	19.4	43.986	17.6	-	-	57.327	3.5	30.718	8.9	-	-	100.04	79.9	67.79	18
Nov-2021	41.883	19	44.086	17.5	-	-	58.027	2.8	30.318	9.3	-	-	100.24	79.7	67.49	18.3
Dec-2021	41.283	19.6	44.236	17.35	-	-	57.927	2.9	30.518	9.1	-	-	100.69	79.25	67.19	18.6
Jan-2022	41.083	19.8	44.586	17	-	-	57.627	3.2	29.818	9.8	-	-	101.14	78.8	66.59	19.2
Feb-2022	41.383	19.5	44.286	17.3	-	-	57.727	3.1	30.118	9.5	-	-	101.24	78.7	66.79	19
Mar-2022	41.133	19.75	43.986	17.6	-	-	57.827	3	30.518	9.1	-	-	101.54	78.4	66.89	18.9
Apr-2022	40.903	19.98	43.486	18.1	-	-	57.527	3.3	31.468	8.15	-	-	101.74	78.2	67.09	18.7
May-2022	40.783	20.1	43.386	18.2	-	-	57.427	3.4	30.418	9.2	-	-	101.29	78.65	65.99	19.8
Jun-2022	35.983	24.9	42.186	19.4	-	-	52.927	7.9	29.868	9.75	-	-	101.24	78.7	64.69	21.1
Jul-2022	33.283	27.6	39.686	21.9	-	-	46.027	14.8	29.418	10.2	-	-	101.24	78.7	63.79	22
Aug-2022	32.283	28.6	37.986	23.6	-	-	37.127	23.7	28.868	10.75	-	-	101.19	78.75	61.39	24.4
Sep-2022	32.883	28	38.386	23.2	-	-	53.827	7	28.918	10.7	-	-	101.24	78.7	60.59	25.2
Oct-2022	33.583	27.3	38.636	22.95	-	-	55.377	5.45	28.918	10.7	-	-	101.34	78.6	60.14	25.65
Nov-2022	48.183	12.7	49.086	12.5	-	-	59.277	1.55	33.068	6.55	-	-	101.04	78.9	60.69	25.1
Dec-2022	47.333	-	48.486	-	-	-	58.937	-	33.218	-	-	-	101.24	178.85	64.541	20.239
Jan-2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb-2023	45.943	-	46.816	-	-	-	58.117	-	32.758	-	-	-	101.54	77.31	72.171	12.609
Mar-2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr-2023	47.883	-	48.186	-	-	-	57.527	-	33.118	-	46.47		101.04	77.81	74.491	10.289
May-2023	47.333	-	47.986	-	-	-	57.027	-	33.418	-	46.37		100.84	78.01	74.391	10.389

	BH1		BH2		BH3		BH4		BH5		BH6		F		H	
Minimum	32.283	7.35	37.986	9.1	49.631	1.5	37.127	1.5	28.868	5.2	46.37	0	100.04	76.4	60.14	10
Average	42.77804	18.25101	45.1625	16.51445	58.17996	4.351039	56.51724	4.356303	31.77572	7.887731	46.42	0	101.7798	78.95426	71.71487	14.04202
Maximum	53.533	28.6	52.486	23.6	61.031	12.9	59.327	23.7	34.418	10.75	46.47	0	103.54	178.85	75.79	25.65
Range	21.25	21.25	14.5	14.5	11.4	11.4	22.2	22.2	5.55	5.55	0.1	0	3.5	102.45	15.65	15.65


Groundwater Hydrograph with Rainfall
Groundwater Level mAOD
Daily Rainfall mm
Date
0
20
40
60
80
100
120
0
50
100
150
200
250
300
350
Sep-2012
Dec-2012
Mar-2013
Jun-2013
Sep-2013
Dec-2013
Mar-2014
Jun-2014
Sep-2014
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Jun-2021
Sep-2021
Dec-2021
Mar-2022
Jun-2022
Sep-2022
Dec-2022
Mar-2023
Rainfall
BH1
BH2
BH3
BH4
BH5
BH6
BHF
BHH

APPENDIX C

Correspondence with Natural Resources Wales

Cyfoeth Naturiol Cymru
Natural Resources Wales

Ein cyf/Our ref: CAS-25294-Q6G0
Eich cyf/Your ref:16/02483/MJR

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Ebost/Email:
southeastplanning@cyfoethnaturiolcymru.gov.uk
Ffôn/Phone: (0300) 0655027

Cardiff County Council
County Hall
Atlantic Wharf
Cardiff
CF10 4UW

Dyddiad/Date 15th November 2016

Annwyl Syr/Madam / Dear Sir/Madam

DISCHARGE OF CONDITION 29 (HYDRO GEOLOGICAL ASSESSMENT) OF PLANNING PERMISSIONS 3040 AND T56/90/0867 AT CEMEX UK MATERIALS LTD TAFFS WELL QUARRY, HEOL GOCH, PENTYRCH, CARDIFF, CF15 9PN

Thank you for referring the above planning application consultation, which was received by us on 26th October 2016 and for forwarding the decision notice for 3040. We assume the wording of condition 29 for planning permission T56/90/0867 is the same as for 3040. If it is different please let us know, forwarding a copy of the decision notice.

NRW advises against the discharge of condition 29 (Hydro Geological Assessment) of planning permissions 3040 and T56/90/0867 at Cemex UK Materials Ltd, Taffs Well Quarry, Heol Goch, Pentyrch, Cardiff, CF15 9PN.

Our comments are as follows:

We have reviewed the following Information:
1. Planning decision notice for 3040
2. Taffs Well Quarry: Hydrogeological Impact Assessment. Cemex UK Operations Limited, Report Reference: ST1282_TS_040216, February 2016.

There are a number of matters that need further clarification before we are able to comment fully on the discharge of this condition; these are detailed below.

1. What is the current quarry floor depth – is it 50 mAOD?
2. Figure 4 details the location of the old iron workings, but where are the locations of the Big Pit, Little Pit and the Lakes mentioned within the report?
3. How does the iron working and also the lead working mentioned in section 5.7 relate in depth and lateral extent to the quarry workings? Please present this information using cross sections (schematic – i.e. does not have to be scale) and/or maps/plans.

4. Figure 3 only includes the geology on half of the site – the northern section is missing the geology – please can the geology be presented for the whole quarrying area (redline boundary).
5. Table 1 includes the geology in the local area, is this sequence in stratigraphical order and where is the Black Rock Limestone (unit being quarried) within the sequence?
6. Please explain further the perched water body within the upper sequences of strata close to the quarry.
7. What is the likelihood of the old iron (and lead) mine water entering the quarry void and flooding it, as the regional water level is drawn down during dewatering?
8. Table 7 should also include the depth and length of the screened sections (monitored horizon) of all the groundwater monitoring boreholes.
9. Some of the boreholes are located within the quarry void – will they be lost as part of the quarry operations? If lost, will they be replaced?
10. Ongoing monitoring – what are the plans for ongoing monitoring once dewatering commences? Will the abstraction from the sump be monitored on a daily basis? Will the groundwater monitoring continue on a monthly basis?
11. The mitigation measures detailed in table 11 define mitigation measures to be employed if an impact is observed – how will the features be monitored and what will be the criteria for an observed impact?
12. The submitted information contains is no mention of Taffs Well and Ton Mawr SSSI. Consideration needs to be given to the potential impact of the works on this SSSI, in particular the long term stability/visibility/accessibility of the feature (mineralogy).

Please note the following:
In considering some of the above matters, currently, the detail on the base map on all the figures makes seeing the presented information difficult. We therefore advise that where possible, the background detail should be reduced in order to increase the detail being presented.

Pollution Prevention Guidance (PPGs) has been changed to Guidance for Pollution Prevention (GPPs) and can be viewed on NetRegs website using the link, http://www.netregs.org.uk/environmental-topics/pollution-prevention-guidelines-ppgs-and-replacement-series/guidance-for-pollution-prevention-gpps-full-list/

Carboniferous Limestone has been classified as Principal Aquifer by Natural Resources Wales not Primary.

Dewatering from quarrying will cease to be exempt from licensing under the implementation of the Water Act 2003. As you may be aware, a consultation was published earlier this year regarding the intended approach to implementing these changes. The consultation document and summary of responses are available at https://www.gov.uk/government/consultations/water-abstraction-licensing-changes-to-exemptions-in-england-and-wales. We expect a joint consultation response, providing details on the final approach, to be published by early 2017. Post this the Regulations will commence to make the relevant changes to existing exemptions. Once the regulations have been commenced Operators will be required to apply for an abstraction licence. The

Applicant should contact our Water Resources Permitting Team on 0300 065 3016 for further details and advice on making an applications.

Our comments above only relate specifically to matters that are included on our checklist Natural Resources Wales and Planning Consultations (March 2015) which is published on our website at this link (https://naturalresources.wales/planning-and-development/planning-and-development/?lang=en). We have not considered potential effects on other matters and do not rule out the potential for the proposed development to affect other interests, including environmental interests of local importance. The applicant should be advised that, in addition to planning permission, it is their responsibility to ensure that they secure all other permits/consents relevant to their development.

If you have any queries on the above please do not hesitate to contact us.

Yn gywir / Yours faithfully

Annabelle Evans
Ymgynghorydd Cynllunio Datblygu/ Development Planning Advisor
Cyfoeth Naturiol Cymru / Natural Resources Wales
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Ein diben yw sicrhau bod adnoddau naturiol Cymru yn cael eu cynnal, eu gwella a'u defnyddio yn gynaliadwy, yn awr ac yn y dyfodol.

Our purpose is to ensure that the natural resources of Wales are sustainably maintained, enhanced and used, now and in the future.

Your ref: CAS-25294-Q6G0
Our ref: ST1282.TS.NRW.200117

20th January 2017

Ms Annabelle Evans
Development Planning Advisor
Natural Resources Wales
Rivers House
St Mellons Business Park
Fortran Road
Cardiff
CF3 0EY

Dear Ms Evans,

Discharge of Condition 29 (Hydrogeological Assessment) of Planning Permissions 3040 and T56/90/0867 at CEMEX UK Materials Ltd Taffs Well Quarry, Heol Goch, Pentyrch, Cardiff, CF15 9PN.

I refer to your letter to Cardiff County Council dated 15th November 2016 requesting for additional information to support the Hydrogeological Assessment to discharge the above condition.

I have addressed raised issues in the enclosed main report and summarised the responses below:

1. The current quarry floor depth is 45 mAOD within the flooded quarry sump as shown on the enclosed quarry survey carried out in February 2016, drawing number *TWL site MOD 0216 rjj.pdf.*

2. Figure 4 has been updated to show the location of the Big Pit, Little Pit and the lakes referred to in the main report. An additional Figure 4a adapted from Garth Iron Mine Survey by Martyn Farr (2006) showing mine plan and cross sections has been included.

3. Schematic section showing depth of permitted quarry development relative to the adjacent old mine workings taken from Gunn Engineering and Environmental Consultancy (2002) report on Survey of Underground mine workings is shown on Figure 4b.

4. Geological map has been updated to include the northern section, updated Figure 3 is included in the main report.

5. The geological sequence included in table 1 of the main report is in stratigraphical order. The geological unit being quarried at Taffs Well is within the Friars Point Limestone (Upper section of the Black Rock Limestone) and the Barry Harbour Limestone (Lower section of the Black Rock Limestone). Table 1 has been updated to include this information.

6. The perched water body below the Garth Wood SSSI is within the Lesser Garth Cave System which was formed within the High Tor Limestone which lies above the less permeable Caswell Bay Mudstone. The perched water body comprises of pools which are considered to be more than 50m above the 'true' groundwater table (Wardell Armstrong, 1990). This water body within the High Tor Limestone is not considered to be in hydraulic continuity with the underlying Black Rock Limestone quarried at Taffs Well due to the intervening low permeable Caswell Bay Mudstone.

7. The likelihood of old iron mine workings water entering the quarry void and flooding it during quarry deepening is very low due to the following reasons:

    - Recent survey indicated that the old mine workings are dry close to the quarry and become deeper and flooded away from the quarry in a north-westerly direction. The old mine workings followed the dip directions of the strata which trends at 30^{o} – 40^{o} to the north-west.
    - Historically the quarry used to discharge silt laden water from the quarry to the old mine workings. It is likely that silt has built up at the bottom of the mine pits there by reducing their depth and sealing off any fissures at the bottom of the lakes.
    - Quarry benches shall be stepped away from the old mine workings as the quarry is deepened. This increases the distance between the old mine working lakes and the quarry sump thus reducing the likelihood of connecting them.

8. Table 7 has been updated to include the depth and length of the screened sections of groundwater monitoring boreholes.

9. CEMEX intends to maintain the existing monitoring borehole throughout the quarry operations. However, in the event of any borehole on the current monitoring network being lost due to quarry operations, replacement boreholes shall be drilled.

10. Ongoing monitoring shall be continued once dewatering commences. Telemetry flow meter recording daily pumping rates from the sump shall be used. In addition to monthly manual dip measurements, dataloggers measuring hourly groundwater levels will be installed in three boreholes (BH2, 4 and 5) in order to record more frequent groundwater level fluctuations. The dataloggers shall be installed in the next two months to

start collecting detailed background groundwater level fluctuations prior to the commencement of dewatering.

11. The potential impacts and mitigation measures detailed in table 11 are generic for a limestone quarry and most of these do not apply at Taffs Well Quarry as most receptors (springs, abstractions, etc) are outside the dewatering drawdown zone of influence. Quarry operations adhere to CEMEX's Environmental Management System (EMS) and best practices which are monitored through regular internal and external Environmental audits. Taffs Well quarry is ISO14001 certified site and best operational practices shall be continued during the entire lifespan of the quarry. Potential impacts from discharge of water from the quarry shall be monitored through ongoing water sampling and analysis to demonstrate compliance with discharge permit conditions on suspended solids, pH and oils outlined on the permit by Natural Resources Wales.

12. Taffs Well and Ton Mawr SSSI relating to the exposure of mineralisation on quarry faces will not be impacted by the proposed quarry deepening. The deepening of the quarry will expose more quarry faces which could potentially reveal more layers of geological interest. The quarry workings are progressively exposing more mineralisation dominated by dolomitisation i.e the primary calcite [calcium carbonate –$CaCO_3$] being altered over time to dolomite (calcium magnesium carbonate – $CaMg[CO_3]_2$). The already exposed mineralisation on the on the quarry faces shall be preserved, the quarry designs for future quarry development (see Figure 15) have given due consideration to ensure long term stability, visibility and accessibility of the mineral exposures.

I trust this response adequately addresses the issues raised in your letter. However, I shall be happy to address any outstanding issues you might have.

Yours sincerely

Tenant Sibanda
Principal Hydrogeologist

cc S Denny, CEMEX UK Materials Limited
D Goodman, CEMEX UK Materials Limited

Your ref: CAS-28949-V2Y9
Our ref: ST1282.TS.NRW.070317

7th March 2017

Ms Annabelle Evans
Development Planning Advisor
Natural Resources Wales
Rivers House
St Mellons Business Park
Fortran Road
Cardiff
CF3 0EY

Dear Ms Evans,

Discharge of Condition 29 (Hydrogeological Assessment) of Planning Permissions 3040 and T56/90/0867 at CEMEX UK Materials Ltd Taffs Well Quarry, Heol Goch, Pentyrch, Cardiff, CF15 9PN.

Thank you very much for your letter dated 1st March 2017 and follow up telephone conversation on 6th March 2017 in response to the additional information supplied in support of discharge of the above condition.

As discussed, the assessment which was carried out in fulfilling parts A and B of the planning condition did not identify any water features which could be impacted by deepening the quarry from 45mAOD to 30mAOD. There are no receptors within the vicinity of the quarry which would require any form of mitigation as a result of quarry dewatering to a level of 30mAOD.

Groundwater monitoring shall be continued on a monthly basis and on hourly basis for three selected boreholes on the monitoring network. These levels shall be used to demonstrate that groundwater levels will not go below 30mAOD. I am suggesting that we set trigger levels in BH2 and BH4 which have been installed with dataloggers to record hourly groundwater levels. In case of groundwater levels in any of the boreholes reaching the 30mAOD trigger level, dewatering shall be stopped temporarily allowing groundwater levels to recover before proceeding.

It is proposed to set warning and action trigger levels for monitoring boreholes BH2 and BH4 which are on the edge of the quarry excavation and are unlikely to be affected by the ongoing quarry development. Should the warning levels be reached in either of boreholes BH2 and BH4 this would trigger controlled dewatering to ensure that water levels are not dropped below 30mAOD in any of the boreholes.

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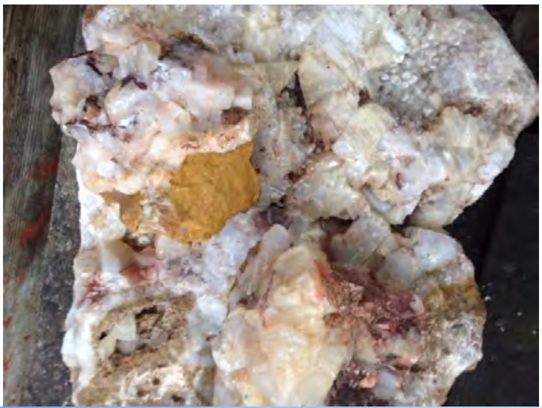
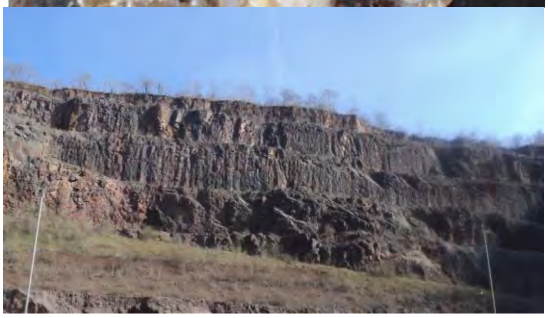
Table 1: Groundwater triggers levels

Borehole	BH2	BH4
Warning level (mAOD)	30.5	30.5
Action level (mAOD)	30.0	30.0

With regards to Taffs Well and Ton Mawr SSSI, the northern and north-eastern quarry faces have been worked to the full lateral extent so these will not change due to future quarry developments. These quarry faces expose dolomitic limestone and veins of spectacular crystals of calcite from which the SSSI designation was based on. Some pictures of worked out quarry faces and rock specimens from these faces are shown below:



I trust this clarifies issues raised in your letter. I am happy to discuss the above with your Groundwater Technical team if there are any further clarifications required.

Yours sincerely,

Tenant Sibanda
Principal Hydrogeologist

cc S Denny, CEMEX UK Materials Limited
D Goodman, CEMEX UK Materials Limited

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Ein cyf/Our ref: CAS-30417-W6V7
Eich cyf/Your ref: ST1282.TS.NRW.070317

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16 March 2017

Annwyl Syr/Madam / Dear Sir/Madam

DISCHARGE OF CONDITION 29 (HYDRO GEOLOGICAL ASSESSMENT) OF PLANNING PERMISSIONS 3040 AT CEMEX UK MATERIALS LTD TAFFS WELL QUARRY, HEOL GOCH, PENTYRCH, CARDIFF, CF15 9PN

Thank you for referring additional information regarding the above discharge of condition, which was received by us on 7th March 2017.

In our previous letter dated 1st March we advised that the information submitted at that time satisfied parts A and B of the condition and that part E is a rolling condition for review every 5 years but that it was not appropriate to discharge parts C and D.

We have reviewed the additional information submitted to us in your letter dated 7th March 2017 entitled *'Discharge of Condition 29 (Hydrogeological Assessment) of Planning Permissions 3040 and T56/90/0867 at CEMEX UK Materials Ltd Taffs Well Quarry, Heol Goch, Pentyrch, Cardiff, CF15 9PN*'. We would advise you that, in terms of parts C and D of condition 29, we note the trigger and action levels set for BH2 and BH4 and the measure to be undertaken if these are exceeded. Having regard to this we have no further comment and would not object to the discharge of condition 29 should we be asked to comment on it further by the mineral authority.

Please note part E of this condition required regular reviews every 5 years.

With regard to the additional information relating to the Taffs Well and Ton Mawr SSSI, thank you for confirming that the northern and north-eastern quarry faces will not change due to future quarry developments.

In order to discharge condition 29 we would advise you that you will need to apply to the mineral authority submitting all information you have provided to us. You may also wish to provide the mineral authority with copies of all our correspondence to reflect our dialogue.

If you have any queries on the above please do not hesitate to contact us.

Yn gywir / Yours faithfully

Annabelle Evans
Ymgynghorydd Cynllunio Datblygu/ Development Planning Advisor
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Ein diben yw sicrhau bod adnoddau naturiol Cymru yn cael eu cynnal, eu gwella a'u defnyddio yn gynaliadwy, yn awr ac yn y dyfodol.

Our purpose is to ensure that the natural resources of Wales are sustainably maintained, enhanced and used, now and in the future.

APPENDIX D

Abstraction License and Discharge Permits

Licensed Groundwater Abstractions						
Licence number	Licence holder name	Use	Annual Qty m^3	Source type*	NGR	Distance from Site
21/57/25/0047	Breedon Trading Group	General use Dust suppression Mineral washing	136,380	GW:-	ST 1184 8235	Within the Site
21/57/25/0075	Tarmac Aggregates Ltd.	Process Water	33,000	GW: Borehole	ST 1248 8292	82m east
21/57/25/0023	South Wales Forgemasters Ltd.	Evaporative cooling	163,656	GW: -	ST 1260 8323	0.4km northeast
WA/057/0025/0014	Rhondda Cynon Taf County Borough Council	Heat pump	27,466.44	GW: Spring	ST 11925 83639	0.86km north
21/57/25/0080	Radyr Golf Club	Spray irrigation	15,750	GW: Borehole	ST 12383 80291	1.56km south
21/57/25/0066	Whitechurch (Cardiff) Golf Club	Make up or top up water	4546	GW: Borehole	ST 14873 81384	2.15km southeast
*GW – groundwater						

Private Water Supplies					
ID	Source	Daily abstraction rate m^3	NGR	Distance from Site	Local authority
289	N/A	N/A	ST 13000 83700	1.01km northeast	Rhondda Cynon Taf
133	N/A	N/A	ST 11100 84600	2.11km northwest	
300	Borehole	N/A	ST 11800 84900	2.12km north	
314	Borehole	N/A	ST 11100 85500		
315	Borehole	N/A	ST 11100 85500		
316	Borehole	N/A	ST 11100 85500		
6	Spring	1.6	ST 09661 83343	2.17km northwest	Vale of Glamorgan
85	N/A	N/A	ST 12500 85200	2.31km north	Rhondda Cynon Taf
25	Stream	N/A	ST 11400 85300	2.62km north	
26	Stream	N/A	ST 11400 85300		
96	N/A	N/A	ST 09600 84200	2.70km northwest	
238	N/A	N/A	ST 10900 85300	2.82km north	
250	N/A	N/A	ST 13800 85400	2.88km northeast	
3	Borehole	0.8	ST 15259 83642	2.9km east	Vale of Glamorgan
292	N/A	N/A	ST 10100 84800	2.92km northwest	Rhondda Cynon Taf

Licensed Surface Water Abstractions						
Licence number	**Licence holder name**	**Use**	**Annual Qty m^3**	**Source**	**NGR**	**Distance from site**
21/57/25/0046	Breedon Southern Limited	Process Water	6819	Nant-y-Forest	ST 13569 82856	1.12km east
WA/057/0025/005	Cardiff Council	Hydroelectric Power Generation	5,13,216,000	Radyr weir	ST 13076 80819	1.26km south
WA/057/0025/009	Cardiff Council	Hydroelectric Power Generation	-	-	ST 13094 80791	1.3km south

Discharge permits within 3km radius of the Site						
Discharge Permit No.	**Permit Holder**	**NGR**	**Discharge Type**	**Receiving waterbody**	**Distance from Site**	**Maximum Discharge**
AN0222302	Breedon Trading Ltd	ST 12720 82270	General Construction site	River Taff	23m east	-
AN0222301	Breedon Trading Ltd	ST 12600 82800	General Construction site	River Taff	122m east	-
KP3520GT	Fairfield Industrial Estate	ST 12547 82914	Industrial estates	Tributary of Taff	144m east	$2m^3/d$
AF4028201	Halladale Investments (London) Ltd	ST 12650 82790	General Construction site	River Taff	166m east	$5m^3/d$
AN0200101	Dwr Cymru Cyfyngedig	ST 12700 82450	Sewerage network – pumping station – water company	River Taff	180m east	-
AB3590FB	Dwr Cymru Cyfyngedig	ST 12938 82318	Sewerage network CSO – water company	Afon Taff	226m east	-
AN0298101	T S Rees Limited	ST 11420 82270	-	Tributary of Nant Dowlais	267m west	14l/s
AF4021301	Short Bros Ltd	ST 12747 81683	Sewage disposal works	Groundwater via infiltration	331m south	$2.73m^3/d$
AG0019001	Mr & Mrs M Brock	ST 12795 81578	Domestic Property (Single)	River Taff tributary	447m south	$1m^3/d$
AN0137501	Dwr Cymru Cyfyngedig	ST 13200 81700	General Construction site	Taff	479m south	-
AN0007701	Dwr Cymru Cyfyngedig	ST 12100 83400	Sewerage network – pumping station – water company	Taff River	592m north	-
AN0319201	Dwr Cymru Cyfyngedig	ST 13174 81536	Sewerage network CSO – water company	River Taff	638m south	-

Discharge permits within 3km radius of the Site						
Discharge Permit No.	Permit Holder	NGR	Discharge Type	Receiving waterbody	Distance from Site	Maximum Discharge
AF4004701	Dwr Cymru Cyfyngedig	ST 13160 81380	Farm industry	Melingriffith Feeder	752m south	-
AN0278601	Ian Gordon Trueman	ST12450 83950	Domestic Property (Single)	Nant y Brynnau	1.05Km north	2m³/d
AF3005001	Dwr Cymru Cyfyngedig	ST13640 81360	Water Treatment Works	Melingriffith Feeder	1.05km southeast	-
BB3299ZH	Forest Tea Room	ST13553 82919	Snack bars & Cafes	Groundwater via infiltration	1.13km east	4.1m³/d
AF4027102	Breedon Southern Limited	ST13700 82950	General Construction site	Nant Y Forest	1.28km east	-
AF4022001	Cardiff City Council	ST 14119 81184	-	River Taff	1.53km southeast	1.18m³/d
AN0022601	Dwr Cymru Cyfyngedig	ST 14160 80880	-	Taff	1.74km southeast	-
AN0316801	Dwr Cymru Cyfyngedig	ST 11070 79870	Sewerage network – Pumping Station – water company	The Nant Dowlias	2km southwest	-
AE2021601	Dwr Cymru Cyfyngedig	ST 11067 79713	Sewerage Disposal works – including a sewage pumping station atteh head of a works	Nant Dowlais	2.06km southwest	792m³/d
AE2021601	Dwr Cymru Cyfyngedig	ST 11067 79713	Sewage Disposal Works – including a sewage pumping station at the head of a works	Nant Dowlais	2.1km southwest	-
AN0110005	Dwr Cymru Cyfyngedig	ST 14260 80200	Sewerage Network - Pumping Station - water company	Taff	2.29km southeast	-
AB3492CP	Mountain View Ranch Ltd	ST 14253 84337	Snack Bars & Cafes	Groundwater via infiltration system	2.37km northeast	4.5m³d
AN0085101	Dwr Cymru Cyfyngedig	ST 12400 85400	Sewerage Network - Pumping Station - water company	Nant Garw	2.5km northeast	-
AE1014801	Cardiff County Council	ST 09800 80100	Sewage Disposal Works – including a sewage pumping station at the head of a works	Tributary of Nant Dowlais	2.63km southwest	5.09m³/d

Discharge permits within 3km radius of the Site						
Discharge Permit No.	**Permit Holder**	**NGR**	**Discharge Type**	**Receiving waterbody**	**Distance from Site**	**Maximum Discharge**
AN0086701	Dwr Cymru Cyfyngedig	ST 14020 79760	Sewerage Network CSO - water company	Taff	2.64km southeast	-
UP3029GL	Four Seasons Healthcare Limited	ST 09897 79942	Hospitals – hospice, nursing homes (medical)	Tributary of Nant-y-Glaswg	2.66km southwest	20m^3/d
WQD009196	MITCHELLS & BUTLERS PLC	ST 14398 84727	Public Houses and bars	Groundwater via infiltration system	2.75km northeast	9m^3/d
CB3193HL	Alun Fowler	ST 11147 85535	Domestic Property (Multiple)	Nant-y-Gedrys	2.92km north	5.8m^3/d
AN0032201	Dwr Cymru Cyfyngedig	ST 09199 80405	Sewage Disposal Works – including a sewage pumping station at the head of a works	Nant Glaswg	2.99km southwest	2,223m^3/d
- data not provided						

APPENDIX E

Groundwater Inflow Calculations

Radius of Influence Calculation

$$H = \sqrt{h_s^2 + \frac{P}{K_{h1}}\left[R_0^2 \ln\left(\frac{R_0}{r_w}\right) - \frac{R_0^2 - r_w^2}{2}\right]}$$

The following assumptions apply to this equation
- steady-state, unconfined, horizontal radial flow
- uniformly distributed recharge at the water table
- pit walls are approximated as a right circular cylinder
- the static water table is horizontal
- groundwater flow is horizontal
- groundwater flow to the pit is axially symmetric

(Niccoli et al, 1998)

Input Parameters

Parameter		Value	Justification
Height of water table at radius of influence (m)	H	56, 38,32	Saturated thickness for quarry depths of 18mAOD (32m), 12mAOD (38m) and -6mAOD (56m)
Saturated thickness to seepage face (m)	h_s	0	Assume dry working conditions
Horizontal hydraulic conductivity (m/d)	K_{h1}	0.001, 0.01, 0.1, 1	Range to account for varying hydraulic conductivity of the limestone
Recharge (m/d)	P	3.1×10^{-4}	Assume 10% of average annual rainfall, see report.
Radius of quarry (m)	r_w	320	Effective radius based on 700m x 450m quarry pit

Results

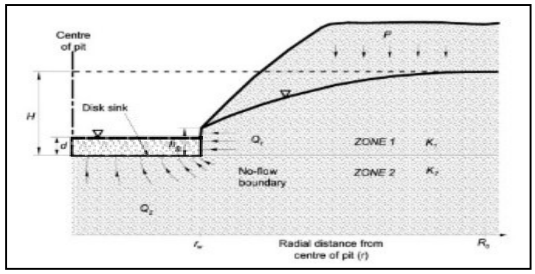
ROI distance (m)				
Depth of quarry mAOD (saturated thickness m)	Hydraulic conductivity m/d			
	0.001	0.01	0.1	1
18 (32)	375.93	488.99	808.56	1676.95
12 (38)	386.12	518.61	890.23	1897.25
-6 (56)	416.18	604.8	1125.73	2532.92

Groundwater Inflow Calculations

Marinelli and Niccoli

$$Q_2 = 4\left(\frac{K_{h2}}{m_2}\right) r_w (H-d)$$

$$Q_1 = P\pi\left(R_0^2 - r_w^2\right)$$



The following assumptions apply to this equation
- There is no groundwater flow between zones 1 and 2

Zone 1
- steady-state, unconfined, horizontal radial flow
- uniformly distributed recharge at the water table
- pit walls are approximated as a right circular cylinder
- initial static water table and groundwater flow are both horizontal
- groundwater flow to the pit is axially symmetric

Zone 2
- steady state flow to one side of a circular disk sink of constant and uniform drawdown
- hydraulic head is initially uniform throughout Zone 2.
- initial head is equal to the elevation of the initial water table in Zone 1
- disk sink has a constant hydraulic head equal to the elevation of the pit lake water surface
- flow to the disk sink is three-dimensional and axially symmetric
- materials are anisotropic, prinicipal directions for K are horizontal and vertical

(Marinelli & Niccoli, 1998)

Input Parameters

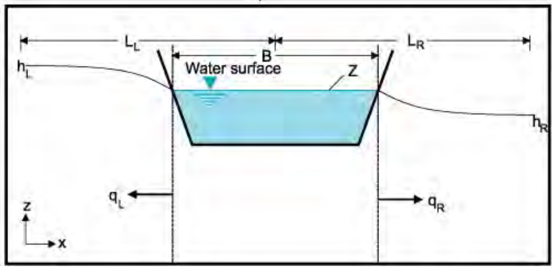
Parameter		Value	Justification
Height of wt at radius of influence (m)	H	56, 38,32	Saturated thickness for quarry depths of 18mAOD (32m), 12mAOD (38m) and -6mAOD (56m)
Depth of Ponded Area (m)	d	0	Assume no seepage, dry working
Horizontal Conductivity (m/s)	K_{h2}	1.16×10^{-8}, 1.16×10^{-7}, 1.16×10^{-6}, 1.16×10^{-5}	Range to account for varying hydraulic conductivity of the limestone (equivalent o 0.001, 0.01, 0.1 and 1m/d)
Vertical Conductivity (m/s)	K_{v2}	Calculated	Calculated as 10% of the respective horizontal conductivity values used in equation
Distributed recharge (m/s)	P	3.6×10^{-9}	Assume 10% of average annual rainfall, see report. Equivalent to 3.1×10^{-4} m/d.
Radius of quarry (m)	r_w	320	Effective radius based on 700m x 450m quarry pit
Radius of influence (m)	R_o	As calculated	Calculated using Niccoli 1998 ROI equation

Results

Groundwater Inflow (m^3/d)				
Depth of quarry mAOD (saturated thickness m)	Hydraulic conductivity m/d			
	0.001	0.01	0.1	1
18 (32)	51	263.1	1834	15,600.60
12 (38)	61	316.6	2212.5	18,798.60
-6 (56)	91.9	484	3405	28,836.30

Leaky River Aquifer Calculation

$$q = \frac{Tl(Z - hl)}{Ll - (B/2)} + \frac{Tr(Z - hr)}{Lr - (B/2)}$$



The following assumptions apply to this equation
- the aquifer is unconfined
- the aquifer has infinite areal extent
- the aquifer is homogeneous, and of uniform thickness
- there is only a small water table gradient
- steady state conditions have been reached
- groundwater heads are measured at a distance outside the channel
- there is full penetration of the aquifer by the channel i.e. there is no vertical flow from the base of the channel

Input Parameters

Parameter		Value	Justification
Surface-water elevation in the channel	Z	30	Height of River Taff at 30mAOD
Top width of the channel	B	25	Measured width of River Taff from OS map
Distance from centre of channel	L_L	210	Measured distance from the edge of the quarry excavation to the centre of the River Taff at the closest point
Height of water table on LHS of channel	h_L	28, 22, 4	Height of water table for descending quarry floor at 18mAOD, 12mAOD and -6mAOD
Transmissivity on LHS of channel	T_L	4, 63, 130	Transmissivity for south Wales 4 to 130m2d-, median of 63
Distance from centre of channel	L_R	-	Not applicable
Height of water table on RHS of channel	h_R	-	Not applicable
Transmissivity on RHS of channel	T_R	-	Not applicable
Length of channel for which flow occurs	x	600	Approximate length of River Taff adjacent to excavation

Results

Leaky River Aquifer Inflow (m^3/d)			
Depth of quarry mAOD	Transmissivity m2/d		
	4	63	130
18	145.82	2296.71	4739.24
12	218.73	3445.06	7108.86
-6	437.47	6890.13	14217.72

Rainfall into quarry void

The nearest Met Office with rainfall data to the site is Rhiwbina rainfall gauging station, which is approximately 2.5km east of the site.

For the current standard period1 2010 - 2020, average rainfall (mm). The average annual rainfall is 1271.5mm.

There are 365 days in a year, therefore on average the amount of rainfall per day is 3.48mm.

1271.5/365 = 3.48356164 mm or 0.00348356 m

The catchment area (quarry void area at phase -6mAOD) is approximatey 36ha or 366,355m2

Therefore, the maximum daily rainfall to fall within the quarry void is 1275m3

0.003m x 366355m2 = 1276.22023 m3 /d o 1276220.23 l/d 0.24618446 l/s

For the purpose of the maximum daily discharge volume calculations it has been assumed that all rainwater that falls within the quarry will be abstracted and therefore would be discharged.

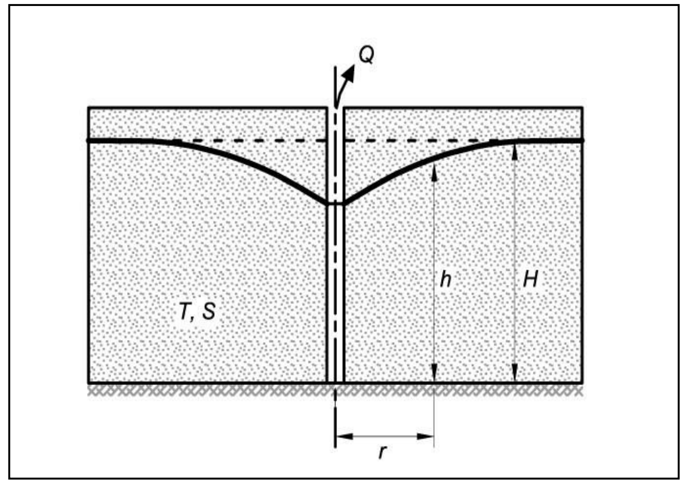
The calculations have not taken into account evaporation or rainfall that is intercepted by the drainage system, hard standing and building roofs.

APPENDIX F

Impact Assessment Drawdown at Receptor

Cooper Jacob Calculations

$$Q = \frac{4\pi Ts}{2.3\log\left(\frac{2.25Tt}{r^2 S}\right)}$$



The following assumptions apply to this equation

- the aquifer is unconfined
- the aquifer has infinite areal extent
- the aquifer is homogeneous, and of uniform thickness
- flat initial water table
- the aquifer is pumped at a constant discharge rate
- the water removed from storage is discharged instantaneously with decline of head
- the diameter of the well is small, i.e. the storage in the well can be ignored
- the pumping well is fully penetrating, therefore receiving water from the entire saturated thickness of the aquifer

(from Kruseman & de Ridder, 1994)

To find drawdown (s) if Q is known:

$$s = \frac{2.3Q}{4\pi T}\log\frac{2.25Tt}{r^2 S}$$

Impact Assessment Drawdown at Receptor

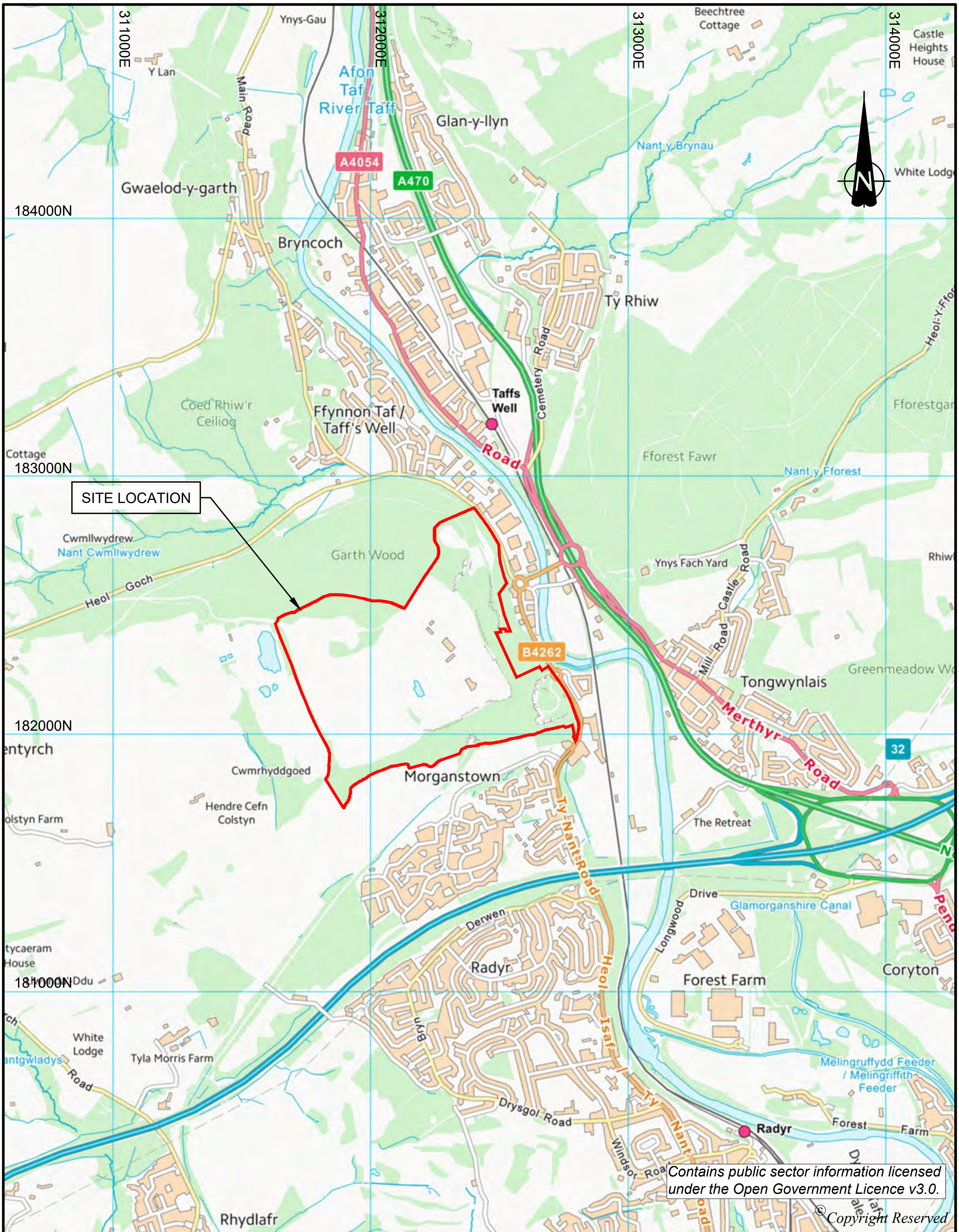
		Units	Most likely scenario (0.1m3/d -6mAOD) Q= 3405 m3/d		Worst case scenario ($1m^3/d$ at -6mAOD) Q= 28,836m3/d	
			Input value	Drawdown (m)**	Input value	Drawdown (m)**
Transmissivity (T) *Maximum T for limestone in South Wales**		M2/d	130	-	130	-
Storage coefficient (S) Average S for limestone in South Wales*			0.0007	-	0.0007	-
Time (t) One year of pumping provided in brackets		Days	1 (365)	-	1 (365)	-
Total discharge from well (Q)		M3/d	3405	-	28836	-
Licensed groundwater abstractions (r)	WA/057/0025/0014	m	1545	0 (8.7)	1545	0 (73)
	21/57/25/0023	m	1159	0 (9.9)	1159	0 (83.4)
	21/57/25/0075	m	827	0 (11.3)	827	0 (95.3)
	21/57/25/0047	m	461	1.4 (13.7)	461	11.9 (115.9)
	21/57/25/0080	m	1841	0 (7.9)	1841	0 (67.1)
PrWS (r)	289	m	1745	0 (8.1)	1745	0 (69)
Surface watercourses ®	River Taff	m	500	1.1 (13.4)	500	9.1 (113.1)
	Unnamed to the north	m	1000	0 (10.5)	1000	0 (88.6)
	Nant Gladys	m	2100	0 (7.4)	2100	0 (62.5)
Springs (r)	Spring S1	m	750	0 (11.7)	750	0 (98.8)
	Spring S2	m	1027	0 (10.4)	1027	0 (87.7)

Surface water abstraction (r)	21/57/25/0046	m	1512	0 (8.7)	1512	0 (74.1)
	WA/057/0025/005	m	1550	0 (8.6)	1550	0 (74.3)
	WA/057/0025/009	m	1583	0 (8.6)	1583	0 (72.4)
SSSI	Garth Wood	m	410	1.9 (14.2)	410	16.1 (1.1)
	Glamorgan Canal / Long Wood	m	1,490	0 (8.8)	1,490	0 (74.6)

*from major aquifer properties manual

**one year of pumping 365 days provided in brackets

FIGURES



CLIENT: BREEDON GROUP PLC	DRG No. ST19539-001		REV A	SUIT.
PROJECT: TAFFS WELL QUARRY	SIZE A4	SCALE 1:20,000	DATE 04/05/23	
DRAWING TITLE: SITE LOCATION PLAN	DRAWN BY SJB			
	CHECKED BY BG			
	APPROVED BY EK			

wardell armstrong

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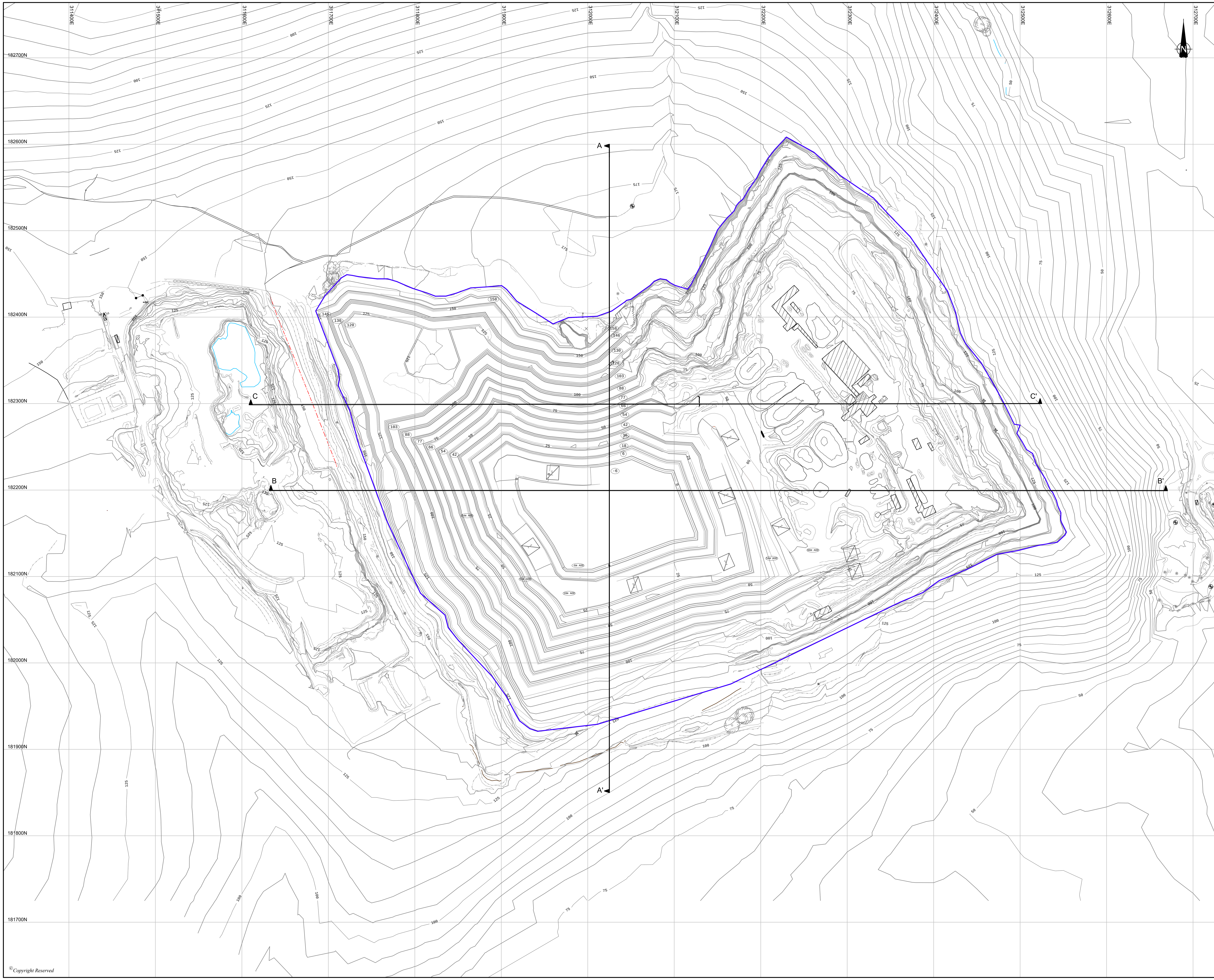
DO NOT SCALE FROM THIS DRAWING



KEY

- PIT BOUNDARY
- A A' SECTION LINE LOCATION
- 125 EXISTING CONTOURS @ 1m INTERVAL

NOTE:
BASE PLAN PROVIDED BY CLIENT REFERENCED:
T08-SRJ-2023-02-23 TAFFS WELL - QUARRYING BELOW PLANNING TO -6M AOD.

REVISION	DETAILS	DATE	DRAWN	CHK'D	APP'D
P0	PRELIMINARY ISSUE	24/08/23	SJB		

CLIENT
BREEDON GROUP PLC

PROJECT
TAFFS WELL QUARRY

DRAWING TITLE
SITE LAYOUT

PRELIMINARY

DRG No. ST19539-003	REV P0	SUIT. CODE
DRG SIZE A1	SCALE 1:2000	DATE 02/07/23
DRAWN BY SJB	CHECKED BY	APPROVED BY

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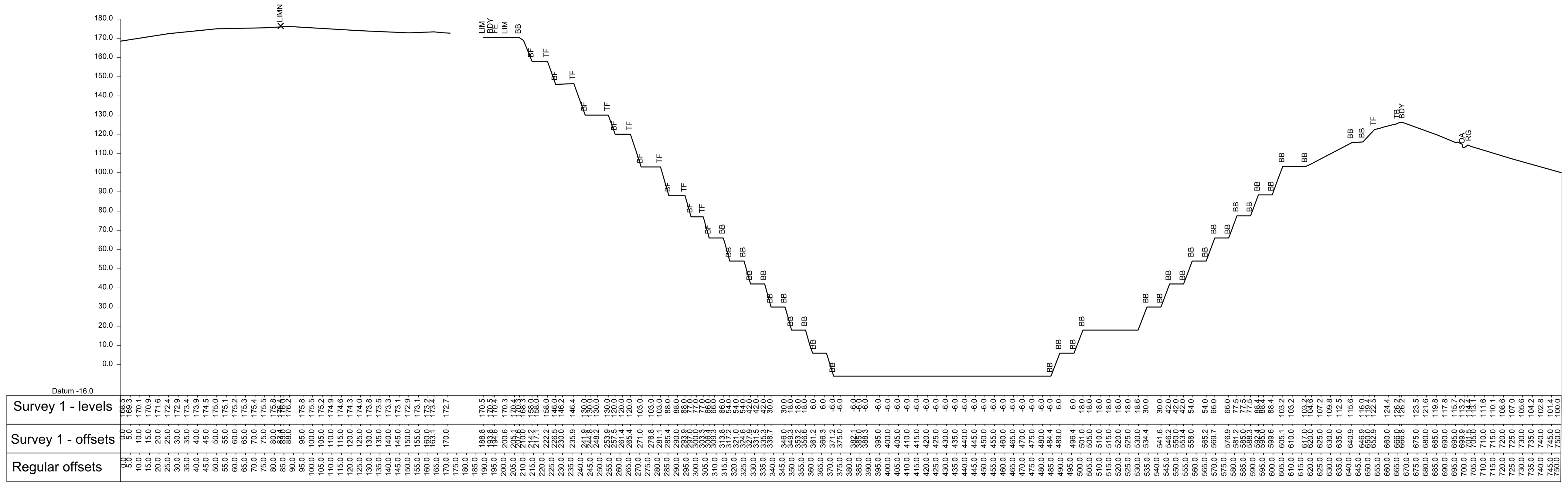
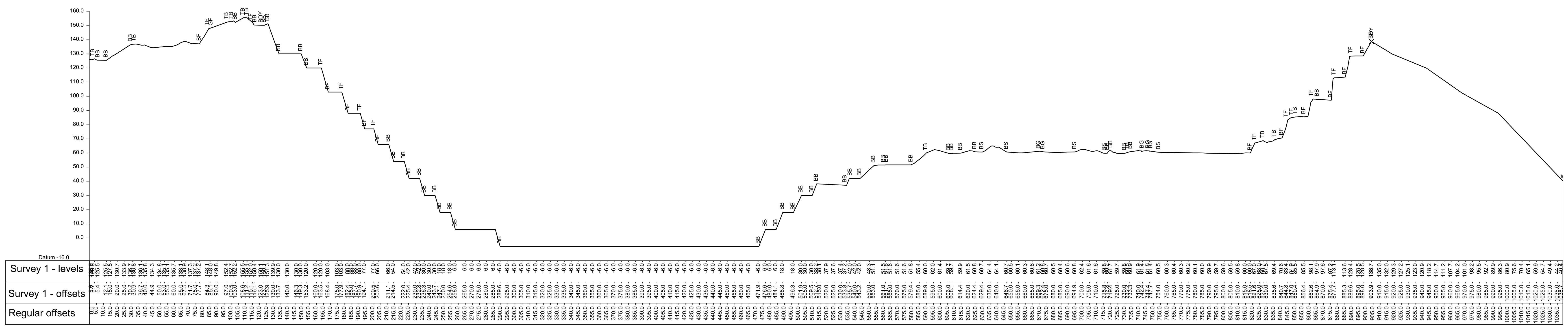


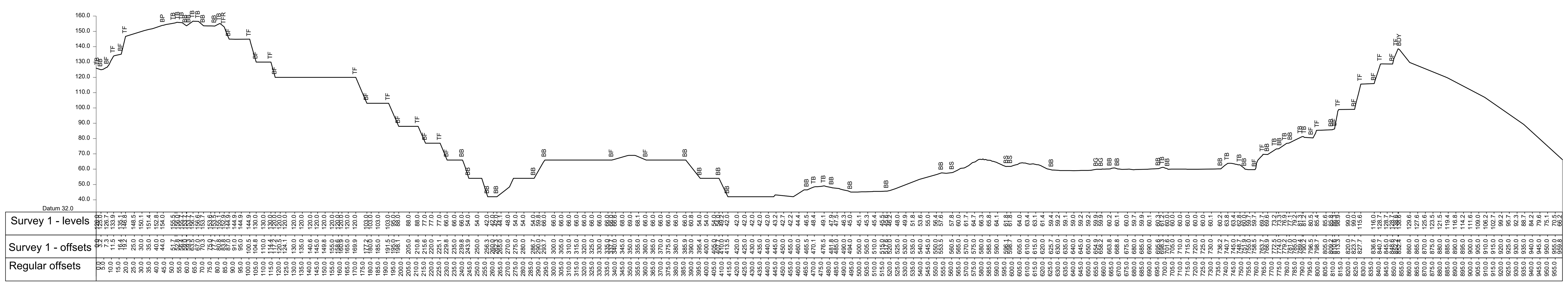
CROSS SECTION A - A' NORTH - SOUTH

Scale H 1:2000 V 1:2000



CROSS SECTION B - B' EAST - WEST CENTRED

Scale H 1:2000 V 1:2000



CROSS SECTION C - C' EAST - W EST

Scale H 1:2000 V 1:2000

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REVISION	DETAILS	DATE	DRAWN	CHK'D	APP'D
P0	PRELIMINARY ISSUE	24/08/23	SJB		

CLIENT

BREEDON GROUP PLC

PROJECT

TAFFS WELL QUARRY

DRAWING TITLE

CROSS SECTIONS

DRG No.	REV	SUIT. CODE
ST19539-004	P0	

DRG SIZE	SCALE	DATE
A1	1:2000	02/08/23

DRAWN BY	CHECKED BY	APPROVED BY
SJB		

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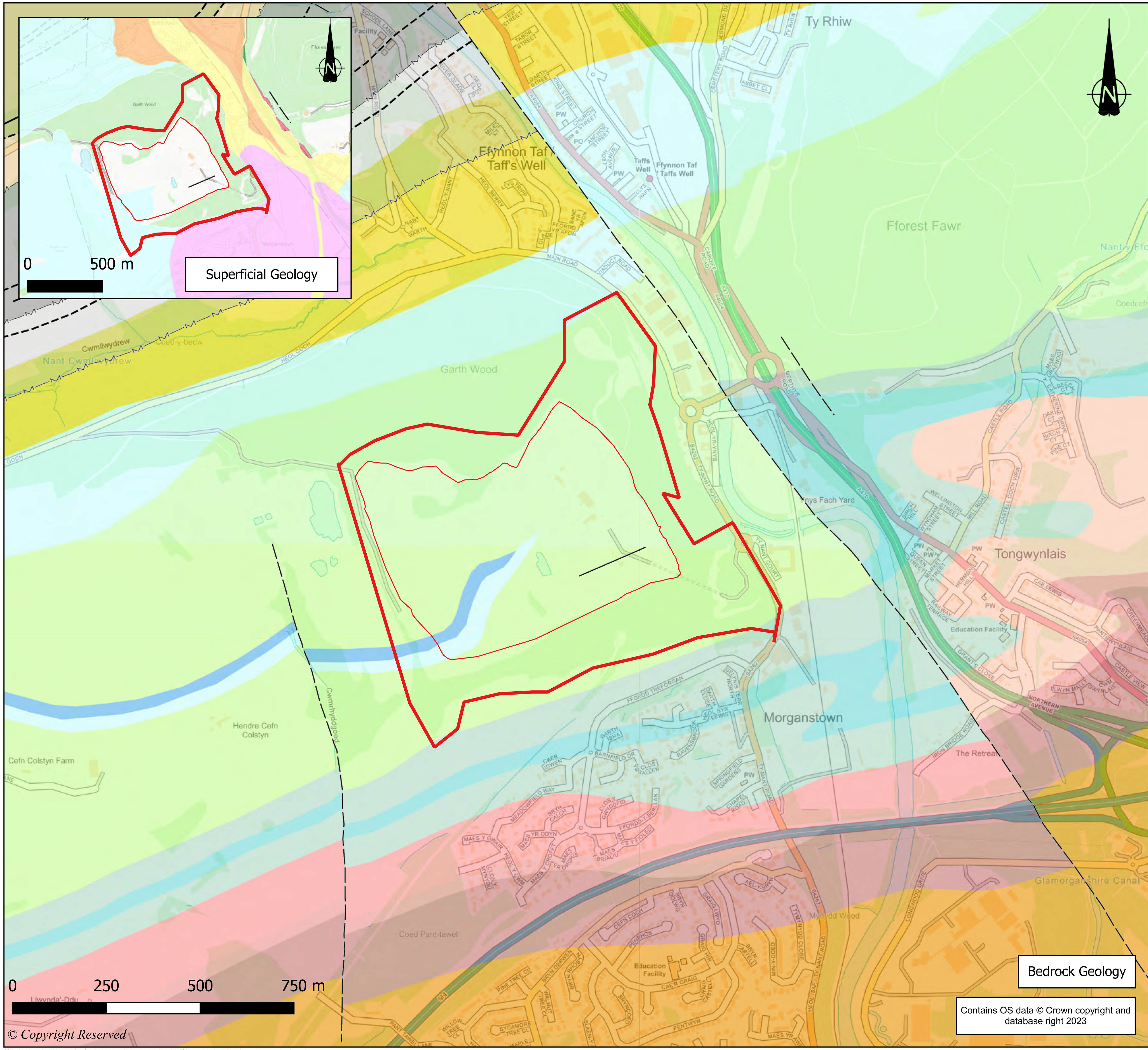

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DO NOT SCALE FROM THIS DRAWING

KEY

- Site Boundary
- Pit Boundary
- Rhondda Member - Sandstone
- South Wales Upper Coal Measures Formation - Mudstone, Siltstone and Sandstone
- South Wales Middle Coal Measures Formation - Mudstone, Siltstone and Sandstone
- South Wales Lower Coal Measures Formation - Mudstone, Siltstone and Sandstone
- South Wales Lower Coal Measures Formation - Sandstone
- Marros Group - Mudstone, Sandstone and Conglomerate
- Hunts Bay Oolite Subgroup - Limestone, Ooidal
- Pembroke Limestone Group - Limestone, Dolomitic
- Caswell Bay Mudstone Formation - Limestone and Mudstone, Interbedded
- Gully Oolite Formation - Limestone, Ooidal
- Cwmyniscoy Mudstone Formation - Mudstone and Limestone, Interbedded
- Castell Coch Limestone Formation - Limestone, Ooidal
- Quartz Conglomerate Group (South Wales) - Sandstone
- Quartz Conglomerate Group (South Wales) - Sandstone and Conglomerate, Interbedded
- Brownstones Formation - Sandstone and Argillaceous Rocks, Interbedded
- Llanishen Conglomerate - Conglomerate and Sandstone, Interbedded
- Till, Devensian - Diamicton
- Glaciofluvial Deposits, Devensian - Sand and Gravel
- Alluvium - Clay, Silt, Sand and Gravel
- River Terrace Deposits (Undifferentiated) - Sand and Gravel

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D

CLIENT

BREEDON GROUP PLC

PROJECT

TAFFS WELL QUARRY

DRAWING TITLE

GEOLOGY OF SITE AND SURROUNDING AREA

PRELIMINARY

DRG No. ST19539-005		REV A
DRG SIZE A3	SCALE 1:10,000	DATE August 2023
DRAWN BY BJ	CHECKED BY AS	APPROVED BY AB

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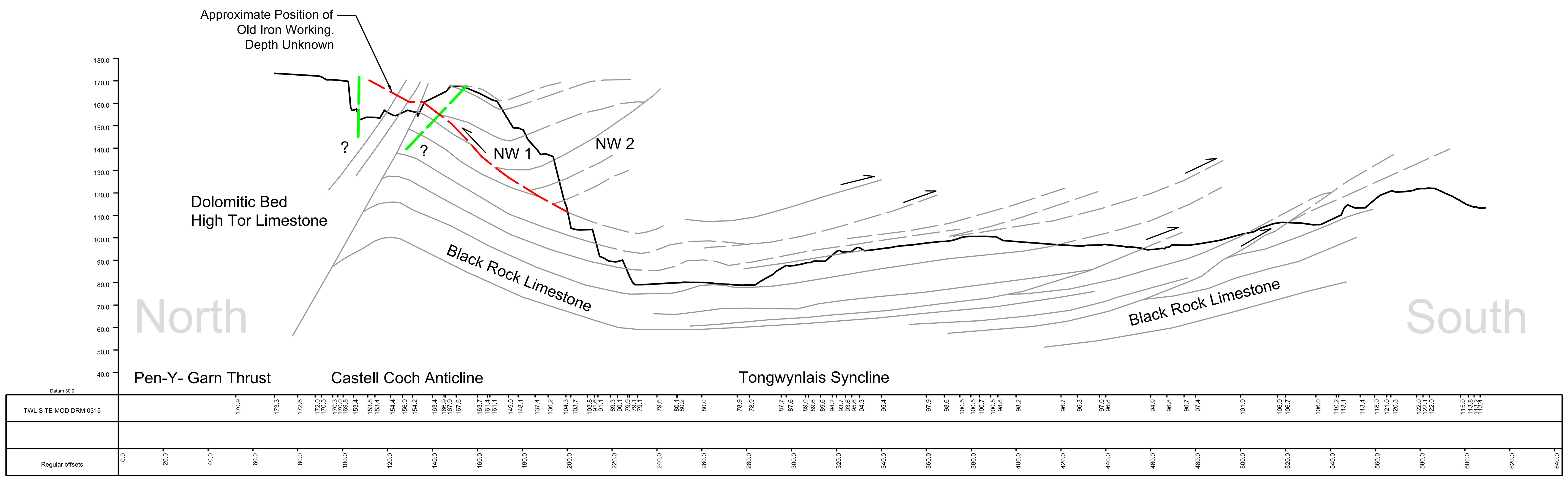
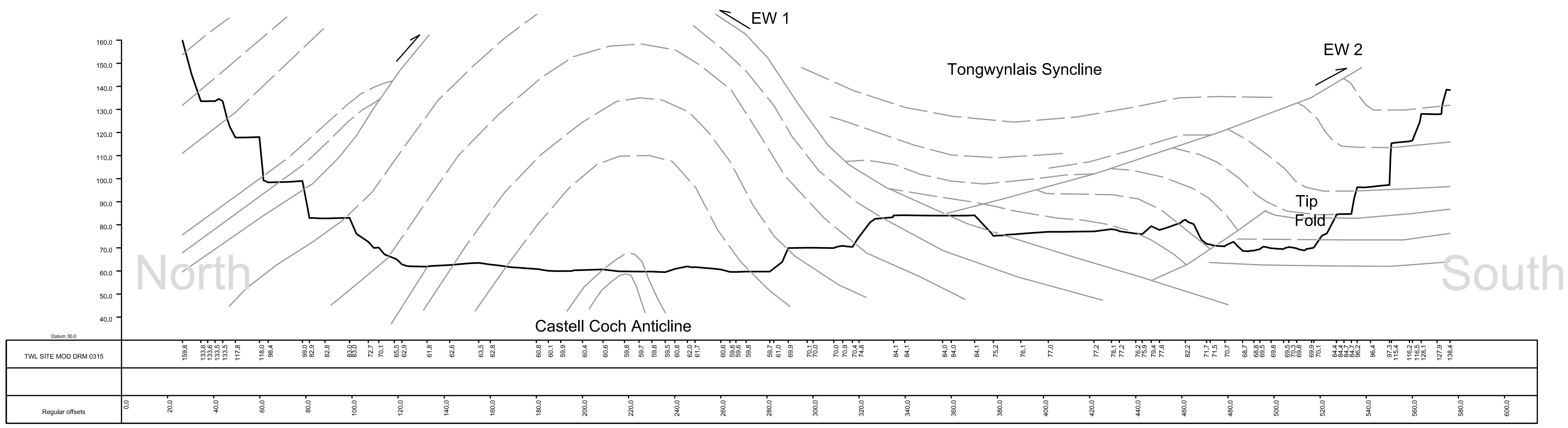


Section A - A'



Section B - B'

Revisions	
F	
E	
D	
C	
B	
A	

Drawn By: TS/caw	Company
Date: August 2020	Site: Taffs Well Quarry
Scale(s): 1 : 2 000 @ A2	Project: Hydrogeological Assessment
Checked/Model(s): ts	Title: Figure 7 - Geological Cross Sections
Site Reference: ST1282	Drawing Number: 2008_C034_TAFF_007

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DO NOT SCALE FROM THIS DRAWING

KEY
- Site Boundary
- Pit Boundary
- Groundwater Monitoring Boreholes

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D

CLIENT
BREEDON GROUP PLC

PROJECT
TAFFS WELL QUARRY

DRAWING TITLE
CURRENT MONITORING NETWORK

PRELIMINARY

DRG No. ST19539-006		REV A
DRG SIZE A3	SCALE 1:5,000	DATE August 2023
DRAWN BY BJ	CHECKED BY AS	APPROVED BY AB

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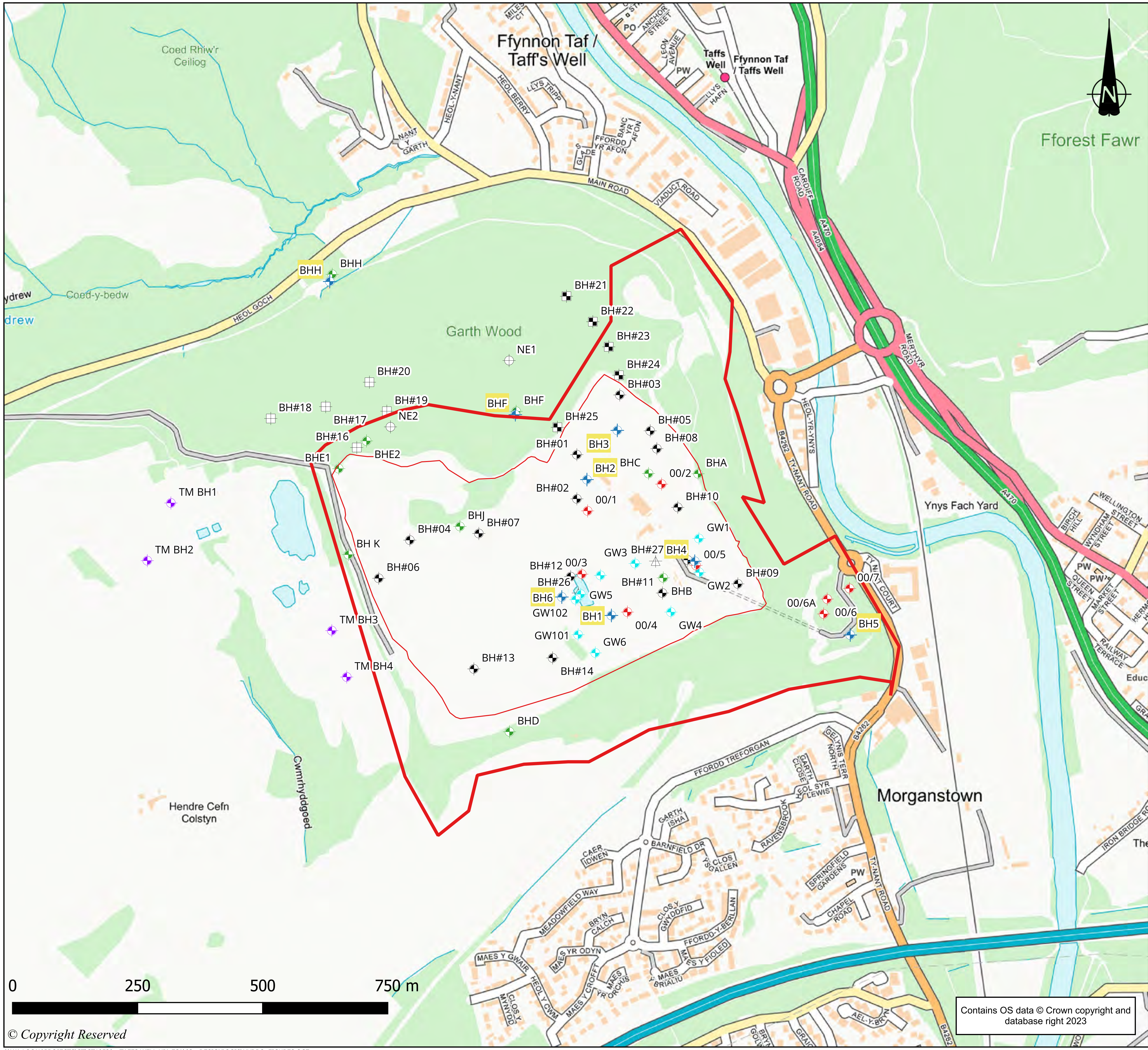

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DO NOT SCALE FROM THIS DRAWING

KEY

- Site Boundary
- Pit Boundary
- Boreholes Drilled 1986
- Boreholes Drilled 1948 - 1949
- Boreholes Drilled 1957
- Boreholes Drilled 1973
- Boreholes Drilled 1985 - 1986
- Boreholes Drilled 1990 - 1991
- Ton Mawr Boreholes Drilled 1998
- Boreholes Drilled 2000
- Boreholes Drilled 1978
- Groundwater Monitoring Boreholes

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D

CLIENT: BREEDON GROUP PLC

PROJECT: TAFFS WELL QUARRY

DRAWING TITLE: SITE INVESTIGATION BOREHOLE LOCATIONS

PRELIMINARY

DRG No. ST19539-007		REV A
DRG SIZE A3	SCALE 1:7,500	DATE August 2023
DRAWN BY BJ	CHECKED BY AS	APPROVED BY AB

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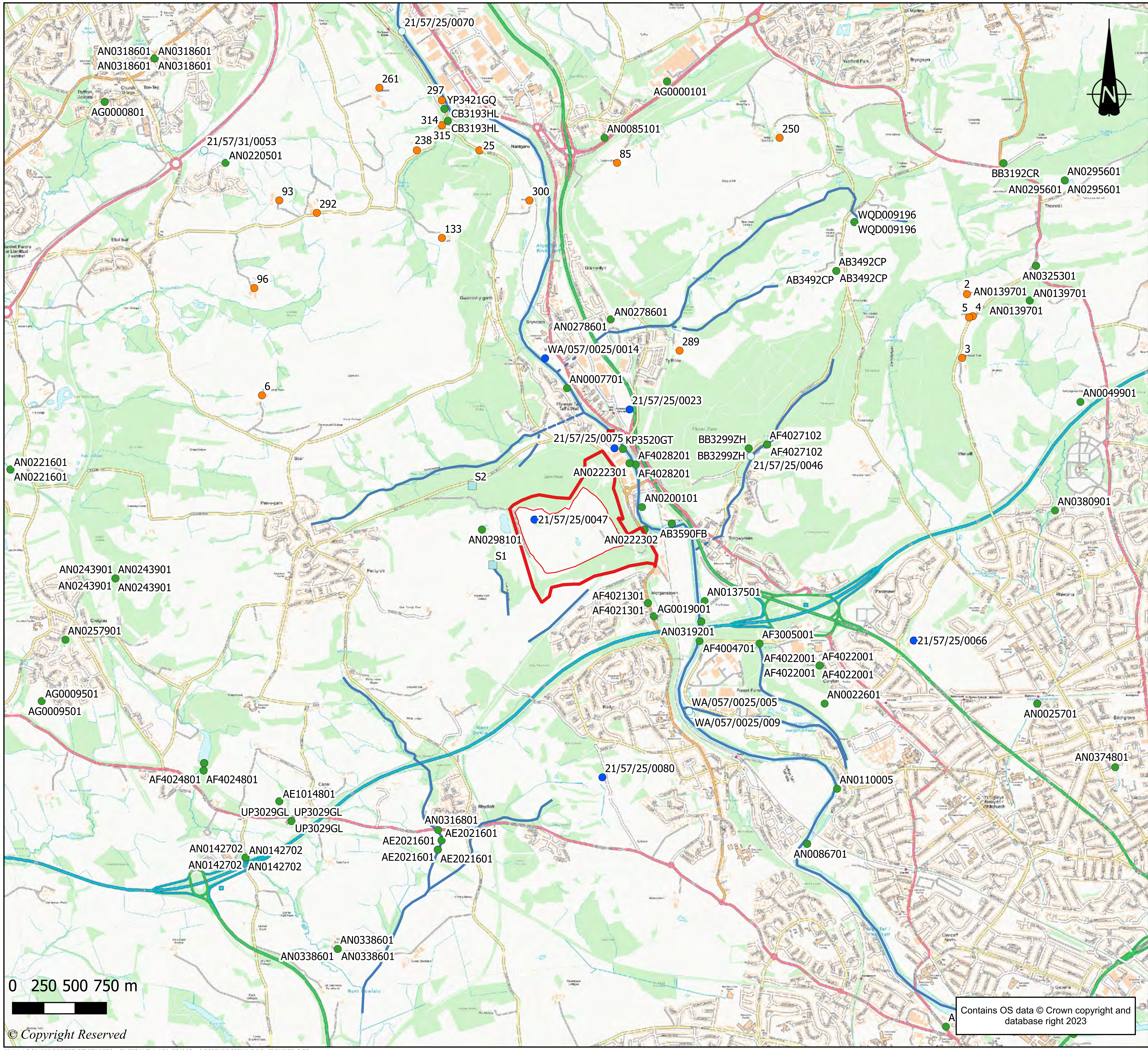

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DO NOT SCALE FROM THIS DRAWING

KEY
- Site Boundary
- Pit Boundary
- Watercourse
- Inferred Watercourse
- Groundwater Abstraction
- Surface WaterAbstraction
- Discharge Consent
- Private Water Supplies
- Spring
- Spot Flow Gauge

PrWS No.	Address
25	Main Road, CF15 9JJ
26	Main Road, CF15 9JJ
85	Caerphilly Road, CF15 7TP
93	Heol-Y-Parc, CF38 1SN
96	Heol Ffrwyd Philip, CF38 1SN
133	Main Road, CF15 9HJ
238	Main Road, CF15 9HJ
250	Lane to Craig Fach Farm, CF83 1NF
261	Willowford Road, CF38 1SL
289	South View, CF15 7RZ
292	Heol-Y-Parc, CF38 1SN
297	Main Road, CF15 9HJ
300	Main Road, CF15 9HJ
314	Main Road, CF15 9JL
315	Main Road, CF15 9JL
316	Main Road, CF15 9JL

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D

CLIENT
BREEDON GROUP PLC

PROJECT
TAFFS WELL QUARRY

DRAWING TITLE
WATER FEATURES, ABSTRACTIONS, AND DISCHARGES

PRELIMINARY

DRG No. ST19539-008			REV A
DRG SIZE A3	SCALE 1:30,000		DATE August 2023
DRAWN BY BJ	CHECKED BY AS		APPROVED BY AB

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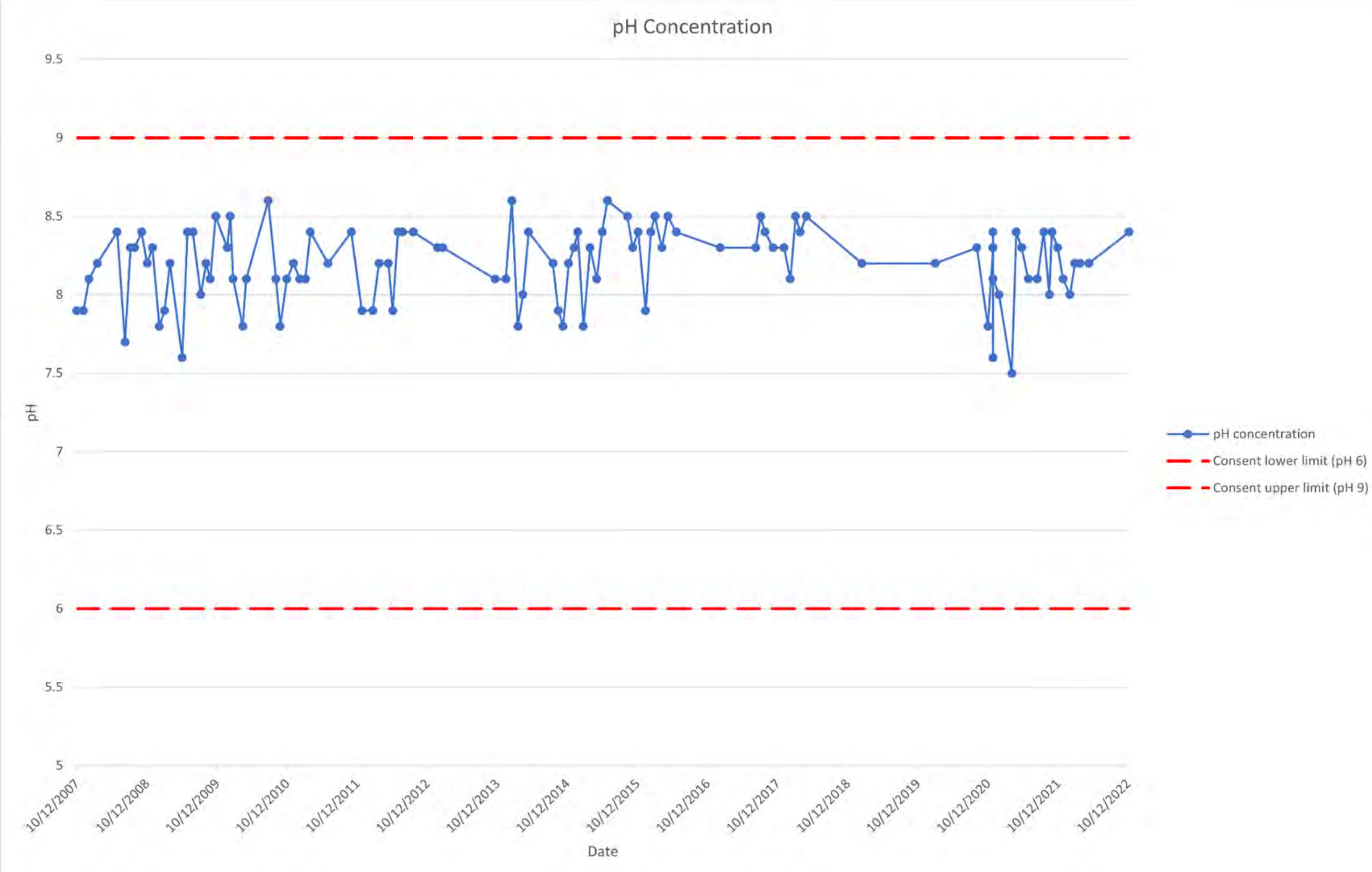

Figure Number	ST19359-009
Figure Title	pH Concentration

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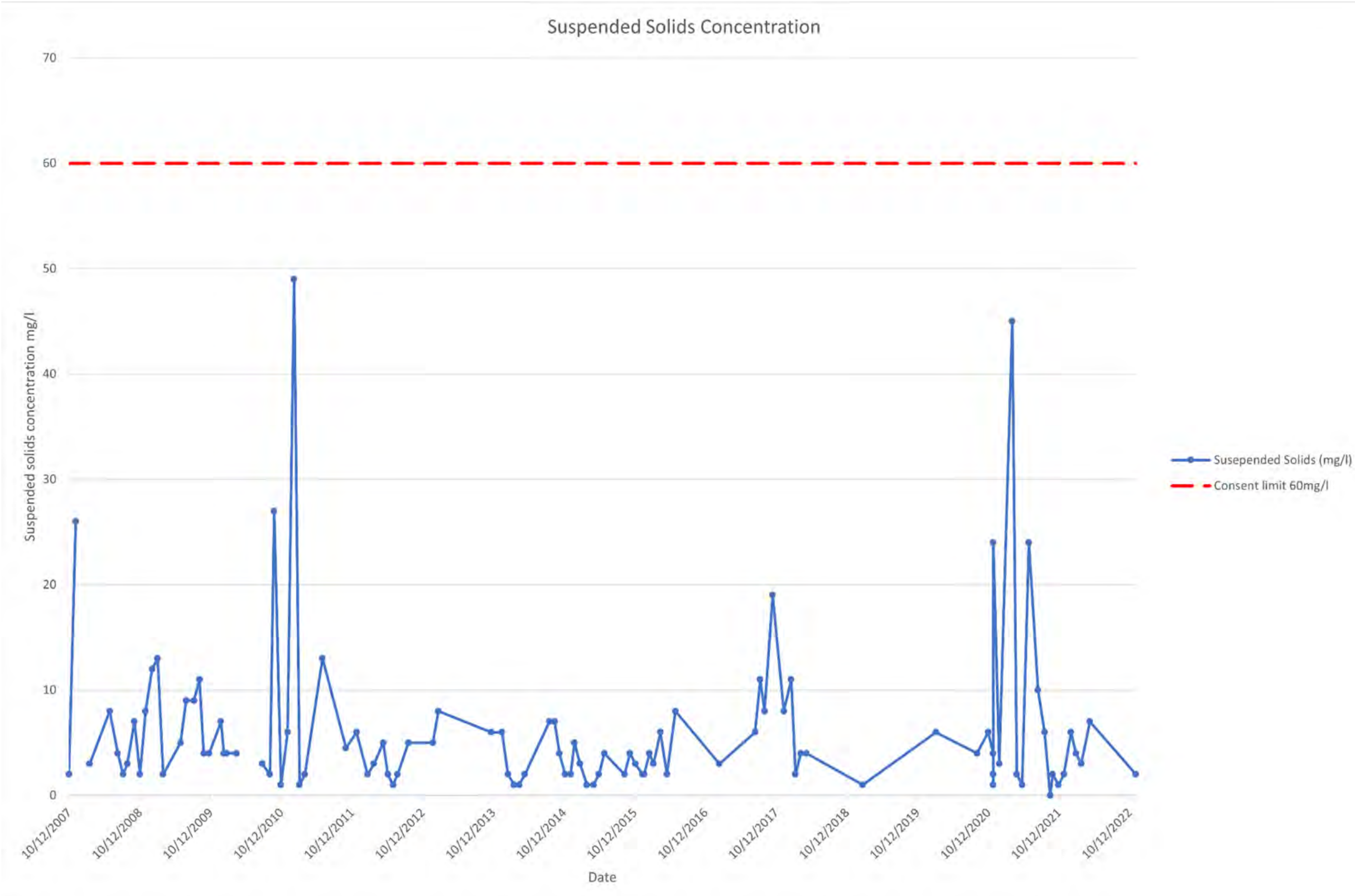

Figure Number	ST19359-010
Figure Title	Suspended Solids Concentration

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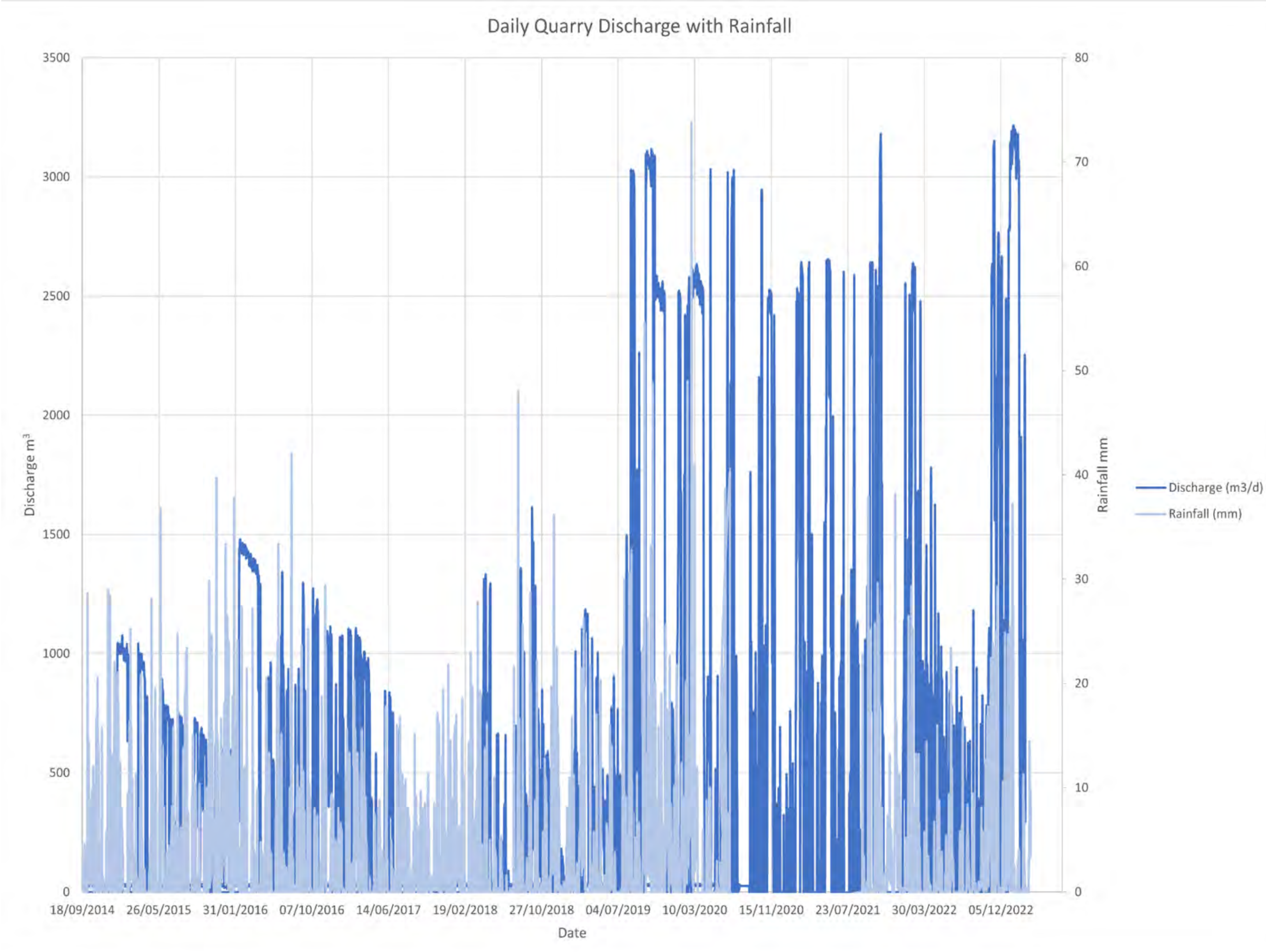

Figure Number	ST19539-011
Figure Title	Daily Quarry Discharge with Rainfall

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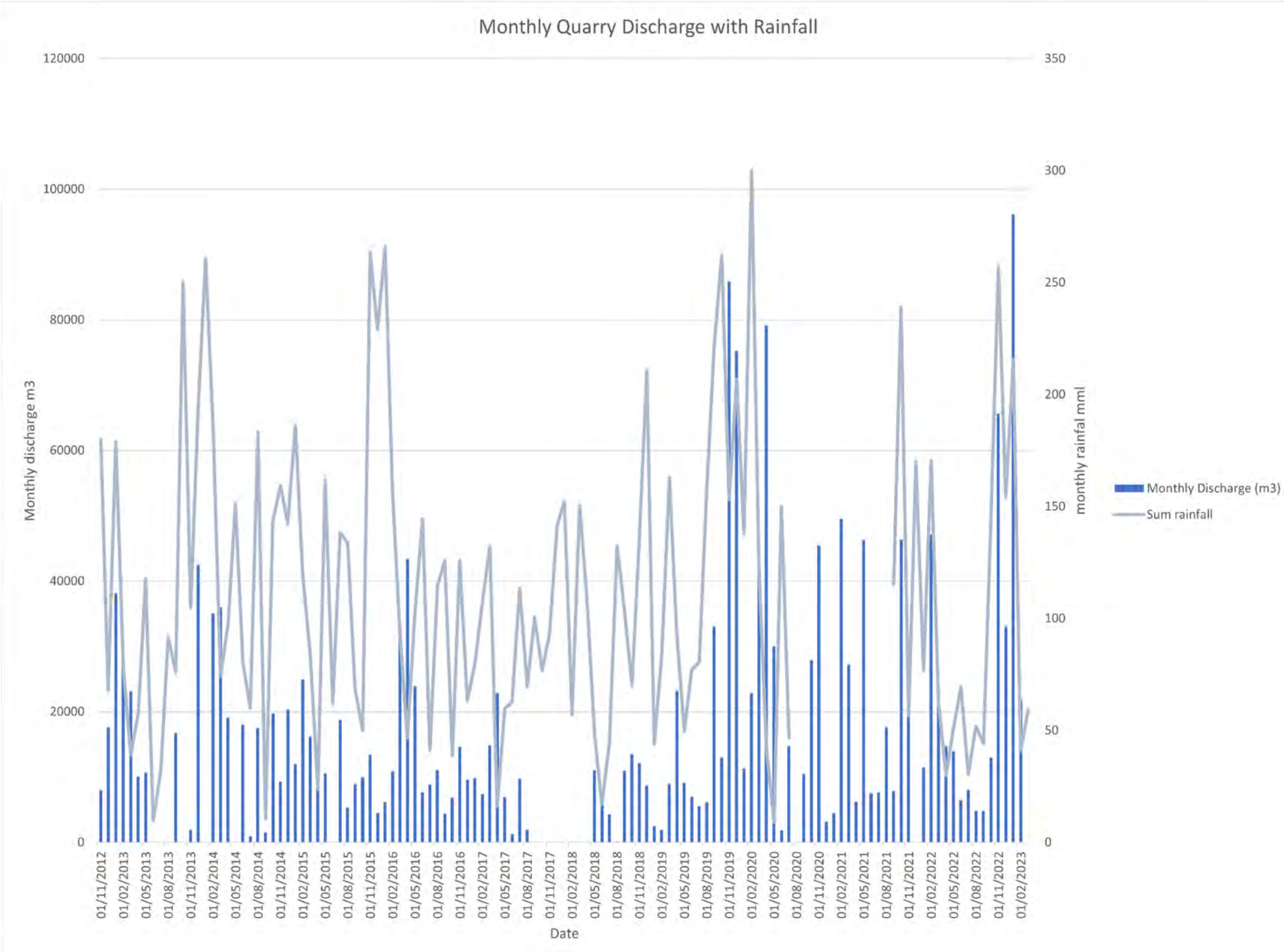

Figure Number	ST19539-012
Figure Title	Monthly Quarry Discharge with Rainfall

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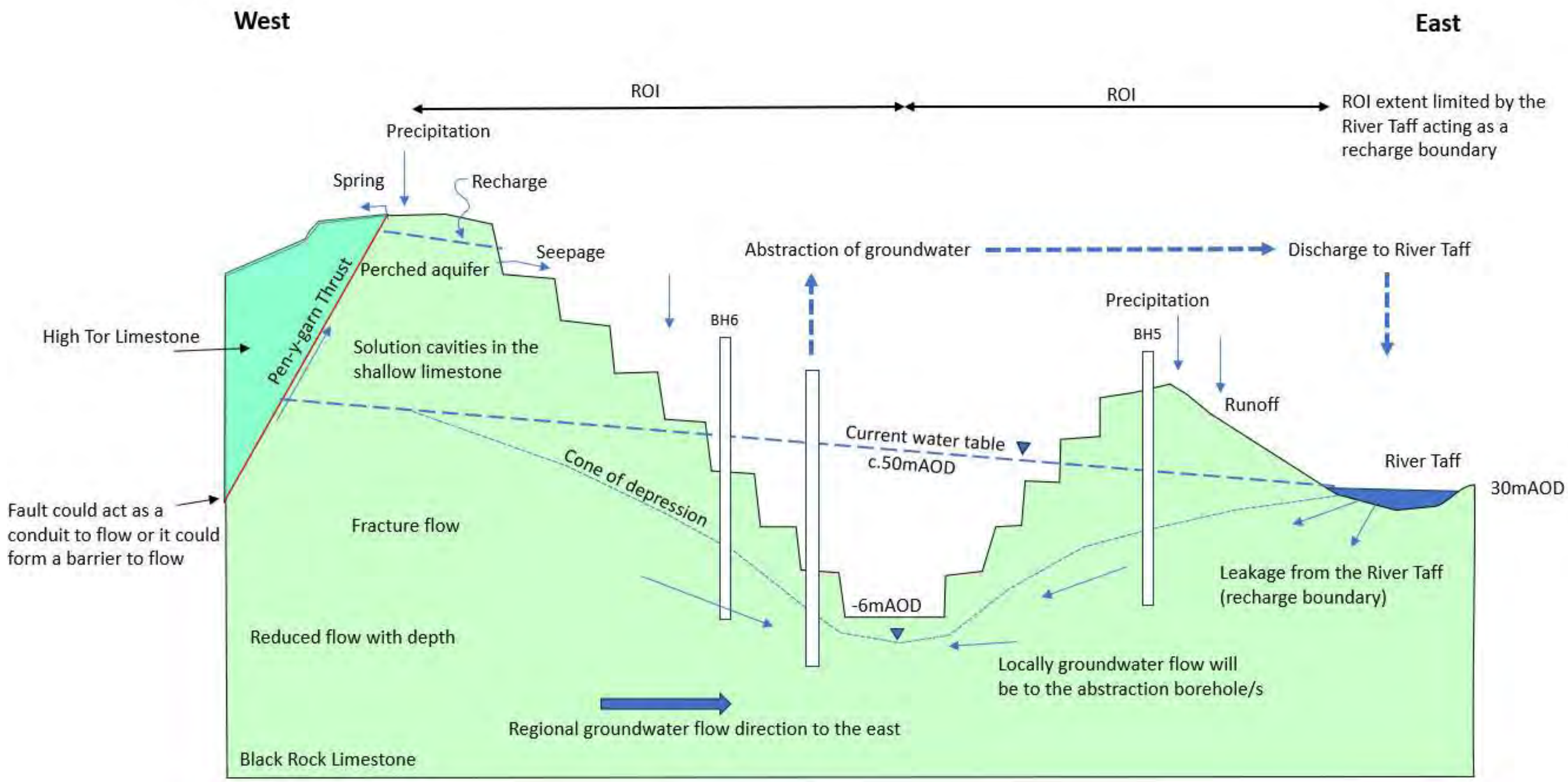

Not to scale

Colours in keeping with British Geological Survey key

Schematic void as representation only

Figure Number	ST19539-013
Figure Title	Conceptual Site Model Schematic

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APPENDIX 2

Water Features Survey

NGR used to calculate distances
311840 182350 21/57/25/0 Abstraction from old mine workings at Taffs Well Quarry

Type of feature	Feature ref.	Point X	Point Y	Third party feature ID	Description	Distance (m)	Screened in for further assessment	Rationale	Source
Spring	S1	311511	181980		Spring to Cwmrhyddgoed	495	Yes	Groundwater dependent	OS Maps
Spring	S2	311347	182615		Spring to Nant Cwmllwydrew	560	Yes	Groundwater dependent	OS Maps
Groundwater body	GWB1	N/A	N/A	GB40901G203600	Principal Aquifer / SE Valleys Carboniferous Limestone	Abstraction point within water body	Yes	Groundwater dependent	Water Watch Wales
Groundwater body	GWB2	N/A	N/A	GB40902G201900	Secondary A Aquifer / SE Valleys Carboniferous Coal Measures	Ca. 600 m	Yes	Possibility for continuity with Carboniferous Limestone aquifer	Water Watch Wales
Groundwater body	GWB3	N/A	N/A	GB40902G201500	Secondary A Aquifer / SE Valleys Southern Devonian Old Red Sandstone & Triassic Mercia Mudstone	Ca. 800 m	Yes	Possibility for continuity with Carboniferous Limestone aquifer	Water Watch Wales
Surface water body subcatchment	SWB1	N/A	N/A	GB109057027270	River / Taff - conf Rhondda R to Castle Street	Abstraction point within water body	Yes	Groundwater dependent	Water Watch Wales
Surface water body subcatchment	SWB2	N/A	N/A	GB109057027080	River / Nant Dowlais - source to conf Ely R	Ca. 900 m	Yes	Potential for hydraulic connection with site via Carboniferous Limestone Principal Aquifer	Water Watch Wales
Surface water body subcatchment	SWB3	N/A	N/A	GB109057027100	River / Nant Clun - source to conf Ely R	Ca. 1,800 m	No	No pathway for effects - catchment not underlain by Carboniferous Limestone Principal Aquifer within search area	Water Watch Wales
Surface water course	SW1	311722	182780		Un-named watercourse at Garth Woods (tributary of Nant Cwmllwydrew) (closest point)	446	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW2	311509	181971		Nant Cwmllwydrew (tributary of Nant Dowlais) (closest point)	503	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW3	311521	182812		Nant Cwmllwydrew (tributary of River Taff) (closest point)	561	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW4	312265	181785		Un-named watercourse north of Morganstown (tributary of Nant Dowlais) (closest point)	707	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW5	312673	182378		River Taff (closest point)	833	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW6	311766	180942		Nant Dowlais (closest point)	1410	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW7	313289	182205		Nant Fforest (tributary of the River Taff, joining from east at Tongwnlais) (closest point)	1456	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW8	312352	183795		Nant y Brynau (tributary of the River Taff, joining from east at Taffs Well village) (closest point)	1533	No	Underlain by Secondary A aquifer - no pathway for effects from Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW9	313047	183875		Nant Llwydd (tributary of Nant y Brynau (closest point)	1945	No	Underlain by Secondary A aquifer - no pathway for effects from Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Surface water course	SW10	310700	180732		Nant Gwladys (closest point)	1979	Yes	Groundwater dependent and hydraulically connected to Carboniferous Limestone Principal Aquifer	?OS Open Rivers?
Prviate Water Supply	PrWS01	313000	183700	289	Private water supply at South View, CF15 7RZ	1780	Yes	Groundwater supply	Local Authority Data
Licensed groundwater abstraction	GWABS1	312480	182920	21/57/25/0075	Tarmac Aggregates, Borehole at Taffs Well, Industrial, Process Water	857	Yes	Groundwater supply	NRW data
Licensed groundwater abstraction	GWABS2	312600	183230	21/57/25/0023	South Wales Forgemasters Ltd, Abstraction from borehole at Garth Works, Industrial, Evaporative Cooling	1163	Yes	Groundwater supply	NRW data
Licensed groundwater abstraction	GWABS3	311925	183639	WA/057/0025/0014	Rhondda Cynon Taf County Borough Council, Taff's Well Thermal Spring, Private Water Supply	1292	Yes	Groundwater supply	NRW data
Licensed surface water abstraction	SWABS1	313569	182856	21/57/25/0046	Breedon Aggregates, Cefn Garw quarry, Industrial, Process Water	1802	Yes	Groundwater supply	NRW data
Licensed surface water abstraction	SWABS2	313076	180819	WA/057/0025/005	Cardiff Council, Impoundment, Hydroelectric Power Generation	1968	Yes	Dependent on flow in River Taff	NRW data
Licensed surface water abstraction	SWABS3	313094	180791	WA/057/0025/009	Cardiff Council, Production of energy, Hydroelectric Power Generation	2001	Yes	Dependent on flow in River Taff	NRW data
Permitted surface water discharge	SWDIS1	311420	182270	AN0298101	Ton Mawr Quarry Heol Goch Pentyrch to Trib Of Nant Dowlais	428	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS2	312700	182450	AN0200101	Taffs Well PS Taffs Well Cardiff to River Taff	866	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS3	312600	182800	AN0222301	RMC Aggregates South Wales Ltd to River Taff.	883	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS4	312720	182270	AN0222302	Taffs Welll Quarry Heol Goch to River Taff	884	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS5	312547	182914	KP3520GT	Fairfield Industrial Estate to Trib Of Taff	904	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS6	312650	182790	AF4028201	Warehouse Development Ynys Bridge T to River Taff	922	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS7	312100	183400	AN0007701	Taffs Well SPS Emergency Cardiff to Taff River	1082	No	No surface water pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS8	312938	182318	AB3590FB	Ynys Bridge CSO to Afon Taff	1098	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS9	312747	181683	AF4021301	Short Bros (Plant) Limited to Groundwater Via Infiltration System	1126	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS10	312795	181578	AG0019001	Primrose Cottage Ty Nant Road to River Taff Trib	1228	Yes	Potential pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS11	313200	181700	AN0137501	Housing And Hotel Tongwynlais to Taff	1507	No	No surface water pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS12	313174	181536	AN0319201	Tongwynlais CSO to The River Taff	1563	No	No surface water pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS13	313160	181380	AF4004701	Cardiff Whitchurch Forest Farm Indu to Melingriffith Feeder	1638	No	No surface water pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS14	312450	183950	AN0278601	Dorian House Old Parish Road Taffs to Nant Y Brynnau	1712	No	No surface water pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS15	313553	182919	BB3299ZH	Forest Tea Room to Groundwater Via Infiltration System	1805	No	No surface water pathway between abstraction point and this receptor	NRW data
Permitted surface water discharge	SWDIS16	313700	182950	AF4027102	Cefn Garw Quarry Tongwynlais to Nant Y Forest	1954	No	No surface water pathway between abstraction point and this receptor	NRW data
SSSI	SSSI1	311856	182310		Cwarrau Ton Mawr a Ffynnon Taf - Ton Mawr and Taffs Well Quarries	43	No	Not groundwater dependent	Magic Map
SSSI / SAC	SSSI2	311849	182456		Cardiff Beech Woods / Garth Wood	106	Yes	Possibility of groundwater dependent features	Magic Map
SSSI	SSSI3	311530	182745		Coed y Bedw	502	No	Not groundwater dependent	Magic Map
SSSI / SAC	SSSI4	312829	182622		Cardiff Beech Woods / Castell Coch Woodlands and Road Section	1026	No	Not groundwater dependent	Magic Map
SSSI	SSSI5	310453	182439		Cauau Blaen-bielly	1390	No	Not groundwater dependent	Magic Map
Non-statutory conservation site	SNCI1	311572	182093		Cwmrhyddgoed Site of Nature Conservation Interest	371	No	Not groundwater dependent	LERC Wales
Scheduled Monument	SCHM1	312833	181879	GM256	Morganstown Castle Mound	1099	No	Not groundwater dependent	DataMapWales
Scheduled Monument	SCHM2	310852	181009	GM180	Llwynda-Ddu Camp	1666	No	Not groundwater dependent	DataMapWales
Scheduled Monument	SCHM3	313082	182654	GM206	Castell Coch	1279	No	Not groundwater dependent	DataMapWales
Scheduled Monument	SCHM4	310407	183541	GM107	Five Round Barrows on Garth Hill	1863	No	Not groundwater dependent	DataMapWales

APPENDIX 3

Assessment of Impacts to Water Features

Type of feature	Feature ref.	Point X	Point Y	Third party feature ID	Description	Distance (m)	Assessment of Impacts	Source
Spring	S1	311511	181980		Spring to Cwmrhyddgoed	495	Loced up-hydraulic gradient of the abstraction, coincides with a fault and geologica boundary and is likely to be supported by perferential pathways along the fault (north-south trending).	OS Maps
Spring	S2	311347	182615		Spring to Nant Cwmllwydrew	560	Located outside of calculated Radius of Influence therefore no anticipated impact	OS Maps
Groundwater body	GWB1	N/A	N/A	GB40901 G203600	Principal Aquifer / SE Valleys Carboniferous Limestone	Abstraction point within water body	The drawdown within the Carboniferous Limestone principal aquifer will be localised around the mine workings. Any impact will be minimal in comparison to the size of the aquifer. The overall balance of groundwater within the aquifer will be unaffected as the abstracted water will be returned to the River Taff, which is in hydraulic connection with the groundwater.	Water Watch Wales
Groundwater body	GWB2	N/A	N/A	GB40902 G201900	Secondary A Aquifer / SE Valleys Carboniferous Coal Measures	Ca. 600 m	Located outside of calculated Radius of Influence therefore no anticipated impact	Water Watch Wales
Groundwater body	GWB3	N/A	N/A	GB40902 G201500	Secondary A Aquifer / SE Valleys Southern Devonian Old Red Sandstone & Triassic Mercia Mudstone	Ca. 800 m	Located outside of calculated Radius of Influence therefore no anticipated impact	Water Watch Wales
Surface water body subcatchment	SWB1	N/A	N/A	GB10905 7027270	River / Taff - conf Rhondda R to Castle Street	Abstraction point within water body	See Appendix 4	Water Watch Wales
Surface water body subcatchment	SWB2	N/A	N/A	GB10905 7027080	River / Nant Dowlais - source to conf Ely R	Ca. 900 m	Located outside of calculated Radius of Influence therefore no anticipated impact	Water Watch Wales
Surface water course	SW1	311722	182780		Un-named watercourse at Garth Woods (tributary of Nant Cwmllwydrew) (closest point)	446	Located outside of calculated Radius of Influence therefore no anticipated impact	?OS Open Rivers?
Surface water course	SW2	311509	181971		Nant Cwmllwydrew (tributary of Nant Dowlais) (closest point)	503	Located outside of calculated Radius of Influence therefore no anticipated impact	?OS Open Rivers?
Surface water course	SW3	311521	182812		Nant Cwmllwydrew (tributary of River Taff) (closest point)	561	Located outside of calculated Radius of Influence therefore no anticipated impact	?OS Open Rivers?
Surface water course	SW4	312265	181785		Un-named watercourse north of Morganstown (tributary of Nant Dowlais) (closest point)	707	Located outside of calculated Radius of Influence therefore no anticipated impact	?OS Open Rivers?
Surface water course	SW5	312673	182378		River Taff (closest point)	833	See Appendix 4	?OS Open Rivers?
Surface water course	SW6	311766	180942		Nant Dowlais (closest point)	1410	Located outside of calculated Radius of Influence therefore no anticipated impact	?OS Open Rivers?
Surface water course	SW7	313289	182205		Nant Fforest (tributary of the River Taff, joining from east at Tongwnlais) (closest point)	1456	Located outside of calculated Radius of Influence therefore no anticipated impact	?OS Open Rivers?
Surface water course	SW10	310700	180732		Nant Gwladys (closest point)	1979	Located outside of calculated Radius of Influence therefore no anticipated impact	?OS Open Rivers?
Prviate Water Supply	PrWS01	313000	183700	289	Private water supply at South View, CF15 7RZ	1780	Located outside of calculated Radius of Influence therefore no anticipated impact	Local Authority Data
Licensed groundwater abstraction	GWABS1	312480	182920	21/57/25/ 0075	Tarmac Aggregates, Borehole at Taffs Well, Industrial, Process Water	857	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Licensed groundwater abstraction	GWABS2	312600	183230	21/57/25/ 0023	South Wales Forgemasters Ltd, Abstraction from borehole at Garth Works, Industrial, Evaporative Cooling	1163	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Licensed groundwater abstraction	GWABS3	311925	183639	WA/057/0 025/0014	Rhondda Cynon Taf County Borough Council, Taff's Well Thermal Spring, Private Water Supply	1292	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Licensed surface water abstraction	SWABS1	313569	182856	21/57/25/ 0046	Breedon Aggregates, Cefn Garw quarry, Industrial, Process Water	1802	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Licensed surface water abstraction	SWABS2	313076	180819	WA/057/0 025/005	Cardiff Council, Impoundment, Hydroelectric Power Generation	1968	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Licensed surface water abstraction	SWABS3	313094	180791	WA/057/0 025/009	Cardiff Council, Production of energy, Hydroelectric Power Generation	2001	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS1	311420	182270	AN02981 01	Ton Mawr Quarry Heol Goch Pentyrch to Trib Of Nant Dowlais	428	No anticpated impact to discharge as a result of proposed abstraction	NRW data
Permitted surface water discharge	SWDIS2	312700	182450	AN02001 01	Taffs Well PS Taffs Well Cardiff to River Taff	866	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS3	312600	182800	AN02223 01	RMC Aggregates South Wales Ltd to River Taff.	883	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS4	312720	182270	AN02223 02	Taffs Welll Quarry Heol Goch to River Taff	884	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS5	312547	182914	KP3520G T	Fairfield Industrial Estate to Trib Of Taff	904	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS6	312650	182790	AF402820 1	Warehouse Development Ynys Bridge T to River Taff	922	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS8	312938	182318	AB3590F B	Ynys Bridge CSO to Afon Taff	1098	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS9	312747	181683	AF402130 1	Short Bros (Plant) Limited to Groundwater Via Infiltration System	1126	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
Permitted surface water discharge	SWDIS10	312795	181578	AG00190 01	Primrose Cottage Ty Nant Road to River Taff Trib	1228	Located outside of calculated Radius of Influence therefore no anticipated impact	NRW data
SSSI / SAC	SSSI2	311849	182456		Cardiff Beech Woods / Garth Wood	106	Located outside of calculated Radius of Influence therefore no anticipated impact	Magic Map

APPENDIX 4

Hydrogeological Impact Assessment Addendum

Technical Note

CLIENT:	**Breedon Trading Limited**
PROJECT:	**Taffs Well Quarry**
SUBJECT:	**Hydrogeological Impact Assessment Addendum**
JOB NO.:	**ST19539**
DATE:	**14 August 2024**
PREPARED BY:	**Amelia Ebanks – Hydrogeologist**
REVIEWED BY:	**Bethan Joule – Principal Hydrogeologist**
APPROVED BY:	**Rik Ingram – Technical Director – Hydrogeology**

1 INTRODUCTION

1.1 Background

1.1.1 Wardell Armstrong LLP (WA) has been appointed by Breedon Trading Limited (the Client) to vary Conditions 1 and 6 of their planning permission (20/02351/MJR), with Condition 6 relating to quarrying depth at Taffs Well Quarry (the Site). The current depth in Condition 6 is set at 30 m above ordnance datum (AOD) and it is sought to vary this to -6 mAOD, thereby deepening the quarry by 36 m with no lateral extension to the existing quarry footprint.

1.2 Purpose

1.2.1 WA submitted a Hydrogeological Impact Assessment (HIA) in October 2023 (2023 HIA)[1], which fed into an Environmental Impact Assessment (EIA) submitted in support of the planning application for deepening the quarry from 30 mAOD to -6 mAOD. The planning application was received by Natural Resources Wales (NRW) on 8 March 2024.

1.2.2 NRW responded to the planning application on 18 April 2024 advising that there was a lack of technical supporting information submitted with the application. Further information was requested. The following Technical Note has been prepared by WA to provide further technical information regarding Controlled Waters and Designated Sites to support the planning application.

[1] Wardell Armstrong (2023) Hydrogeological Impact Assessment Report Reference: ST19539/001/FINAL

2 REQUEST FOR FURTHER SUPPORTING INFORMATION

2.1 Controlled Waters

2.1.1 Regarding controlled waters, NRW responded to the planning application:

> *"Our concerns relate to the impact on the River Taff as deepening the quarry will lower the groundwater levels below the current bed level of the river. This could potentially reverse the hydraulic gradient between groundwater and river, thereby inducing flow from the river to the quarry and reducing the river flows along the reach adjacent to the quarry."*

2.1.2 NRW requested further information that addresses the following point:

> *"[the HIA] does not fully quantify the likely impact, for example, what percentage of river flows effected at Q95 is… the HIA does not assess the risk upstream or how far upstream this impact could occur. There has been no assessment of the existing flows and levels within the river and how these will be affected by the dewatering and lowering of the groundwater in the quarry, especially during low flow periods (i.e. drought periods)"*

2.1.3 To address these concerns and requests, Qube Flow Estimation Reports have been obtained from Wallingford HydroSolutions for two points on the River Taff (report refs. Q985/24, see Appendix 1). The points selected were National Grid Reference (NGR) ST 12450 83000 (upstream of the quarry) and ST 12752 82289 (downstream of the quarry) (see Drawing No. ST19539-009). The 95th percentile from the natural monthly flow duration curve statistics has been used to calculate the percentage of river flows affected at Q95 (Appendix 1).

2.1.4 To validate the Qube model data, spot flow gaugings from near to the Site and data from nearby gauging stations were used. The 2023 HIA details spot flow gauging carried out by NRW on the River Taff at NGR ST 12450 83040 during summer of 2001 and 2002. This flow data was compared to the flow duration curve statistics from the National River Flow Archive (NRFA) monitoring point 57005: Taff at Pontypridd[2], located at NGR ST 07900 89700, approximately 8 km upstream from the flow gauging point. The flow percentiles corresponding to the days when spot flow surveys were completed were calculated and then compared to the flow duration curve statistics

[2] National River Flow Archive (2024) 57005: Taff at Pontypridd [online] Accessed: 19/06/2024 Available at: https://nrfa.ceh.ac.uk/data/station/meanflow/57005

from the Qube Flow Estimation Report at NGR ST 12450 83000. The results are summarised in Table 1.

Table 2: Comparison between NRW Spot Flow Gauging, NRFA Monitoring Point 57005 and Qube Flow Estimation Report			
Date	NRW Spot Flow Gauging (ST 12450 83040)	NRFA 57005: Taff at Pontypridd Flow Duration Curve Statistics (ST 07900 89700)	Qube Flow Estimation Report Statistics Flow Duration Curve Statistics (ST 12450 83000)
	Flow (m^3/s)		
23/05/2001	5.61	80th percentile = 4.61	80th percentile = 4.70
31/07/2001	5.05	84th percentile = 5.07	84th percentile = 4.05
26/09/2001	5.08	84th percentile = 5.07	84th percentile = 4.05
28/08/2002	3.71	95th percentile = 3.63	95th percentile = 2.29

2.1.5 Table 3 shows that the data presented in the Qube Flow Estimation Report is conservative in comparison to the spot gauging (i.e. Qube model estimates are lower than the gauged flows), which would mean that the impact quantification calculations presented below are likely to overestimate the impacts in percentage terms.

2.1.6 Conceptually, it is estimated that there is a 1,500 m reach of the River Taff adjacent to the Site where effects of deepening of the quarry could be expected (see Drawing No. ST19539-009). This reach has been determined by the geological extent of the limestone that is likely to be in hydraulic continuity with the Site. A pro-rata impact for the two flow assessment points has been calculated based on this affected reach, so each 1 m section of the River Taff upstream will bear 1/1500th of the impact. The calculations showing the percentage of river flow affected at the upstream and downstream points for quarrying depths of 18 mAOD, 12 mAOD and -6 mAOD for transmissivities 4 m^2/d, 63 m^2/d and 130 m^2/d are presented in Appendix 2. Transmissivity values in the Carboniferous Limestone range from 4 m^2/d to 130 m^2/d with a median value of 63 m^2/d and a geometric mean of 34 m^2/d[3].

2.1.7 The upstream point is 530 m downstream of the start of the reach, meaning that it will bear 35.3% of the impact. In the worst-case scenario, a maximum depth of -6 mAOD and a maximum transmissivity of 130 m^2/d, the percentage of river flow

[3] British Geological Survey (1997) The physical properties of major aquifers in England and Wales. British Geological Survey Technical Report WD/97/34. 312pp. Environment Agency R&D Publication 8.

affected ranges from 0.9% in December to 4.4% in August based on the Q95 statistics for these months.

2.1.8 The downstream point is 1386 m downstream of the start of the reach, meaning that it will bear 92.4% of the impact. In the worst-case scenario, a maximum depth of -6 mAOD and a maximum transmissivity of 130 m^2/d, the percentage of river flow affected ranges from 2.4% in December to 11.7% in August based on the Q95 statistics for these months.

2.1.9 Immediately after the downstream point, dewatering from the quarry will be discharged to the River Taff. This is located 1387m downstream of the start of the reach. This point would bear 92.5% of the impact, however, this will be compensated by 100% of the dewatering inflow being discharged at this point. Therefore, at the discharge point there will be an increase in river flow by 7.5% from natural. This river flow will equilibrate over the remaining 113 m of the reach. At the 1500 m point, there should be a net zero impact as the loss from the river into the quarry will be equilibrated by the discharge into the River Taff.

2.1.10 A worst-case scenario has been presented, but it is more likely that the rates of leakage and dewatering will be better represented by the 63 m^2/d scenarios: as described in the 2023 HIA, inflows calculated using this transmissivity more closely match recent data from the site and data from other limestone quarries. At the downstream point, with a transmissivity of 63 m^2/d and at the maximum depth of the quarry (-6 mAOD), the percentage of river flow affected ranges from 1.1% in December to 5.7% in August based on the Q95 statistics for these months, which is significantly less than the worst-case scenario. It should also be noted that the Qube flow estimates for Q95 are lower than the gauged flow estimates (Table 1) and therefore the percentage impacts estimated using Qube model data are likely to be higher than would be observed in reality.

2.1.11 The flows and river levels of the River Taff will be temporarily affected by the dewatering and lowering of groundwater in the quarry but the percentage of river flow affected is small and unlikely to result in a significant impact on the River Taff. Overall, there would be a net zero impact of the deepening of the quarry downstream of the River Taff and upstream impacts are limited to the extent of the limestone strata.

Proposed Mitigation Measure

2.1.12 NRW requested further information that addresses the following point:

> *"The proposed mitigation measure is the discharge of pump quarry water from dewatering. However, there is limited assessment on how successful the discharge will be in mitigating the flows and what impact this will have downstream of the river."*

2.1.13 As detailed in section 2.1.9, overall, there should be a net zero impact of the deepening of the quarry downstream of the River Taff. All water leakage from the river into the quarry, along with rainfall, surface run off from surrounding land and groundwater flow intercepted by the quarry faces, will be pumped out of the quarry and discharged back into the River Taff. This means that the discharge will be successful in mitigating the flows and there will be no net impact on long-term river downstream of the quarry.

Monitoring of Mitigation Measure

2.1.14 NRW requested further information that addresses the following point:

> *"Regarding monitoring of the mitigation measure, we note the continued groundwater monitoring of the three boreholes as per the water resources abstraction licence. However, we request further information as to what other monitoring around the quarry will be undertaken."*

2.1.15 The current groundwater monitoring programme consists of eight monitoring boreholes (BH1 to BH6, BHF and BHH) and can be seen in Drawing No. ST19539-006. The programme is intended to monitor the impact of quarrying and dewatering on both local groundwater levels and baseflow contribution to the River Taff. Monthly groundwater level monitoring data from September 2012 to May 2024 is available for BH1, BH2, BH4, BH5, BHF and BHH. Monthly groundwater level monitoring data from September 2012 to May 2019 is available for BH3. Groundwater level monitoring in BH6 commenced in April 2023, so data for April and May 2024 is available. All groundwater level monitoring data up to May 2023 can be found in Appendix B of the 2023 HIA.

2.1.16 Warning and action trigger levels (minimum elevations) for BH2 and BH4 that were previously agreed with NRW (see Appendix C of 2023 HIA) were set to avoid groundwater levels being drawn down below the level of the River Taff (around

30mAOD). These warning and action levels will no longer be appropriate after the base of the quarry is deepened below the level of the river. It is therefore proposed that these trigger levels are not taken forward as the quarry is deepened.

2.1.17 As the quarry is deepened, it is suggested that warning and action trigger levels are instead established for BH5 which is located 200m south of the downstream discharge point, between the quarry and the River Taff.

2.1.18 The predicted drawdown at the location of BH5 has been calculated using the Cooper-Jacob analytical solution, similarly to the drawdown impact assessment calculations in the 2023 HIA. The predicted drawdown at quarry depth -6mAOD is 22.2m. Input values for this equation and results can be found in Appendix 3. The minimum recorded groundwater elevation in BH5 was 28.87mAOD in August 2022. Based on the predicted drawdown and minimum baseline groundwater elevation, the proposed action trigger level of BH5 is 6.7mAOD with a warning level of 7.2mAOD.

2.1.19 The predicted drawdown for a quarry base of 18mAOD is 7.4m and for a base of 12mAOD is 11.1m. Using these calculations, groundwater elevations at BH5 are predicted to be 21.5mAOD at quarry depth 18mAOD and 17.8mAOD at quarry depth 12mAOD. The predicted groundwater elevations would be compared with observations to assess the reliability of the action trigger levels throughout the phased mineral extraction. Should groundwater elevations be significantly lower than the predicted elevations, the drawdown impact assessment would be updated, and the action trigger level reset. Warning and action trigger levels will be agreed with NRW prior to further quarry deepening and dewatering.

2.1.20 During dewatering activities, monitoring includes recording daily pumping rates from the sump using a telemetry flow meter and hourly groundwater elevation monitoring in BH5. Should trigger levels be reached dewatering shall be stopped temporarily and redirected to the upstream discharge location (Consent Number: AN0222301) in order to minimise further impact.

2.1.21 Groundwater level and quality monitoring will be continued during mineral extraction and following completion of mineral extraction until restoration has been completed according to the approved planning permission (to be agreed with the regulatory authorities). In particular, data from BH2, BH4, BH5 and BH6 should be kept up to date.

2.1.22 The 2023 HIA identifies which water features within the ROI will receive impact from drawdown in the most likely scenario and the worst-case scenario. The receptors which are identified as receiving an impact from drawdown are: licenced groundwater abstraction (Licence No. 21/57/25/0047), the River Taff and Garth Wood. The groundwater abstraction licence (Licence No. 21/57/25/0047) is held by the Client however, the Site is currently not abstracting water under this licence number therefore there will be no impact on the current abstraction activities. The impact to the River Taff is expected not to be significant and will be mitigated by discharge of the abstracted groundwater to the river, as detailed in section 2.1.9. Garth Wood is in a different groundwater body and is therefore not in hydraulic continuity with the Site so will therefore not be affected by the Site, as discussed further in section 2.2.

2.1.23 In order to mitigate the potential impacts on water quality, the Site will follow best industry practise, using the Guidance on Pollution Prevention (GPP) as a relevant and effective source of best practise information. The conditions of the discharge permit issued by NRW will continue to be used to regulate and monitor the quality of discharge water. The discharge permit states that pH, suspended solids and oil and grease must be monitored. Since 2007, the discharge to the River Taff has always been compliant with the permit conditions.

Water Resource Abstraction Licence

2.1.24 NRW request further information that addresses the following point:

> *"The site currently has a Water Resource Licence for abstraction from the Garth Iron Workings. It should be clarified whether this includes the dewatering of the wider quarry."*

2.1.25 The Site is currently abstracting for dewatering and dust suppression under abstraction licence No: WA/057/0025/0015. The abstraction licence permits 255.5m^3/hr, 6,090m^3/d and 643,770 m^3/yr for dewatering and 2.5m^3/hr, 20m^3/d and 6,000m^3/yr for dust suppression both at an instantaneous rate not exceeding 70l/s. The abstracted water will be discharged to the River Taff under the current downstream discharge consent (Consent Number: AN0222302). The upstream discharge consent (Consent Number: AN0222301) is currently not used (see Drawing No. ST19539-006).

Discharge Rate

2.1.26 NRW commented:

"Figure ST19539-011 has a noticeable increase in discharge rate from around July and August 2017 from 1500 to 3000 m3 /day. We request an explanation of this. For example, did the quarry workings encounter groundwater for the first time in quantities that required management?"

2.1.27 From July 2017, as a result of the deepening of the quarry within the current planning permission, larger amounts of groundwater were encountered which required management. This groundwater was pumped out of the quarry which led to an increased daily discharge to the River Taff.

2.2 Designated Species

2.2.1 The Site is bounded to the north, south and east by Garth Wood, a Site of Special Scientific Interest (SSSI). Garth Wood SSSI forms part of Cardiff Beech Woods Special Area of Conservation (SAC). NRW has requested justification and supporting evidence for the following conclusion which was made by WA in the 2023 HIA:

"The potential impact of the quarry extension on the seepages within Garth Wood SSSI is considered to be low. The seepages which have been raised by NRW as an area of concern are the result of surface water infiltrating into fractures before re-emerging. Therefore the potential impacts of the deepening of the quarry is considered to be low."

2.2.2 The perched water body below the Garth Wood SSSI is within the Lesser Garth Cave System which was formed within the High Tor Limestone which lies above the less permeable Caswell Bay Mudstone. The perched water body comprises of pools which are considered to be more than 50 m above the phreatic surface at the Site[4]. The water body within the High Tor Limestone is not considered to be in hydraulic continuity with the underlying Black Rock Limestone quarried at Taffs Well due to the intervening low permeability Caswell Bay Mudstone. Therefore, there is unlikely to be a pathway for impact between the site and Garth Wood SSSI. Due to there being no lateral extension to the existing quarry footprint, there is unlikely to be a change in the pathway between the quarry and the seepages as the quarry is deepened. The seepages will not be intercepted and therefore are unlikely to be impacted by the quarry deepening.

[4] CEMEX UK Operations Ltd (February 2016) Taffs Well Quarry: Hydrogeological Impact Assessment (ST1282_TS_040216)

3 CONCLUSION

3.1.1 Based on the information presented, it is considered that any potential impacts on the flow of the River Taff caused by the proposed deepening of Taffs Well quarry would not be significant and would be mitigated downstream of the quarry by dewatering discharge into the River Taff. The magnitude of impact will be measured through the continuation of groundwater monitoring and flow monitoring at the Site and controlled through the use of warning and action trigger levels applied at BH5. Other water receptors for effects from quarry deepening are the nearby licenced groundwater abstraction (Licence No. 21/57/25/0047) and Garth Wood SSSI. These features have been scoped out of the impact assessment due to the abstraction being unused and Garth Wood SSSI not being in hydraulic continuity with the Site. All relevant permissions will be in place before any increase in the rate of abstraction and dewatering discharge from the quarry is undertaken.

APPENDIX 1

Qube Flow Estimation Reports

Qube Report Q985/24

May 2024

Flow estimate for Afon Taff (NGR: 312450, 183000)

Wardell Armstrong

Flow estimate for Afon Taff (NGR: 312450, 183000)

For and on behalf of Wallingford HydroSolutions Ltd.

Client	Wardell Armstrong
Prepared by	Ajani Jacobs
Approved by	Daniel Hamilton
Position	*Principal Consultant*
Invoice value	£360 (excl. VAT)

The WHS Quality & Environmental Management system is certified as meeting the requirements of ISO 9001:2015 and ISO 14001:2015 providing environmental consultancy (including monitoring and surveying), the development of hydrological software and associated training.

Registered Office Stables 4, Howbery Business Park, Wallingford, OX10 8BA
www.hydrosolutions.co.uk

Contents

1 Introduction

This report presents the annual and monthly flow statistics for the site(s) requested using the WHS Qube water resource modelling system. The site location(s) have been confirmed using a digital map and copies of the correspondence are contained within Annex 1.

Qube is the online evolution of the LowFlows Enterprise water resource modelling system to move beyond the estimation of natural and influenced flow statistics. Qube enables the seamless modelling of both flow statistics and time series anywhere in the UK and Ireland.

Developed by WHS in partnership with the Environment Agency, Qube is used as a best practice tool for the estimation of flows in ungauged catchments by the Environment Agency, Natural Resources Wales, Scottish Environment Protection Agency, Northern Ireland Environment Agency, Environmental Protection Agency and the UK water industry.

The Qube underpinning science has been widely published in the scientific literature.

Section 2 presents the methods for the derivation of catchment characteristics and the annual and monthly flow estimates. Following the results for each site, Sections 4 and 5 present the assumptions and uncertainties within the flow estimates, followed by the consideration for use in section 6 and the warranty and liability in section 7.

WHS is committed to continuously improving company performance and customer satisfaction. We are proud of our ISO9001 quality certification and ISO14001 environmental management certification for the provision of environmental consultancy services, development of hydrological software and associated training. For further information on all of our services and software, please visit our website www.hydrosolutions.co.uk.

2 Derivation of the Qube Flows Results

The flow statistic estimates contained in this report have been produced by Qube using models and relationships that relate these flow statistics to the climatic and hydrological characteristics of the catchment of interest. Qube is the evolution of LowFlows Enterprise[1]. All flow statistics provided in this report are for natural flows, thus do not contain any artificial influences such as abstractions, discharges or impounding reservoirs.

The following catchment characteristics and flow statistics are provided:

- Catchment Area: The catchment boundary may be derived using either a Digital Terrain Model (DTM) to determine the topographic boundaries of the catchment or imported by the user.
- Annual Mean Flow (MF): The estimation of Mean Flow is based on a 1km grid of long term average annual runoff for the given period of record (POR). The POR runoff grids were modelled using the CERF rainfall runoff model and calibrated to the UK Centre for Ecology and Hydrology 1961-1990 runoff grid (an output of a deterministic water balance model using observed data from over 500 gauged catchments[2]).
- Mean Monthly Flows (MMF): The MMF for each month are derived from the natural MF estimate by distributing the total average flow volume for the year between the months of this year. This distribution is based upon observed data from hydrologically similar gauged catchments.
- Annual Flow Duration Curve (FDC) statistics: The flow duration curve statistics are estimated using a procedure based on measured flow data from hydrologically similar gauged catchments. The methodology was initially developed in 2002[3] and has been subsequently further refined. Where nested local data gauges (LDG) are available, the FDC is improved using naturalised gauged FDCs for the given period of record.
- Mean Monthly Flow Duration Curves (MFDC): The MFDC for each month is estimated using gauged MFDCs from hydrologically and climatologically similar catchments and the estimate of MMF for that month. Where LDG have been used, the MFDC's are adjusted using the LDG improved annual FDC.
- Base-Flow Index (BFI): The proportion of a hydrograph occurring as base flow, hence varying between zero and unity. BFI is indicative of catchment permeability with values approaching unity associated with highly permeable systems. BFI is estimated from a revised form of the BFIHOST multivariate linear regression equation[4].

If these long term natural flow statistics were calculated directly from a gauged flow record the annual statistics would be equivalent to those calculated using all of the daily flow data from all years of record and the monthly statistics for a month equivalent to those calculated from the gauged data for that month from all years.

[1] Young A. R., Grew R. and Holmes M.G.R. 2003. Low Flows 2000: A national water resources assessment and decision support. Water Science and Technology, 48 (10).
[2] Holmes, M.G.R., Young, A.R., Gustard, A.G. and Grew, R. 2002. A new approach to estimating Mean Flow in the United Kingdom. Hydrology and Earth System Sciences. 6(4) 709-720.
[3] Holmes, M.G.R., Young, A.R., Gustard, A.G. and Grew, R. 2002. A Region of Influence approach to predicting Flow Duration Curves within ungauged catchments. Hydrology and Earth System Sciences. 6(4) 721-731.
[4] Boorman, D.B., Hollis, J.M. and Lilly, A. 1994. Hydrology of Soil Types: a Hydrologically-based Classification of the Soils of the United Kingdom. IH Report 126.

3 Flow Results for Afon Taff (NGR: 312450, 183000)

3.1 Catchment Characteristics

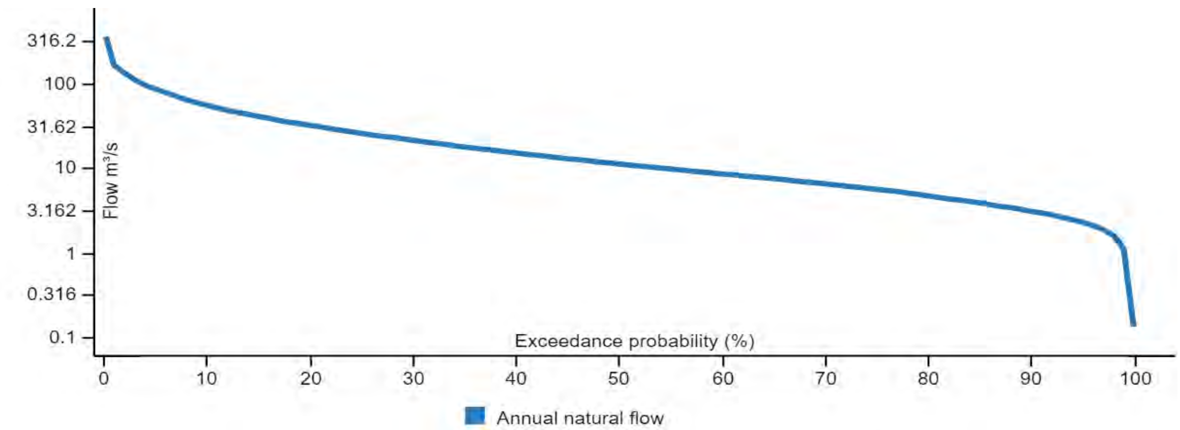
The catchment characteristics and map for this catchment are presented in the table and figure below. The catchment is underlain by bedrock consisting of mudstone, siltstone, sandstone, limestone and argillaceous rocks. Superficial deposits of diamicton and peat are also present within the catchment. A gauge (57005 – Taff at Pontypridd) located within the same part of the river network as the target site was flagged as a source of local data and was used to improve the flow estimates.

Catchment name	Catchment at 312450,183000	Catchment area	480.9 km²
Location	312450, 183000	Hydrometric area	57

Catchment Boundary Map (Contains Ordnance Survey data © Crown copyright and database right 2024)

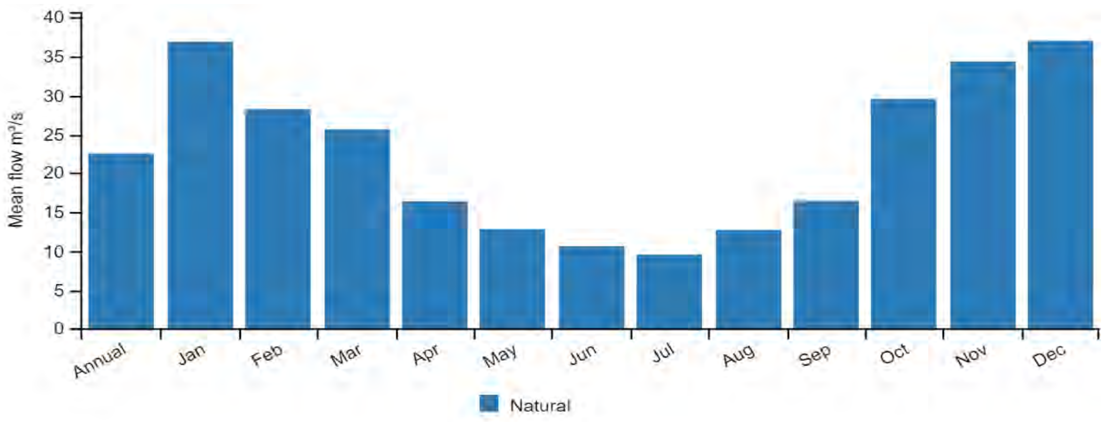
3.2 Long Term Flow Statistics

Period of record	Full period of record	Runoff (Period of record)	1437.7 mm
BFIHOST	0.417		



Annual Flow Duration Curve

Flow Estimate Q985/24



Annual and Monthly Mean Flow

Annual Flow Duration Curve Statistics (m^3/s)

Percentile	Natural Flow
5	86.73
10	55.82
20	32.14
30	21.4
40	15.09
50	11.24
60	8.515
70	6.523
80	4.698
90	3.074
95	2.288
99	1.104

Annual and Monthly Mean Flows (m^3/s)

	Natural Flow
Annual	22.44
January	36.82
February	28.15
March	25.55
April	16.32
May	12.72
June	10.54
July	9.449
August	12.63
September	16.36
October	29.47
November	34.28
December	36.95

Region of Influence Stations

Reference number	Weight (%)	Q95 % MF
59001	28.9	11.71
58008	22.2	12.27
57004	19.3	12.45
58001	14.8	14.82
58007	14.7	15.95

Local Data Gauges - On

Gauge	Location	Area km²	MF m³/s	Q95 m³/s
Taff at Pontypridd	upstream	451.7	21.52	2.143

Lake Adjustment - Off

Local data gauge(s) have been used to improve the flow estimate, therefore only lakes in the incremental area are considered. No lakes were found in the incremental catchment area.

Natural Monthly Flow Duration Curve Statistics (m^3/s)

Percentile	January	February	March	April	May	June
5	113.5	92.99	82.52	51.12	37.92	32.33
10	87.16	62.52	53.59	34.74	26	20.9
20	57.81	39.87	32.94	21.25	16.02	12.62
30	42.25	29.04	24.22	15.06	11.52	9.011
40	31.86	20.97	18.65	11.89	8.956	6.857
50	24.5	15.85	14.49	9.72	7.389	5.59
60	19.29	12.45	11.59	8.053	6.107	4.584
70	14.93	10.07	9.481	6.701	5.089	3.798
80	11.13	8.08	7.834	5.416	4.093	3.005
90	7.752	6.198	6.121	4.081	3.148	2.399
95	5.694	5.047	4.843	3.333	2.716	1.978
99	3.433	3.321	3.633	2.359	1.961	1.23

Percentile	July	August	September	October	November	December
5	29.36	43.53	63.97	106.7	109.4	115
10	18.58	28.41	39.6	70.55	81.78	88.52
20	10.83	15.23	21.78	43.01	51.41	55.54
30	7.768	10.33	14.19	28.61	36.73	39.47
40	5.912	7.701	9.968	20.62	27.81	29.25
50	4.756	5.895	7.271	15.14	21.58	22.94
60	3.898	4.491	5.391	11.37	16.9	17.33
70	3.243	3.451	4.158	8.498	12.87	13.46
80	2.659	2.506	3.196	6.294	9.74	10.52
90	2.062	1.789	2.277	3.857	7.289	7.901
95	1.678	1.312	1.655	2.588	5.861	6.418
99	0.814	0.46	0.374	1.272	3.648	4.911

4 Assumptions

Assumptions implicit in the estimated flow estimates are:

- Only natural flow statistics have been estimated and the impact of any artificial influences (for example abstractions, discharges or impounding reservoirs) is not included.
- The topographic catchment area identified is assumed to accurately reflect the true catchment area contributing to flows at the catchment outlet.
- The flow estimates are based on long term average records.

5 Model Uncertainty

The figures for factorial standard error of estimate for long term mean flow and Q95 are shown in the below table. So, as an example the uncertainty in the estimate of mean flow in Scotland will generally be less than 11%. These standard errors are presented as a general guide only and should be considered in the context of the information presented within section 6. These errors are broadly comparable to the sampling errors that might be expected if mean flow was calculated from two to three years of error free gauged data and Q95 for in the order of five years error free gauged data.

If these estimates are to be used for high value decision making we would recommend that the estimates are corroborated through appropriate local flow measurement. For advice on flow measurement please contact us at info@hydrosolutions.co.uk.

Model Factorial Standard Error (FSE)

Regions of the UK	FSE Mean Flow	FSE Q95
England and Wales	16	42
Scotland	11	35
Northern Ireland	11	30

6 Consideration for Use

The predictive performance of the Mean Flow and FDC Estimation Models may vary according to local conditions. The following is a list of significant, but not comprehensive, issues that need to be considered when estimating flows within ungauged catchments:

- Care needs to be taken when interpreting the results in smaller groundwater catchments in which river flows may be strongly influenced by point geological controls (such as spring lines and swallow holes).
- A catchment water balance is assumed, which may be incorrect in smaller groundwater fed catchments where part of the regional groundwater flow bypasses the surface water catchment.
- The estimation of Mean Flow is based on a 1km grid of long term average annual runoff, derived using the CERF rainfall runoff model and calibrated using the outputs from a deterministic water balance model using observed data from over 500 gauged catchments. The predictive performance of the model may therefore be reduced in areas of low rainfall gauge density.
- Care needs to be taken when interpreting the result in very small catchments as the size of the catchment approached the spatial resolution of the underlying catchment characteristic datasets

(1 km^2). For very small catchments it is recommended that the topographic contributing catchment is confirmed by a site walkover to identify any unmapped features that might modify the catchment area.

- Where available local measured flow data should be used to corroborate the flow estimates, which is good practice when using any generalised hydrological model.

7 Warranty and Liability

1. The assumptions and uncertainties associated with the flow estimation methods must be considered when making use of flow estimates produced by the system.
2. You are responsible for the interpretation of the Results presented within this report and training in the use of the estimation methods is strongly recommended.
3. Subject to 1 and 2 above, WHS do not seek to limit or exclude liability for personal injury or death arising from our negligence.
4. Except for 3 above our entire liability for any breach of our duties, whether or not attributable to our negligence, is limited to the fee that you have paid for this report.
5. Except for 3 and 4 above, in no event will WHS be liable to you for any damages, including lost profits, lost savings or other incidental or consequential damages arising on your use of the results even if we have been advised of the possibility of such damages.
6. Should any of these provisions be ruled invalid under any law or Act of Parliament, they shall be deemed modified or omitted only to the extent necessary to render them valid and the remainder of these provisions shall be upheld.

Annex 1: Copies of key correspondence with the client

Hi Dan,

We are happy for you to go ahead with the works. The PO is ST33440.

Thank you,
Kind regards,
Amelia

Amelia Ebanks | Hydrogeologist
Wardell Armstrong LLP
Sir Henry Doulton House, Forge Lane, Etruria, Stoke on Trent, ST1 5BD
07442 916 756 01782 276700

From: LowFlows <lowflows@hydrosolutions.co.uk>
Sent: Thursday, May 30, 2024 11:03 AM
To: Ebanks, Amelia <aebanks@wardell-armstrong.com>
Subject: Re: WHS Website enquiry - Wed, 29 May 2024 15:03:30 +0000

Hello Amelia,

Thanks for your email, I can advise that two flow estimates at the locations specified will £360+VAT at 20%.

As an existing customer WHS will require either a formal PO number or formal go ahead in advance before commencing the works. If you wish to make payment of our invoice by credit, debit or AMEX cards, please can you confirm and I can arrange for our accounts team to provide you with a 'PAY NOW' invoice which has an imbedded link to the secure Sage Pay portal. Alternatively, payment can be made via BACS by your accounts team:

By BACS Account- Wallingford Hydrosolutions Ltd Sort Code- 40-34-27 Account- 52177145

Once go ahead is received we will begin progressing the report and will look to deliver the report within 10 working days.

Kind regards,

Dan
Qube Estimation Service

---------- Forwarded message ---------
From: WHS Website Enquiry <noreply@hydrosolutions.co.uk>
Date: Wed, 29 May 2024 at 16:03
Subject: WHS Website enquiry - Wed, 29 May 2024 15:03:30 +0000
To: <software@hydrosolutions.co.uk>

Name: Amelia Ebanks
Email: aebanks@wardell-armstrong.com

Message:
Hi,

Please could I purchase two river flow estimate reports for the following locations:
- ST 12752 82289
- ST 12450 83040

The PO is ST33440

Please would you be able to let me know how long it will take to obtain the data?

Thank you,

Kind regards,

Amelia

Qube Report Q985/24

May 2024

Flow estimate for Afon Taff (NGR: 312750, 182300)

Wardell Armstrong

Flow estimate for Afon Taff (NGR: 312750, 182300)

For and on behalf of Wallingford HydroSolutions Ltd.

Client	Wardell Armstrong
Prepared by	Ajani Jacobs
Approved by	Daniel Hamilton
Position	*Principal Consultant*
Invoice value	£360 (excl. VAT)

Registered Office Stables 4, Howbery Business Park, Wallingford, OX10 8BA
www.hydrosolutions.co.uk

Contents

1 Introduction

This report presents the annual and monthly flow statistics for the site(s) requested using the WHS Qube water resource modelling system. The site location(s) have been confirmed using a digital map and copies of the correspondence are contained within Annex 1.

Qube is the online evolution of the LowFlows Enterprise water resource modelling system to move beyond the estimation of natural and influenced flow statistics. Qube enables the seamless modelling of both flow statistics and time series anywhere in the UK and Ireland.

Developed by WHS in partnership with the Environment Agency, Qube is used as a best practice tool for the estimation of flows in ungauged catchments by the Environment Agency, Natural Resources Wales, Scottish Environment Protection Agency, Northern Ireland Environment Agency, Environmental Protection Agency and the UK water industry.

The Qube underpinning science has been widely published in the scientific literature.

Section 2 presents the methods for the derivation of catchment characteristics and the annual and monthly flow estimates. Following the results for each site, Sections 4 and 5 present the assumptions and uncertainties within the flow estimates, followed by the consideration for use in section 6 and the warranty and liability in section 7.

WHS is committed to continuously improving company performance and customer satisfaction. We are proud of our ISO9001 quality certification and ISO14001 environmental management certification for the provision of environmental consultancy services, development of hydrological software and associated training. For further information on all of our services and software, please visit our website www.hydrosolutions.co.uk.

2 Derivation of the Qube Flows Results

The flow statistic estimates contained in this report have been produced by Qube using models and relationships that relate these flow statistics to the climatic and hydrological characteristics of the catchment of interest. Qube is the evolution of LowFlows Enterprise[1]. All flow statistics provided in this report are for natural flows, thus do not contain any artificial influences such as abstractions, discharges or impounding reservoirs.

The following catchment characteristics and flow statistics are provided:

- Catchment Area: The catchment boundary may be derived using either a Digital Terrain Model (DTM) to determine the topographic boundaries of the catchment or imported by the user.
- Annual Mean Flow (MF): The estimation of Mean Flow is based on a 1km grid of long term average annual runoff for the given period of record (POR). The POR runoff grids were modelled using the CERF rainfall runoff model and calibrated to the UK Centre for Ecology and Hydrology 1961-1990 runoff grid (an output of a deterministic water balance model using observed data from over 500 gauged catchments[2]).
- Mean Monthly Flows (MMF): The MMF for each month are derived from the natural MF estimate by distributing the total average flow volume for the year between the months of this year. This distribution is based upon observed data from hydrologically similar gauged catchments.
- Annual Flow Duration Curve (FDC) statistics: The flow duration curve statistics are estimated using a procedure based on measured flow data from hydrologically similar gauged catchments. The methodology was initially developed in 2002[3] and has been subsequently further refined. Where nested local data gauges (LDG) are available, the FDC is improved using naturalised gauged FDCs for the given period of record.
- Mean Monthly Flow Duration Curves (MFDC): The MFDC for each month is estimated using gauged MFDCs from hydrologically and climatologically similar catchments and the estimate of MMF for that month. Where LDG have been used, the MFDC's are adjusted using the LDG improved annual FDC.
- Base-Flow Index (BFI): The proportion of a hydrograph occurring as base flow, hence varying between zero and unity. BFI is indicative of catchment permeability with values approaching unity associated with highly permeable systems. BFI is estimated from a revised form of the BFIHOST multivariate linear regression equation[4].

If these long term natural flow statistics were calculated directly from a gauged flow record the annual statistics would be equivalent to those calculated using all of the daily flow data from all years of record and the monthly statistics for a month equivalent to those calculated from the gauged data for that month from all years.

[1] Young A. R., Grew R. and Holmes M.G.R. 2003. Low Flows 2000: A national water resources assessment and decision support. Water Science and Technology, 48 (10).
[2] Holmes, M.G.R., Young, A.R., Gustard, A.G. and Grew, R. 2002. A new approach to estimating Mean Flow in the United Kingdom. Hydrology and Earth System Sciences. 6(4) 709-720.
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[4] Boorman, D.B., Hollis, J.M. and Lilly, A. 1994. Hydrology of Soil Types: a Hydrologically-based Classification of the Soils of the United Kingdom. IH Report 126.

3 Flow Results for Afon Taff (NGR: 312750, 182300)

3.1 Catchment Characteristics

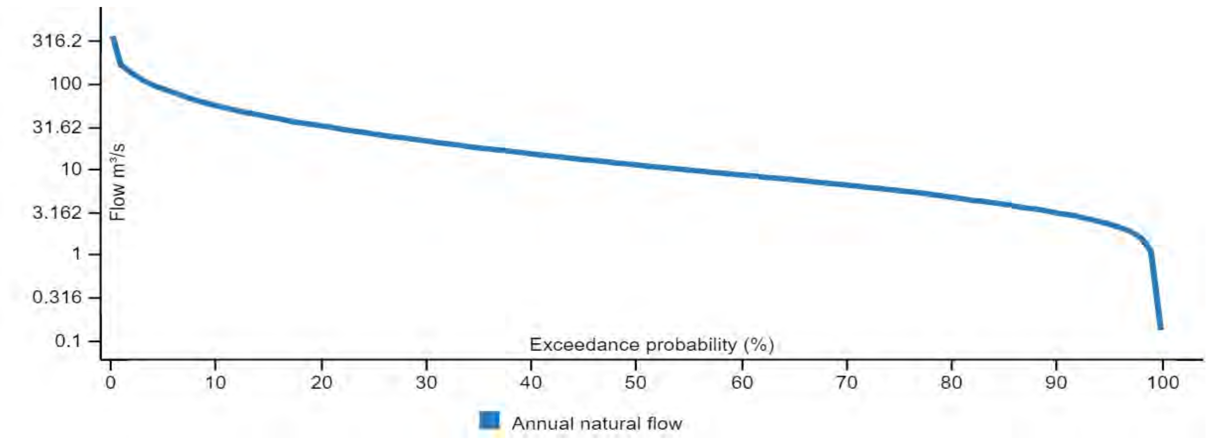
The catchment characteristics and map for this catchment are presented in the table and figure below. The catchment is underlain by bedrock consisting largely of mudstone, siltstone, sandstone, limestone and argillaceous rocks, interbedded. Superficial deposits of diamicton and peat are also present within the catchment. A gauge (57005 – Taff at Pontypridd) located within the same part of the river network as the target site was flagged as a source of local data and was used to improve the flow estimates.

Catchment name	Catchment at 312750,182300	Catchment area	481.4 km²
Location	312750, 182300	Hydrometric area	57

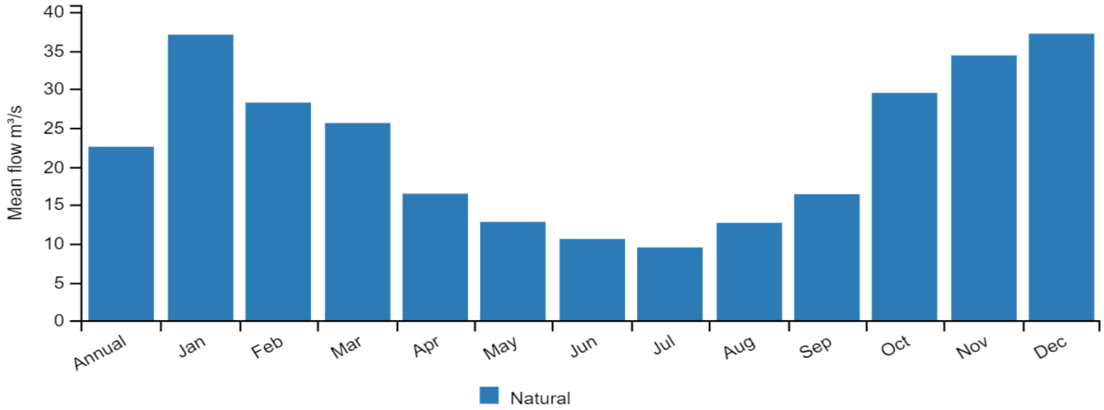
Catchment Boundary Map (Contains Ordnance Survey data © Crown copyright and database right 2024)

3.2 Long Term Flow Statistics

Period of record	Full period of record	Runoff (Period of record)	1437.7 mm
BFIHOST	0.418		



Annual Flow Duration Curve



Annual and Monthly Mean Flow

Annual Flow Duration Curve Statistics (m^3/s)

Percentile	Natural Flow
5	86.86
10	55.85
20	32.15
30	21.4
40	15.08
50	11.23
60	8.506
70	6.512
80	4.687
90	3.066
95	2.279
99	1.096

Annual and Monthly Mean Flows (m^3/s)

	Natural Flow
Annual	22.45
January	36.96
February	28.17
March	25.52
April	16.38
May	12.73
June	10.52
July	9.43
August	12.61
September	16.32
October	29.43
November	34.27
December	37.09

Region of Influence Stations

Reference number	Weight (%)	Q95 % MF
59001	29.1	11.71
58008	22.1	12.27
57004	19.3	12.45
58001	14.8	14.82
58007	14.7	15.95

Local Data Gauges - On

Gauge	Location	Area km²	MF m³/s	Q95 m³/s
Taff at Pontypridd	upstream	451.7	21.52	2.143

Lake Adjustment - Off

Local data gauge(s) have been used to improve the flow estimate, therefore only lakes in the incremental area are considered. No lakes were found in the incremental catchment area.

Natural Monthly Flow Duration Curve Statistics (m^3/s)

Percentile	January	February	March	April	May	June
5	113.7	93.14	81.9	51.15	37.94	32.22
10	87.97	62.94	53.62	34.87	26	20.83
20	58.19	40.03	32.83	21.25	15.98	12.53
30	43.04	29.05	24.29	15.14	11.51	8.985
40	32.34	20.97	18.58	11.95	8.949	6.846
50	24.58	15.89	14.48	9.714	7.379	5.566
60	19.35	12.45	11.56	8.043	6.096	4.559
70	14.92	10.06	9.425	6.722	5.1	3.775
80	11.15	8.071	7.809	5.43	4.071	2.986
90	7.792	6.172	6.111	4.097	3.141	2.39
95	5.709	5.057	4.85	3.349	2.722	1.935
99	3.443	3.313	3.609	2.377	1.953	1.222

Percentile	July	August	September	October	November	December
5	29.26	43.55	63.66	106.8	109.6	115.2
10	18.52	28.21	39.49	70.64	81.18	88.66
20	10.82	15.18	21.65	42.78	51.44	55.57
30	7.726	10.3	14.12	28.52	36.76	39.63
40	5.867	7.656	9.911	20.62	27.81	29.37
50	4.746	5.884	7.243	15.09	21.52	23.13
60	3.889	4.481	5.368	11.32	16.89	17.33
70	3.235	3.434	4.148	8.461	12.82	13.53
80	2.651	2.498	3.172	6.284	9.734	10.52
90	2.053	1.781	2.268	3.848	7.279	7.892
95	1.669	1.304	1.646	2.58	5.85	6.437
99	0.807	0.455	0.369	1.263	3.624	4.9

4 Assumptions

Assumptions implicit in the estimated flow estimates are:

- Only natural flow statistics have been estimated and the impact of any artificial influences (for example abstractions, discharges or impounding reservoirs) is not included.
- The topographic catchment area identified is assumed to accurately reflect the true catchment area contributing to flows at the catchment outlet.
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5 Model Uncertainty

The figures for factorial standard error of estimate for long term mean flow and Q95 are shown in the below table. So, as an example the uncertainty in the estimate of mean flow in Scotland will generally be less than 11%. These standard errors are presented as a general guide only and should be considered in the context of the information presented within section 6. These errors are broadly comparable to the sampling errors that might be expected if mean flow was calculated from two to three years of error free gauged data and Q95 for in the order of five years error free gauged data.

If these estimates are to be used for high value decision making we would recommend that the estimates are corroborated through appropriate local flow measurement. For advice on flow measurement please contact us at info@hydrosolutions.co.uk.

Model Factorial Standard Error (FSE)

Regions of the UK	FSE Mean Flow	FSE Q95
England and Wales	16	42
Scotland	11	35
Northern Ireland	11	30

6 Consideration for Use

The predictive performance of the Mean Flow and FDC Estimation Models may vary according to local conditions. The following is a list of significant, but not comprehensive, issues that need to be considered when estimating flows within ungauged catchments:

- Care needs to be taken when interpreting the results in smaller groundwater catchments in which river flows may be strongly influenced by point geological controls (such as spring lines and swallow holes).
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2. You are responsible for the interpretation of the Results presented within this report and training in the use of the estimation methods is strongly recommended.
3. Subject to 1 and 2 above, WHS do not seek to limit or exclude liability for personal injury or death arising from our negligence.
4. Except for 3 above our entire liability for any breach of our duties, whether or not attributable to our negligence, is limited to the fee that you have paid for this report.
5. Except for 3 and 4 above, in no event will WHS be liable to you for any damages, including lost profits, lost savings or other incidental or consequential damages arising on your use of the results even if we have been advised of the possibility of such damages.
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Annex 1: Copies of key correspondence with the client

Hi Dan,

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Thank you,
Kind regards,
Amelia

Amelia Ebanks | Hydrogeologist
Wardell Armstrong LLP
Sir Henry Doulton House, Forge Lane, Etruria, Stoke on Trent, ST1 5BD
07442 916 756 01782 276700

From: LowFlows <lowflows@hydrosolutions.co.uk>
Sent: Thursday, May 30, 2024 11:03 AM
To: Ebanks, Amelia <aebanks@wardell-armstrong.com>
Subject: Re: WHS Website enquiry - Wed, 29 May 2024 15:03:30 +0000

Hello Amelia,

Thanks for your email, I can advise that two flow estimates at the locations specified will £360+VAT at 20%.

As an existing customer WHS will require either a formal PO number or formal go ahead in advance before commencing the works. If you wish to make payment of our invoice by credit, debit or AMEX cards, please can you confirm and I can arrange for our accounts team to provide you with a 'PAY NOW' invoice which has an imbedded link to the secure Sage Pay portal. Alternatively, payment can be made via BACS by your accounts team:

By BACS Account- Wallingford Hydrosolutions Ltd Sort Code- 40-34-27 Account- 52177145

Once go ahead is received we will begin progressing the report and will look to deliver the report within 10 working days.

Kind regards,

Dan
Qube Estimation Service

---------- Forwarded message ---------
From: WHS Website Enquiry <noreply@hydrosolutions.co.uk>
Date: Wed, 29 May 2024 at 16:03
Subject: WHS Website enquiry - Wed, 29 May 2024 15:03:30 +0000
To: <software@hydrosolutions.co.uk>

Name: Amelia Ebanks
Email: aebanks@wardell-armstrong.com

Message:
Hi,

Please could I purchase two river flow estimate reports for the following locations:
- ST 12752 82289
- ST 12450 83040

The PO is ST33440

Please would you be able to let me know how long it will take to obtain the data?

Thank you,

Kind regards,

Amelia

APPENDIX 2

Impact Quantification

312450, 183000		upstream	
Depth =	18	mAOD	
Transmissivity =	4	m2/d	
Total leaky river aquifer inflow =	145.82	m3/d	
Upstream impact (35.3%) =	51.47446		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.010%
February	5.047	436060.8	0.012%
March	4.843	418435.2	0.012%
April	3.333	287971.2	0.018%
May	2.716	234662.4	0.022%
June	1.978	170899.2	0.030%
July	1.678	144979.2	0.036%
August	1.312	113356.8	0.045%
September	1.655	142992	0.036%
October	2.588	223603.2	0.023%
November	5.861	506390.4	0.010%
December	6.418	554515.2	0.009%

312450, 183000		upstream	
Depth =	18	mAOD	
Transmissivity =	63	m2/d	
Total leaky river aquifer inflow =	2296.71	m3/d	
Upstream impact (35.3%) =	810.7386		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.165%
February	5.047	436060.8	0.186%
March	4.843	418435.2	0.194%
April	3.333	287971.2	0.282%
May	2.716	234662.4	0.345%
June	1.978	170899.2	0.474%
July	1.678	144979.2	0.559%
August	1.312	113356.8	0.715%
September	1.655	142992	0.567%
October	2.588	223603.2	0.363%
November	5.861	506390.4	0.160%
December	6.418	554515.2	0.146%

312450, 183000		upstream	
Depth =	18	mAOD	
Transmissivity =	130	m2/d	
Total leaky river aquifer inflow =	4739.24	m3/d	
Upstream impact (35.3%) =	1672.952		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.340%
February	5.047	436060.8	0.384%
March	4.843	418435.2	0.400%
April	3.333	287971.2	0.581%
May	2.716	234662.4	0.713%
June	1.978	170899.2	0.979%
July	1.678	144979.2	1.154%
August	1.312	113356.8	1.476%
September	1.655	142992	1.170%
October	2.588	223603.2	0.748%
November	5.861	506390.4	0.330%
December	6.418	554515.2	0.302%

312450, 183000		upstream	
Depth =	12	mAOD	
Transmissivity =	4	m2/d	
Total leaky river aquifer inflow =	218.73	m3/d	
Upstream impact (35.3%) =	77.21169		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.016%
February	5.047	436060.8	0.018%
March	4.843	418435.2	0.018%
April	3.333	287971.2	0.027%
May	2.716	234662.4	0.033%
June	1.978	170899.2	0.045%
July	1.678	144979.2	0.053%
August	1.312	113356.8	0.068%
September	1.655	142992	0.054%
October	2.588	223603.2	0.035%
November	5.861	506390.4	0.015%
December	6.418	554515.2	0.014%

312450, 183000		upstream	
Depth =	12	mAOD	
Transmissivity =	63	m2/d	
Total leaky river aquifer inflow =	3445.06	m3/d	
Upstream impact (35.3%) =	1216.106		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.247%
February	5.047	436060.8	0.279%
March	4.843	418435.2	0.291%
April	3.333	287971.2	0.422%
May	2.716	234662.4	0.518%
June	1.978	170899.2	0.712%
July	1.678	144979.2	0.839%
August	1.312	113356.8	1.073%
September	1.655	142992	0.850%
October	2.588	223603.2	0.544%
November	5.861	506390.4	0.240%
December	6.418	554515.2	0.219%

312450, 183000		upstream	
Depth =	12	mAOD	
Transmissivity =	130	m2/d	
Total leaky river aquifer inflow =	7108.86	m3/d	
Upstream impact (35.3%) =	2509.428		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.510%
February	5.047	436060.8	0.575%
March	4.843	418435.2	0.600%
April	3.333	287971.2	0.871%
May	2.716	234662.4	1.069%
June	1.978	170899.2	1.468%
July	1.678	144979.2	1.731%
August	1.312	113356.8	2.214%
September	1.655	142992	1.755%
October	2.588	223603.2	1.122%
November	5.861	506390.4	0.496%
December	6.418	554515.2	0.453%

312450, 183000		upstream	
Depth =	-6	mAOD	
Transmissivity =	4	m2/d	
Total leaky river aquifer inflow =	437.47	m3/d	
Upstream impact (35.3%) =	154.4269		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.031%
February	5.047	436060.8	0.035%
March	4.843	418435.2	0.037%
April	3.333	287971.2	0.054%
May	2.716	234662.4	0.066%
June	1.978	170899.2	0.090%
July	1.678	144979.2	0.107%
August	1.312	113356.8	0.136%
September	1.655	142992	0.108%
October	2.588	223603.2	0.069%
November	5.861	506390.4	0.030%
December	6.418	554515.2	0.028%

312450, 183000		upstream	
Depth =	-6	mAOD	
Transmissivity =	63	m2/d	
Total leaky river aquifer inflow =	6890.13	m3/d	
Upstream impact (35.3%) =	2432.216		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.694	491961.6	0.494%
February	5.047	436060.8	0.558%
March	4.843	418435.2	0.581%
April	3.333	287971.2	0.845%
May	2.716	234662.4	1.036%
June	1.978	170899.2	1.423%
July	1.678	144979.2	1.678%
August	1.312	113356.8	2.146%
September	1.655	142992	1.701%
October	2.588	223603.2	1.088%
November	5.861	506390.4	0.480%
December	6.418	554515.2	0.439%

312450, 183000		upstream	
Depth =	-6	mAOD	
Transmissivity =	130	m2/d	
Total leaky river aquifer inflow =	14217.72	m3/d	
Upstream impact (35.3%) =	5018.855		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	% of river flow affected
January	5.694	491961.6	1.020%
February	5.047	436060.8	1.151%
March	4.843	418435.2	1.199%
April	3.333	287971.2	1.743%
May	2.716	234662.4	2.139%
June	1.978	170899.2	2.937%
July	1.678	144979.2	3.462%
August	1.312	113356.8	4.427%
September	1.655	142992	3.510%
October	2.588	223603.2	2.245%
November	5.861	506390.4	0.991%
December	6.418	554515.2	0.905%

312750, 182300		downstream	
Depth =	18	mAOD	
Transmissivity =	4	m2/d	
Leaky River aquifer inflow =	145.82	m3/d	
Downstream impact (92.4%) =	134.7377		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	0.027%
February	5.057	436924.8	0.031%
March	4.85	419040	0.032%
April	3.349	289353.6	0.047%
May	2.722	235180.8	0.057%
June	1.935	167184	0.081%
July	1.669	144201.6	0.093%
August	1.304	112665.6	0.120%
September	1.646	142214.4	0.095%
October	2.58	222912	0.060%
November	5.85	505440	0.027%
December	6.437	556156.8	0.024%

312750, 182300		downstream	
Depth =	18	mAOD	
Transmissivity =	63	m2/d	
Leaky River aquifer inflow =	2296.71	m3/d	
Downstream impact (92.4%) =	2122.16		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	0.430%
February	5.057	436924.8	0.486%
March	4.85	419040	0.506%
April	3.349	289353.6	0.733%
May	2.722	235180.8	0.902%
June	1.935	167184	1.269%
July	1.669	144201.6	1.472%
August	1.304	112665.6	1.884%
September	1.646	142214.4	1.492%
October	2.58	222912	0.952%
November	5.85	505440	0.420%
December	6.437	556156.8	0.382%

312750, 182300		downstream	
Depth =	18	mAOD	
Transmissivity =	130	m2/d	
Leaky River aquifer inflow =	4739.24	m3/d	
Downstream impact (92.4%) =	4379.058		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	0.888%
February	5.057	436924.8	1.002%
March	4.85	419040	1.045%
April	3.349	289353.6	1.513%
May	2.722	235180.8	1.862%
June	1.935	167184	2.619%
July	1.669	144201.6	3.037%
August	1.304	112665.6	3.887%
September	1.646	142214.4	3.079%
October	2.58	222912	1.964%
November	5.85	505440	0.866%
December	6.437	556156.8	0.787%

312750, 182300		downstream	
Depth =	12	mAOD	
Transmissivity =	4	m2/d	
Leaky River aquifer inflow =	218.73	m3/d	
Downstream impact (92.4%) =	202.1065		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	0.041%
February	5.057	436924.8	0.046%
March	4.85	419040	0.048%
April	3.349	289353.6	0.070%
May	2.722	235180.8	0.086%
June	1.935	167184	0.121%
July	1.669	144201.6	0.140%
August	1.304	112665.6	0.179%
September	1.646	142214.4	0.142%
October	2.58	222912	0.091%
November	5.85	505440	0.040%
December	6.437	556156.8	0.036%

312750, 182300		downstream	
Depth =	12	mAOD	
Transmissivity =	63	m2/d	
Leaky River aquifer inflow =	3445.06	m3/d	
Downstream impact (92.4%) =	3183.235		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	0.645%
February	5.057	436924.8	0.729%
March	4.85	419040	0.760%
April	3.349	289353.6	1.100%
May	2.722	235180.8	1.354%
June	1.935	167184	1.904%
July	1.669	144201.6	2.207%
August	1.304	112665.6	2.825%
September	1.646	142214.4	2.238%
October	2.58	222912	1.428%
November	5.85	505440	0.630%
December	6.437	556156.8	0.572%

312750, 182300		downstream	
Depth =	12	mAOD	
Transmissivity =	130	m2/d	
Leaky River aquifer inflow =	7108.86	m3/d	
Downstream impact (92.4%) =	6568.587		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	1.332%
February	5.057	436924.8	1.503%
March	4.85	419040	1.568%
April	3.349	289353.6	2.270%
May	2.722	235180.8	2.793%
June	1.935	167184	3.929%
July	1.669	144201.6	4.555%
August	1.304	112665.6	5.830%
September	1.646	142214.4	4.619%
October	2.58	222912	2.947%
November	5.85	505440	1.300%
December	6.437	556156.8	1.181%

312750, 182300		downstream	
Depth =	-6	mAOD	
Transmissivity =	4	m2/d	
Leaky River aquifer inflow =	437.47	m3/d	
Downstream impact (92.4%) =	404.2223		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	0.082%
February	5.057	436924.8	0.093%
March	4.85	419040	0.096%
April	3.349	289353.6	0.140%
May	2.722	235180.8	0.172%
June	1.935	167184	0.242%
July	1.669	144201.6	0.280%
August	1.304	112665.6	0.359%
September	1.646	142214.4	0.284%
October	2.58	222912	0.181%
November	5.85	505440	0.080%
December	6.437	556156.8	0.073%

312750, 182300		downstream	
Depth =	-6	mAOD	
Transmissivity =	63	m2/d	
Leaky River aquifer inflow =	6890.13	m3/d	
Downstream impact (92.4%) =	6366.48		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	1.291%
February	5.057	436924.8	1.457%
March	4.85	419040	1.519%
April	3.349	289353.6	2.200%
May	2.722	235180.8	2.707%
June	1.935	167184	3.808%
July	1.669	144201.6	4.415%
August	1.304	112665.6	5.651%
September	1.646	142214.4	4.477%
October	2.58	222912	2.856%
November	5.85	505440	1.260%
December	6.437	556156.8	1.145%

312750, 182300		downstream	
Depth =	-6	mAOD	
Transmissivity =	130	m2/d	
Leaky River aquifer inflow =	14217.72	m3/d	
Downstream impact (92.4%) =	13137.17		
Natural Monthly Flow Duration Curve Statistics			
95th percentile	**river flow m3/s**	**river flow m3/d**	**% of river flow affected**
January	5.709	493257.6	2.663%
February	5.057	436924.8	3.007%
March	4.85	419040	3.135%
April	3.349	289353.6	4.540%
May	2.722	235180.8	5.586%
June	1.935	167184	7.858%
July	1.669	144201.6	9.110%
August	1.304	112665.6	11.660%
September	1.646	142214.4	9.238%
October	2.58	222912	5.893%
November	5.85	505440	2.599%
December	6.437	556156.8	2.362%

APPENDIX 3

Drawdown Calculations

Leaky River aquifer inflow m3/d			
Depth of quarry mAOD	Transmissivity m2d-1		
	4	63	130
18	145.82	2296.71	4739.24
12	218.73	3445.06	7108.86
-6	437.47	6890.13	14217.72

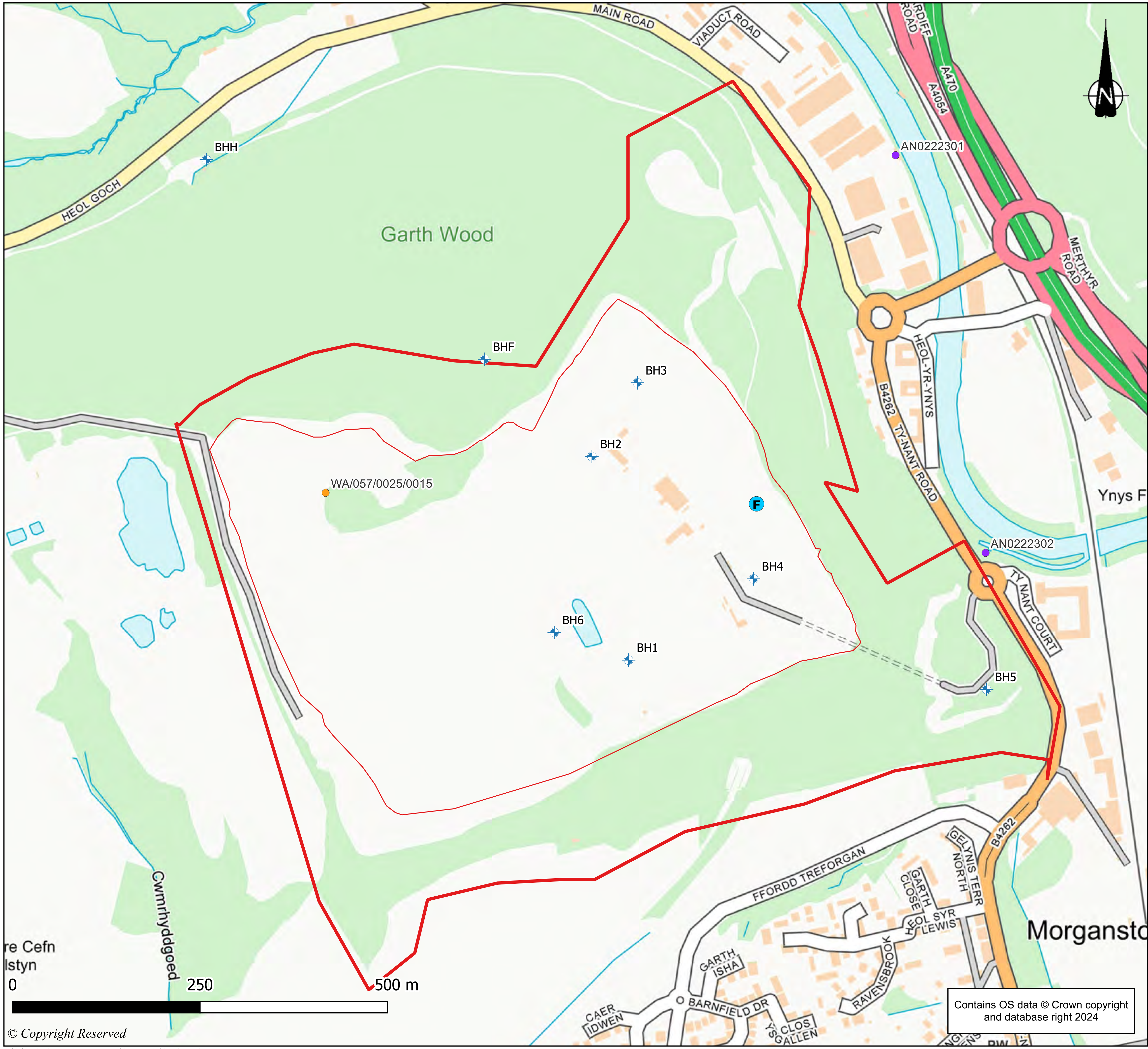
Drawdown at 18mAOD			
Time	t	1.00	d
Storage coefficient	S	0.0007	
Transmissivity	T	130.00	m2/d
Depth		18.00	mAOD
Discharge from Well	Q	4739.24	m3/d
Drawdown	s	7.4	m

Drawdown at 12mAOD			
Time	t	1.00	d
Storage coefficient	S	0.0007	
Transmissivity	T	130.00	m2/d
Depth		12.00	mAOD
Discharge from Well	Q	7108.86	m3/d
Drawdown	s	11.1	m

Drawdown at -6mAOD			
Time	t	1.00	d
Storage coefficient	S	0.0007	
Transmissivity	T	130.00	m2/d
Depth		-6.00	mAOD
Discharge from Well	Q	14217.72	m3/d
Drawdown	s	22.2	m

Minimum groundwater elevation in BH5 (August 2022)	28.9	mAOD
Predicted groundwater elevation in BH5 at 18mAOD (minimum groundwater elevation - drawdown)	21.5	mAOD
Predicted groundwater elevation in BH5 at 18mAOD (minimum groundwater elevation - drawdown)	17.8	mAOD
Predicted groundwater elevation in BH5 at 18mAOD (minimum groundwater elevation - drawdown)	6.7	mAOD

DRAWINGS



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DO NOT SCALE FROM THIS DRAWING

KEY
- Site Boundary
- Pit Boundary
- Groundwater Monitoring Boreholes
- Breedon Trading Ltd Abstraction Licence
- Breedon Trading Ltd Discharge Consents
- F Flow Rate Telemetry*

Note
* Flow rate telemetry located on pathway between abstraction licence and discharge consent

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D
B	Added Abstraction Licence and Discharge Consents	8/24	AE	BJ	RI

CLIENT
BREEDON TRADING LTD

PROJECT
TAFFS WELL QUARRY

DRAWING TITLE
CURRENT MONITORING NETWORK

DRG No. ST19539-006			REV B
DRG SIZE A3	SCALE 1:5,000		DATE August 2024
DRAWN BY BJ	CHECKED BY AS		APPROVED BY AB

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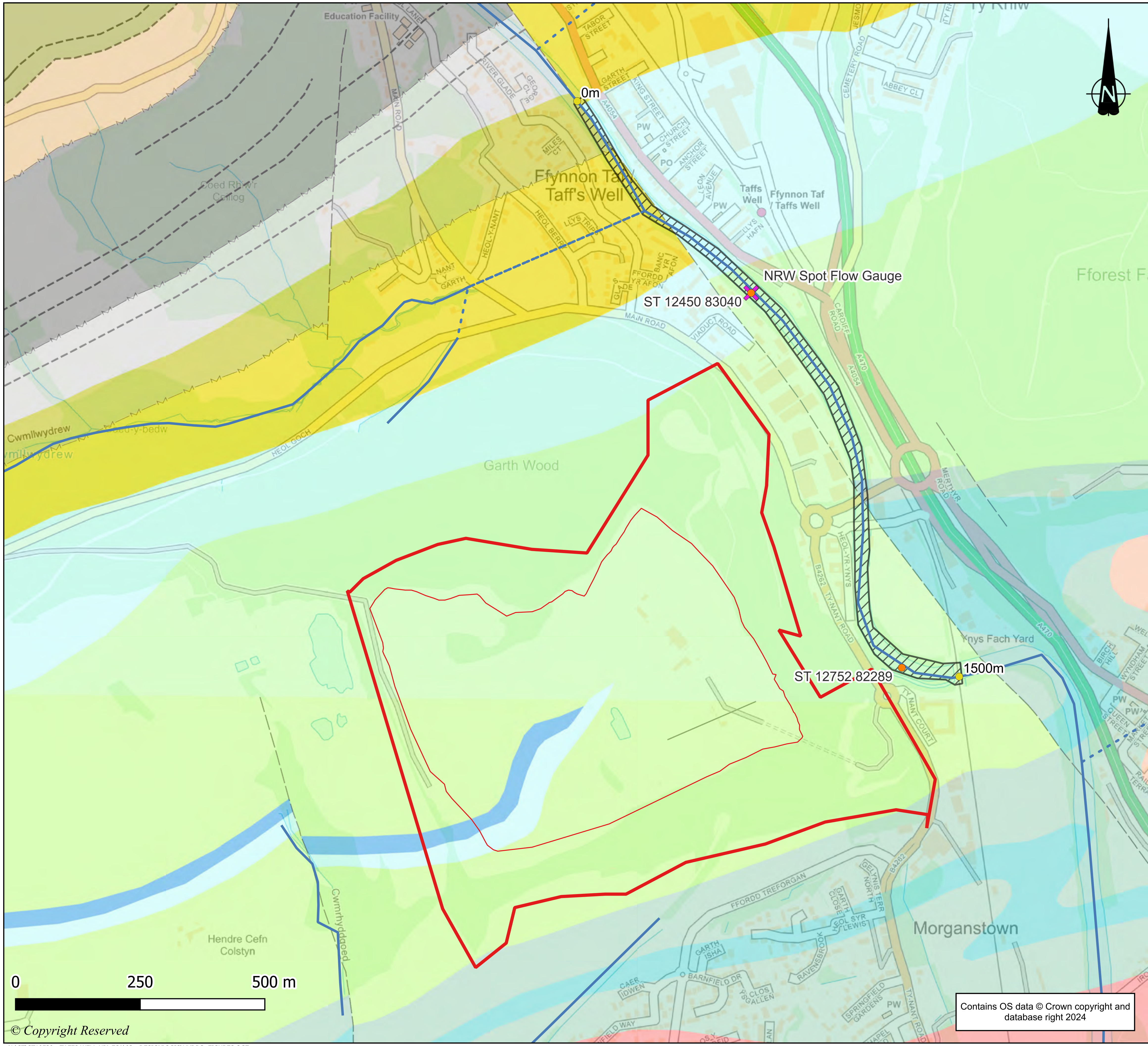

DO NOT SCALE FROM THIS DRAWING

KEY

- Site Boundary
- Pit Boundary
- Start / End of 1500m Reach
- 1500m Reach
- Qube Flow Estimation Report Q985/24 Locations
- NRW Spot Flow Gauge
- Watercourse
- Inferred Watercourse

BGS 1:50k Bedrock

- Pembroke Limestone Group
- Hunts Bay Oolite Subgroup - Limestone
- Marros Group - Mudstone, Sandstone and Conglomerate
- South Wales Lower Coal Measures Formation - Sandstone
- South Wales Lower Coal Measures Formation - Mustone Siltstone and Sandstone
- South Wales Middle Coal Measures Formation - Mudstone Siltstone and Sandstone
- South Wales Upper Coal Measures Formation - Mudstone Siltstone and Sandstone
- Rhonda Member - Sandstone
- Cwmyniscoy Mudstone Formation - Mudstone and Limestone, Interbedded
- Castell Coch Limestone Formation - Limestone
- Quartz Conglomerate Group (South Wales) - Sandstone and Conglomerate, Interbedded
- Quartz Conglomerate Group (South Wales) - Sandstone

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D

CLIENT

BREEDON TRADING LIMITED

PROJECT

TAFFS WELL QUARRY

DRAWING TITLE

RIVER TAFF IMPACT QUANTIFICATION

DRG No. ST19539-009		REV A
DRG SIZE A3	SCALE 1:7,500	DATE June 2024
DRAWN BY AE	CHECKED BY BJ	APPROVED BY RI

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