Trefil Quarry: Hydrogeological Impact Assessment

Prepared for

Ken Williams
Gryphonn Quarries Limited
Trefil
Tredegar
NP12 4HG

Report reference: 6878R1rev1, June 2008
Report status: Final report

Confidential

Prepared by

ESI Ltd

New Zealand House,160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel *+44(0)1743 276100* ***Fax*** *+44 (0)1743 248600* ***email*** *esi@esinternational.com*

Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

Trefil Quarry: Hydrogeological Impact Assessment

Principal Author(s)
Andrew Tait

Checked by: Andrew Tait

Reviewed by: Mike Streetly

Confidential

Prepared by

ESI Ltd

New Zealand House,160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel *+44(0)1743 276100* ***Fax*** *+44 (0)1743 248600* ***email*** *esi@esinternational.com*
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

CONTENTS

FIGURES

TABLES

APPENDICES

1 INTRODUCTION

1.1 Background

Trefil Quarry is located about 5 km to the north east of Tredegar, Gwent, and is centred an approximate national grid reference of 31200, 213500. The quarry location (“the Site”) is shown in Figure 1.1. The quarry covers an area of 20 ha with the extraction area covering around 8 ha.

Trefil Quarry has been worked as a limestone source since the 19th century until quarry operations ceased in the mid 1950s. The site was reopened in 1994 by Gryphonn Quarries Ltd.

The reserves within the current permitted quarry are approaching exhaustion. In 2006, Gryphonn Quarries Ltd submitted a planning application to revise conditions 1, 2, 17 and 22 of the planning permission for the site (Planning Application 94/0369). The revision to Condition 2 was to allow the quarry to be deepened from its current consented level of 439 mAOD to the base of the Dowlais Limestone at approximately 412 mAOD.

In 2004 Gryphonn Quarries instructed Hyder Consulting Ltd to prepare a report to assess the potential impacts of the proposed deepening of the quarry (Hyder, 2005). The Environment Agency reviewed this report and responded in August 2006 with a series of requests for clarification. The issues raised by the Environment Agency can be broadly grouped in two categories:

1. Issues that reflect the Environment Agency’s concerns about the operation of the quarry within the Source Protection Zone (SPZ) of a Public Water Supply spring; and

2. Issues that reflect the uncertainty regarding the hydrogeological conditions at site. These partly reflect the lack of certain key data sets for the site but also the weakness of the Hyder report, about which the Environment Agency raised a large number of questions.

1.2 Scope of Work

As a result of the concerns raised by the Environment Agency, in 2007, Gryphonn Quarries Ltd. instructed ESI Ltd. to prepare a hydrogeological impact assessment for the proposed development. ESI is an independent consultancy which specialises in hydrogeology and water resource impact assessment. The scope of work included:

- Review of the baseline hydrogeology of the area around the proposed extension;
- Identification of potential impacts on relevant receptors;
- Development of appropriate monitoring and mitigation measures;
- Preparation of a hydrogeological impact assessment for the proposed extension.

In order to ensure that the Environment Agency’s concerns were fully addressed in the new report, a meeting was held on site on 11 July 2007 attended by staff from Gryphonn Quarries, ESI, the Environment Agency and Welsh Water/Dwr Cymru to discuss the site setting and the proposed works. Following the meeting on site, ESI wrote to the Environment Agency on 31 July 2007 setting out the proposed approach to addressing the Agency’s concerns (letter ref 6878MD001.doc).

Staff from the Environment Agency and Dwr Cymru have subsequently been most helpful in the development of the conceptual model presented in this report by the provision of relevant data sets and reports.

As part of the meeting, a site walkover was conducted on 11 July 2007 to help gain a good understanding of the topography and local hydrology of the site. Observations from this walkover are incorporated in this report.

1.3 This Report

This report sets out the hydrological/hydrogeological impact assessment for the proposed development. Section 2 presents an assessment of the relevant baseline conditions and conceptual model for the Site. Section 3 describes the proposed development and Section 4 presents an assessment of the potential impacts of these developments and recommendations for appropriate monitoring and mitigation measures to ameliorate any potential impacts. The results of the assessment are summarised in Section 5. Supplementary details are presented in three appendices.

2 BASELINE CONDITIONS

2.1 Site Setting

Trefil Quarry is located about 5 km to the north east of Tredegar, and about 300 m north of Trefil village, in Gwent (Figure 1.1). It is centred an approximate national grid reference of 31200, 213500. The quarry is operated by Gryphonn Quarries Ltd.

The surrounding landscape consists of rolling moorland, with the quarry located on the eastern slope of the steep sided Trefil Valley. Much of the surrounding area is used for rough grazing.

Within the valley, the Nant Trefil stream flows to the south south east, towards the Afon Sirhywi and Shon Sheffrey spring and reservoir.

The hills on each side of the valley fall steeply from about 550 mAOD to about 410 mAOD at the Nant Trefil Stream to the west of the quarry. The land also falls to the south with the Shon Sheffrey reservoir at about 365 mAOD.

The ground levels within the quarry generally range from about 440 mAOD to about 455 mAOD.

2.2 Geology

2.2.1 Regional geology

The geological sequence is taken from the 1:50,000 scale geological map for Abergavenny Solid and Drift Edition (Sheet 232, BGS, 1990 – See Figure 2.1) and summarised in Table 2.1. Approximate thicknesses are taken from a borehole location about 500 m to the south of the quarry (Trefil Borehole 1 (see Figure 2.2 for location) from Welsh Water Authority (WWA), (1980)).

Table 2.1 Summary of regional geological succession (WWA, 1980)

Age	Unit	Approximate thickness (m)	Description
Carboniferous	Millstone Grit Series	20	Quartz conglomerates, quartzitic sandstones and occasional siltstones
	Dowlais Limestone	90	Dark grey bituminous limestone, occasional beds of oolite, isolated beds of sandstone in lower section and extensive dolomitization in upper section
	Llanelly Formation	9.5	Variable thin sandstones, limestones and clay locally
	Oolite Group[1]	25	Massive oolitic limestone with bands of fine grained crystalline dolomite
	Lower Limestone Shale[2]	35	Flaggy calcitic mudstone

The quarry is located on the northern edge of the South Wales syncline.

The strata dip towards the south at an angle of between 3° and 6° with Upper Carboniferous Millstone Grit Series deposits outcropping to the south as a result (lying unconformably on the Lower Carboniferous). Devonian Old Red Sandstone deposits outcrop to the north.

A number of normal faults tending NNW/SSE are present in the area. These are shown in Figure 2.1. The Shon Sheffrey Spring is located adjacent to the Pen-y-Fan fault trace.

[1] Clydach Valley Group on Figure 2.1

[2] The Cywmyniscoy Mudstone effectively forms the base of the formations of interest for this study (Figure 2.1 does not show the Lower Limestone Shales which is an older terminology). The underlying Castell Coch Formation is also oolitic.

2.2.2 Local geology

Available information

Information on local geology is available from a number of boreholes as shown in Figure 2.2 and summarised below. Borehole logs are presented in Appendix A.

- WWA (1982) report on two boreholes (Trefil Borehole 1 and 2) drilled to the south of the site in September/October 1981 as part of an exploratory drilling programme to determine potential groundwater resources in the vicinity.
- Two boreholes were drilled in March 2004 within the quarry during mineral assessment (Hole 1 and Hole 2). These were drilled in the quarry floor in the vicinity of the quarry sump in the north east of the quarry from ground levels of 441.8 and 440.5 mAOD but their exact locations are not known.
- Three monitoring boreholes were drilled in May 2007 (BH1/07, BH2/07 and BH3/07). These boreholes were installed with piezometers for groundwater level monitoring.

A summary of all available boreholes in the vicinity of the Site is given in Table 2.2.

Table 2.2 Available borehole information in site vicinity

Borehole name	Easting	Northing	Ground level (mAOD)	Top of casing (mAOD)	Borehole Depth	Elevation of base (mAOD)	Piezometer base depth (m)
Trefil BH1	312340	212600	≅ 410	-	141	≅ 269	141
Trefil BH2	312110	212090	≅ 393	-	187	≅ 206	187
Hole 1	On quarry floor adjacent to sump		441.8	-	36	405.8	Not installed
Hole 2	On quarry floor adjacent to sump		440.5	-	36	404.5	Not installed
BH1/07	311943	213708	442.23	442.69	30.5	411.73	30.5
BH2/07	311838	213555	452.35	452.75	16.5	435.85	16.5
BH3/07	311966	213230	453.03	453.5	32.5	432.43	20.5

Hole 1 and 2 at base of quarry (2003)

In Hole 1 and 2 on the quarry floor adjacent to sump, the contact between the Dowlais Limestone and Llanelly Formation was proved at 414.8 and 412.5 mAOD respectively, proving thicknesses of 27 and 28 m of Dowlais Limestone (Ramsey, 2003a).

Ramsey (2003a and 2004) reported that:

- the Dowlais Limestone beneath the Site consists of good quality limestone generally described as a dark limestone containing quartz sand with the lower 4 m consisting of a calcareous sandstone with interbedded mudstones.
- The Llanelly Formation is approximately 12 m in thickness beneath the Site and consists of a succession of limestone and calcareous sandstones and clays. An upper 6 m thickness of a hard green clay was found at Hole 1 and 2.
- The Oolitic Group (approximately 27 m) is a good quality limestone.

Monitoring well installation (2007)

Three monitoring boreholes were drilled and installed in May 2007. Their locations are shown in Figure 2.2 with borehole logs given in Appendix A.

The boreholes were completed using 25 mm UPVC pipe with a 5 m slotted section placed at the base of the borehole to allow groundwater level monitoring. Aggregate was placed down the annulus to provide borehole stability and integrity.

BH1/07 was drilled to the top of the clay layer at the top of the Llanelly Formation and installed within the Dowlais Limestone.

BH2 and BH3 are drilled and installed within the Dowlais Limestone.

Other information

WWA (1979) reports that the Carboniferous Limestone and overlying Millstone Grit outcrop display considerable evidence of karstification in the area, with swallow and sinkholes, collapsed dolines and other solution subsidence features being well developed. A large number of these features can be seen on the hills to the north of the quarry.

During the site visit on 11 July 2007 it was noted that there appeared to be a significant number of clay infilled palaeokarst features in the upper benches of the quarry. However the frequency of these features and degree of fissuring of the limestone reduced with depth.

On the basis of the available data, geological cross sections through the study area have been prepared and are presented in Figures 2.9 to 2.10 (see Figure 2.8 for locations).

2.3 Hydrogeology

Table 2.3 is taken from WWA (1980) and summarises the regional hydrogeology of the main formations in the area. Hydrogeological information is also presented in Figure 2.3.

Table 2.3 Lithology hydrogeological significance

Unit	Hydrogeological significance
Millstone Grit Series (Basal Grit)	Secondary (fracture) permeability. Direct recharge through fractures and via sinkholes extending to the underlying Dowlais Limestone. Potentially in hydraulic continuity with the Dowlais Limestone.
Dowlais Limestone	Aquifer. High permeability in upper levels. Decreased hydraulic conductivity towards base.
Llanelly Formation	Generally low permeability. Impermeable where upper member present as clay.
Oolite Group	Moderate secondary (fracture) permeability.
Lower Limestone Shale	Impermeable. Forms base of aquifer.

2.3.1 Millstone Grit

BGS (1986) reports that, in the Millstone Grit, groundwater movement occurs predominantly through secondary discontinuities of high permeability. Yields from boreholes generally range from 10-12 l/s. BGS reports that it is little used as an aquifer in South Wales due to its predominantly shaley nature in this area and that it recharges the Carboniferous Limestone, especially where the Upper Limestone Shale is absent.

Jones *et al*. (1997) reports that leakage of groundwater from the Millstone Grit Series to the underlying Main Limestone is considered to be facilitated by collapsed sinks in the areas where these occur. The sinkholes represent areas of percolation into the limestone, in which flow may subsequently be of diffuse or conduit type, according to the extent of fissure opening by solutional processes.

Jones *et al*. (1997) considers that the Basal Grit is generally in hydraulic continuity with the Carboniferous Limestone.

2.3.2 Carboniferous Limestone

The Carboniferous Limestone consists of the Dowlais Limestone, Llanelly Formation and the Oolitic Group. It is classified as a major aquifer (a highly permeable and productive formation able to support large abstractions for public supply). Shon Sheffrey spring Source Protection Zone (SPZ) is located within the Carboniferous Limestone (see Section 2.6.1).

Aquifer properties

Little relevant information is available on aquifer properties of the Carboniferous Limestone in this area. Estimates of aquifer properties from pumping tests etc at other locations cannot be used to realistically predict aquifer behaviour elsewhere.

The Carboniferous Limestone aquifer is considered to be most permeable at or above the zone of water table fluctuation (WWA, 1979). Below this level, fissure and secondary permeability development are markedly reduced.

WWA (1979) reports that at Rhymney Bridge, about 4 km to the south west of the quarry, the aquifer is confined and has a transmissivity of 10-20 m^2/d and storage coefficient of $4X10^{-4}$ to $9X10^{-4}$ (obtained from pumping tests). This suggests poor solution development of fractures at depth. WWA (1979) considers a specific yield of 0.5% to be appropriate in the unconfined parts of the aquifer.

WWA (1982) indicates that at Trefil Borehole 1 (Figure 2.2) during water level monitoring a 130 mm rainfall event in the area resulted in a rise in groundwater level of 9 m suggesting a specific yield of about 1%.

WWA (1982) reported that at Trefil Borehole 1, despite the area showing evidence of significant subsurface dissolution of the limestone, a pumping test on the borehole gave poor results with an estimated long term yield of only 2 l/s with transmissivity calculated to be only 10 m^2/d possibly as a result of fractures being filled with sediment from the Millstone Grit.

Trefil Borehole 2, about 500 m to the southwest of the quarry, also provided a low estimate of transmissivity of 35 m^2/d. It was concluded that the fractures are mainly developed above the water table and provide conduits for rapid through flow to springs and resurgences but do not provide a water bearing system at depth suitable for exploitation by boreholes (WWA, 1982).

WWA (1980) report the Dowlais Limestone has a very low primary permeability with most groundwater movement a result of secondary permeability. Hyder 2005 reports that the upper 40 m of the Dowlais Limestone is extensively dolomitized/breciated and this has lead to enhanced permeability in this zone.

The Llanelly Formation is approximately 12 m in thickness beneath the Site and consists of a succession of limestone and calcareous sandstones and clays. An upper 6 m clay unit is present which may inhibit vertical groundwater flow in this area. Below this is the Oolite Group which is a more permeable formation.

2.3.3 Lower Limestone Shale

The Lower Limestone Shale is considered to be impermeable and forms the base of aquifer (WWA, 1980).

2.3.4 Groundwater levels and flow

General

WWA (1978) reports that groundwater movement in the Carboniferous Limestone occurs in karstic features with groundwater made up of a combination of swallet water, percolation water and resident groundwater.

- The swallet water is largely from surface runoff.

- Percolation water infiltrates cracks and fissures and passes slowly through superficial soils to contribute to conduit or diffuse flow of resident groundwater.
- Residential groundwater is situated in the perennially saturated part of the aquifer and passes more slowly through the aquifer.

Resurgent conduit flow of swallet water is liable to dry up in the summer unless there is a significant proportion of percolation or resident groundwater.

WWA (1979) reports that it is likely that regional groundwater movement in the area is predominantly down dip above the water table and predominantly strike orientated within the saturated zone.

Allen *et al,* (1997) suggests that, below the permanent water table, permeability reduces with depth as the frequency of conduits reduces.

Allen *et al,* (1997) also suggests that the zone of greatest water movement occurs just below the water table along strike oriented passages with the unsaturated drainage down dip with groundwater in the saturated zone flowing mainly along the strike oriented conduits towards springs on the flanks of the Carboniferous outcrop.

WWA (1980) suggests that, in the vicinity of the Site, there is a correlation of springs with faults; but whether this is due to faults acting as zones of high transmissivity, or as barriers, is not clear from the available evidence.

<u>Site groundwater levels</u>

Hyder (2005) reported that, although anecdotal evidence suggests that small amounts of flow intermittently issued from fissures from the north eastern quarry face, no such flow was observed during a site visit by Hyder in October 2004 or during a site visit conducted for this current study on 11 July 2007. It is concluded that these inflows represent intermittent flow along bedding planes/conduits in the unsaturated zone during and after periods of rainfall. This is consistent with the conceptual model described in Section 2.7.

The sump at the base of the quarry is at an elevation of about 440 mAOD and is permanently flooded. This suggests that this reflects the position of the water table within the Dowlais Limestone and that the water pumped from the sump constitutes both groundwater and surface water runoff from within the site.

Groundwater levels are available from the three monitoring boreholes installed in May 2007 from 23 May 2007 to 16 May 2008 with groundwater levels recorded every few days. The following points were noted during the construction of these boreholes:

- Borehole 1/07 was drilled close to the quarry sump to the base of Dowlais Limestone. Groundwater was encountered from a shallow depth during drilling.
- Groundwater also encountered in borehole 2/07 from a shallow depth during drilling.
- No water strike was noted during drilling of borehole 3/07. However, water entered the borehole after installation.

The groundwater hydrographs from these boreholes are shown in Figure 2.4. Groundwater level statistics are summarised in Table 2.4. The data for BH2/07 to 25 June 2007 is not included in the statistics as this data appears to be anomalous (see Figure 2.4).

Daily rainfall data from Rhymney, about 3 km to the south west of the Site, between 1 April 2007 and 2 November 2007 was provided by the Environment Agency. The cumulative departure from mean rainfall and daily rainfall is shown on Figure 2.4 to illustrate trends in rainfall and highlight correlations with groundwater levels[3]. The period during which groundwater levels have been monitored on site includes both very wet and dry periods. It is

[3] A falling trend of cumulative departure from mean rainfall indicates below average rainfall and a rising trend above average rainfall

noted that rainfall levels in May and July 2007 were the highest on record in South Wales and therefore the groundwater levels recorded in the summer of 2007 may not have fallen to typical summer levels. This does not have any significance for any interpretations made within this report. The overall range in levels observed (~3 m) is similar to those seen elsewhere in the Carboniferous Limestone of South Wales during this period, perhaps slightly on the low side.

Table 2.4 Groundwater level statistics (May 2007 to May 2008)

Borehole	Maximum groundwater level (mAOD)	Minimum groundwater level (mAOD)	Average groundwater level (mAOD)	Groundwater range in period (m)
BH1/07	436.9	434.0	435.5	2.9
BH2/07	440.5	437.7	439.2	2.7
BH3/07	436.3	433.1	434.5	3.2

In general the three hydrographs follow each other fairly closely, suggesting that they are monitoring groundwater levels in a single groundwater body. BH3 does show some sharper peaks in response to rainfall events which may reflect local conditions (note that no water strikes were noted during drilling which suggests that the limestone is locally of low permeability and presumably has a low storage coefficient).

Spatial patterns of groundwater levels are discussed further below after all the relevant data sets have been described.

<u>Other site groundwater level information</u>

Ramsey (2004) interprets the main regional groundwater table in the Carboniferous Limestone in the vicinity of the site to occur in the Oolitic Group below the Llanelly Formation.

In Hole 2, drilled at the base of the quarry, the borehole was dry to about 30 mbgl, when a water strike was noted near the top of the Llanelly Formation following which water levels rose rapidly to about 440 mAOD. Flow ceased when the Oolitic Group beneath the Llanelly Formation was encountered. This supports the view that the piezometric level in the underlying Oolitic Group is lower than the groundwater level in the Dowlais Limestone (as observed in the quarry sump) and that the vertical groundwater head gradient between these formations is controlled by the 6 m of clay at the top of the Llanelly Formation which locally restricts vertical groundwater movement.

<u>Off site groundwater levels</u>

The Nant Trefil has an elevation of around 410 mAOD in the vicinity of the quarry (i.e. significantly below groundwater levels recorded in the boreholes on site despite a horizontal separation of only a few hundred metres – implied hydraulic gradient of 0.06). There are two intermittent ponds along the course of the stream and it dries up in summer to the south of Trefil, which suggests a good connection with a highly permeable underlying aquifer (see more discussion of this in Section 2.4). The Shon Sheffrey Spring (see Section 2.6.1) emerges at about 365 mAOD (Simpson & Partners, 1995) to the south of the quarry (70 m fall in groundwater levels over 1500 m – hydraulic gradient of 0.047).

A limited amount of groundwater level information is available from Trefil Boreholes 1 and 2, which were completed in September and October 1981 respectively.

- Trefil Borehole 1 had a rest water level of 52.8 mbgl. This equates to about 357 mAOD based on an estimate of ground level of 410 mAOD reported in the borehole log. However the Ordnance Survey map suggests the ground level is about 430 mAOD at this location, which would imply a rest water level after drilling of about 377 mAOD. This latter estimate is considered to be more realistic given the estimated level of the Shon Sheffrey Spring at 365 mAOD.

- Trefil Borehole 2 encountered a water strike at 26 m below ground level with a rest water level of 24.87 mbgl (368 mAOD).

These levels suggest a fairly shallow hydraulic gradient (0.005) between these boreholes and Shon Sheffrey Spring, flatter by an order of magnitude than the hydraulic gradient between the quarry boreholes and the spring.

WWA (1980) reports that an intermittent spring at Rhymney Bridge about 4 km to the south west of the quarry acts as an overflow system from the Shon Sheffrey spring groundwater catchment.

Tracer tests

WWA (1980) reports on a number of tracer tests undertaken in 1980 using dyed Lycopodium spores. The spores were injected in sinkholes within the Millstone Grit at localities believed to be on the flow lines to Shon Sheffrey spring. The proved connection results to Shon Sheffrey spring are shown in Figure 2.3. Water tables were high at the time, with connections established in 1-3 days. It was reported that a travel time of 48 hrs from one of these injection point 2000 m from the spring was encountered (1 km/d).

Based on the WWA (1980) tracer work, a groundwater catchment for Shon Sheffrey Springs of 12.2 km^2 was defined as shown in Figure 2.3. The limestone outcrop in this catchment area is 3.9 km^2.

Wimpey Environmental Limited (1994c) reported that dye tracing performed from the quarry in December 2003 showed that a stream entering a sink on the floor of Trefil Quarry reappeared in the Nant Trefil. No other details were available.

Groundwater flow patterns

The tracer tests suggest that Shon Sheffrey is the main discharge point for the Carboniferous Limestone in this area. The tracer tests show groundwater flow towards the spring from both the north and north west (Figure 2.3) although the actual flow paths cannot be directly determined from these results.

The very flat hydraulic gradient between the Trefil boreholes and the spring suggest that the aquifer is highly permeable in this area and this is supported by the fact that the stream is intermittent to the south of Trefil (i.e. groundwater gradients are flatter than the stream profile due to high transmissivity). This high transmissivity zone is likely to be related to the faulting along the Trefil valley and possibly to subsequent karstification. The location of the Shon Sheffrey spring along this fault zone is also an indication of enhanced transmissivity along the fault which allows flow through the overlying Millstone Grit[4].

Groundwater levels appear to be higher to the north of Trefil village (supporting baseflow in the upper reaches of the Nant Trefil throughout the year) and higher still at the quarry. The relatively steep hydraulic gradients implied by these groundwater levels are considered to be due to lower transmissivity in the former case and steep vertical hydraulic gradients in the latter case (see discussion about the role of the Llanelly Formation above).

From the regional setting, it would be anticipated that the hydraulic gradient across the site itself would be to the south and/or west. In fact, groundwater levels are highest in BH2 and lower in BH1 and BH3. There are two possible explanations for this:

1. BH1 is the deepest borehole and the lower water level may reflect a downwards vertical hydraulic gradient (see more discussion on this above); or
2. The water table has been locally lowered around BH1 (near to the current sump) by the dewatering activities on site but the effect of this lowering is fairly localised and has not

[4] Note that, while faults may act s zones of enhanced transmissivity, they can also form barriers to flow.

been transmitted as far as BH2 and BH3. However, this is not consistent with the reported position of the quarry sump level at 439 mAOD, which is above the level in BH1.

2.3.5 Groundwater quality

BGS (1986) reports that groundwater quality in the Carboniferous Limestone is usually good under low flow conditions, with total hardness of 250-300 mg/l (mainly carbonate) and chloride ions concentrations less than 30 mg/l. The water can be turbid and polluted after heavy rainfall with the quality reflecting that of the infiltrate, with total hardness as low as 150 mg/l and possibly high concentrations of suspended solids, organic matter, bacteria and nitrates.

WWA (1980) reports that the chemical characteristics of Shon Sheffrey Spring indicates that the water is derived from a combination of stored groundwater (diffuse flow) and rapidly moving conduit flow, which supports a two layered aquifer concept (Table 2.5). It was reported that

- during periods of low rainfall high concentrations of calcium and bicarbonate and moderate to low electrical conductivity (EC) readings were encountered due to discharge of a larger percentage of water with a longer residence time within the limestone
- during higher rainfall these values were lower due to a larger component of rapidly moving conduit flow.

Table 2.5 Chemical Composition of Shon Sheffrey Spring (WWA, 1980)

	Minimum	Mean	Maximum
Na (mg/l)	3.3	4.4	5.9
K (mg/l)	0.27	0.69	2.6
Ca (mg/l)	9.9	30.8	55.2
Mg (mg/l)	0.5	2.9	7.7
HCO3 (mg/l)	36.8	92.1	142.7
NO3 (mg/l)	1.33	1.97	2.66
Cl (mg/l)	4.1	6.0	9.0
SO4	3.9	10.5	13.8
EC (uS/cm)	80	170	250
pH	7.1	7.7	8.3

No information is available on groundwater chemistry within the quarry.

WWA (1982) reports that analysis from Trefil Borehole 1 showed a similar ionic content to Shon Sheffrey spring in September 1979, suggesting a connection of the groundwater within this borehole with the spring. It was also noted that sand was present in the borehole which was derived from the Millstone Grit and that sand also reaches Shon Sheffrey Spring after heavy rainfall.

2.4 Hydrology

2.4.1 Rainfall

Monthly rainfall data were provided by the Environment Agency for a rain gauge located at Rhymney about 3 km to the south west of the Site from 1971 to 2003 (Table 2.6). Average long term monthly mean rainfall data in this period is 1655 mm/a.

Table 2.6 Average rainfall at Rhymney (1971 to 2003)

Month	Total (mm)
Jan	199
Feb	148
Mar	139
Apr	99
May	96
Jun	84
Jul	80
Aug	108
Sep	133
Oct	181
Nov	179
Dec	211
Total	**1655**

WWA (1980) reports on rainfall data between 1961 and 1979 from eight gauge locations in the vicinity, with mean annual rainfall ranging from 1443 mm/a to 1655 mm/a. They report that during this period the mean annual rainfall at Rhymney Bridge was 1518 mm/a. Based on Thiessen polygon analysis, the same source calculated a mean annual rainfall of 1593 mm/a within the Shon Sheffrey spring catchment.

Simpson & Partners, (1995) reports that the average annual rainfall is as much as 2000 mm/a over the higher ground.

Daily rainfall data from Rhymney between 1 April 2007 and 2 November 2007 was also provided by the Environment Agency. The data is presented in conjunction with groundwater levels in Section 2.3.4. It is noted that rainfall levels in May and July 2007 were the highest on record in South Wales.

2.4.2 Effective precipitation and recharge

WWA (1979) reports that average effective rainfall in the region was computed by the Meteorological Office as 1125 mm/a for the period 1968 to 1978.

Simpson & Partners (1995) reports that the average effective precipitation is 748 mm/a (from MORECS square 146). This may not take into account areas within the MORECS square where rapid recharge does not occur and therefore may not represent effective rainfall rates within the Shon Sheffrey catchment as discussed below.

Simpson & Partners (1995) reports that rapid recharge occurs due to absent or thin soils with recharge also occurring through sinkholes and collapsed dolines in areas underlain by Millstone Grit. The fissured nature of the limestone suggests that little runoff occurs with almost all of effective rainfall recharging.

WWA (1980) reports that:

- the limestone surface is densely covered with small sinkholes due to active solution and enlargement of joints by percolation water with surface water runoff considered to be low with the majority of rainfall contributing to aquifer recharge with low evapotranspiration losses.
- recharge over the Millstone Grit occurs via collapsed dolines which extend through the Millstone Grit to the limestone with additional contribution through well developed joints in the Millstone Grit. The Grit supports typical moorland vegetation which can support a substantial thickness of peat which may hold a significant volume of water which is slowly released. Stream flows over the Millstone Grit are generally small.

These estimates of effective precipitation are discussed further in Section 2.4.4 in the context of the observed flows at Shon Sheffrey spring.

2.4.3 Surface water features

Surface water features in the vicinity of the Site are shown in Figure 2.5.

The Nant Trefil is the main surface water feature in the vicinity of the quarry. It rises about 1 km to the north west of the quarry at an elevation of about 460 mAOD and flows towards the south east through the Trefil Valley. A small but distinct spring rises in the middle of the valley floor near the Duke's Table (NGR 31097 21412) and contributes a significant proportion of the flow to the upper reaches of the stream. This spring is located near to the base of the Oolite Group where is overlies the Cwmyniscoy Mudstone.

There are some small seeps rising from spoil heaps that form the eastern side of the valley to the south of this point. The discharge from the quarry runs steeply down the hillside and under the road at approximately (NGR 3118 2133). The stream is at an elevation of about 410 mAOD to the immediate west of the quarry.

Two intermittent pools exist along the Nant Trefil to the north of Trefil village (Upper and Lower Pool Figure 2.5). The Nant Trefil flows into the Upper Pool from which there is little or no surface water outflow at most times of the year. The Lower Pool is located in the village to the west of Trefil Road. These pools are discussed in more detail in Section 2.4.4. The Nant Trefil appears to be dry through much of the summer along the reach from Trefil village to Shon Sheffrey.

The Ordnance Survey map shows the Nant Trefil to join the Afon Sirhywi (Sirhowy River) about 450 m to the north west of Shon Sheffrey reservoir. The Afon Sirhywi rises on Millstone Grit strata and flows into the reservoir. It has a number of spring fed tributaries and appears to be perennial, in contrast to the Nant Trefil.

Shon Sheffrey spring also provides flow to the reservoir which is a public water supply operated by Welsh Water/Dwr Cymru (see Section 2.6.1). This spring issues at an elevation of about 365 mAOD (Simpson & Partners, 1995).

To the east of the quarry a number of springs, mainly within the Millstone Grit, flow to the south east before joining the Nant Milgarw which flows towards the south west where it joins the Afon Sirhywi south of Shon Sheffrey reservoir.

There are some springs noted on the escarpment to the north of the quarry (Figure 2.5). However, examination of the geological map indicates that none of these rise from the main limestone formations and as such they are not considered further in this assessment.

2.4.4 Surface water flow

<u>Evidence from literature</u>

The following information on flow at Shon Sheffrey spring was obtained:

- WWA (1979) reports on gauging of the two spring resurgences immediately upstream of Shon Sheffrey reservoir between 4 September and 12 October 1979 to assess dry weather flows and the contribution of stream flow from the limestone. The observed flow was highly variable and dependent on antecedent rainfall. After rainfall on 19 September up to 250 l/s was issuing from the two springs, but earlier in the month the smaller resurgence was dry and the other was flowing at about 20 l/s. A flow range of 20 – 200 l/s into the reservoir corresponds to a unit run-off from 4.0 to 26.5 l/s km^2 (equivalent to 0.13 to 0.84 m/a effective precipitation). The low value was attributed to low flow conditions with the higher value due to additional swallet water.

- WWA (1980) reported on further gauging in February/March 1980 during winter conditions, with four results from 11 to 14 February giving flows of 238 to 415 l/s with a flood peak of 1105 l/s on 12 March 1980.

- WWA (1980) suggests a mean summer flow of 65 to 75 l/s and a mean winter flow of 300-400 l/s at the spring.

WWA (1980) reports that, based on rainfall data and flow data at Shon Sheffrey spring between 11 – 14 February 1980 it was estimated that 43% of the total rainfall discharged at the spring during the period. It noted that during this period some groundwater discharge to an intermittent spring at Rhymney Bridge about 4 km to the south west of the quarry, at a rate of about 50-60 l/s with this spring representing an overflow system from the Shon Sheffrey catchment.

Wimpey Environmental Limited (1994b) reports that the surface water catchment to Shon Sheffrey spring is 8.67 km^2.

WWA (1980) defined a groundwater catchment for Shon Sheffrey spring of 12.2 km^2 (see Section 2.3.4).

Based on the effective precipitation of 1125 mm/a and the estimated groundwater catchment of 12.2 km^2, this implies an average recharge rate of 435 l/s over the catchment. This is somewhat lower than the estimated mean flow at Shon Sheffrey, even taking into account the small potential overflow to the west.

In summary, it seems likely that the effective precipitation is somewhat lower than 1125 mm/a –perhaps closer to 1000 mm/a and the catchment area of the spring may also be lower than 12.2 km^2 (say 10 km^2). This combination would yield an average discharge at the spring of around 300 l/s, which seems more in line with the rather sparse available data on spring flows and the annual average licensed rate at the spring (320 l/s see Section 2.6.1).

<u>Recent flow gauging</u>

Stream flows in the vicinity of the quarry were obtained at monthly intervals on 3 August, 5 September and 1 October 2007 as part of this study at various points along the Nant Trefil, to the west of the quarry, and on the Afon Sirhywi approximately 750 m to the south. The locations of these stream gauging locations are shown on Figure 2.5 and summarised from north to south below:

1. NT Spring 1: This site is the most northern gauging point and represents spring discharge which joins the Nant Trefil approximately 10 m downstream of the discharge point.

2. NT1: Site on Nant Trefil after confluence between spring discharge channel and main Nant Trefil channel.

3. NT2: Site on Nant Trefil downstream of NT1 prior to a series of drainage channels flowing into the Nant Trefil from the east

4. NT3: Site on Nant Trefil downstream of the aforementioned drainage channel inflows

5. NT4: Site on Nant Trefil downstream of quarry discharge inflow and upstream of inflow to Upper Pool north of Trefil

6. AS1: Site on Afon Sirhywi immediately east of Trefil Road.

Accretion profiles of gauging results are shown in Figure 2.6. The stream generally was observed to be gaining slightly between NT1 and NT3 apart from on 1 October 2007 when a loss was observed between NT2 and NT3. NT4 was observed to be dry on all gauging dates with the loss occurring over a short distance between NT3 and NT4 (immediately upstream of the Upper Pool). During the site walkover on 11 July 2007 the stream bed between NT3 and NT4 was observed to be dominated by cobble/course gravel materials. There were no obvious sinkhole features to which flow loss occurred.

During the site visit in July 2007 the Nant Trefil was observed to have a very small amount of flow for a short distance immediately before joining the Afon Sirhywi.

The stream gauging results suggest that, during dry weather, the gain in flow in the Nant Trefil as it flows past the quarry (a few l/s) is a very small percentage of the dry weather flows in the Shon Sheffrey Spring (65-75 l/s).

Most of the flow in the upper reaches of the Nant Trefil derives from the spring at the Duke's Table and the reaches of the stream to the north of this (i.e. 500 m or more to the north of the quarry). This flow is then subsequently naturally lost back into the aquifer in the vicinity of the Upper Pool (at rates of up to 35 l/s) and presumably finds its way to Shon Sheffrey Spring from there.

There is currently no flow monitoring on the quarry discharge. During the site visit in July 2007 the discharge rate was visually estimated at 2-3 l/s. Similarly, the rate observed on 17 December 2007 was estimated at 3-5 l/s. Given the extraction area (8 ha) and the effective precipitation (1 m/a), the average discharge rate would be 2.5 l/s. Using the whole site area (20 ha) yields an average flow of 6 l/s. These calculated flow rates are broadly in line with those estimated during the site visit.

Flows in the Afon Sirhywi at site AS1 ranged from 1.9 to 12.2 l/s on the three measurement dates.

<u>Upper and Lower Pools</u>

Directly downstream of the gauged reach (downstream of NT4), the Upper and Lower Pools were fairly full (although not overflowing) during the site visit on 11 July 2007. However, the amount of water in the pools gradually fell over the period of the three gauging dates and the pools were fairly dry on a subsequent site visit on 27 November 2007.

There are two end member conceptual models for the way in which these ponds behave:

- The ponds could be a direct reflection of the position of the water table along the valley bottom throughout the year;
- Alternatively they could be surface water bodies that leak to the underlying aquifer at a fairly low rate and hence overflow at times of high inflow. Note that the geological map (Figure 2.1) shows a small amount of Millstone Grit in the valley floor that could allow the pools to 'perch', whilst good connection between the stream and the limestone via the faults means that the stream loses flow downstream.

The actual situation is likely to be some combination of the two, with the ponds reflecting (and controlling) groundwater levels during winter and leaking to a slightly deeper water table during summer. In either case, the behaviour of the ponds suggests a sharp contrast in the groundwater levels in the limestone in this area and this is probably fault controlled.

2.4.5 Surface water quality

<u>Electrical Conductivity (EC)</u>

WWA 1980 reports the EC of Shon Sheffrey as varying between 80 µS/cm in winter and 280 µS/cm in summer (see more discussion in Section 2.3.5).

EC measurements were taken at a number of surface water locations during the site visit on 11 July 2007. These showed that:

- The EC at the Quarry discharge location on the Nant Trefil was 217 µS/cm. This is marginally lower than the EC seen in the Nant Trefil along this reach, which varied between 260-265 µS/cm.
- Seeps from the base of the spoil heaps along the eastern valley sides had higher ECs of approximately 300-350 µS/cm.
- The spring at the Duke's Table had an EC of 309 µS/cm, while the Nant Trefil immediately upstream of this location recorded a distinctly lower EC of 219 µS/cm.

- Taken together this suggests that the EC of the Carboniferous Limestone groundwater may be around 300 µS/cm and that the quarry discharge contains an element of surface water runoff.
- The Afon Sirhywi had a markedly lower EC than the Nant Trefil, with values varying around 150 µS/cm. This is consistent with this stream being derived from rainfall runoff from the Millstone Grit rather than the Carboniferous Limestone.

Suspended Solids and Hydrocarbons

Suspended solids data were provided by the Environment Agency for the quarry discharge for the period 2002 and 2007 (Figure 2.7). These show periodic exceedance of the discharge limit of 100 mg/l. Nant Trefil quality data from 1997 directly upstream and downstream of the site discharge point to the Nant Trefil (further discussed in Section 2.5) shows a possible slight deterioration of suspended solids quality downstream. The stream dries up almost immediately downstream of the quarry discharge point in most conditions which will limit the periods of suspended solids impact downstream.

During the 12 years that the quarry has been operated by its current owners there have been no reports of any contamination from hydrocarbons in any of the local water courses. This suggests that the current precautionary measures (Section 3.1) are effective at protecting the local water environment from accidental spillages from operating heavy plant in the area.

Only one suspended solids data point was available for Shon Sheffrey spring (22 March 2007). This gave a result below detection limit. However, WWA (1982) reports that sand derived from the Millstone Grit reaches Shon Sheffrey Spring after heavy rainfall.

Impacts from suspended solids and hydrocarbons are further discussed in Section 4 and 5.

2.5 Discharges Consents

Data received from the Environment Agency showed three discharge consents within 2 km of the Site. These are shown in Appendix B.

One discharge consent (reference: AN0258201) is associated with Trefil Quarry for discharge of trade effluent to the Nant Trefil. Details of the discharge consent are given in Appendix B. It specifies that the total suspended solids shall not exceed 100 mg/l and the concentration of total oil and grease shall not exceed 10 mg/l.

The discharge from the quarry was qualitatively estimated as flowing at 2-3 l/s during the site visit on 11 July 2007. The electrical conductivity was 217 µs/cm. The stream at this location had an electrical conductivity of 265 µs/cm.

Environment Agency records also show reference AC0121201 to have a site name of Trefil Quarry (this is thought to be associated with the Tarmac cement plant directly to the south of the quarry).

A discharge consent (reference: AB0069201) downstream of the Shon Sheffrey reservoir is located at Garnddu Farm Nantybwch, Tredegar.

2.6 Potential Receptors

2.6.1 Shon Sheffrey spring public water supply

Shon Sheffrey Spring is a licensed public water supply operated by Welsh Water/Dwr Cymru. Trefil Quarry is located about 1.3 km to the north of this spring which feeds Shon Sheffrey reservoir from where the actual abstraction takes place.

Trefil Quarry is located within the Shon Sheffrey total catchment source protection zone (SPZ III –see Figure 2.3). Due to the fissured nature of the aquifer, it is difficult to define the total area of the groundwater catchment and thus only a “total catchment” exists for this source rather than a Zone I, II, II as is usual (Environment Agency letter as shown in Appendix B).

Hyder Consulting (2005) reports that Shon Sheffrey reservoir and treatment works were constructed in 1930. The reservoir supplies storage for low flow periods and has a capacity of about 345 Ml/d. All spring flow enters the reservoir.

Simpson & Partners (1995) reports that:

- Shon Sheffrey spring consists of two separate springs which discharge from the Carboniferous Limestone via the Millstone Grit to a common collection area and subsequently over a weir into Shon Sheffrey reservoir, which is operated by Welsh Water.
- The spring has an annual licensed abstraction of 10,148 Ml/a (equivalent to 28 Ml/d, 320 l/s).
- Rough grazing and stock occurs on the catchment.
- The spring is associated with a fault zone which runs down Trefil Valley.
- The upper levels of the Dowlais Limestone are the most permeable and where the major perennial (a stream or river that flows all year round) springs occur.

During the site visit, a series of stone chambers linked by a large diameter pipe were noted at intervals along the length of the Nant Trefil from the Upper Pool through to the southern part of Trefil village. The purpose of these chambers and their connection to the spring or reservoir could not be determined on site or from subsequent discussions with Welsh Water/Dwr Cymru staff. However, it seems very likely that these are some form of collecting chamber system that was designed to enhance/protect flows to the spring/reservoir.

Due to the location of the quarry within the SPZ and the dependence of the spring supply on good quality groundwater from the Carboniferous Limestone, this site is taken forward to the impact assessment stage as a potential receptor (Section 4).

2.6.2 Other licensed abstractions

Apart from Shon Sheffrey Spring, data received from the Environment Agency (Appendix B) showed two abstraction licences within 2 km of the Application Area. These are both located at the Shon Sheffrey reservoir (Point A and Point B) and are effectively considered to be part of the same receptor for impact assessment purposes.

There are no other licensed abstractions in the vicinity of the quarry.

2.6.3 Other abstractions

A query to Blaenau Gwent County Borough Council regarding private water supplies was made in November 2007. The Environmental Health Department indicated that there is one private water supply in the vicinity of the quarry at Dros-y-Lynn, about 1.3 km to the south of the quarry and 400 m to the north west of Shon Sheffrey reservoir. It was reported that this supply is from a spring and is treated as a precaution for suspended solids and bacteria. This is at an elevation of about 380/370 mAOD.

This spring is considered to be sourced from the Millstone Grit rather than the underlying Carboniferous Limestone and is therefore not considered to be potentially vulnerable to dewatering activities at the quarry.

There are no other known abstractions in the vicinity of the quarry.

2.6.4 Groundwater

Groundwater within the Carboniferous Limestone is a receptor to be considered by the impact assessment.

2.6.5 Surface water features

Apart from Shon Sheffrey Spring, the only other surface water feature considered to be potentially vulnerable to the proposed deepening of the quarry is the Nant Trefil and this is taken forward as a potential receptor.

2.6.6 Designated sites

There are no Special Areas of Conservation, SSSIs or nature reserves in the vicinity of the Application Area.

Brecon Beacons National Park is located about 800 m to the north west of the Site but is only slightly within the surface water catchment of the Site. It is at a much greater elevation than the Site and is not considered to be hydraulically connected with the site. It is therefore not considered further in this assessment.

Bryn Back Country Park located about 2 km to the south of the Site contains a man-made lake at about 390 mAOD. This is above expected groundwater levels in the area is not considered to be hydraulically connected with the site. It is therefore not considered further in this assessment.

There are no other designated sites in the vicinity of the Site.

2.7 Conceptual Model

This section summarises the hydrogeological conceptual model of the area around Trefil Quarry (Figure 2.11). The conceptual model is supported by the data sets collected as part of this study as well as data obtained from a literature review. A qualitative water balance to support the conceptual model is presented in Section 2.8. Figure 2.9 and 2.10 show cross sections in the vicinity of the quarry with Figure 2.8 showing the section locations.

2.7.1 Aquifer system

The local geology in the vicinity of the quarry comprises Carboniferous Limestone, overlain by Millstone Grit. The strata dip to the south at approximately 5°. Old Red Sandstone outcrops to the north of the quarry, which works the Carboniferous Limestone. The Carboniferous Limestone is subdivided into two aquifers: the Dowlais Limestone and the Oolite Group separated by the clay rich Llanelly Formation.

The effective rainfall is estimated to be around 1000 mm/a. The fissured nature of the limestone results in little runoff occurring with almost all of effective rainfall recharging. However, there may also be significant lateral flow of water along karst conduits within the unsaturated zone, particularly along bedding planes. The shalier Millstone Grit probably allows a significant amount of effective precipitation to run off. However, where the Millstone Grit is thin or disrupted by faulting, the runoff may enter the underlying Carboniferous Limestone. Due to the aggressive (low pH) nature of the runoff from the Millstone Grit (and associated peat deposits), this will enhance dissolution and karstification in the limestone.

The Carboniferous Limestone and overlying Millstone Grit outcrop display considerable evidence of karstification in the area with swallow and sinkholes, collapsed dolines and other solution subsidence features being well developed.

It is considered that the fractures are mainly developed above the water table and within the upper 40 m of the Dowlais Limestone, which is dolomitized and brecciated. The fractures provide conduits for rapid through flow to springs and resurgences but do not provide a water bearing system at depth suitable for exploitation by boreholes. This results in a two layered aquifer concept for the Dowlais Limestone.

The Llanelly Formation is present below the Dowlais Limestone. It is approximately 12 m in thickness beneath the Site and consists of a succession of limestone and calcareous sandstones and clays. An upper 6 m clay unit is present which may inhibit vertical groundwater flow in this area. Below this is the Oolite Group which is a more permeable formation.

The Lower Limestone Shale (Cwmyniscoy Mudstone) is relatively impermeable and forms the base of aquifer.

2.7.2 Shon Sheffrey Spring

The Shon Sheffrey spring is the main outflow from the local groundwater system and emerges, via the Millstone Grit, at about 365 mAOD to the south of the quarry. The catchment area of the spring is estimated to be around 10 km^2 (although the SPZ is 12.2 km^2) with the quarry located within this area.

The spring displays a highly variable discharge rate with rapid responses to rainfall. WWA (1980) suggest a mean summer flow of 65 to 75 l/s and a mean winter flow of 300-400 l/s at the spring. The low value was attributed to low flow conditions via the saturated limestone with the higher value having a significant component of flow via swallet water, some of which is likely to be via the unsaturated zone. The annual licensed abstraction rate for the spring is equivalent to 320 l/s which is likely to be a good estimate of the average flow at the spring and is broadly consistent with the recharge rate and catchment area discussed above.

The two layered aquifer system theory within the Dowlais Limestone is supported by the chemical characteristics of Shon Sheffrey Spring, which suggest that it is derived from a combination of stored groundwater (diffuse flow) and rapidly moving conduit flow. Sand derived from the Millstone Grit reaches Shon Sheffrey Spring after heavy rainfall due to this conduit flow.

2.7.3 Directions of groundwater flow

The highest groundwater levels in the area are those monitored at Trefil Quarry (433-440 mAOD). This high level is attributed to the occurrence of an upper groundwater system in the Dowlais Limestone that is maintained by the low vertical hydraulic conductivity of the underlying Llanelly Formation (and the low transmissivity of the lower parts of the Dowlais Limestone). Water recharging this body either leaks slowly downwards through the underlying clay or flows laterally to the Nant Trefil (as indicated by tracer test results).

The groundwater body in the underlying Oolite Group provides baseflow to the upper reaches of the Nant Trefil. As this flows downstream (and up the stratigraphic sequence) there is a small amount of baseflow contributed from the Dowlais Limestone. However, just upstream of the Upper Pool most of this flow is lost naturally back to the aquifer through a cobble/course gravel stream bed. Examination of Figure 2.10 suggests that this may be due to the way in which the faulting disrupts the Llanelly Formation, allowing water to leak down to the deeper water table in the Oolite Group at this point. However, as the groundwater flows southwards along the fault zone it must pass back up through the Dowlais Limestone again en-route to Shon Sheffrey spring.

The tracer tests show that recharge into sink holes to the north and north west of Shon Sheffrey spring reach the spring within a few days. This clearly shows rapid flow, presumably in the upper dolomitized parts of the Dowlais Limestone. It is likely that a significant proportion of this flow is via karstic conduits within the unsaturated zone.

The direction of groundwater flow within the saturated zone of the limestone to the east and west of the quarry cannot be determined from available data. However, if the relatively flat hydraulic gradients observed between the spring and Trefil Boreholes 1 and 2 are extrapolated northwards, they would intercept the base of the Dowlais Limestone somewhere just north of the quarry. The extrapolated levels are much lower than the observed levels at the quarry. This implies a low transmissivity in the Dowlais Limestone between the quarry and the spring, in contrast to the evidence from the tracer tests which imply that the Dowlais Limestone to the north of the spring is highly transmissive.

This apparent contradiction may be resolved by postulating a two layer model of the Dowlais Limestone. The upper layers are karstic and highly transmissive and are recharged via swallow holes in the overlying Millstone Grit. This recharge predominantly flows along conduits and bedding planes, initially within the unsaturated zone, towards Shon Sheffrey Spring. In the vicinity of Trefil Quarry, tracer test information suggests that this flow is locally westwards to the Nant Trefil.

Some water recharges downwards to the water table in the deeper, less permeable parts of the Dowlais Limestone (the available pumping test data suggests transmissivities in the range 10-30 m^2/d). From here groundwater flows either southwards to the Shon Sheffrey Spring, westwards to the Nant Trefil or downwards through the underlying Llanelly Formation to the Oolite Group. Flow in the saturated zone is likely to be significantly slower than in the unsaturated zone.

The current discharge from Trefil Quarry is considered to comprise predominantly rainfall runoff with a smaller component of groundwater inflow.

2.8 Water Balance

The available flow data from Shon Sheffrey spring suggests an effective precipitation of around 1 m/a over a catchment area of around 10 km^2, which leads to an average flow of around 320 l/s. Low flows are typically of 65 to 75 l/s (i.e. 4.5 smaller than average flows).

By comparison with summer flows in Shon Sheffrey, summer flows measured in the upper reaches of the Nant Trefil (5-10 l/s) imply a catchment area of around 1 km^2, whilst the observed discharge rates at Trefil Quarry are consistent with the quarry area (~20 ha).

3 PROPOSED DEVELOPMENT

3.1 Current development

The quarry site is approximately 200,000 m^2 in area with extraction focussed over 8 ha. Quarrying has been undertaken in three benches, which are worked from north to south (see plan in Appendix C).

The processing area, comprising crushing works, fuel storage, electricity sub station and dust shed, is located in the north west of the site at 454 mAOD. Fuel is stored internally in an appropriately bunded, above ground tank. A refuelling area is located within the process area adjacent and external to the fuel storage tank. The area is concrete lined with emergency spillage equipment and rules and guidelines for refuelling posted visibly (Hyder, 2005).

Details of surface water management at the quarry are presented in Appendix C.

Water entering the main excavation is collected in a sump (settlement pond 2) on the lowest bench (approximate water level 439 mAOD). From this point water can be pumped up to a clay lined settlement lagoon near to the main works (455 mAOD) from where it is gravity fed by a drainage ditch down to the Nant Trefil via two further settlement ponds (Number 3 and 6 in Appendix C). An oil boom is installed in settlement pond 3 and 6 with the outflow from settlement pond 6 also fitted with a 90° elbow.

Water from the north western part of the site is diverted to the Nant Trefil via an open drainage ditch and settlement lagoon 1 adjacent to the main access road. This lagoon is fitted with an oil boom.

The flows from the two points at which water leaves the site come together at a point to the south of the main discharge point. This is the point at which the samples are collected by the Environment Agency. The fact that the quality of the discharge water sometimes exceeds the limits of the discharge consent during high rainfall periods shows that the capacity of some parts of this settlement system is currently inadequate. This is further discussed in Section 4 and 5. The stream dries up almost immediately downstream of the quarry discharge point in most conditions which will limit the periods of suspended solids impact downstream.

There are no reports of any hydrocarbon pollution from the site during 12 years of operation.

The current rate of quarry discharge is not monitored. However, it is likely to be somewhere in the range 2.5-6 l/s on average (Section 2.4.4).

3.2 Proposed development

Gryphonn Quarries Ltd proposes to deepen the quarry from its current consented level of 439 mAOD to the base of the Dowlais Limestone at approximately 412 mAOD. Approximately 0.5 to 1 m of Dowlais Limestone will be left in-situ above the Llanelly Formation deposits. The mineral will be worked dry, which will require the excavation to be dewatered by up to 27 m. The rate of dewatering required to keep the quarry dry is discussed in Section 3.2.1 below.

The material will be processed through the existing crushing and screening plant on the existing quarry site.

As part of the proposed deepening of the quarry, the capacity of the site drainage system will need to be enhanced in order to ensure compliance with the existing discharge consent. This is discussed further in Section 5. Various other proposed mitigation measures are also discussed in Section 5.

3.2.1 Inflows to the excavations

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 in the limestone which control the rate of inflow. The approach used here is to focus on the overall water balance for the site and surrounding area and then to do a reality check by comparison with other limestone quarries in South Wales.

Current hydraulic gradients in the saturated zone of the Dowlais Limestone around the quarry are around 0.05 (Section 2.3.4). Combining this with an estimated dewatering depth of 27 m produces a zone of influence of around 540 m. This is at the upper end of values that might typically be expected given the low transmissivity of the lower parts of the Dowlais Limestone as this assumption of a linear gradient is probably conservative. From Figure 2.10 it can be seen that the zone of influence is unlikely to extend as far as this to the west as the Dowlais Limestone is cut by the Nant Trefil in this direction. Likewise the Dowlais Limestone is cut off to the north by the underlying Llanelly Formation. After excluding these areas, the final zone of influence is conservatively estimated to have an area of around 0.7 km^2 at full quarry development.

If it is assumed that all the effective precipitation over this zone of influence is intercepted by the quarry, then the average discharge rate at final quarry development would be around 20 l/s (i.e. 3 to 8 times more than present). However, this is viewed as being a fairly conservative estimate. The zone of influence is conservative and the conceptual model suggests that a significant proportion of the effective precipitation flows along bedding planes to the south and thus would not flow to the quarry sump.

The low flow rate is likely to be 4 or 5 times lower than the mean (using the flow ratios at Shon Sheffrey as a guide) i.e. 4 to 5 l/s, whilst the high rates might be up to 3 times higher (by analogy with other South Wales Quarries (see below)).

<u>Comparison with other Carboniferous Limestone Quarries in South Wales</u>

Whilst conditions at different sites vary significantly, comparison with pumping rates at other quarries provides a useful comparator for estimates of potential flow rates.

Torcoed and Torcoed Fawr Quarries – These two quarries are similar in size to Trefil Quarry. The water table in both quarries has been lowered by around 40 m (more than Trefil). The average pumping rates are typically 10 l/s (900 m^3/d) and 8 l/s (700 m^3/d) respectively. The Q_5 pumping rates (exceeded 5% of the time) were around three times the mean rate.

Cornelly Quarry – This is a much larger quarry (76 ha) with the water table having been reduced by over 60 m. Off site pumping has been around 2000-3000 m^3/d. However, the block of limestone being worked at Cornelly is acknowledged to be of fairly low permeability and the effective precipitation is slightly lower in that area.

This comparison suggests that the estimated average inflows for Trefil Quarry are probably on the high side. However, given the lack of existing information on flow rates in the area, this is probably appropriate.

3.3 Proposed Restoration

The current planning permission requires a restoration scheme to be submitted prior to the completion of working. For the purposes of this assessment, it has been assumed that the site will be restored as an open water feature. It is anticipated that the water level will recover to current groundwater levels (i.e. to around 440 mAOD).

4 ASSESSMENT OF POTENTIAL IMPACTS

The assessment of all potential hydrological and hydrogeological impacts relating to the development of Trefil Quarry is presented below. Many of these can be easily avoided by the implementation of good practice and standard planning conditions. Monitoring and mitigation measures are discussed in Section 5.2.

In Section 2.6, three main receptors for the impact assessment are identified:

1. Shon Sheffrey Spring;
2. The Nant Trefil; and
3. Groundwater in the Carboniferous Limestone.

4.1 Potential Impacts of Proposed Development

The potential impacts during quarry development are discussed in the following sections. Where any significant negative impacts are identified, mitigation measures are proposed.

4.1.1 Surface water flows

In Section 3.2.1 it is conservatively estimated that average discharge rates of up to 20 l/s may be required to lower the water table at Trefil Quarry by the required 27 m. At present this flow goes in four directions: some is discharged by the quarry to the Nant Trefil, some flows naturally westwards to the Nant Trefil, some flows downwards through the Llanelly Formation to the underlying Oolite Group and thence to Shon Sheffrey, and some may flow slowly southwards to Shon Sheffrey. The exact distribution between these directions is not clear at present.

As all water pumped from the quarry will be discharged to the Nant Trefil from where it will ultimately find its way to Shon Sheffrey (either as surface water flow or as groundwater flow after sinking back naturally into the ground), there will be no net loss from the system. The proposed depth of working is still above the level of the Nant Trefil near to the quarry and thus it is not considered likely that the dewatering will alter the rate at which the stream currently loses water to the aquifer.

It is possible that the extension of the zone of influence northwards might capture some of the baseflow to the upper reaches of the Nant Trefil. However, the conceptual model presented in this report suggests that most of this flow is derived from the underlying Oolite Group and is thus not vulnerable to dewatering of the Dowlais Limestone at the quarry. All this flow re-enters the aquifer as the stream naturally loses flow in the reach above the Upper Pool.

In summary, whilst the current distribution of groundwater flows on site is not entirely clear, it is clear that there will be no net impact on surface water flows. Low flows in the Nant Trefil may in fact be slightly augmented at the expense of groundwater throughflow. However, this will only benefit a short reach of stream before the water re-enters the aquifer upstream of the Upper Pool.

Dewatering operations can also affect the temporal distribution of flows through the year. However, as the proposed development does not involve significant development in the unsaturated zone/epikarst zone (which provides significant storage for the Carboniferous Limestone system), it is considered that this will not be a significant aspect of this operation, particularly as all the discharged water is likely to soak back to groundwater via the Nant Trefil.

4.1.2 Surface water and groundwater quality

The proposed development involves two main hazards with respect to groundwater and surface water quality:

1. Spills from plant operating on site.
2. Discharge of sediment-laden water to drains etc.

The potential for hydrocarbon pollution is considered to be the most significant hazard associated with the current and proposed operations.

Any intermittent increase in suspended solids at Shon Sheffrey would not be problematic for supply as the spring flows straight into the reservoir which provides significant settlement capacity. WWA (1982) reports that sand derived from the Millstone Grit reaches Shon Sheffrey Spring after heavy rainfall.

Suspended solids impacts in the Nant Trefil from quarry discharge will be controlled site by means of a discharge consent. If exceedences of the discharge consent did occur impacts on the Nant Trefil are likely to be limited as the stream dries up immediately downstream of the discharge point in dry conditions or flows into a large, ephemeral lake in wet conditions. However, it is clear that some additional works are required to comply with the existing consent with respect to suspended solids and this is further discussed in Section 5.

Groundwater in the limestone aquifer, Shon Sheffrey public water supply and the Nant Trefil are all potentially susceptible to impacts from these hazards via the following pathways (with discussion of associated timescales):

- Discharge of water contaminated by hydrocarbons from the quarry to the Nant Trefil (immediate impact, although, as the stream is usually dry immediately downstream of the discharge the impact on surface water is localised);
- From the Nant Trefil water naturally leaks back into groundwater thus any contaminated water from the quarry would potentially affect groundwater quality in this area within a few days of discharge;
- Surface water in the Nant Trefil near to the quarry is likely to reach the Shon Sheffrey spring either via surface water (when the stream is flowing or via the collecting chambers) or via groundwater. In the former case the spring could be impacted within a few days, in the latter case within days or weeks given the apparent high transmissivity of the limestone downstream of Trefil;
- Tracer tests have shown that water can reach Shon Sheffrey spring within a few days along karst conduits, which appear to be concentrated in the unsaturated zone in the upper parts of the Dowlais Limestone. A tracer test at the quarry suggested rapid discharge via this route to the Nant Trefil (i.e. similar pathway to the quarry discharge), however, the potential to discharge down dip to Shon Sheffrey cannot be discounted.
- There are some groundwater pathways from the quarry to Shon Sheffrey spring via the saturated zone of the limestone. However, the steep hydraulic gradient between the quarry and the spring suggests that the overall transmissivity along this route is low and transport rates will be correspondingly low. In addition, once the quarry is actively dewatering, these flows will be captured by the quarry dewatering and discharged off site to the Nant Trefil (i.e. the first pathway described above is the key one).

There are thus two main categories of pathway via which the hazards discussed above can impact the potential receptors discussed at the start of Section 4:

1. Discharge via off-site pumping to the Nant Trefil; and
2. Accidental discharge into a sink hole in the upper parts of the Dowlais Limestone and flow via karst conduits mostly via the unsaturated zone of the limestone.

The first pathway can be effectively controlled by means of the site discharge consent, although it is clear that some additional works are required to comply with the existing consent with respect to suspended solids.

The second pathway suggests that the most significant risks are related to works in the upper benches of the quarry rather than the deeper sections below the water table that are the focus of this assessment. The risk here is no different to the risk under the current development.

It is anticipated that these possible impacts will be addressed by standard planning conditions that have been applied to similar developments in the area (see discussion in Section 5.2). The quarry has operated for 12 years with no significant hydrocarbon contamination occurring to the spring which suggests that the measures in place at site are broadly effective.

4.2 Potential Impacts of Proposed Restoration

The proposed quarry restoration is to open water. It is anticipated that the recovery water level of the water body created will be similar to current groundwater levels at the quarry (e.g. around 440 mAOD). This will lead to a recovery of most of the associated groundwater flow systems to a similar condition to present. However, the large volume of water in the quarry void may act as a slight dampener to fluctuations in groundwater level and flow. This would generally be considered to be a net benefit.

There will be a small amount of additional evapotranspiration from the open water surface. However, it is anticipated that this will be small (say of the order of 20 m^3/d) and be unlikely to have a significant effect on local flow systems.

During the period when the quarry void is re-filling with water (1-2 years), there will be lower outflows from the system and so it may be necessary to maintain a small amount of residual pumping during dry periods if any impacts have been detected on surface water flows during the course of quarry development.

5 SUMMARY AND RECOMMENDATIONS

5.1 Summary

This report presents an assessment of the proposed deepening of Trefil Quarry near Tredegar. A significant body of data on the geology, hydrogeology and hydrology of the site has been collected and reviewed in order to develop a good conceptual understanding of the local flow systems. Key components of this conceptual model include:

- The quarry works the Dowlais Limestone. The upper horizons of this formation are highly permeable and allow rapid flow of recharge water from sinkholes to spring discharges, with much of this flow being along bedding planes conduits in the unsaturated zone. In the vicinity of the quarry, tracer tests indicate flow westwards towards the Nant Trefil. However, to the east and west of the quarry, tracer tests show flow towards Shon Sheffrey spring.
- The lower part of the Dowlais Limestone is less permeable and there are steep horizontal hydraulic gradients, which imply that there is slow flow of groundwater from the vicinity of the quarry to the spring. In the area along the fault zone along the Trefil valley, hydraulic gradients are much flatter, implying high transmissivity associated with the fault zone.
- The groundwater body in the Dowlais Limestone lies over a thick clay layer (the Llanelly Formation), which restricts the flow of groundwater downwards to the underlying Oolite Group.
- The Nant Trefil flows along the valley to the west of the quarry. This stream initially rises from groundwater discharges from the Oolite Group. However, as it flows past the quarry it naturally leaks back into groundwater and, during most of the summer, is dry downstream of this point. There are two ephemeral pools along the course of the Nant Trefil.

The main receptors identified for the impact assessment are

- Shon Sheffrey Spring;
- The Nant Trefil; and
- Groundwater in the Carboniferous Limestone.

The conclusion of the impact assessment is that the proposed dewatering activities will not have any significant effect on flows in the Nant Trefil or Shon Sheffrey spring due to the re-circulation of water discharged to the Nant Trefil.

The proposed development involves two main hazards with respect to groundwater and surface water quality:

- Spills from plant operating on site.
- Discharge of sediment-laden water to drains etc.

The potential for hydrocarbon pollution is considered to be the most significant hazard associated with the current and proposed operations. Any intermittent increase in suspended solids at Shon Sheffrey would not be problematic for supply as the spring flows straight into the reservoir which provides significant settlement capacity. Suspended solids in the quarry discharge are likely to impact on the Nant Trefil. This impact is likely to be limited as the stream dries up immediately downstream of the discharge point in dry conditions or flows into a large, ephemeral lake in wet conditions. Suspended solids impacts in the Nant Trefil from quarry discharge will be controlled site by means of the site discharge consent although it is clear that some additional works are required to comply with the existing consent with respect to suspended solids.

Groundwater in the limestone aquifer, Shon Sheffrey public water supply and the Nant Trefil are all potentially susceptible to impacts from these hazards via the following pathways:

- Discharge via off-site pumping to the Nant Trefil; and
- Accidental discharge into a sink hole in the upper parts of the Dowlais Limestone and rapid flow from there to the springs (much of this initially via bedding plane related karst conduits in the unsaturated zone).

The first pathway can be effectively controlled by means of the site discharge consent, although it is clear that some additional works are required to comply with the existing consent with respect to suspended solids.

The second pathway suggests that the most significant risks are related to works in the upper benches of the quarry rather than the deeper sections below the water table that are the focus of this assessment. The risk here is no different to the risk under the current development.

It is anticipated that these possible impacts will be addressed by standard planning conditions that have been applied to similar developments in the area (see discussion in Section 5.2). The quarry has operated for 12 years with no significant hydrocarbon contamination occurring to the spring which suggests that the measures in place at site are broadly effective.

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

5.2 Proposed Mitigation Measures

5.2.1 Monitoring

In order to quantify the level of impact at key sites and to make sure that the system is continuing to behave as predicted on the basis of the current conceptual model, a monitoring system will be required.

It is anticipated that these proposals for monitoring and mitigation will be included in a Water Management Plan for the site and that agreement of such a document with the relevant regulators will be a condition to the planning permission.

The following monitoring regime is proposed for the site:

- Groundwater levels in the three boreholes on site should be measured at weekly intervals.
- Subject to access agreements, groundwater levels in Trefil Boreholes 1 and 2 should be monitored at monthly intervals.
- The rate of quarry pumping from the sump should be monitored at weekly intervals by means of an in-line flow meter or suitable alternative.
- The suspended solids of the quarry discharge should be measured by the quarry operator at weekly intervals together with a note of the weather conditions at the time.
- Daily rainfall data should be monitored my means of a site rain gauge.
- The site drainage system should be inspected on a daily basis to ensure that the oil booms are in place and that there is no visible oil downstream of the booms.

An updated water balance for the site should be undertaken one year after planning permission is granted at which time the additional monitoring information will be available. Further updated water balances in subsequent years may be necessary depending on the outcome of this updated water balance.

The data should be reviewed annually and an annual report on trends observed with interpretation submitted to the Planning Authority and Environment Agency.

All monitoring should be continued until water levels in the quarries have recovered to their equilibrium position. It is anticipated that this will be one or two years after quarry dewatering ceases.

5.2.2 Mitigation Measures

It is recommended that standard planning conditions relating to this type of operation should be applied. Specific additional actions that are proposed are listed below.

The quality of water discharged from the site will be regulated by a discharge consent issued by the Environment Agency. In order to comply with the requirements of the discharge consent and to cope with the predicted increase in dewatering rates, some additional settlement is needed on site (see below).

It is concluded that these measures will effectively control any risks of impacts on surface water and groundwater quality.

<u>Specific Measures Proposed To Mitigate Risks Presented by the Development</u>

1. The settlement capacity of the main discharge route will be increased by provision of an additional settlement pond upstream of the current clay lined lagoon. This new settlement pond will be fitted with an oil boom and oil interceptor.
2. The concrete pad at the re-fuelling point will be surrounded with a bund which drains to a sump with an oil boom and oil interceptor.
3. The emergency procedure in the case of an oil spill will include switching off the sump pump immediately to reduce the risk that any oil is pumped off-site. Materials to soak up spilt oil and fuel will be stockpiled on site.
4. A stock of flocculants should be kept on site to enhance settlement in the case that a suspended solids measurement indicates that the discharge consent limit has been exceeded. The selection of flocculant should be consistent with the location of the quarry within a source protection zone. The flocculants will be used according to the guidelines provided by the manufacturer
5. A weekly inspection of the working areas will be made (and documented) to look for the presence of any voids which might indicate the presence of fast pathways from the quarry to local receptors. Quarry personnel will be made aware of the following preventative and remedial measures that may be employed following the discovery of preferential flow paths within the quarry face:
    - Isolation of surface water drainage from areas or features of concern.
    - Bunding critical areas or features with suitable material to prevent the ingress of water.
    - Lining critical areas or features with suitable geotextile material.
    - Limiting the quarrying of critical areas or features to dry weather.
    - Leaving unworked stone around the critical area or feature to minimise any risk of groundwater pollution.
    - Where significant ponding of surface water occurs in the vicinity of a critical area or feature, the water will be dispersed to other areas of the quarry where ground conditions are less sensitive.
    - Water seepages from quarry faces to be directed towards the nearest drainage channel or led to a lower level in an area where the ground is competent.
    - Haul roads and drainage channels to be kept open and free from obstruction to ensure site drainage directions are away from any identified features.

REFERENCES

Allen, D.J., Brewerton, L.J., Coleby, L.M., Gibbs, B.R., Lewis, M.A., MacDonald, A.M., Wagstaff, S.J. & Williams, A.T., 1997. The physical properties of major aquifers in England and Wales. British Geological Survey Technical Report WD/97/24. Environment Agency R&D Publication 8.

BGS, (1986). Hydrogeological Map of South Wales. 1:125,000.

BGS (1990), 1:50 000 Geological Map of Abergavenny (Solid & Drift): Sheet 232.

Environment Agency (2000a). The Rhymney catchment abstraction management strategy

Environment Agency (2006). The Rhymney catchment abstraction management strategy

Environment Agency (2007a). Hydrogeological impact appraisal for dewatering abstractions

Environment Agency (2007b). Hydrogeological impact appraisal for dewatering abstractions. (Science Report SC040020/SR).

Hyder Consulting (2005). Proposed deepening of Trefil Quarry: Hydrogeological and Hydrological Assessment.

Ramsey, Dr. A.T.S. (2003a). An assessment of the limestone reserves, North Trefil Quarry. Department of Earth Sciences Cardiff University.

Ramsey, Dr. A.T.S. (2003b). An assessment of the limestone reserves, South Trefil Quarry below 439 mAOD. Department of Earth Sciences Cardiff University.

Ramsey, Dr. A.T.S. (2004). The Dowlais Limestone, Trefil Quarry: Assessment of limestone thickness and quality. Department of Earth Sciences Cardiff University.

Simpson & Partners, (1995). Shon Shreffrey National Rivers Authority Welsh region groundwater protection zones data collection and presentation.

Welsh Water Authority (1978). South East Wales Groundwater Study – Interim Report (by Howard Humphreys and Partners)

Welsh Water Authority (1980). South East Wales Groundwater Study – Reconnaissance Report (by Howard Humphreys and Partners)

Welsh Water Authority (1982). South East Wales Groundwater Study – Results of Exploratory Drilling Report (by Howard Humphreys and Partners)

Wimpey Environmental Limited (1994a). Report on drainage requirements, Trefil Quarry. (Reference S/29471/1).

Wimpey Environmental Limited (1994b). Report on stream flood flows, Trefil Quarry. (Reference S/29471/2).

Wimpey Environmental Limited (1994c). Assessment of potential hydrogeological impact of quarry on Shon Sheffrey reservoir, Trefil Quarry. (Reference S/29471/3).

Wimpey Environmental Limited (1994d). Report on contamination study, Trefil Quarry. (Reference S/29471/4).

FIGURES

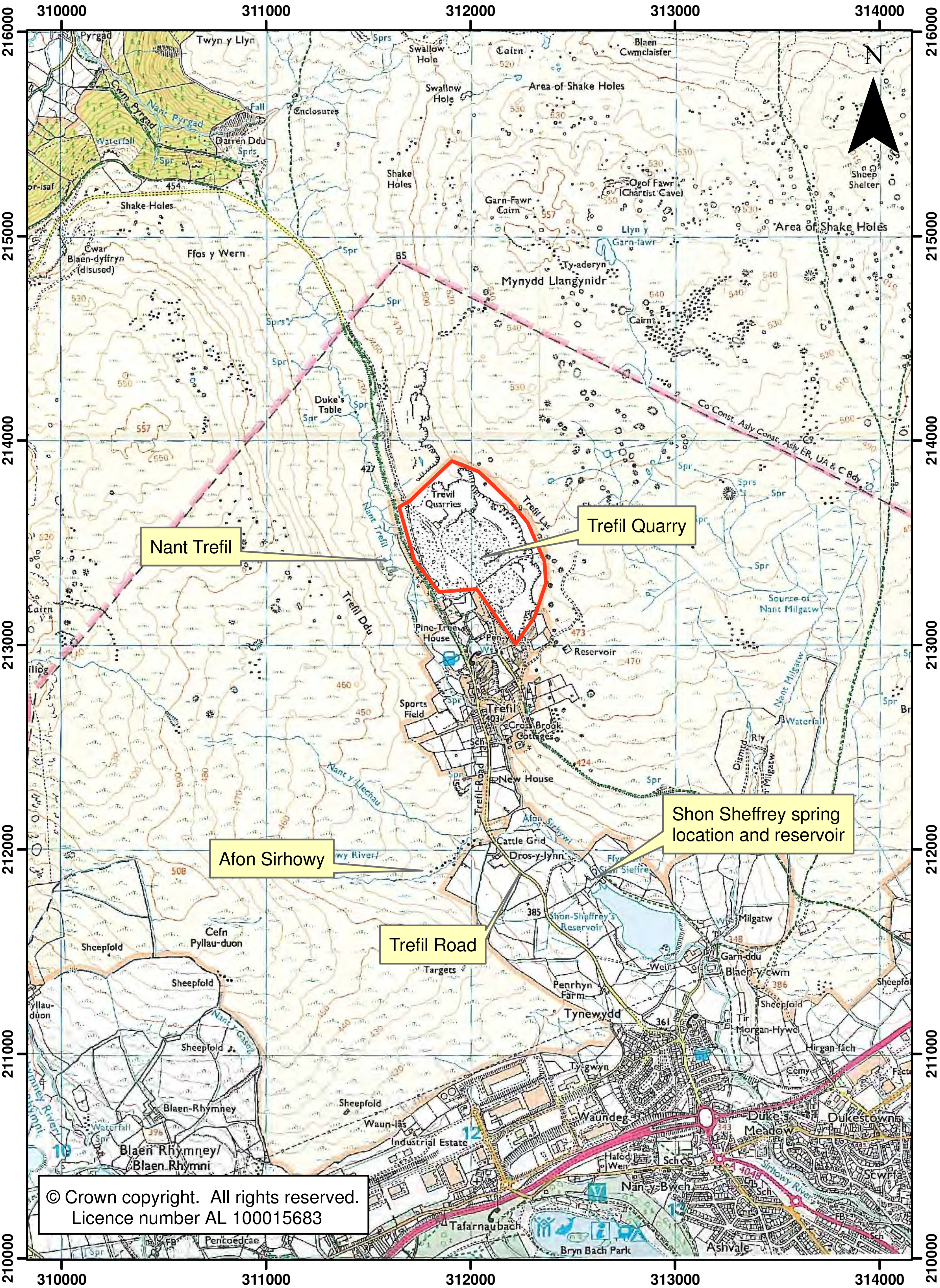


Figure 1.1
Site location

Note: quarry boundary not accurate

Date	Drawn
May 2008	AWT
Scale 1:25,000	Checked MJS
Original A4	Revision 2
File Reference O:\6878 Trefil Quarry\reports\Figures \6878R1rev1Figures\Figure 1.1	

esi soil & groundwater

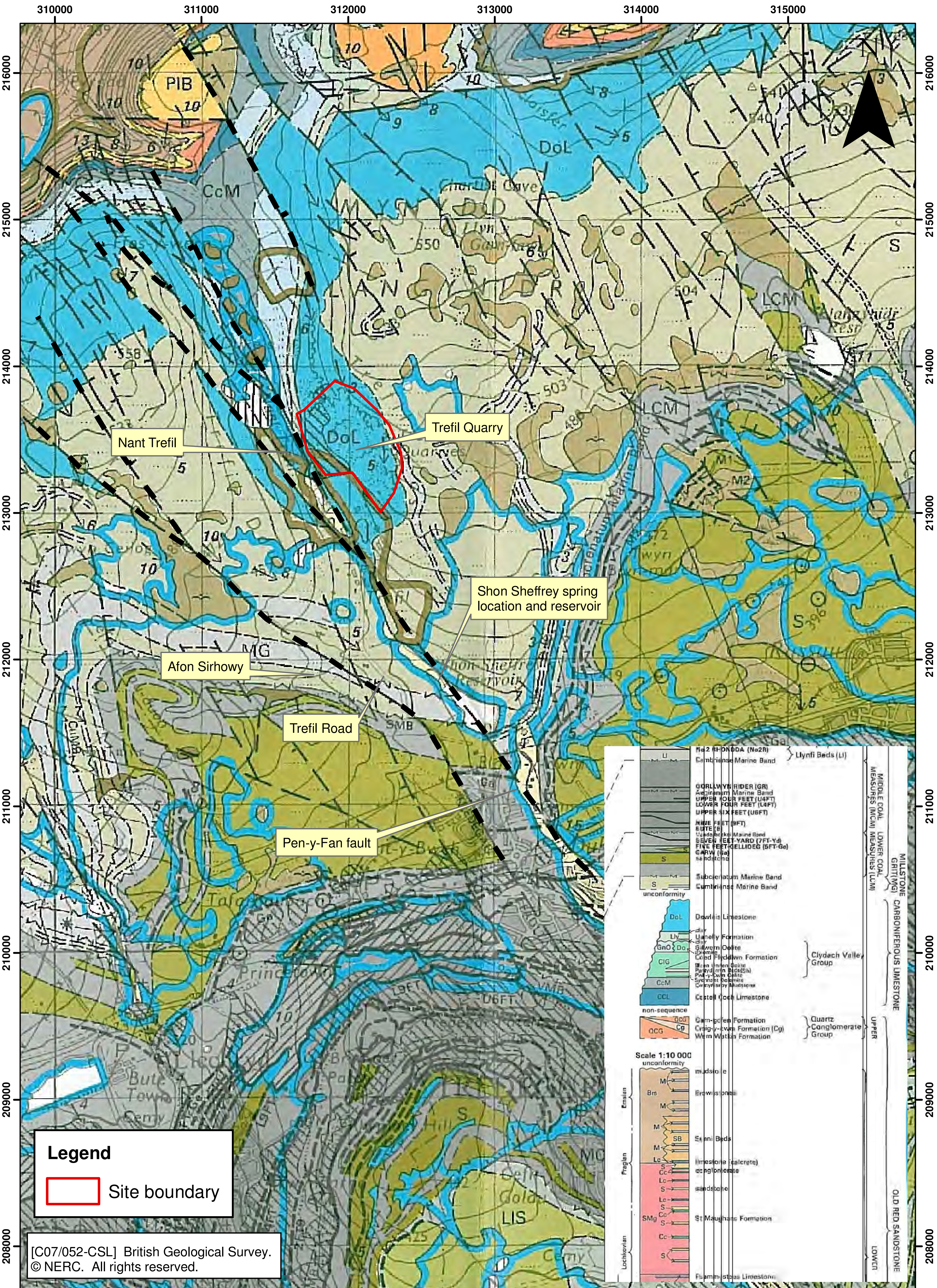


Figure 2.1 Regional geology Note: Quarry boundary is not accurate	Date May 2008	Drawn AWT
	Scale 1:25,000	Checked MJS
	Original A3	Revision 2
	File Reference O:\6878 Trefil Quarry\reports\Figures \6878R1rev1Figures\Figure 2.1	

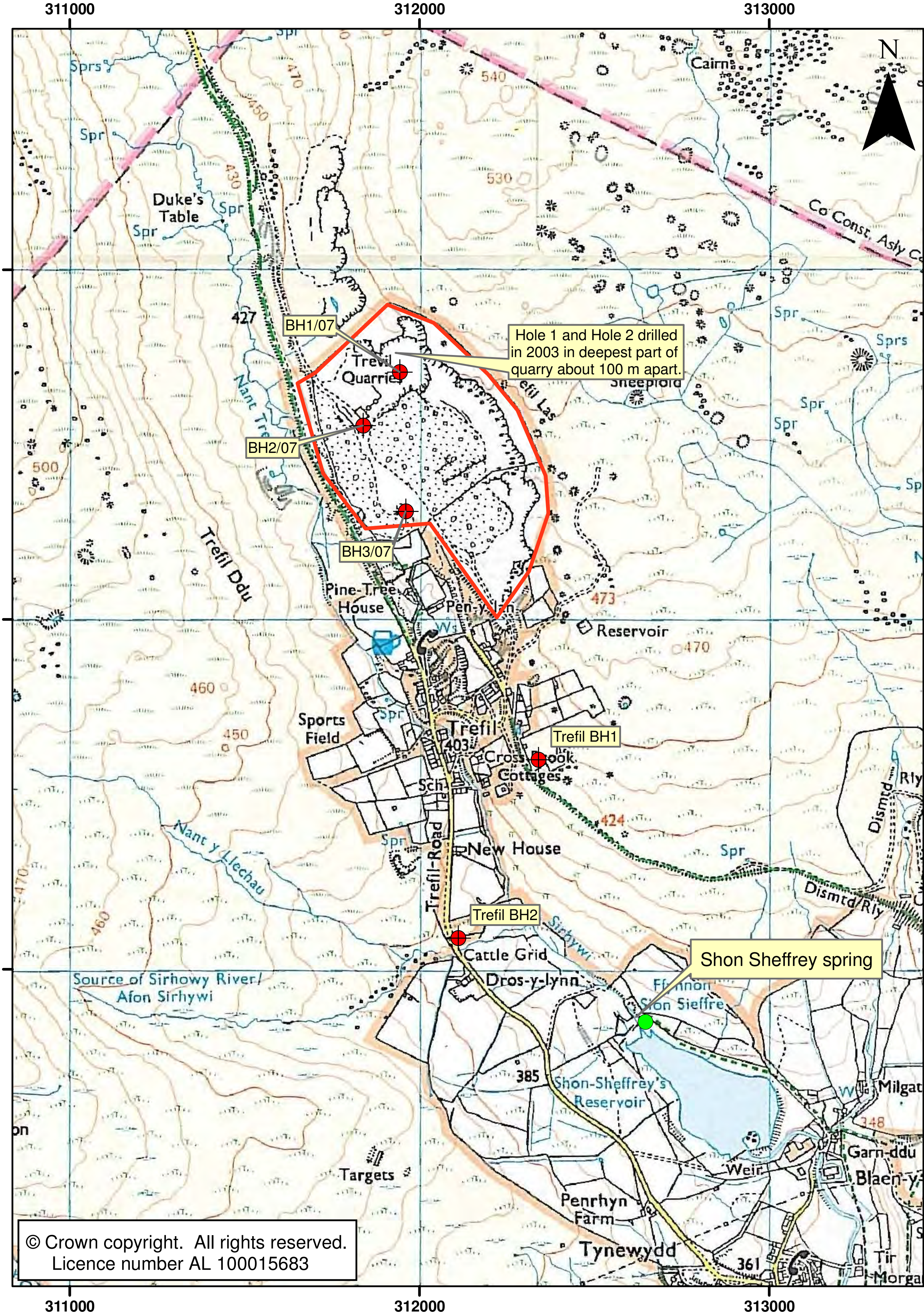


Figure 2.2
Borehole locations
(see Table 2.2 for borehole details)

Note: quarry boundary not accurate

Date	Drawn
May 2008	AWT
Scale 1:15,000	Checked MJS
Original A4	Revision 2

File Reference
O:\6878 Trefil Quarry\reports\Figures \6878R1rev1Figures\Figure 2.2

esi soil & groundwater

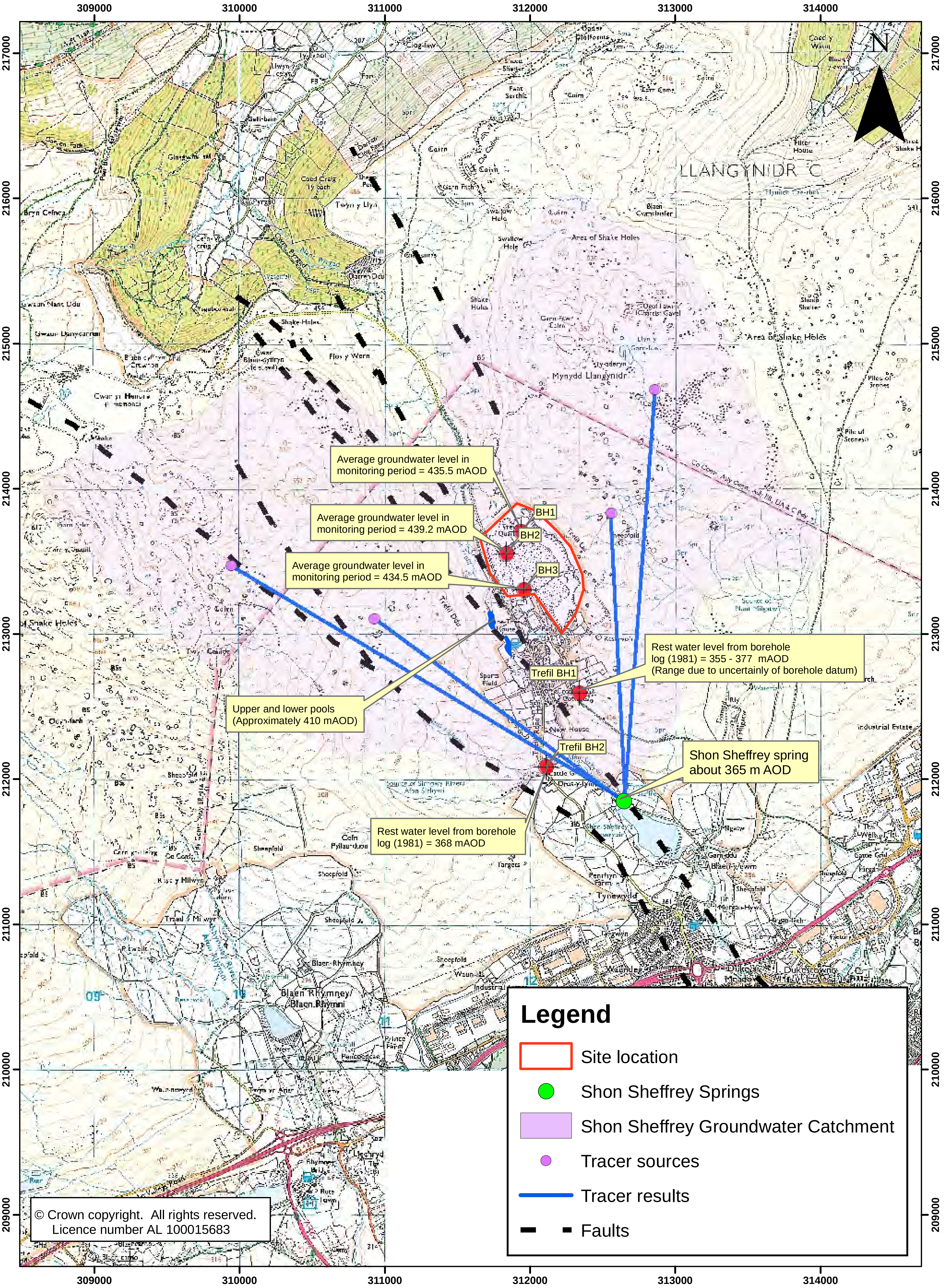
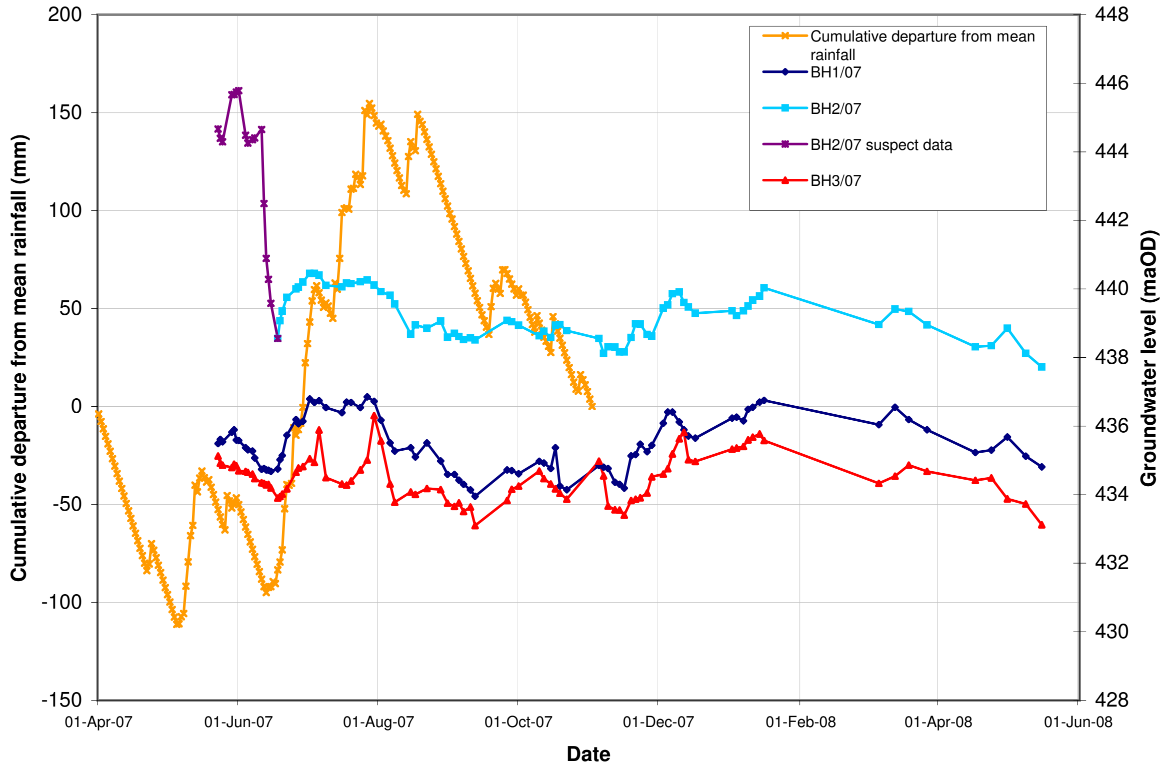


Figure 2.3
Hydrogeological information

Note: Quarry boundary not accurate

Date: May 2008	Drawn: AWT		
Scale: 1:25,000	Checked: MJS		
Original: A3	Revision: 2		
File Reference: O:\6878 Trefil Quarry\reports\Figures \6878R1rev1Figures\Figure 2.3			

esi soil & groundwater



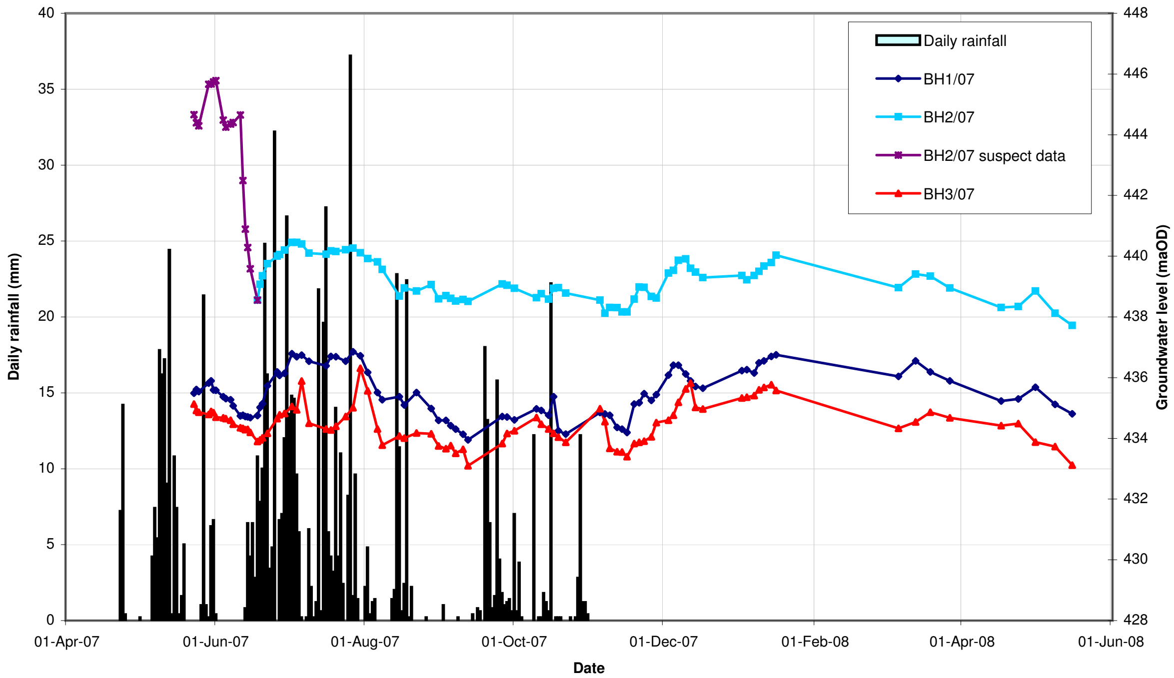


Figure 2.4
Site groundwater level hydrographs

Date	Drawn
May 08	AWT
Scale: dns	Checked: MJS
Original: A4	Revision: 2

File Reference
O:\6878 TrefilQuarry\ Reports \Figures\6878R1rev1Figures\Figure 2.4

esi soil & groundwater

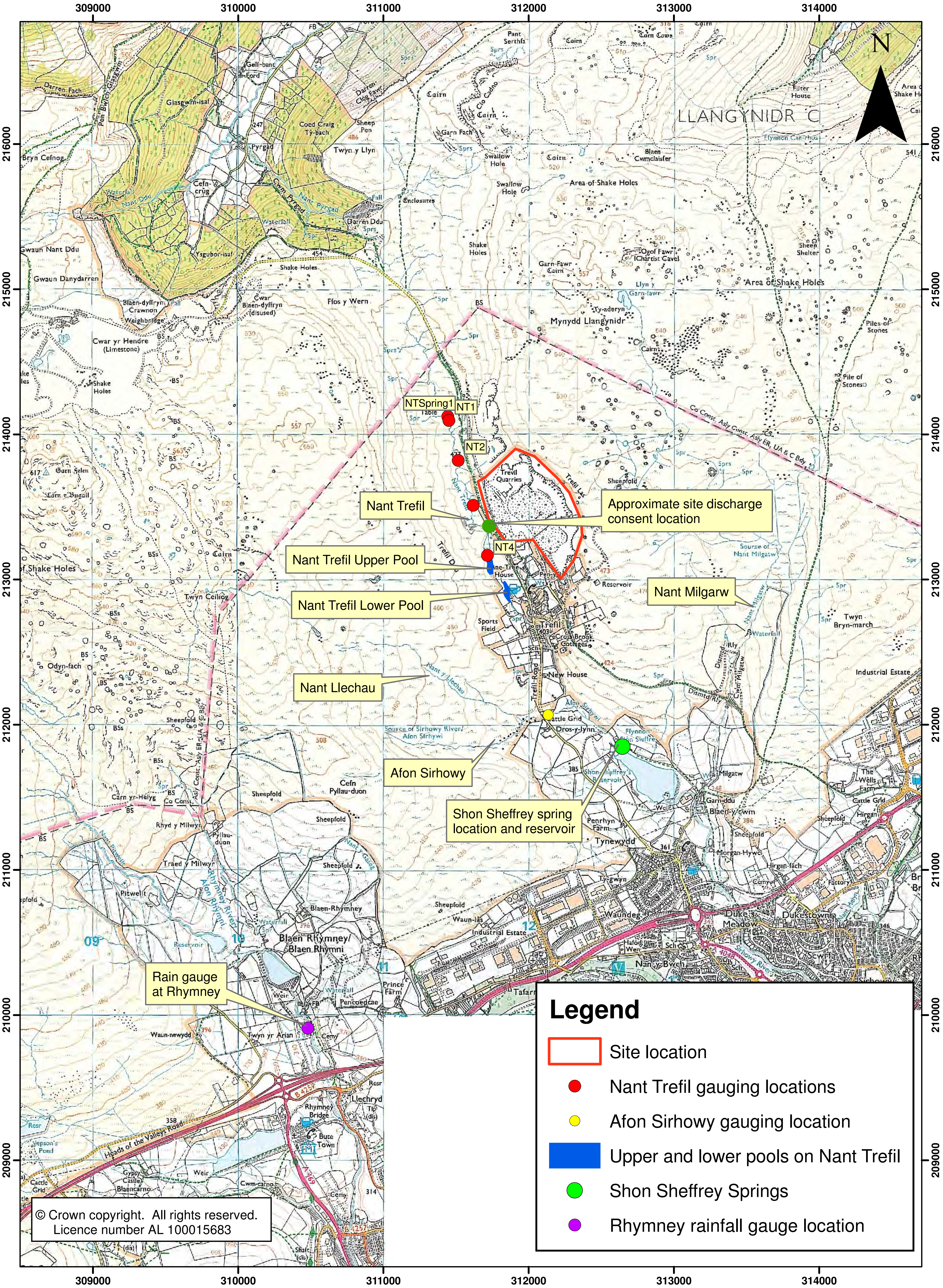


Figure 2.5
Surface water features

Note: Quarry boundary not accurate

Date	May 2008	Drawn	AWT
Scale	1:25,000	Checked	MJS
Original	A3	Revision	2
File Reference	O:\6878 Trefil Quarry\reports\Figures \6878R1rev1Figures\Figure 2.5		

soil & groundwater

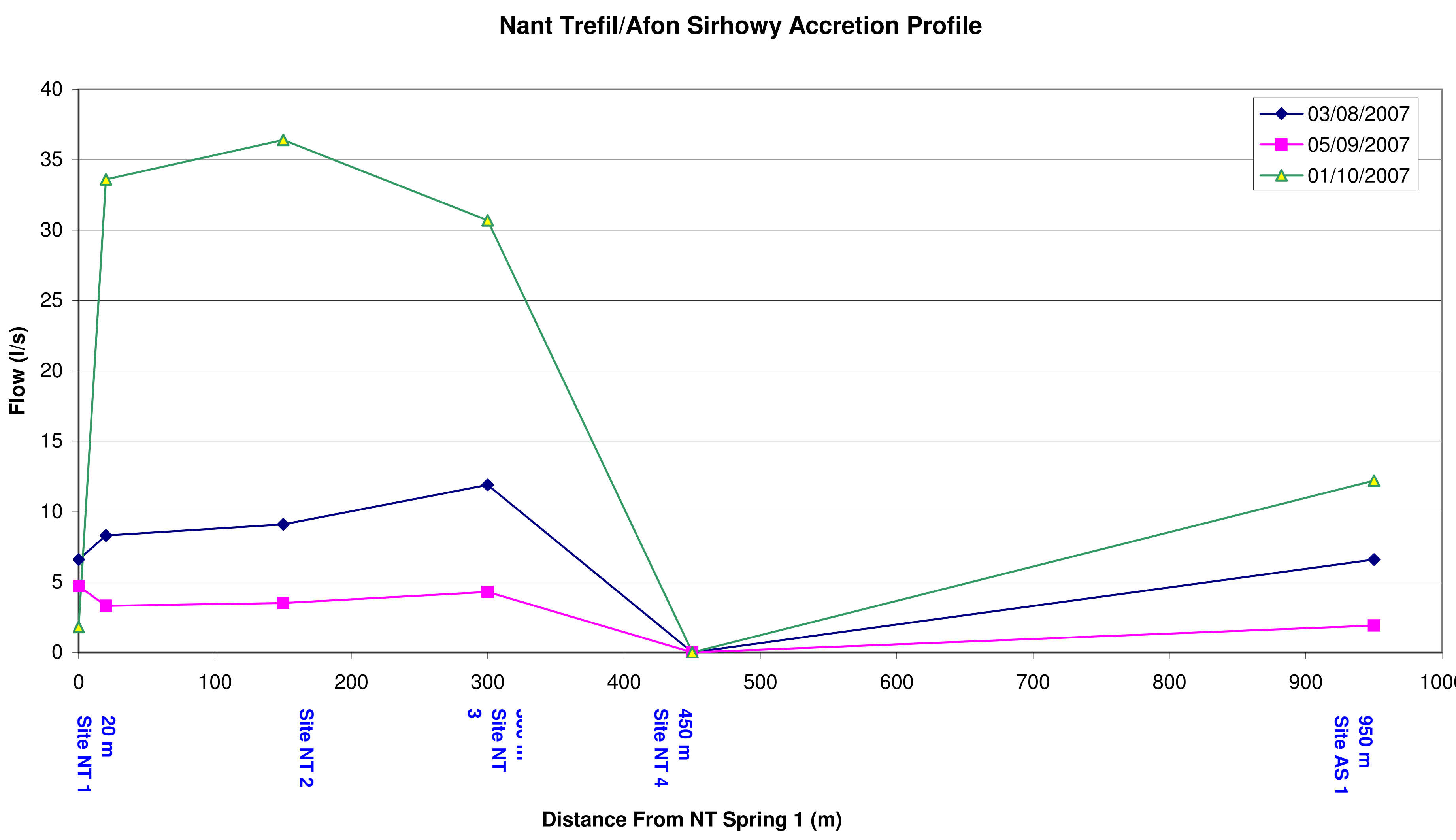


Figure 2.6
Nant Trefil/Afon Sirhowy accretion profiles

Date	Drawn
May 08	AWT
Scale dns	Checked MJS
Original A4	Revision 2

File Reference
O:\6878 Trefil Quarry \reports \Figures\6878R1rev1Figures\Figure 2.6

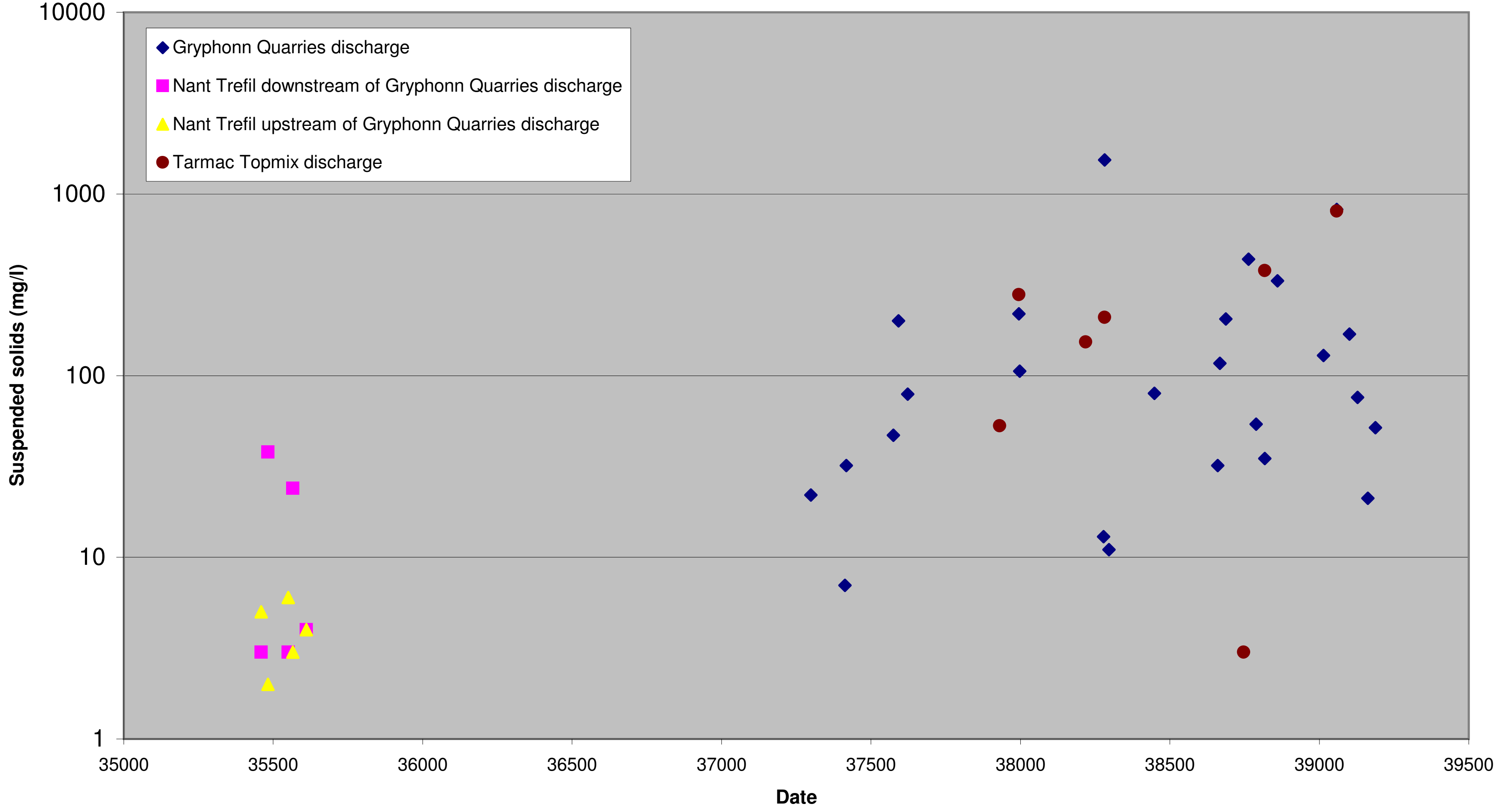


Figure 2.7
Suspended solids data in the vicinity of the quarry

Date	Drawn
May 08	AWT
Scale dns	Checked MJS
Original A4	Revision 2
File Reference O:\6878 TrefilQuarry\ Reports \Figures\6878R1rev1Figures\Figure 2.7	

esi soil & groundwater

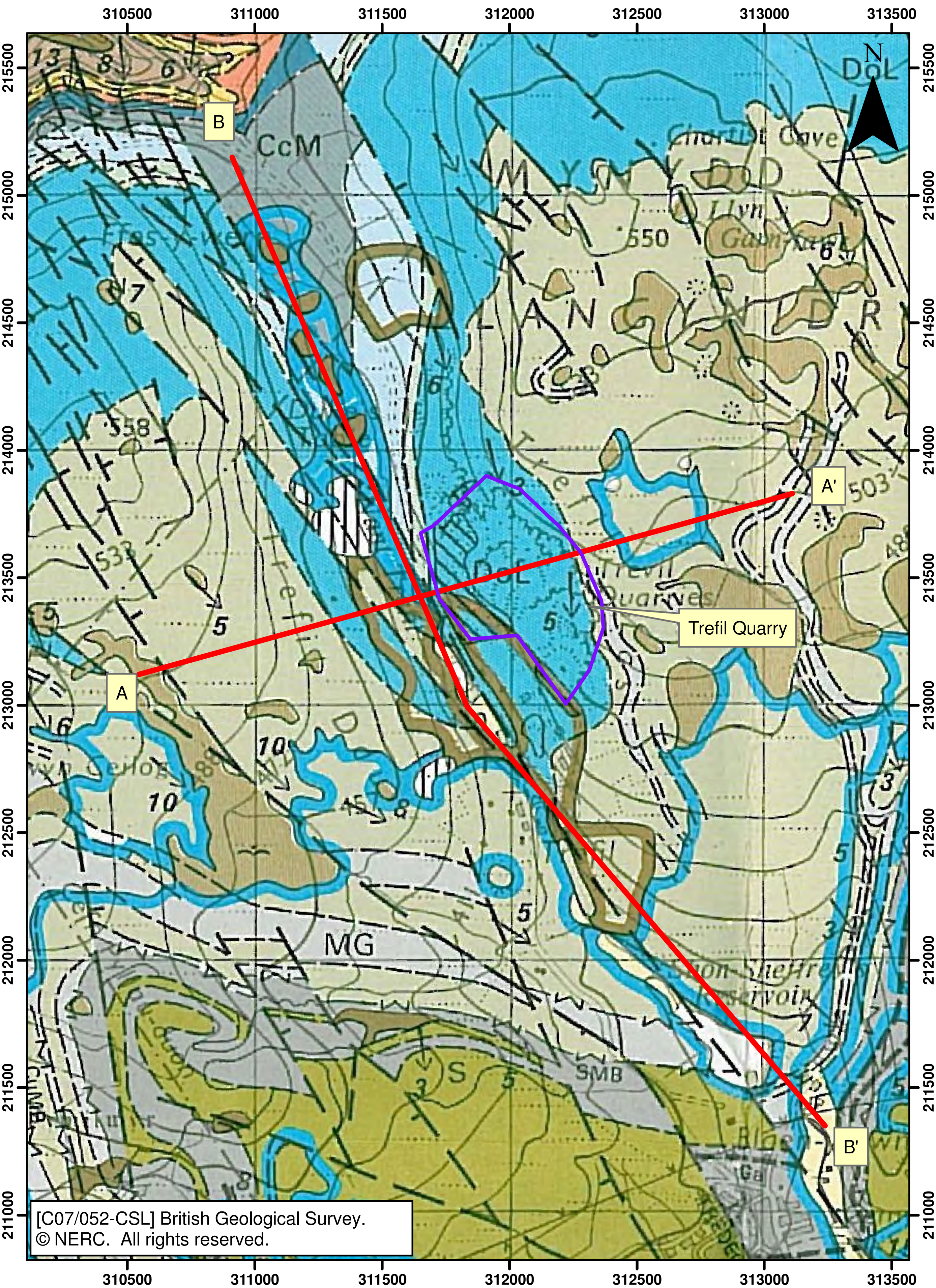


Figure 2.8
Cross section locations

Note: Quarry boundary not accurate

Date	Drawn
May 2008	AWT
Scale 1:20,000	Checked MJS
Original A4	Revision 2

File Reference
O:\6878 Trefil Quarry\reports\Figures\6878R1rev1Figures\Figure 2.8

esi soil & groundwater

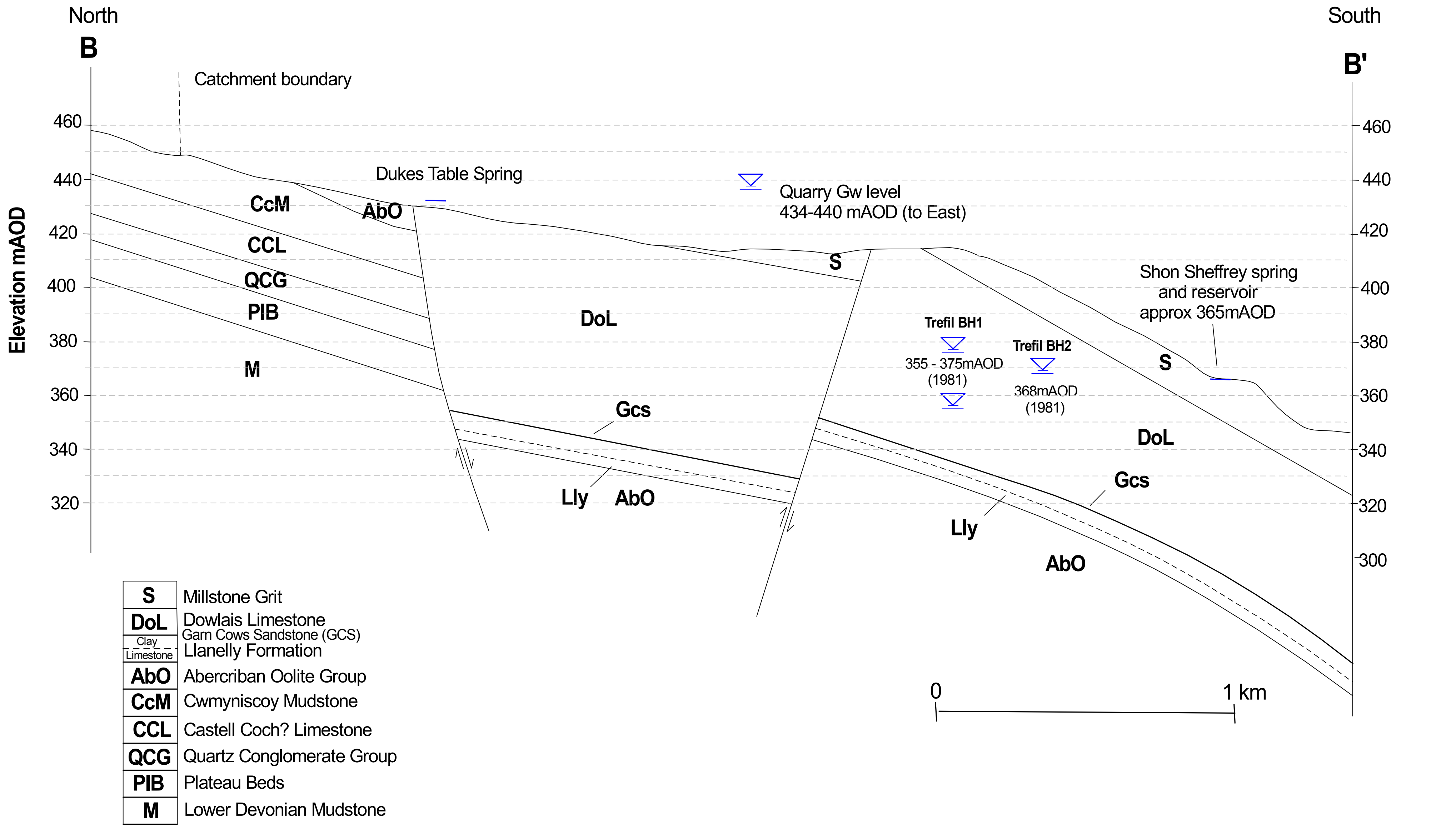


Figure 2.9
North to south cross section

Date	Drawn
May 2008	PCB
Scale	Checked
NTS	AWT
Original	Revision
A4	2

File Reference
O:\6878 Trefil Quarry\reports\Figures\6878R1rev1Figures\Figure 2.9

soil & groundwater

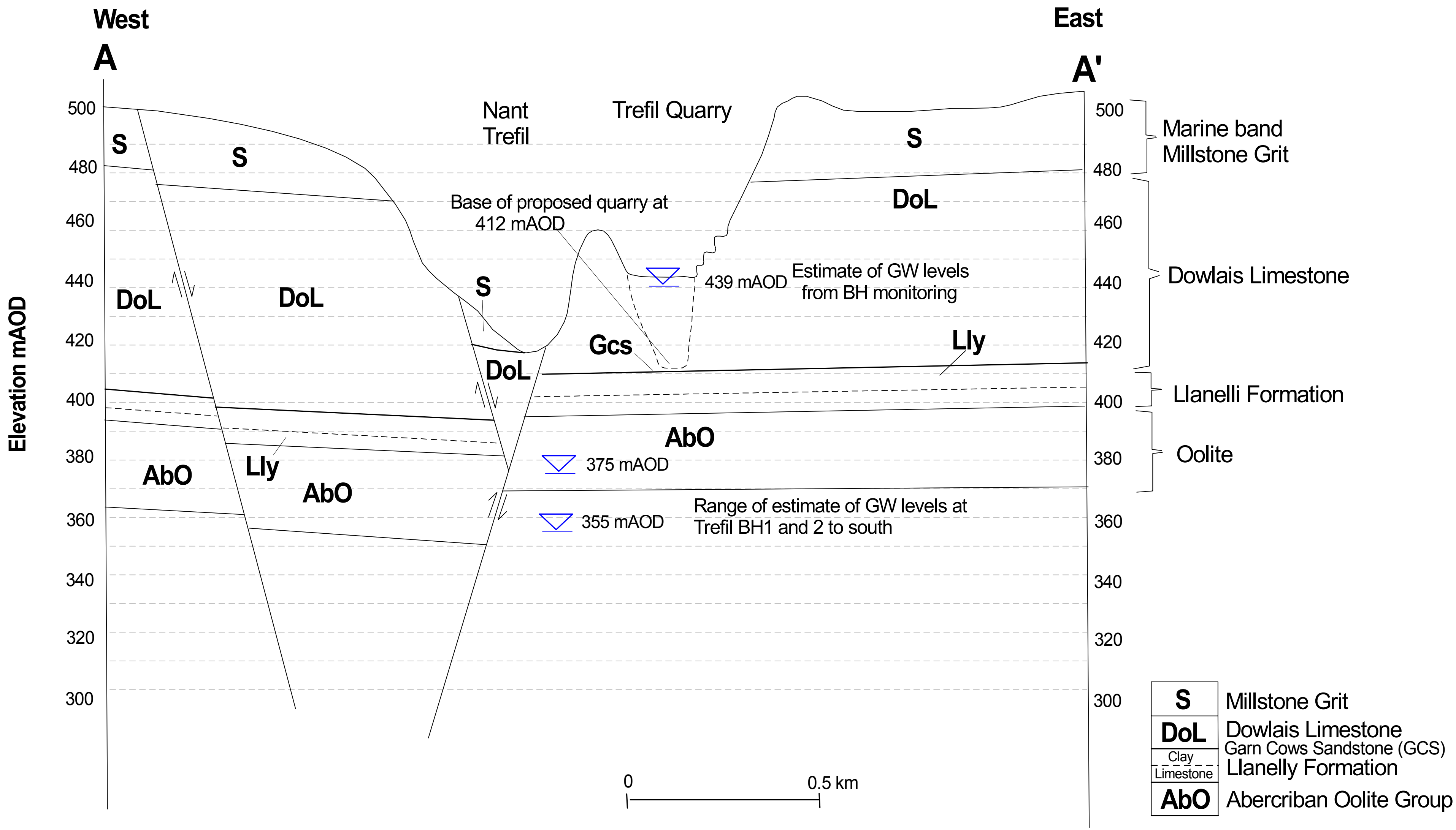
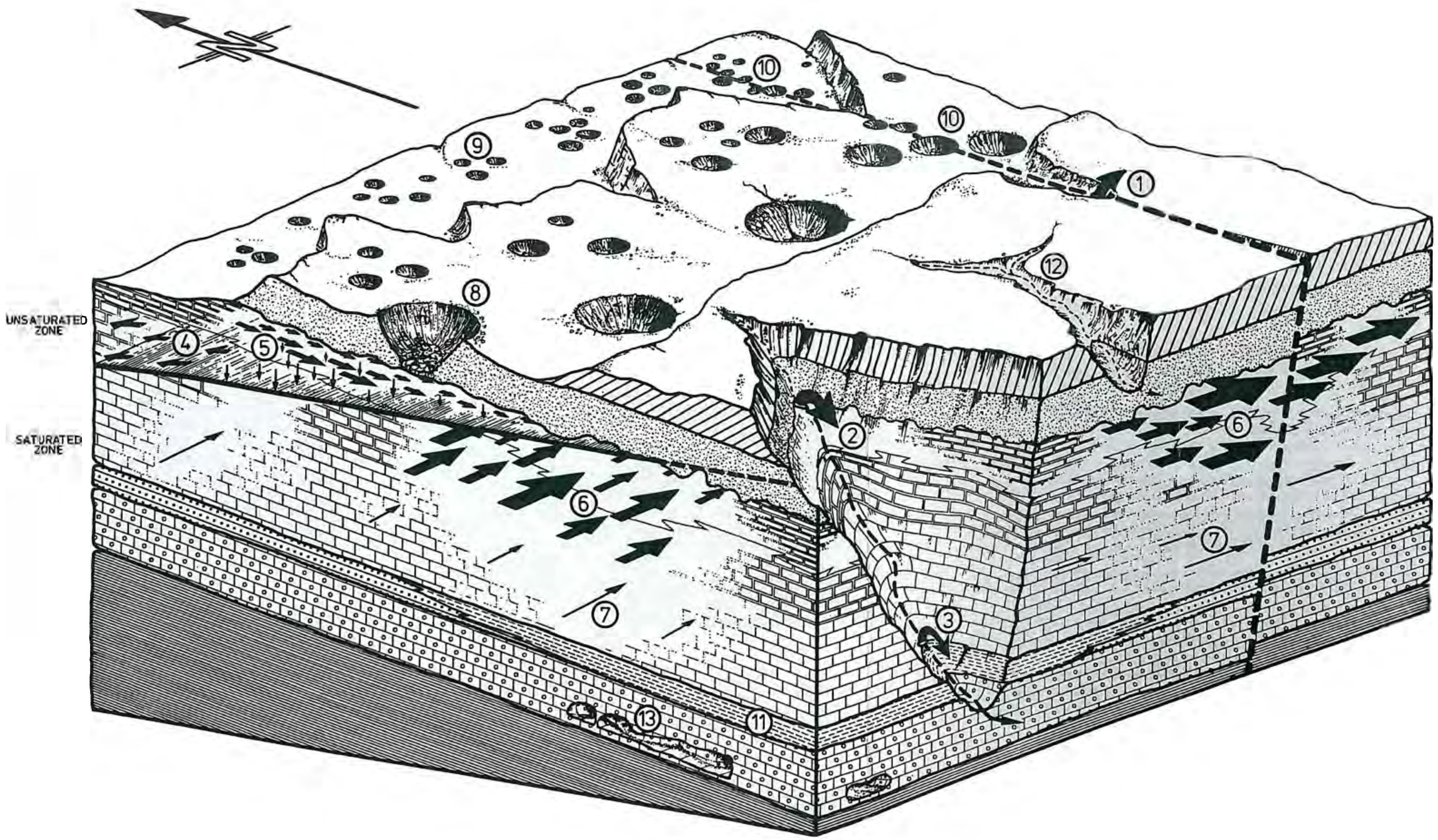


Figure 2.10
East to west cross section

Date	Drawn
May 2008	PCB
Scale	Checked
NTS	AWT
Original	Revision
A4	2

File Reference
O:\6878 Trefil Quarry\reports\Figures\6878R1rev1Figures\Figure 2.10

esi
soil & groundwater



KEY

1. Fault controlled spring issuing through strata overlying Limestone (e.g. Shon Sheffrey's spring)
2. Spring issuing from highly permeable dolomitized upper Dowlais Limestone in deeply incised river valley (e.g. Ffynnon Gisfaen in the Clydach valley)
3. Minor perennial spring issuing from lower Dowlais Limestone (e.g. Ogof Clogwyn resurgence)
4. Minor flow of groundwater northwards within unsaturated zone. A proportion will emerge from the Limestone as small springs in the scarp face
5. Major flow of groundwater down dip in unsaturated zone, towards water table
6. East-west strike oriented groundwater flow in saturated zone, majority of flow concentrated in more permeable zones in the higher levels of the aquifer
7. Smaller volume of flow within less permeable lower levels of the aquifer
8. Large collapse dolines on Millstone Grit extending to underlying Limestone
9. Smaller but more numerous dolines on Limestone outcrop
10. Concentration of dolines along the line of major fault
11. Upper part of Llanelli Formation locally present as Clay
12. Surface stream on Coal Measures, isolated from Limestone aquifer by impermeable Shales
13. Low level cave system in Oolite Group (e.g. Agon Allwedd)

HYDROGEOLOGICAL COLUMN

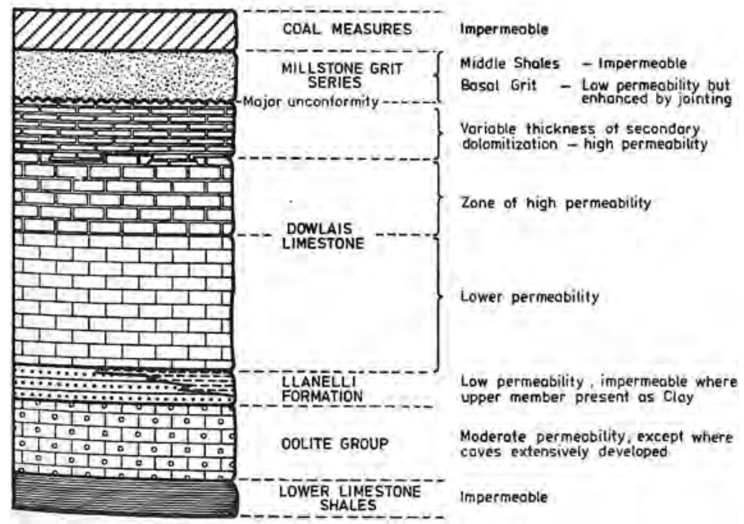


Figure 2.11
Schematic block diagram illustrating hydrogeological features and inferred groundwater flow distribution (from Welsh Water Authority, 1980)

Note: Direction of groundwater flow not relevent to local setting

Date	Drawn
May 2008	LAM
Scale: nts	Checked: AWT
Original: A3	Revision: 2

File Reference
O:\6878 Trefil Quarry\reports\Figures \6878R1rev1Figures\Figure 2.11

esi soil & groundwater

APPENDICES

APPENDIX A

Borehole Logs

Boreholes drilled in May 2007

BH1/07		Description	Installation Details
0	30	Dark grey fine grained LIMESTONE. Light grey in places. (DOWLAIS LIMESTONE)	5 m slotted section from base with plain pipe to surface.
30	30.5	Hard green CLAY (Llanelly Formation)	

BH2/07		Description	Installation Details
0	16.5	Dark grey fine grained LIMESTONE. Light grey in places. (DOWLAIS LIMESTONE)	5 m slotted section from base with plain pipe to surface.

BH3/07		Description	Installation Details
0	32.5	Dark grey fine grained LIMESTONE. Light grey in places. (DOWLAIS LIMESTONE)	5 m slotted section from base with plain pipe to surface.

APPENDIX 1

<u>Drilling Record Trefil Quarry: Hole 1 (441.8 metres OAD)</u>

Upper Unit Dowlais Limestone: limestone with quartz sand

0 -6 meters: dark limestone, contains quartz sand.

6 - 9 metres: dark limestone contains quartz sand.

12 - 13 metres: soft "soil", probably cave fill derived from the surface.

12 - 15 metres: dark limestone, contains quartz sand.

Middle Unit Dowlais Limestone: "clean" limestone "no" quartz sand

15 - 18 metres: dark limestone, no quartz sand recorded.

18 - 21 metres: dark limestone, no quartz sand recorded.

21 - 24 metres: dark limestone, no quartz sand recorded.

Lower Unit Dowlais Limestone: sandy limestone and interbedded shale

24 - 27 metres: a mixture of dark limestone which contains quartz sand; light sandy limestone and shale.

LLanelly Formation

27 - 33 metres: hard green clay.

33 - 36 metres: light fine grained limestone.

<u>Drilling Record Trefil Quarry: Hole 2 (440.5 metres OAD)</u>

NB. No chippings collected from above 24 metres and the quartz sand content was n examined. The occurrence of quartz sand in the Hole 2 section is however probably identical to the Hole 1 section. Below 24 metres the sections are identical based on an evaluation of the quartz sand content below 24 metres in the hole.

Upper Unit Dowlais Limestone: limestone with quartz sand

0 -6 meters: dark limestone (probably contains quartz sand).

6 - 12 metres: dark limestone (probably contains quartz sand).

12 - 15 metres: dark limestone (probably contains quartz sand).

Middle Unit Dowlais Limestone: "clean" limestone "no" quartz sand

15 - 18 metres: dark limestone (probably no quartz sand).

18 - 21 metres: dark limestone (probably no quartz sand).

21 - 24 metres: dark limestone, (probably no quartz sand).

Lower Unit Dowlais Limestone: sandy limestone and interbedded shale

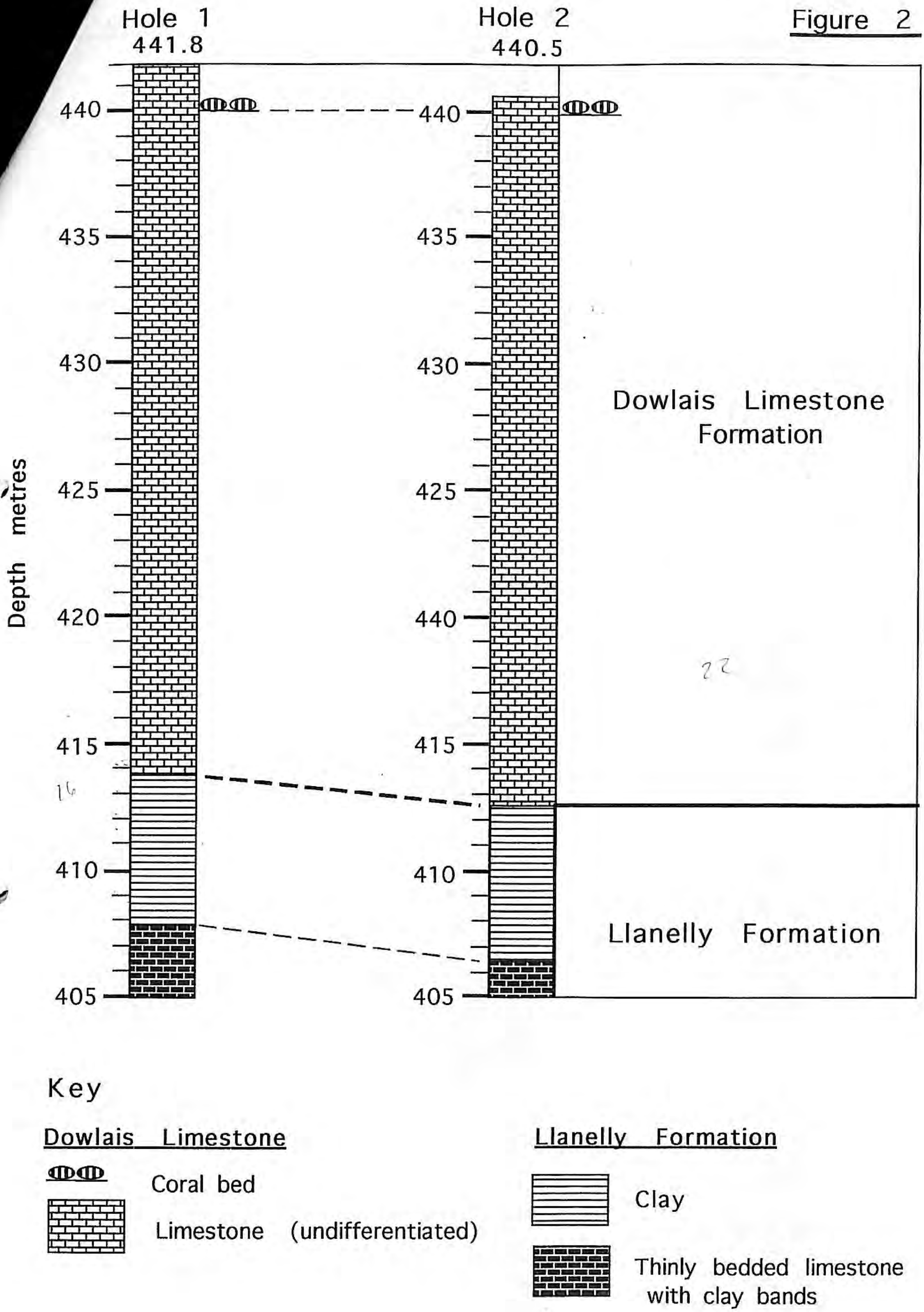
24 - 28 metres: a mixture of dark limestone which contains quartz sand; light sandy limestone and shale.

LLanelly Formation

28 - 33 metres: hard green clay.

33 - 36 metres: light fine grained limestone.

Figure 2



Hole 1
441.8
Hole 2
440.5
Depth metres
440
435
430
425
420
415
410
405
440
435
430
425
440
415
410
405
Dowlais Limestone Formation
Llanelly Formation
Key
Dowlais Limestone
Coral bed
Limestone (undifferentiated)
Llanelly Formation
Clay
Thinly bedded limestone with clay bands

N.15242

GEORGE STOW CO. LTD.

232/159 A

Waterworks Engineers

READING ROAD – HENLEY-on-THAMES. OXON.

RECORD OF WELL (SHAFT OR BOREHOLE)

SO11/6A

DATE COMPLETED 18 September, 1981

BOREHOLE NO. 1 TREFIL 232/159A

All depths to be measured below Ground Level

Work carried out for: Welsh Water Authority SO 1234 1260

Locality (Exact Site): Trefil, Nr. Tredegar, Gwent (N.G. Ref: SO 124128) SO 11 SW/75

Level of Ground Surface above Sea Level (O.D.) .... m.

Depth of Shaft .... m. Diameter .... mm.

Depth of Bore 141 m. (462.62 ft) Diameter: At Top 162 mm. (6.37") At Bottom 162 mm.

Details of Permanent Lining Tubes

Diameter	Length Inserted Plain	Slotted	Top At	above Ground Level
162 mm.	80.29 m.	Nil m.	0.63 m	above
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"

Water Struck at depth of (in m.) Not Known – Foam Drilling

Rest Level of Water below ~~above~~ Ground Level 52.80 m.

Yield on Three ~~Hours~~ Days test. Pumping 1.00 litres per sec. Date 12.9.81

Pump Water level 58.35 m. below Ground Level.

Time of Recovery After 24 hours water level had recovered to 52.97m (subsequent step test gave the following results: Rate: 1.5 l/sec; W/L: 61.70m; Rate: 2.20 l/sec; 63.49m.

Remarks ....

See back for Strata Record.

SO11b A   232/109A

DETAILS OF STRATA

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA (and any additional remarks)	THICKNESS METRES	DEPTH METRES
Head	Clay and stones	1.00	1.00
	Sandstone	0.50	1.50
	Sandstone and grit	4.50	6.00
Millstone	Clay	6.00	12.00
Grit	Shale	2.00	14.00
	Sandstone	1.00	15.00
	Alternative bands of shale and clay	5.00	20.00
*	Sandstone and quartz	12.00	32.00
	Limestone - fissured	20.00	52.00 *
* Circulation lost between 52.00 metres and 81.00 metres. With no returns permanent casing inserted. By "Feel" of drilling strata appeared to be fissured limestone.			
	Grey limestone (from 81 metres)	9.50	90.50
Carboniferous	Sandstone	1.00	91.50
	Grey limestone	6.50	98.00
Limestone	Sandy limestone	4.00	102.00
	Sandy shale	1.00	103.00
	Shaley limestone	4.00	107.00
	Sandstone and quartz	1.00	108.00
	Grey limestone	1.00	109.00
	Sandstone and limestone	1.00	110.00
	Silty sandstone	5.00	115.00
	Shaley limestone	2.00	117.00
	Brown/grey limestone	2.00	119.00
	Carcareous mudstone	4.00	123.00
	Black, fine carcareous shale	1.00	124.00
	Fine to medium limestone	2.00	126.00
	Grey very fine limestone	3.00	129.00
	Grey fine limestone	4.00	133.00
	Brown/grey fine to medium limestone	3.00	136.00
	Grey medium limestone	4.00	140.00
	Quartz with carcareous sandstone and shale	1.00	141.00

* Discrepancy here; Drilling and lithology log in the 'Report of the drilling results by Howard Humphreys' places the Millstone Grit/Carboniferous Limestone junction at 25m

To Mr. BARCLAY
28/5/82

SO11/6A

WATER RESOURCES BOARD
WELL RECORD SHEET 1

W.R.B. REF. No. SO11/6

R.A. LICENCE No.

1. WELL IDENTITY

NATIONAL GRID REFERENCE SO ~~124178~~ 1234 1260

Well at Trefil

I.G.S. REF. No. 232/159A

~~RIVER AUTHORITY~~ Welsh Water Authority

Town Nr. Tredegar

HYDROMETRIC AREA 56

County Gwent

SUB-CATCHMENT

Owner of well Welsh Water Authority

Well made by George Stow Co. Ltd

Date of sinking

Information from

Date received

2. WELL DESCRIPTION

Level of ground surface c. 410 m. above sea level (O.D.) ft.

If well top is not at above* / below ground level how far m. / ft.

Shaft m. / ft. deep; Diameter at top mm. / in.; at bottom mm. / in.

Bore 141 m. / ft. deep; Diameter at top 375 mm. / in.; at bottom 156 mm. / in.

Details of headings

DETAILS OF PERMANENT LINING TUBES

Length Plain 5.22 m. / ft.; Diam. 310 mm. / in.; Length Slotted m. / ft.; Diam. mm. / in.; Top m. / ft. ~~above~~* ~~below~~ at surface

Length Plain 80.10 m. / ft.; Diam. 179 mm. / in.; Length Slotted m. / ft.; Diam. mm. / in.; Top 0.43 m. / ft. above* ~~below~~ surface

Length Plain m. / ft.; Diam. mm. / in.; Length Slotted m. / ft.; Diam. mm. / in.; Top m. / ft. above* / below surface

Details of well screen

DETAILS OF REST WATER LEVELS DURING CONSTRUCTION

Water struck at depths of Not known - foam drilling below well top

Rest level of water 52.80 m. / ft. ~~above~~* below O.D.* / well top when bore m. / ft. deep. Date

Rest level of water m. / ft. above* / below O.D.* / well top when bore m. / ft. deep. Date

Rest level of water on completion of bore 52.80 m. / ft. ~~above~~* below ~~O.D.~~* well top when bore 141 m. / ft. deep. Date 12.9.81

Method of drilling Rotary - Foam drilling

Brief details of well development e.g. acid treatment etc. Borehole developed by - Swabbing, Air Lift, Acidization - 10 tonnes 35% hydrochloric acid

* delete as applicable

(18127/1)

[SO11SW BJ 75 .]

DETAILS OF PUMPING TEST

Water level depressed from .... m. / .... ft. above* / below well top to .... m. / .... ft. below well top, pumping at .... 1/s / .... galls/hr.

Water level depressed from .... m. / .... ft. above* / below well top to .... m. / .... ft. below well top, pumping at .... 1/s / .... galls/hr.

Water level depressed from .... m. / .... ft. above* / below well top to .... m. / .... ft. below well top, pumping at .... 1/s / .... galls/hr.

Suction at........ft. below well top. Capacity of pump .... 1/s / galls/hr. Test from..../..../19.... to..../..../19....

DETAILS OF PERMANENT PUMPING EQUIPMENT

Make and/or type........ Motive Power........

Capacity .... 1/s / galls/hr. Suction at .... m. / .... ft. below well top.

Amount pumped........ m³/day* / galls/day. Pumping for........hrs./day.

Estimated consumption .... m³/week* / galls/week .... m³/year* / galls/year

3. WELL DATA

WELL USE. Abstraction ☐, Recharge ☐, Observation ☐, Disused ☐, Filled-in ☐

WATER USE. Public Supply ☐, Industrial ☐, Irrigation ☐, Agriculture ☐, Domestic ☐, Unused ☐, Misc. ☐

WATER LEVEL OBSERVATIONS

	Rest Water Level	Pumping Water Level	Depression	Rate of Pumping	Date
1	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... 1/s / .... galls/hr.	
2	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... 1/s / .... galls/hr.	
3	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... 1/s / .... galls/hr.	
4	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... 1/s / .... galls/hr.	

GEOPHYSICAL DATA AVAILABLE

Resistivity ☑ Conductivity ☐ Temperature ☐ Any other logs ....*gamma, caliper*........

PARTIAL ANALYSIS DETAILS in milligrams per litre

Date	TDS	Tot H	Carb H	Non-Carb H	Alk	SO4	Cl	E.C.

Site marked on: 1 inch (print)........, 1 inch (master)........, 2½ inch .... (use symbol and give data)

(18127/1)

SO 11/6A

WATER RESOURCES BOARD WELL RECORD SHEET 2	W.R.B. REF NO. SO 11/6 R.A. LICENCE NO.

4. HYDROGEOLOGY

Topography AT WELL SITE

Local depression ☐, Flat surface ☐, Hill top ☐, Hillside ☐, Valley bottom ☐, Terrace ☐

MAJOR AQUIFER Carboniferous Limestone Lithology ....

Depth to top of aquifer	32.00 m. / .... ft.	Thickness penetrated	109.00 m. / .... ft.
Top of aquifer	3.78 m. / .... ft. AOD* ~~BOD~~	Total thickness of aquifer	.... m. / .... ft.
Coefficient of storage	....	Transmissivity	.... m2/day* / galls/day/ft.

MINOR AQUIFER .... Lithology ....

Depth to top of aquifer	.... m. / .... ft.	Thickness penetrated	.... m. / .... ft.
Top of aquifer	.... m. / .... ft. AOD* BOD	Total thickness of aquifer	.... m. / .... ft.
Coefficient of storage	....	Transmissivity	.... m2/day* / galls/day/ft.

ADDITIONAL NOTES:

* delete as applicable

RR 18127/1/2173 5m 5/71 TP

5. STRATA

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA	THICKNESS METRES	DEPTH METRES	DEPTH FEET	DEPTH IN
HEAD	Clay and stones	1·00	1·00		
	Sandstone	0·50	1·50		
	Sandstone and grit	4·50	6·00		
MILLSTONE	Clay	6·00	12·00		
GRIT	Shale	2·00	14·00		
	Sandstone	1·00	15·00		
	Alternative bands of shale and clay	5·00	20·00		
——— *	Sandstone and quartz	12·00	32·00		
	Limestone fissured	20·00	52·00		
Circulation	lost between 52·00 m and 81·00 m. With no returns permanent casing				
inserted.	By 'Feel' of drilling strata appeared to be fissured limestone.				
	Grey limestone (from 81·00 metres)	9·50	90·00		
	Sandstone	1·00	91·00		
	Grey limestone	6·50	98·00		
CARBONIFEROUS	Sandy limestone	4·00	102·00		
LIMESTONE	Sandy shale	1·00	103·00		
	[illegible] limestone	4·00	107·00		
	Sandstone and quartz	1·00	108·00		
	Grey limestone	1·00	109·00		
	Sandstone and limestone	1·00	110·00		
	Silty sandstone	5·00	115·00		
	Shaley limestone	2·00	117·00		
	Brown/grey limestone	2·00	119·00		
	Calcareous mudstone	4·00	123·00		
	Black, fine calcareous shale	1·00	124·00		
	Fine to medium limestone	2·00	126·00		
	Grey very fine limestone	3·00	129·00		
	Grey fine limestone	4·00	133·00		
	Brown/grey fine to medium limestone	3·00	136·00		
	Grey medium limestone	4·00	140·00		
	Quartz with calcareous sandstone and shale	1·00	141·00		

* Discrepancy here: Drilling and lithology log in the report of the drilling results by Howard Humphreys places the Millstone Grit / Carboniferous Limestone junction at 25 m

NB: also that strata dip steeply here probably down into the Penyrylan fault

RR 18127/1/2173 5m 5/71 TP

SO11/6M

WATER RESOURCES BOARD (Geology Division)

Reference Number G.S.M. 232.1157A...

Chemical analysis of water sample (to be copied in the same units as original document)

Source of sample ...I.C.L.S.

N.G.R. ....SO..1236...1255.......... Date Collected ..12/9/81...........

Aquifer .Carboniferous Limestone.

Analyst .... Analyst's ref.no. .H/BL474I.......

Appearance ...Opalescent

E. cond. at 20°C ...480.............. Turbidity (silica scale) ....

Reaction pH ....6.6.............. Colour (hazen) ....3...........

S.G. at .... Odour ....

Temperature ......°C / ......°F Taste ....

Constituents (the units of the original analysis to be indicated, if not mg/l)

	Units:	mg/l		Units:	mg/l
T.D.S. (dried at 180°C)	....	315	Nitrogen in nitrates	....	LT.0.1
Hardness, Total*	....	275	Nitrogen in nitrites	....	.....
Carbonate*	....	135	Free ammonia	....	.....
Non-carbonate*	....	140	Albuminoid ammonia	....	.....
Alkalinity* as $CaCO_3$	....	135	Oxygen absorbed in 4 hours at 27°C	....	.....
Chlorine in chlorides	....	84			
Free carbon dioxide	....	50	Residual chlorine	....	.....
Silica	....	6		....	.....
Fluoride	....	.....		....	.....
Metals	....	Fe-0.22 Zn-LT0.03 Cu-LT0.03 Pb-LT0.03			

* expressed as calcium carbonate

		Units:	mg/l	me/l	Percentage reacting equivalents
Calcium	(Ca)	....	89	4.43	.....
Magnesium	(Mg)	....	13	1.07	.....
Sodium	(Na)	....	5	0.21	.....
Potassium	(K)	....	1	0.03	.....
			Total	5.74	
Carbonate	(CO_3)	....	81	2.70	.....
[Bicarbonate	(HCO_3)]	....	.....	.....	.....
Sulphate	(SO_4)	....	32	0.67	.....
Chloride	(Cl)	....	84	2.37	.....
Nitrate	(NO_3)	....	0	.....	.....
			Total	5.74	

Remarks: (continue overleaf if necessary)

DR 44378/1/89 2m 3/66 XL

SE Wales GW Study
– results of exploratory drilling report.
A. Humphreys/WWA 1982.

SO11/6A+B MJP 10/2202
MJB 1/113

1.

7

CHAPTER 1 - INTRODUCTION

1.1 SCOPE OF THE STUDY

The Carboniferous Limestone cropping out in the north east part of the South Wales Coalfield basin has been the subject of hydrogeological investigations since August 1979.

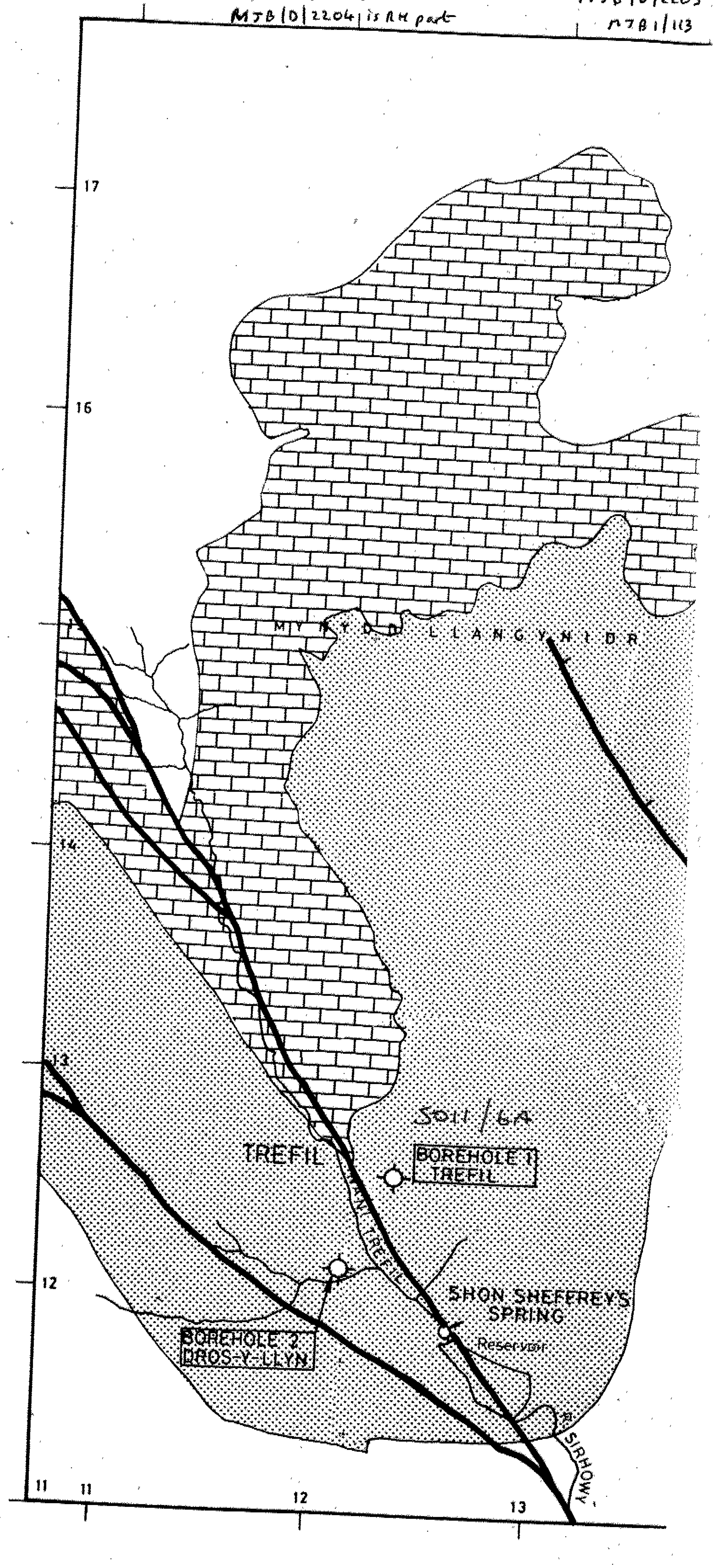
The first phase of the study was a preliminary reconnaissance of the region extending from the Neath Valley in the west to the Afon Lwyd Valley in the east as described in the South East Wales Groundwater Study Interim Report (December 1979). This reconnaissance recognised six areas where the potential resources justified more detailed study.

The Authority chose for further investigation three areas where high costs of the present supply together with proposed industrial development made additional local sources attractive. Two of these areas were within the Heads-of-the-Valleys region; Trefil, north of Tredegar, and Clydach Bridge, east of Brynmawr. The third area comprised the Afon Lwyd Valley north of Pontypool. The second phase investigations examined these areas in more detail but without resort to drilling. The dearth of subsurface information made it apparent early on that exploratory drilling would have to be undertaken to investigate more fully the properties of the limestone aquifer, and tender documents for a drilling contract were accordingly prepared in May 1980. The second phase findings are presented in the South East Wales Groundwater Study Reconnaissance Report (September 1980), in which details of the proposed drilling sites are also given.

The third phase of the study comprised an evaluation of drilling contract tenders (April 1981) and the construction and testing of three exploratory boreholes by a drilling contractor under the supervision of Howard Humphreys and Partners. The results of the drilling programme are presented in this report, and the locations of the boreholes are shown in Figure 1.

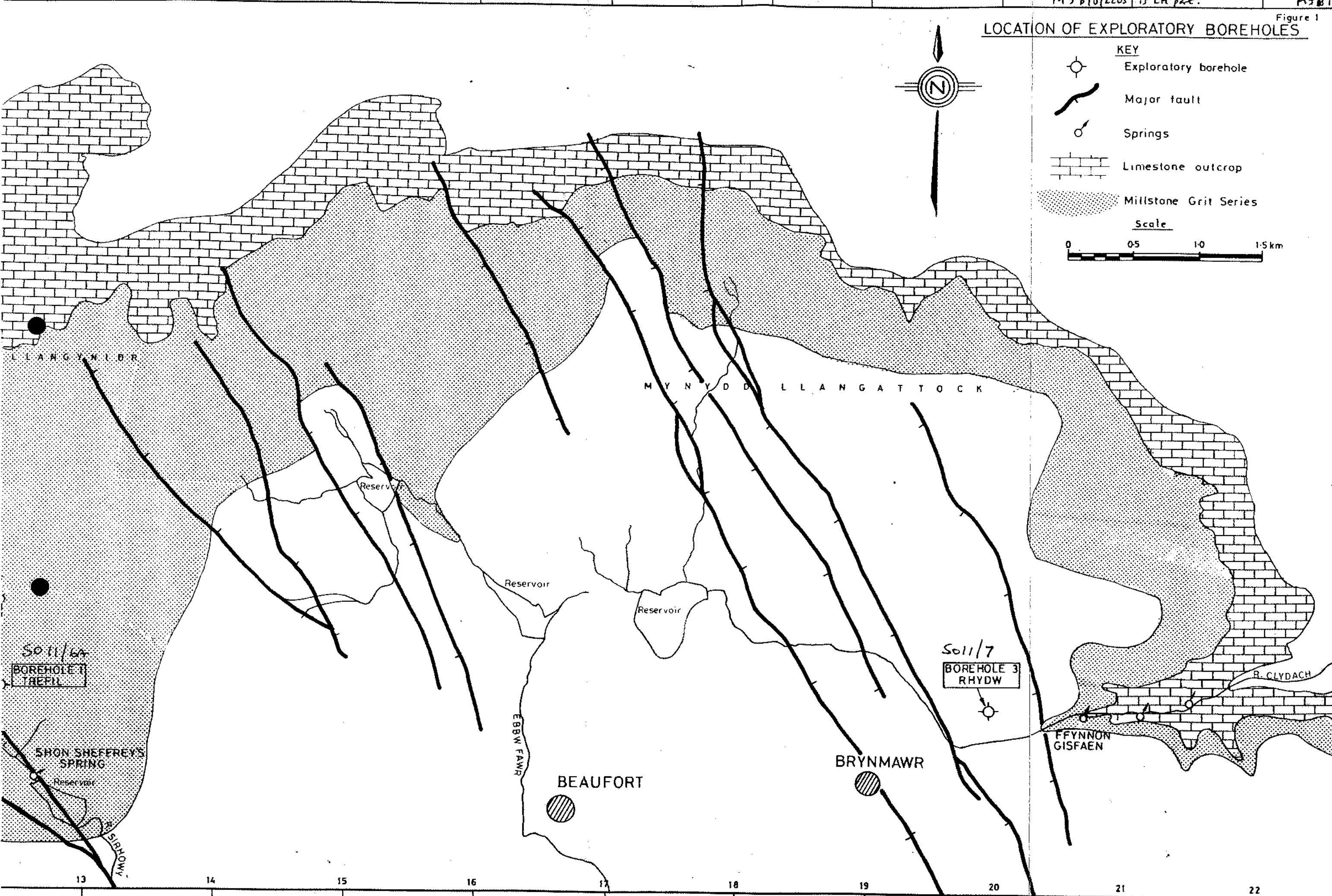
LH part of diagram
MJB/D/2204 is RH part

MJB/D/2203
MJB1/113



RH part of diagram.
MJB/D/2203 is LH part.

MJB/D/2204
MJB/1/13



SO11/6A+B MJB/D/2205
7 MJB1/113

CHAPTER 2 - CONCLUSIONS AND RECOMMENDATIONS

2.1 GENERAL

The exploratory boreholes have enabled an assessment to be made of the properties and development potential of the limestone aquifer at Trefil and East Brynmawr. The boreholes have adequately met their primary objectives but the findings in terms of resource potential have not been all that was originally hoped for. Nevertheless, development of the limestone aquifer appears practicable in the East Brynmawr area although the region around Trefil should not be considered further for groundwater development by boreholes.

2.2 TREFIL AND SHON SHEFFREY'S

The pumping tests at the two sites have shown that specific capacities were low and that yeilds greater than 2 l/s could not be sustained for long periods. From the tests, it can be concluded that borehole yields will be small less than 1.5 l/s with corresponding drawdowns of 10 m or more. The poor productivity of the aquifer does not therefore justify groundwater development in this area.

2.3 EAST BRYNMAWR

The Rhydw borehole encountered sufficiently productive strata for groundwater development to be practicable. From an analysis of the test data it appears that the borehole at this site may yield between 10 and 15 l/s with corresponding drawdowns between 6m and 11 m. Because, however, the test was undertaken in December when the level of the water table was not at a minimum, the estimates should be confirmed by further pump-testing at the end of the summer. The test will confirm whether groundwater storage in the area is transient or permanent.

Previous investigations (1980) found that groundwater drains through the limestones to the Clydach Valley from a large infiltration area and the potential resources comprise some 110 l/s. It would therefore appear possible to exploit the aquifer at about 50 l/s by one or more boreholes providing the permeability and nature of storage are favourable. It is considered that about 3 to 4 production boreholes would be required, although there is a good chance of a smaller number depending on the productivity of the aquifer in the E. Brynmawr area. On the basis of the transmissivity obtained from the test and assumed parameters of geometry, pumping water levels may be about 100m below ground level corresponding to 250 - 260m A.O.D.

2.4 RECOMMENDATIONS

In the light of the results of the exploratory drilling programme, it is recommended that consideration be given to groundwater development in the East Brynmawr region. Before further drilling for production purposes is undertaken, however, it will be necessary to confirm the assumptions which have been made in the hydrogeological analysis. In particular, therefore, the following courses of action should be taken:-

a) regular measurement of water levels in the Rhydw borehole by either twice weekly dip meter readings or, preferably, by autographic recorder. The principal objective would be to confirm that the rest water level of 79.7m.b.g.l. represents a low natural level (an assumption which has been made on the basis that the aquifer had received little replenishment during the drier than average summer of 1981 and the area was experiencing freezing conditions at the time of pump testing). Water level monitoring would also provide an indication of the rate of response of natural water levels to rainfall, and consequently an assessment of the nature of the flow system feeding the East Brynmawr area.

b) an additional pumping test on the Rhydw borehole towards the end of the 1982 dry summer conditions i.e. when the natural water table is at a minimum. This test, at the maximum rate possible for the test pump, should continue for seven days, in order to confirm the extrapolations utilised in this report for yield determination.

c) Gauging of the Ffynnon Gisfaen spring both before and during the pumping test, in order to assess the effects of groundwater abstraction on the spring discharge. It is evident that pumping will be at the expense of natural outflow from the aquifer, but if the borehole(s) intercept water moving southwards below the Clydach gorge to the Afon Lwyd valley, then the effect on Gisfaen may be insignificant.

In the event of satisfactory results from these investigations, then consideration should be given to the drilling of a large diameter production borehole lined with a 10 inch casing and slotted casing near the existing exploratory hole at Rhydw, and its subsequent pump testing to confirm the maximum yield obtainable from this borehole and from future boreholes in this area. On the basis of these results the precise number of boreholes required to deliver 50 l/sec can then be determined.

CHAPTER 3 - BOREHOLE DRILLING AND TESTING

3.1 GENERAL

All three boreholes were drilled by the direct-circulation rotary method using tricone bits with tungsten carbide inserts. On occasions hard formation rock-bits were used. The Contractor (George Stow & Co. Ltd of Henley-on-Thames) provided two rigs, a failing CF 15 and a Bucyrus-Erie 2400-R. The latter more powerful rig proved better suited to the ground conditions as it handled heavier drill-pipes and gave well aligned and very plumb holes. Whatever the rig and drill-pipe, heavy stabilizers were used above the bit in order to avoid excessive drift and vibration.

Each borehole was drilled in two stages as laid down in the Contract specification (1980). Firstly the upper section was drilled and logged (S.P., Resistivity, Gamma and Caliper) and the casing installed and grouted in place When the grout had hardened, the lower section was drilled by running the tools through the casing and drilling on beneath. The lower section was then logged, and the borehole developed and finally pump tested. At the surface the casing protrudes about half a metre, has a flanged bolted cap with an access plug and is set in a concrete block. Table 1 presents a summary of the borehole construction details.

The three exploratory holes were designed to be test pumped to assess borehole yields and to obtain a measure of aquifer transmissivity. This was done in each case in spite of the collapse of the hole at Dros-y-Lynn which seriously curtailed the test programme. Owing to the absence of obervation wells it was not possible to estimate storage coefficients. Tables 2, 3 and 4 show the tests undertaken and provide a summary of the results obtained from their analysis. The individual test plots prepared by Jacob's method (reference 4) are presented in the Appendices together with the test data.

MJB 10/2209
MJB 1/113

The Appendix to this report includes the detailed records of the investigation, and this chapter is therefore concerned only with the more significant aspects of the drilling and testing programme.

TABLE 1 - EXPLORATORY BOREHOLE CONSTRUCTION DETAILS

	SO11/6A	SO11/6B	SO11/7
BOREHOLE Grid Reference	TREFIL SO 1236 1255	DROS-Y-LYNN SO 1212 1212	RHYDW SO 1994 1244
Ground level m AOD	c 410m	c 393m	c 353m
UPPER HOLE 250mm	0 - 81.0m	0 - 72.0m	0 - 111.5m
LOWER HOLE 156mm	81 - 140.0m	72 - 186.0m	111.5 - 220.0m
TOTAL DRILLED DEPTH	141.0m	188.0m	220.0m
179mm API CASING TO	79.7m	70.8m	110.0m
CEMENT BASKET AT	56.0m	50.0m	99.5m
TOP OF LIMESTONE STRATA AT	25.0m	44.0m	105.0m
REST WATER LEVEL	52.0m (Early Sept. '81)	23.0m (12-10-81)	79.0m (10-12-81)
REMARKS		BOREHOLE CLOSED BY COLLAPSE	COLLAPSED BELOW 190m

N.B. All levels to below ground level

TABLE 2 - PROGRAMME OF PUMPING TESTS

	BOREHOLE	START DATE	PUMPING RATE (l/s)	DURATION (HOURS)	DURATION OF RECOVERY (HOURS)
SO11/6A	TREFIL	8. 9.81	c 2.2	6	6
		9. 9.81	4.3	2	2
		9. 9.81	1	72	24
		14. 9.81	1.5	10	6½
		15. 9.81	2.2	6	6
		16. 9.81	0.66	6	6
SO11/6B	DROS-Y-LYNN	15.10.81	0.8	6	6
SO11/7	RHYDW	10.12.81	1.2,3.4,9	6½	6
		11.12.81	11	6	6
		14.12.81	11	72	24

TABLE 3 - SPECIFIC CAPACITIES

	BOREHOLE	PUMPING RATE (l/s)	DRAWDOWN (m)	SPECIFIC CAPACITY (l/s/m)	DURATION OF TEST (hours)
SO11/6A	TREFIL	1.0	2.46	0.41	72
SO11/6B	DROS-Y-LYNN	0.8	1.17	0.68	6
SO11/7	RHYDW	11.0	7.88	1.42	72

MTB/D/2211
MTD1/113

TABLE 4 - TRANSMISSIVITY VALUES DERIVED BY TEST ANALYSIS (JACOB'S METHOD)

	BOREHOLE	PUMPING	RECOVERY	SELECTED REPRESENTATIVE VALUE
SO11/6A	TREFIL	-	10	
		-	6	
		10	8	10 m^2/d
		4.5	12	
		4.5	10	
		5	5	
SO11/6B	DROS-Y-LYNN	32	41(11)	35 m^2/d
SO11/7	RHYDW	173	158	
		166	134	130 m^2/d
		127	130	
	RHYMNEY	-	-	10-20 m^2/d (1)

(1) Reference 3

3.2 BOREHOLES IN THE TREFIL REGION (TREFIL AND DROS-Y-LLYN)

3.2.1 Trefil Borehole SO11/6A

The Trefil site (SO 1236 1255) is immediately adjacent to one of the collapse dolines or sinkholes which pockmark the Mynydd Llangynidr moorland tract. These dolines are evidence of considerable subsurface limestone dissolution and therefore it was thought likely that the borehole would encounter solutional voids. During drilling fissures were met with but most evidently in the vadose zone above the saturated limestone. Drill-foam and cuttings were lost into the rock but apparently above the water-table.

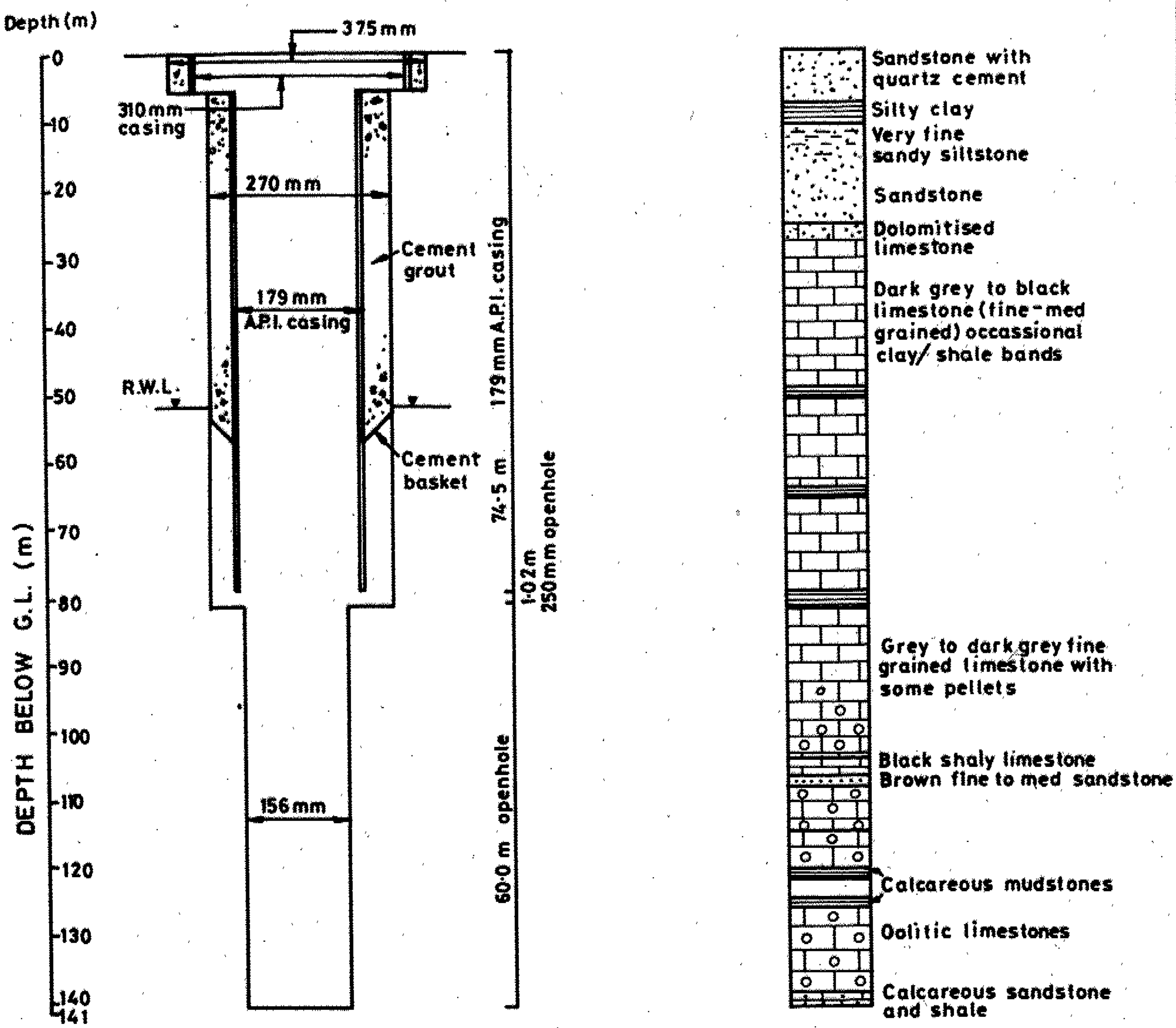
In order to facilitate connections between the borehole and any neighbouring karstic fissure system, the borehole was treated with 10 tonnes of hydrochloric acid (35%). Limestone consists

SO11/6A

MJB (D) 2212
MJB1/III

Figure 2

TREFIL BOREHOLE CONSTRUCTION DIAGRAM



Horizontal scale : 1:10
Vertical scale : 1:1000

essentially of calcium carbonate which the acid attacks and dissolves. Carbon dioxide gas is a major product of the reaction and the pressure built up by the emission of this gas into the capped borehole pushes acid into the surrounding rock where it opens up the crevices through which it is forced. Some hours later when the acid is spent the borehole is uncapped and pumped to waste.

During the development and subsequent pumping test, large quantities of fine quartz sand with silt and clay were pumped from this borehole. This sand fills the joints and fissures of the limestone and is derived from the sandstones of the Millstone Grit Series which overlie the limestones in this locality. The sandy infilling is considered to reduce the permeability of the limestone by clogging solutional fissures and restricting groundwater flow to karstic conduits.

Borehole development operations leading to the removal of this sandy detritus no doubt enhanced the permeability of the limestone in the immediate vicinity of the hole, but are considered to have had negligible effect on the overall permeability of the aquifer as evaluated by the pumping tests.

The Trefil borehole construction details and lithostratigraphic log of the site, interpreted from drilling returns and geophysical logs, are presented in Figure 2.

3.2.2 Dros-y-Lynn Borehole

The Dros-y-Lynn site (SO 1212 1212) is some 490 metres to the SW of the Trefil borehole on the downthrown western side of the Pen-y-Fan Fault (Figure 1).

The unstable ground encountered by this borehole led to considerable problems during its construction. Initially the shales of the Millstone Grit sequence were found liable to slough into the hole and consequently had to be supported by permanently

CHAPTER 4 - HYDROGEOLOGICAL ANALYSIS AND INTERPRETATION

4.1 TREFIL AND DROS-Y-LYNN

The pumping test results in the Trefil region indicate that the perennially saturated limestone is poorly permeable, with significant fissure development being restricted to the limestones above the standing water table. Whilst the fissures act as conduits for rapid throughflow to springs and resurgences, they do not provide a water bearing system at depths suitable for exploitation by boreholes. This is disappointing since the karst terrain and the persistence and recession characteristics of the Shon Sheffrey's spring argue for a greater development of solutional fissures and secondary aquifer properties.

The borehole water level at Trefil fluctuates markedly in response to rainfall (Figure 5), the fluctuations being due to changes in the water table rather than the piezometric response recorded at Rhymney Bridge (Interim Report 1979, Figure 13 and page 52).

In the Interim Report it was suggested that a value of about 0.5% was a reasonable estimate of the specific yield (interlinked porosity) of the limestone within the zone of water-table fluctuation. Owing to the absence of observation well data during pump-testing, it has not been possible to determine storage coefficients and the type of storage at the two sites, and hence confirm or otherwise the suggested value. It is to be noted, however, that from observations of the water level response at the Trefil Site (a rise of 9 m following on 130 mm rainfall at Nant-y-Bwch) a value of specific yield of about 1% is indicated. It is to be expected that deeper levels within the limestone aquifer have less solutional voids and therefore a lower effective porosity.. This or indeed the elastic storage coefficient cannot be derived from the existing data..

SO11/6A+B MJB|D|2219 MJD1|113

The water level response recorded at Trefil confirms the apparent rapidity of deep infiltration to replenish the aquifer and the subsequent drainage from the uppermost water bearing levels of the limestone. Unfortunately the secondary development of permeability and space available to store groundwater deeper in the limestone has been found insufficient to justify a wellfield in the Trefil region.

4.2 RHYDW BOREHOLE AND EAST BRYNMAWR SO11/7

The pumping test results at Rhydw indicate that the limestone aquifer in the region is potentially productive. The borehole itself is hydraulically efficient, i.e. small well losses (Figure 6), and the aquifer permeability appears moderately high. The borehole was tested to 11 l/s, the maximum delivered by the test pump, although it is estimated that the safe yield of the borehole is 15 l/s. The extrapolations used to estimate this yield are presented in Table 5 and Figure 7, whilst Figure 8 models the pumping water level decline for various pumping rates. It should be noted that these predictions are based on the assumption that the rest water level of 79.7 metres is for a low natural rest water level, and that the predictions utilise pumping rates and periods much in excess of the longest pumping test carried out (72 hours).

TABLE 5 - SPECIFIC CAPACITY DATA FOR RHYDW BOREHOLE SO11/7

PUMPING RATE, Q (l/s)	WATER LEVEL (m)	DRAWDOWN, s (m)	SPECIFIC CAPACITY, Q/s l/s/m
-	79.70	-	-
1.2	80.25	0.55	2.18
3.4	81.35	1.65	2.06
9	84.53	4.83	1.86
11.2	85.72	6.02	1.86
11	85.66	5.96	1.85

(Data for 120 minutes of pumping)

DRILLING AND LITHOLOGY LOG BOREHOLE

CLIENT:- WELSH WATER AUTHORITY	PROJECT:- S.E.WALES GROUNDWATER STUDY / COUNTRY:- U.K.
LOCATION:- TREFIL, GWENT	CO-ORDINATES:- SO 1236 1255
GROUND LEVEL:- c. 410m AOD.	LOG DATUM:- GROUND LEVEL
RIG:- FAILING CF 15	DRILLING METHOD:- ROTARY WITH DIRECT CIRCULATION
DRILLING FLUID:- FOAM	CONTRACTOR:- GEO. STOW & CO. Ltd.
REST WATER LEVEL:- 52 m (Early September 1981)	

BOREHOLE:-

NOMINAL DIAMETER	FROM	TO
375 mm	G.L.	5·25 m
270 mm	5·25	81 m
156 mm	81	140m

CASING/SCREEN:-

NOMINAL DIAMETER	CASING OR SCREEN TYPE	SLOT WIDTH	FROM	TO
310 mm	JOHNSON	—	G.L.	5·22 m
179 mm	API	—	+ 0·43	79·67 m

GROUTED TO CEMENT BASKET AT 56m

TOTAL DRILLED DEPTH 141m

REMARKS:-
Borehole developed by Swabbing
Air-lift
Acidization – 10tonnes 35% hydrochloric acid

DRILLING AND LITHOLOGY LOG BOREHOLE 1
TREFIL BOREHOLE

Figure A1

SO11/6A

N. 15242

SO 11 SW/75.

GEORGE STOW CO. LTD.

232/159 A

Waterworks Engineers

READING ROAD – HENLEY-on-THAMES. OXON.

RECORD OF WELL (SHAFT OR BOREHOLE)

DATE COMPLETED 18 September, 1981

BOREHOLE NO. 1 TREFIL 232/159A

All depths to be measured below Ground Level

Work carried out for Welsh Water Authority SO 1234 1260

Locality (Exact Site) Trefil, Nr. Tredegar, Gwent (N.G. Ref: SO 124128) SO 11 SW

Level of Ground Surface above Sea Level (O.D.) .... m.

Depth of Shaft .... m. Diameter .... mm.

Depth of Bore 141 m. 462.62 ft Diameter: At Top 162 mm. 6.37" At Bottom 162 mm.

Details of Permanent Lining Tubes

Diameter		Length Inserted				Top At		
162	mm.	80.29	m. Plain	Nil	m. Slotted	0.63	m above ~~below~~	Ground Level
	"		"		"	"		"
	"		"		"	"		"
	"		"		"	"		"
	"		"		"	"		"
	"		"		"	"		"

Water Struck at depth of (in m.) Not Known - Foam Drilling

Rest Level of Water below ~~above~~ Ground Level 52.80 m.

Yield on Three ~~Hours~~ Days test. Pumping 1.00 litres per sec. Date 12.9.81

Pump Water level 58.35 m. below Ground Level.

Time of Recovery After 24 hours water level had recovered to 52.97m (subsequent step test gave the following results: Rate: 1.5 l/sec; W/L: 61.70m; Rate: 2.20 l/sec; 63.49m.

Remarks ....

See back for Strata Record.

[redacted]

SO11SW/75

DETAILS OF STRATA

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA (and any additional remarks)	THICKNESS METRES	DEPTH METRES
HEAD	Clay and stones	1.00	1.00
	Sandstone	0.50	1.50
	Sandstone and grit	4.50	6.00
MILLSTONE	Clay	6.00	12.00
GRIT	Shale	2.00	14.00
	Sandstone	1.00	15.00
	Alternative bands of shale and clay	5.00	20.00
	Sandstone and quartz	12.00	32.00
*	Limestone - fissured	20.00	52.00 *
Circulation lost between 52.00 metres and 81.00 metres. With no returns permanent casing inserted. By "Feel" of drilling strata appeared to be fissured limestone.			
	Grey limestone (from 81 metres)	9.50	90.50
CARBONIFEROUS	Sandstone	1.00	91.50
	Grey limestone	6.50	98.00
LIMESTONE	Sandy limestone	4.00	102.00
	Sandy shale	1.00	103.00
	Shaley limestone	4.00	107.00
	Sandstone and quartz	1.00	108.00
	Grey limestone	1.00	109.00
	Sandstone and limestone	1.00	110.00
	Silty sandstone	5.00	115.00
	Shaley limestone	2.00	117.00
	Brown/grey limestone	2.00	119.00
	Carcareous mudstone	4.00	123.00
	Black, fine carcareous shale	1.00	124.00
	Fine to medium limestone	2.00	126.00
	Grey very fine limestone	3.00	129.00
	Grey fine limestone	4.00	133.00
	Brown/grey fine to medium limestone	3.00	136.00
	Grey medium limestone	4.00	140.00
	Quartz with carcareous sandstone and shale	1.00	141.00

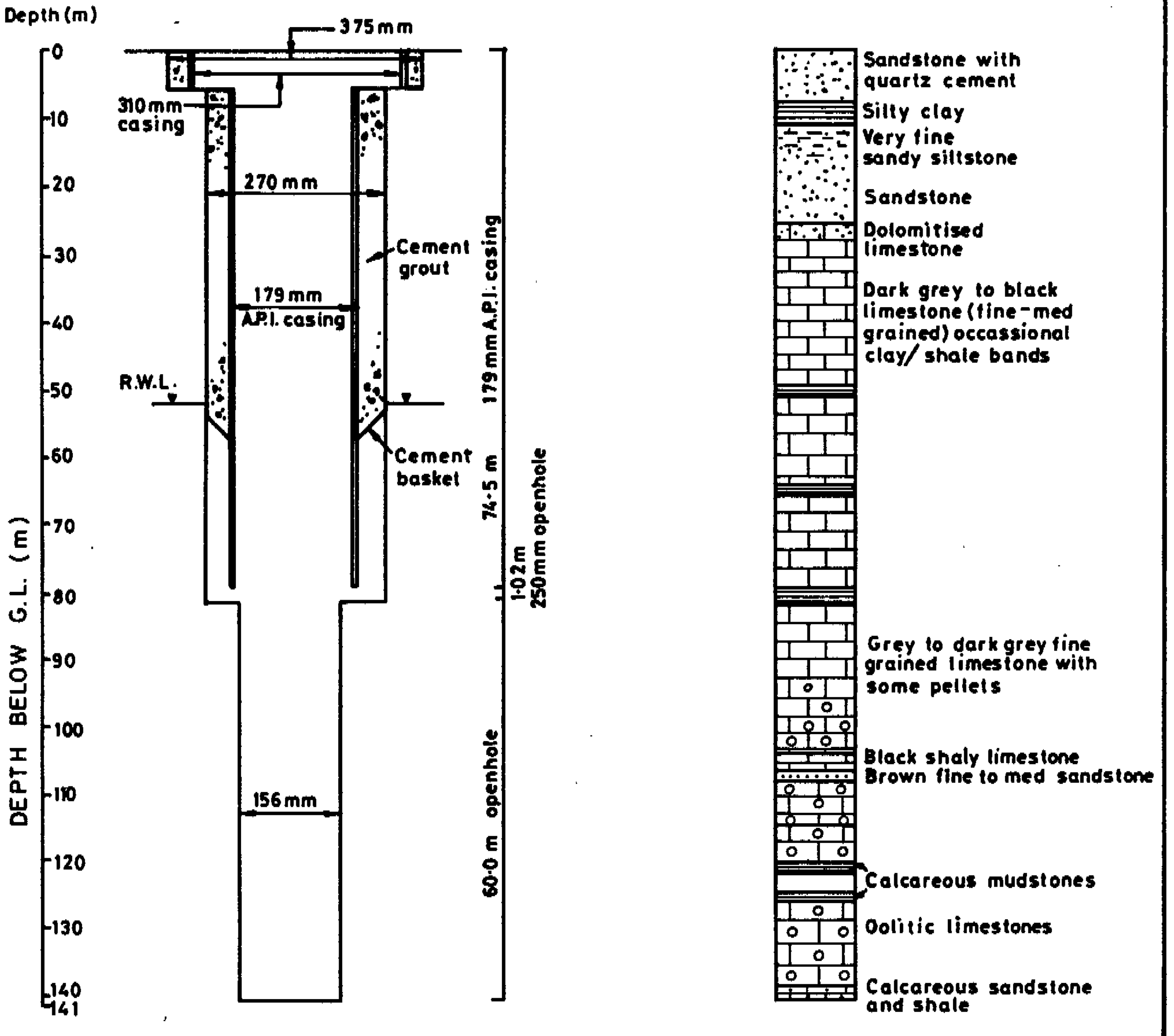
* Discrepancy here; Drilling and lithology log in the Report on this Exploratory Drilling programme by Howard Humphreys places the Millstone Grit / Carboniferous Limestone junction at 25m.

W. J. Barclay
28/5/82.

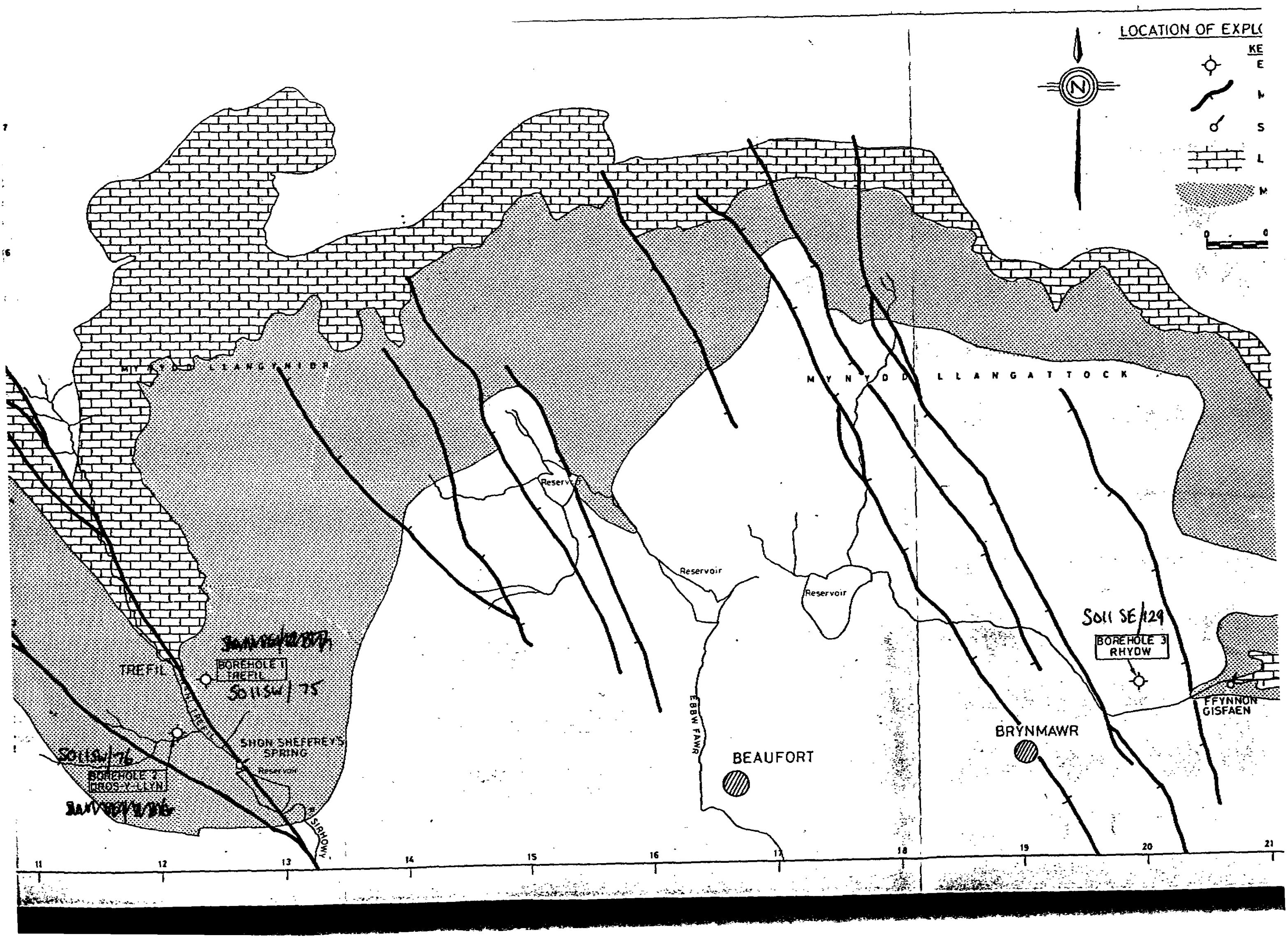
SO11SW/75

Figure 2

TREFIL BOREHOLE CONSTRUCTION DIAGRAM



Horizontal scale : 1 : 10
Vertical scale : 1 : 1000


LOCATION OF
N
MYNYDD LLANGYNIDR
MYNYDD LLANGATTOCK
Reservoir
Reservoir
Reservoir
Reservoir
TREFIL
BOREHOLE 1 TREFIL
SO11SW/75
SO11SW/76
BOREHOLE 2 DROS-Y-LLYN
SHON SHEFFREYS SPRING
SIRHOWY
EBBW FAWR
BEAUFORT
BRYNMAWR
SO11 SE/129
BOREHOLE 3 RHYDW
FFYNNON GISFAEN
11
12
13
14
15
16
17
18
19
20
21

GEORGE STOW CO. LTD.

N 15245

SO11/6B

232/159 B

Waterworks Engineers

READING ROAD – HENLEY-on-THAMES. OXON.

RECORD OF WELL (SHAFT OR BOREHOLE)

DROS-Y-LYNN NO. 2 B.H.

DATE COMPLETED 27 October, 1981

232/159 B

SO 11 SW

All depths to be measured below Ground Level

Work carried out for Welsh Water Authority SO 12 11 12 09

Locality (Exact Site) Trefil, Nr. Tredegar, Gwent. (N.G. Ref. SO.122122) SO 11 SW/76

Level of Ground Surface above Sea Level (O.D.) .... m.

Depth of Shaft .... m. Diameter .... mm.

Depth of Bore 187 m. Diameter: At Top 162 mm. At Bottom 162 mm.

613.55 ft 6.37"

Details of Permanent Lining Tubes

Diameter	Length Inserted Plain	Slotted	Top At (above Ground Level)
162 mm.	72.19 m.	Nil m.	0.50 m
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"

Water Struck at depth of (in m.) 26.00 metres

Rest Level of Water below Ground Level 24.87 m.

Yield on .... Hours / Days test. Pumping .... litres per sec. .... Date ....

Pump Water level .... m. below Ground Level.

Time of Recovery ....

Remarks Submersible Pump installed and tests of short duration carried out but because of large amounts of sand/silt infall results of any pumping not reliable. Borehole eventually filled to bottom of lining tubes with infall before being abandoned.

See back for Strata Record.

232/1598

DETAILS OF STRATA

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA (and any additional remarks)	THICKNESS METRES	DEPTH METRES
	Clayey topsoil	1.00	1.00
	Brown, fine silty sandstone	5.00	6.00
Millstone	Brown, fine to medium sandstone and quartz	1.00	7.00
	Grey shale	2.00	9.00
Grit	Dark grey shale	11.00	20.00
	Brown, grey silty shale	2.00	22.00
	Grey, with traces of brown silty shale	12.00	34.00
	Brown quartz sandstone	6.00	44.00
	Grey calcareous sandy mudstone	4.00	48.00
	Buff and grey/buff calcareous sandstone	7.00	55.00
Carboniferous	Grey calcareous siltstone	5.00	60.00
	Grey calcareous silty shale/mudstone	9.00	69.00
Limestone	Black limestone (Shaley from 91 to 98 metres and pale grey calcareous sandy limestone between 84 and 85 metres).	48.00	117.00
	Grey calcareous mudstone	6.00	123.00
	" " " /oolitic limestone	16.00	139.00
	" " clay/shale	1.00	140.00
	Grey, fine limestone	2.00	142.00
	Pale grey fine limestone	10.00	152.00
	Pale dark grey fine limestone	4.00	156.00
	Very pale grey limestone/oolitic	11.00	167.00
	Medium grain, grey limestone	8.00	175.00
	" " dark grey limestone	4.00	179.00
	Dark grey fine limestone	8.00	187.00

pp. W.V. Barclay

28/5/82

SO11/68

WATER RESOURCES BOARD
WELL RECORD

SHEET 1

W.R.B. REF. No. SO11/68

R.A. LICENCE NO.

1. WELL IDENTITY

NATIONAL GRID REFERENCE SO ~~1272~~ ~~1212~~ 1211 1209

Well at Dros-y-Wyn (no.2 BH)

I.G.S. REF. NO.

~~RIVER AUTHORITY~~ Welsh Water Authority

Town Trefil, nr Tredegar

HYDROMETRIC AREA 56

County Gwent

SUB-CATCHMENT

Owner of well Welsh Water Authority

Well made by George Stow Co Ltd

Date of sinking

Information from

Date received

2. WELL DESCRIPTION

Level of ground surface c 393 m. above sea level (O.D.) ... ft.

If well top is not at ground level how far above* ... m. below ... ft.

Shaft ... m. ... ft. deep; Diameter at top ... mm. ... in.; at bottom ... mm. ... in.

Bore 187 m. ... ft. deep; Diameter at top 162 mm. ... in.; at bottom 162 mm. ... in.

Details of headings

DETAILS OF PERMANENT LINING TUBES

Length Plain	Diam.	Length Slotted	Diam.	Top	
8.9 m.	310 mm.				~~above*~~ ~~below~~ at surface
70.82 m.	179 mm.				~~above*~~ ~~below~~ at surface
					above* below surface

Details of well screen

DETAILS OF REST WATER LEVELS DURING CONSTRUCTION

Water struck at depths of 26.00 metres below well top

Rest level of water 24.00 m. ~~above*~~ below O.D.* well top when bore ... m. deep. Date

Rest level of water ... m. above* below O.D.* well top when bore ... m. deep. Date

Rest level of water on completion of bore 24.00 m. ~~above*~~ below ~~O.D.*~~ well top when bore ... m. deep. Date

Method of drilling Rotary with direct circulation

Brief details of well development e.g. acid treatment etc.

* delete as applicable

(18127/1)

[SO11SW BJ 76 .]

DETAILS OF PUMPING TEST

Water level depressed from .... m. / .... ft. above* / below well top to .... m. / .... ft. below well top, pumping at .... l/s / .... galls/hr.

Water level depressed from .... m. / .... ft. above* / below well top to .... m. / .... ft. below well top, pumping at .... l/s / .... galls/hr.

Water level depressed from .... m. / .... ft. above* / below well top to .... m. / .... ft. below well top, pumping at .... l/s / .... galls/hr.

Suction at .... ft. below well top. Capacity of pump .... l/s / galls/hr. Test from ..../..../19.... to ..../..../19 ....

DETAILS OF PERMANENT PUMPING EQUIPMENT

Make and/or type .... Motive Power ....

Capacity .... l/s / galls/hr. Suction at .... m. / .... ft. below well top.

Amount pumped .... m^3/day* / galls/day. Pumping for .... hrs./day.

Estimated consumption .... m^3/week* / galls/week .... m^3/year* / galls/year

3. WELL DATA

WELL USE. Abstraction ☐, Recharge ☐, Observation ☐, Disused ☐, Filled-in ☐

WATER USE. Public Supply ☐, Industrial ☐, Irrigation ☐, Agriculture ☐, Domestic ☐, Unused ☐, Misc. ☐

WATER LEVEL OBSERVATIONS

	Rest Water Level	Pumping Water Level	Depression	Rate of Pumping	Date
1	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... l/s / .... galls/hr.	
2	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... l/s / .... galls/hr.	
3	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... l/s / .... galls/hr.	
4	.... m. / .... ft. O.D.	.... m. / .... ft. O.D.	.... m. / .... ft.	.... l/s / .... galls/hr.	

GEOPHYSICAL DATA AVAILABLE

Resistivity ☑ Conductivity ☐ Temperature ☐ Any other logs .... gamma ....

PARTIAL ANALYSIS DETAILS in milligrams per litre

Date	TDS	Tot H	Carb H	Non-Carb H	Alk	SO4	Cl	E.C.

Site marked on: 1 inch (print) ...., 1 inch (master) ...., 2½ inch .... (use symbol and give data)

(18127/1)

SO11/16B

WATER RESOURCES BOARD WELL RECORD SHEET 2	W.R.B. REF NO. SO11/16B R.A. LICENCE NO.

4. HYDROGEOLOGY

Topography AT WELL SITE

Local depression ☐, Flat surface ☐, Hill top ☐, Hillside ☐, Valley bottom ☐, Terrace ☐

MAJOR AQUIFER .... Lithology ....

Depth to top of aquifer ......6.9...... m. / .... ft. — Thickness penetrated ......12.8...... m. / .... ft.

Top of aquifer ......32.4...... m. / .... ft. AOD* ~~BOD~~ — Total thickness of aquifer .... m. / .... ft.

Coefficient of storage .... Transmissivity .... m2/day* / galls/day/ft.

MINOR AQUIFER .... Lithology ....

Depth to top of aquifer .... m. / .... ft. — Thickness penetrated .... m. / .... ft.

Top of aquifer .... m. / .... ft. AOD* / BOD — Total thickness of aquifer .... m. / .... ft.

Coefficient of storage .... Transmissivity .... m2/day* / galls/day/ft.

ADDITIONAL NOTES:

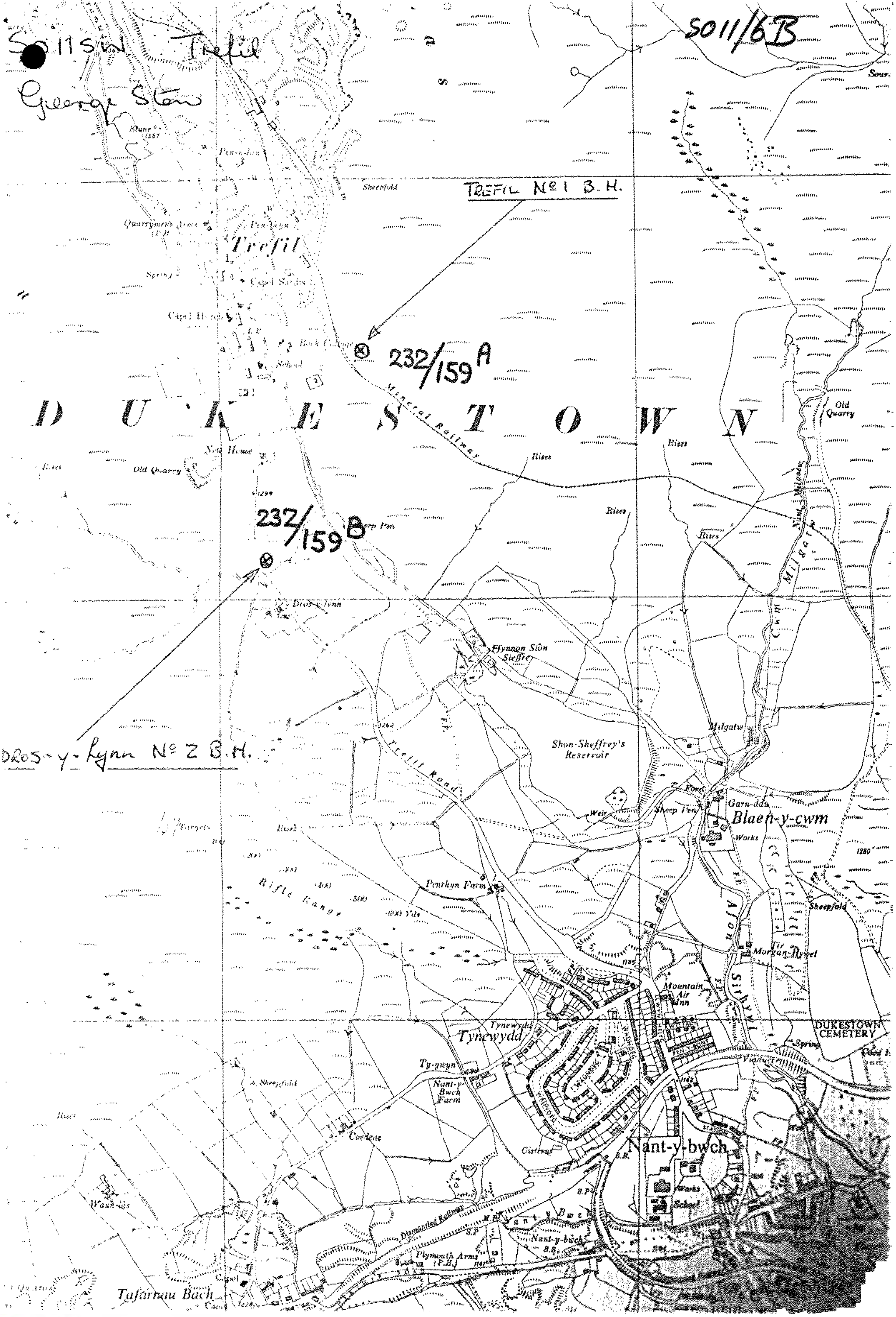
* delete as applicable

RR 18127/1/2173 5m 5/71 TP

5. STRATA

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA	THICKNESS METRES	DEPTH METRES	DEPTH FEET	DEPTH IN
	Clayey topsoil	1·00	1·00		
	Brown, fine, silty sandstone	5·00	6·00		
MILLSTONE	Brown, fine to medium sandstone and quartz	1·00	7·00		
GRIT	Grey shale	2·00	9·00		
	Dark grey shale	11·00	20·00		
	Brown grey silty shale	2·00	22·00		
	Grey, with traces of brown silty shale	12·00	34·00		
	Brown quartz sandstone	6·00	44·00		
	Grey calcareous sandy mudstone	4·00	48·00		
CARBONIFEROUS	Buff and grey/buff calcareous sandstone	7·00	56·00		
LIMESTONE	Grey calcareous siltstone	5·00	60·00		
	Grey calcareous silty shale/mudstone	9·00	69·00		
	Black limestone (Shaley from 91 to 98 metres				
	and pale grey calcareous sandy limestone				
	between 84 and 85 metres)	48·00	117·00		
	Grey calcareous mudstone	6·00	123·00		
	Grey calcareous mudstone/oolitic limestone	16·00	139·00		
	Grey calcareous clay/shale	1·00	140·00		
	Grey, fine limestone	2·00	142·00		
	Pale grey fine limestone	10·00	152·00		
	Pale dark grey fine limestone	4·00	156·00		
	Very pale grey limestone/oolitic	11·00	167·00		
	Medium grain grey limestone	8·00	175·00		
	Medium grain dark grey limestone	4·00	179·00		
	Dark grey fine limestone	8·00	187·00		

RR 18127/1/2173 5m 5/71 TP


SO11SW Trefil
George Stow
SO11/6B
TREFIL No 1 B.H.
232/159 A
232/159 B
DROS-Y-LLYNN No 2 B.H.
DUKESTOWN
Trefil
Quarrymens Arms (P.H.)
Capel Sardis
Capel Horeb
School
Mineral Railway
Old Quarry
New House
Sheepfold
Rises
Dros-y-Llyn
Ffynnon Siôn Sieffre
Shon-Sheffrey's Reservoir
Trefil Road
Milgatw
Cwm Milgatw
Old Quarry
Garn-ddu
Blaen-y-cwm
Works
Ford
Sheep Pen
Weir
Penrhyn Farm
Rifle Range
Targets
Morgan-Hywel
Mountain Air Inn
Sirhywi
DUKESTOWN CEMETERY
Tynewydd
Ty-gwyn
Nant-y-Bwch Farm
Coedcae
Cistern
Nant-y-bwch
Works
School
Dismantled Railway
Plymouth Arms (P.H.)
Waunlas
Tafarnau Bach
Sheepfold
Viaduct
Spring

SE Wales GW Study — results of exploratory drilling report. H. Humphreys/WWA 1982.

SO11/6A+B MJP10/2202 MJB1/113

7

CHAPTER 1 - INTRODUCTION

1.1 SCOPE OF THE STUDY

The Carboniferous Limestone cropping out in the north east part of the South Wales Coalfield basin has been the subject of hydrogeological investigations since August 1979.

The first phase of the study was a preliminary reconnaissance of the region extending from the Neath Valley in the west to the Afon Lwyd Valley in the east as described in the South East Wales Groundwater Study Interim Report (December 1979). This reconnaissance recognised six areas where the potential resources justified more detailed study.

The Authority chose for further investigation three areas where high costs of the present supply together with proposed industrial development made additional local sources attractive. Two of these areas were within the Heads-of-the-Valleys region; Trefil, north of Tredegar, and Clydach Bridge, east of Brynmawr. The third area comprised the Afon Lwyd Valley north of Pontypool. The second phase investigations examined these areas in more detail but without resort to drilling. The dearth of subsurface information made it apparent early on that exploratory drilling would have to be undertaken to investigate more fully the properties of the limestone aquifer, and tender documents for a drilling contract were accordingly prepared in May 1980. The second phase findings are presented in the South East Wales Groundwater Study Reconnaissance Report (September 1980), in which details of the proposed drilling sites are also given.

The third phase of the study comprised an evaluation of drilling contract tenders (April 1981) and the construction and testing of three exploratory boreholes by a drilling contractor under the supervision of Howard Humphreys and Partners. The results of the drilling programme are presented in this report, and the locations of the boreholes are shown in Figure 1.

LH part of diagram
MJB/D/2204 is RH part

MJB/D/2203
MJB1/113

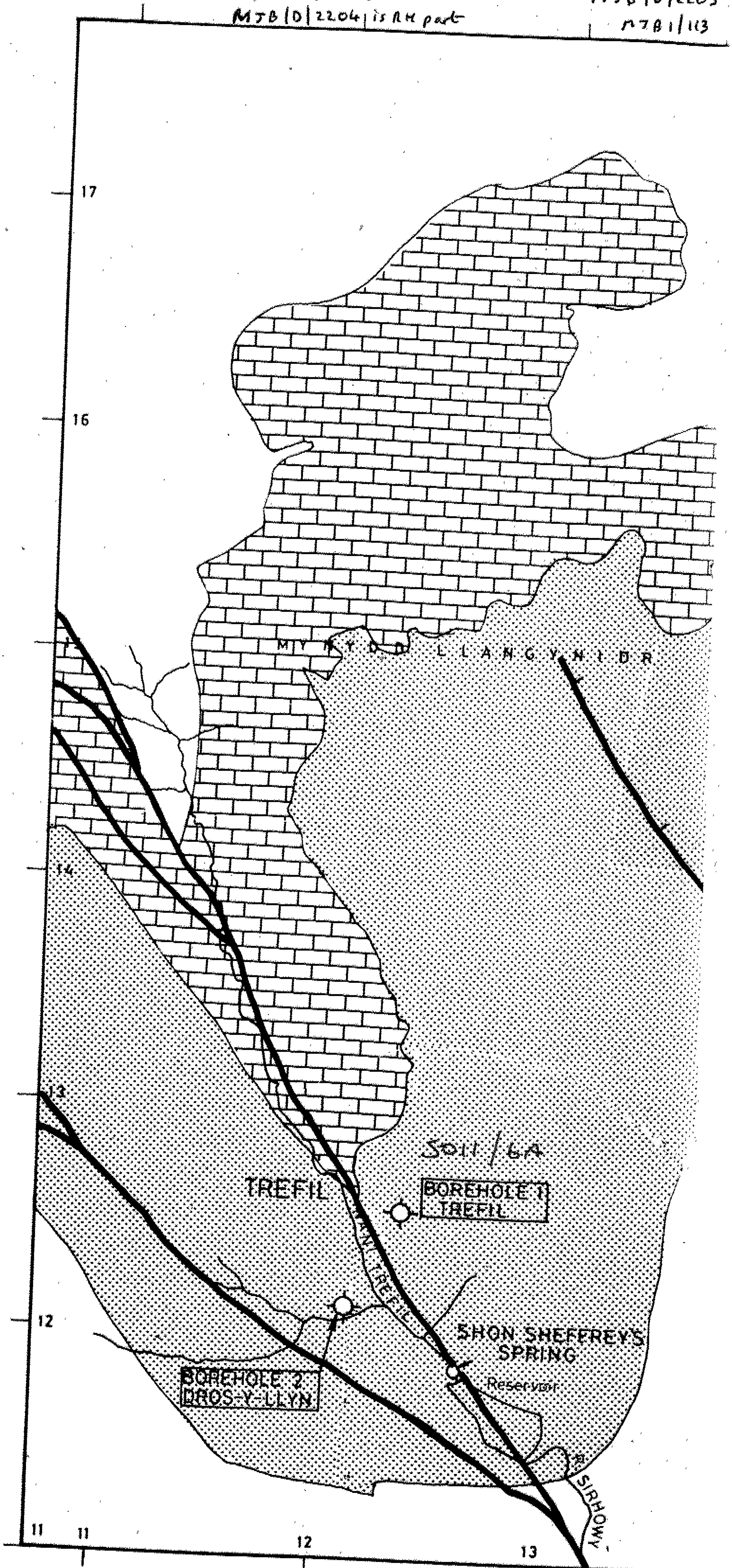
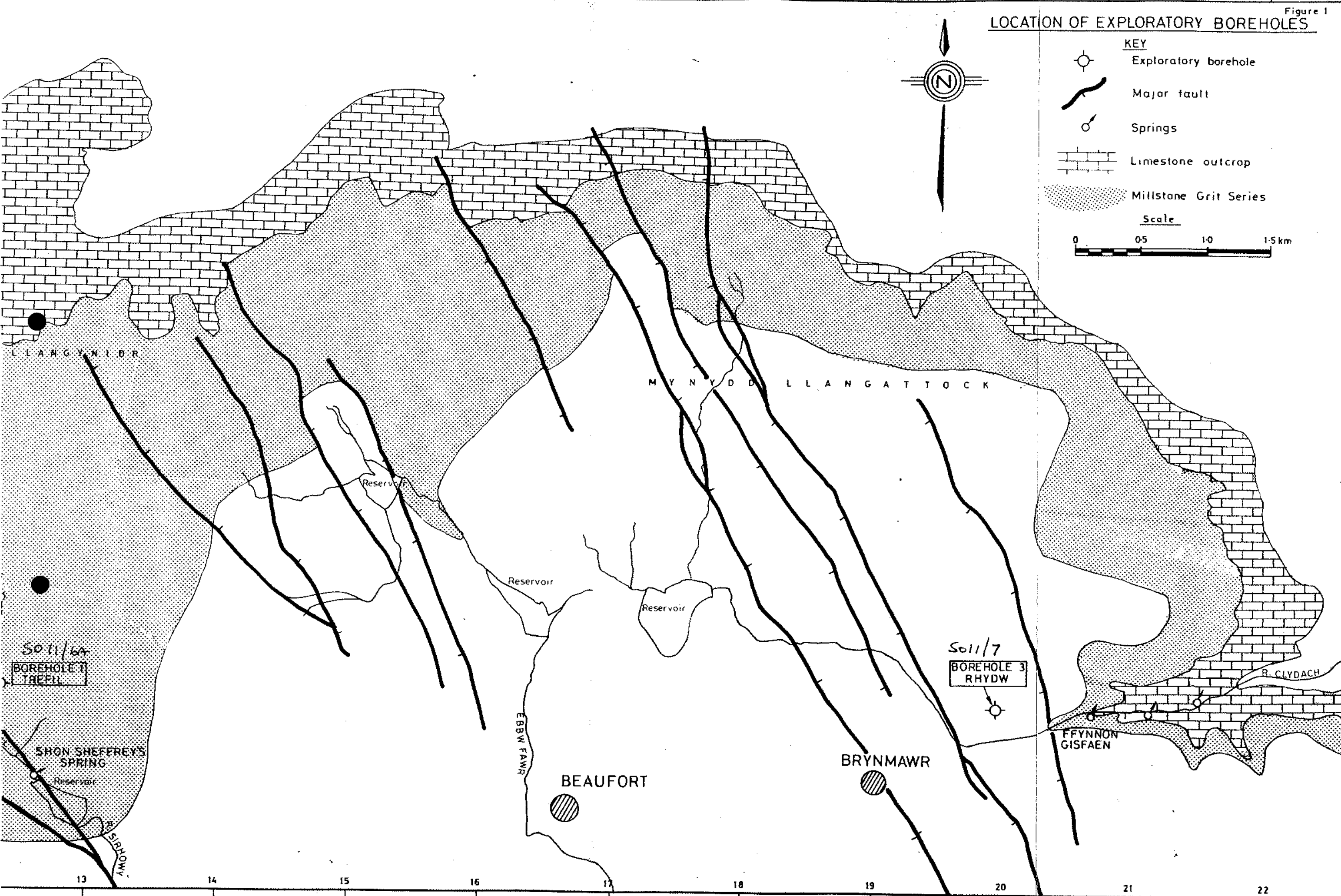


Figure 1


LOCATION OF EXPLORATORY BOREHOLES
KEY
Exploratory borehole
Major fault
Springs
Limestone outcrop
Millstone Grit Series
Scale
0
0.5
1.0
1.5 km
LLANGYNIDR
MYNYDD LLANGATTOCK
Reservoir
Reservoir
Reservoir
Reservoir
SO11/6A
BOREHOLE 1 TREFIL
SO11/7
BOREHOLE 3 RHYDW
R. CLYDACH
FFYNNON GISFAEN
SHON SHEFFREY'S SPRING
EBBW FAWR
R. SIRHOWY
BEAUFORT
BRYNMAWR
13
14
15
16
17
18
19
20
21
22

SO11/6A+B MJB/D/2205
7 MJB1/113

CHAPTER 2 - CONCLUSIONS AND RECOMMENDATIONS

2.1 GENERAL

The exploratory boreholes have enabled an assessment to be made of the properties and development potential of the limestone aquifer at Trefil and East Brynmawr. The boreholes have adequately met their primary objectives but the findings in terms of resource potential have not been all that was originally hoped for. Nevertheless, development of the limestone aquifer appears practicable in the East Brynmawr area although the region around Trefil should not be considered further for groundwater development by boreholes.

2.2 TREFIL AND SHON SHEFFREY'S

The pumping tests at the two sites have shown that specific capacities were low and that yeilds greater than 2 l/s could not be sustained for long periods. From the tests, it can be concluded that borehole yields will be small less than 1.5 l/s with corresponding drawdowns of 10 m or more. The poor productivity of the aquifer does not therefore justify groundwater development in this area.

2.3 EAST BRYNMAWR

The Rhydw borehole encountered sufficiently productive strata for groundwater development to be practicable. From an analysis of the test data it appears that the borehole at this site may yield between 10 and 15 l/s with corresponding drawdowns between 6m and 11 m. Because, however, the test was undertaken in December when the level of the water table was not at a minimum, the estimates should be confirmed by further pump-testing at the end of the summer. The test will confirm whether groundwater storage in the area is transient or permanent.

Previous investigations (1980) found that groundwater drains through the limestones to the Clydach Valley from a large infiltration area and the potential resources comprise some 110 l/s. It would therefore appear possible to exploit the aquifer at about 50 l/s by one or more boreholes providing the permeability and nature of storage are favourable. It is considered that about 3 to 4 production boreholes would be required, although there is a good chance of a smaller number depending on the productivity of the aquifer in the E. Brynmawr area. On the basis of the transmissivity obtained from the test and assumed parameters of geometry, pumping water levels may be about 100m below ground level corresponding to 250 - 260m A.O.D.

2.4 RECOMMENDATIONS

In the light of the results of the exploratory drilling programme, it is recommended that consideration be given to groundwater development in the East Brynmawr region. Before further drilling for production purposes is undertaken, however, it will be necessary to confirm the assumptions which have been made in the hydrogeological analysis. In particular, therefore, the following courses of action should be taken:-

a) regular measurement of water levels in the Rhydw borehole by either twice weekly dip meter readings or, preferably, by autographic recorder. The principal objective would be to confirm that the rest water level of 79.7m.b.g.l. represents a low natural level (an assumption which has been made on the basis that the aquifer had received little replenishment during the drier than average summer of 1981 and the area was experiencing freezing conditions at the time of pump testing). Water level monitoring would also provide an indication of the rate of response of natural water levels to rainfall, and consequently an assessment of the nature of the flow system feeding the East Brynmawr area.

SO11/6A+B
7

MJB|D|2207
MJB1|113

b) an additional pumping test on the Rhydw borehole towards the end of the 1982 dry summer conditions i.e. when the natural water table is at a minimum. This test, at the maximum rate possible for the test pump, should continue for seven days, in order to confirm the extrapolations utilised in this report for yield determination.

c) Gauging of the Ffynnon Gisfaen spring both before and during the pumping test, in order to assess the effects of groundwater abstraction on the spring discharge. It is evident that pumping will be at the expense of natural outflow from the aquifer, but if the borehole(s) intercept water moving southwards below the Clydach gorge to the Afon Lwyd valley, then the effect on Gisfaen may be insignificant.

In the event of satisfactory results from these investigations, then consideration should be given to the drilling of a large diameter production borehole lined with a 10 inch casing and slotted casing near the existing exploratory hole at Rhydw, and its subsequent pump testing to confirm the maximum yield obtainable from this borehole and from future boreholes in this area. On the basis of these results the precise number of boreholes required to deliver 50 l/sec can then be determined.

CHAPTER 3 - BOREHOLE DRILLING AND TESTING

3.1 GENERAL

All three boreholes were drilled by the direct-circulation rotary method using tricone bits with tungsten carbide inserts. On occasions hard formation rock-bits were used. The Contractor (George Stow & Co. Ltd of Henley-on-Thames) provided two rigs, a failing CF 15 and a Bucyrus-Erie 2400-R. The latter more powerful rig proved better suited to the ground conditions as it handled heavier drill-pipes and gave well aligned and very plumb holes. Whatever the rig and drill-pipe, heavy stabilizers were used above the bit in order to avoid excessive drift and vibration.

Each borehole was drilled in two stages as laid down in the Contract specification (1980). Firstly the upper section was drilled and logged (S.P., Resistivity, Gamma and Caliper) and the casing installed and grouted in place When the grout had hardened, the lower section was drilled by running the tools through the casing and drilling on beneath. The lower section was then logged, and the borehole developed and finally pump tested. At the surface the casing protrudes about half a metre, has a flanged bolted cap with an access plug and is set in a concrete block. Table 1 presents a summary of the borehole construction details.

The three exploratory holes were designed to be test pumped to assess borehole yields and to obtain a measure of aquifer transmissivity. This was done in each case in spite of the collapse of the hole at Dros-y-Lynn which seriously curtailed the test programme. Owing to the absence of obervation wells it was not possible to estimate storage coefficients. Tables 2, 3 and 4 show the tests undertaken and provide a summary of the results obtained from their analysis. The individual test plots prepared by Jacob's method (reference 4) are presented in the Appendices together with the test data.

MJB 10/2209
MJB 1/113

The Appendix to this report includes the detailed records of the investigation, and this chapter is therefore concerned only with the more significant aspects of the drilling and testing programme.

TABLE 1 - EXPLORATORY BOREHOLE CONSTRUCTION DETAILS

	SO11/6A	SO11/6B	SO11/7
BOREHOLE Grid Reference	TREFIL SO 1236 1255	DROS-Y-LYNN SO 1212 1212	RHYDW SO 1994 1244
Ground level m AOD	c 410m	c 393m	c 353m
UPPER HOLE 250mm	0 - 81.0m	0 - 72.0m	0 - 111.5m
LOWER HOLE 156mm	81 - 140.0m	72 - 186.0m	111.5 - 220.0m
TOTAL DRILLED DEPTH	141.0m	188.0m	220.0m
179mm API CASING TO	79.7m	70.8m	110.0m
CEMENT BASKET AT	56.0m	50.0m	99.5m
TOP OF LIMESTONE STRATA AT	25.0m	44.0m	105.0m
REST WATER LEVEL	52.0m (Early Sept. '81)	23.0m (12-10-81)	79.0m (10-12-81)
REMARKS		BOREHOLE CLOSED BY COLLAPSE	COLLAPSED BELOW 190m

N.B. All levels to below ground level

TABLE 2 - PROGRAMME OF PUMPING TESTS

	BOREHOLE	START DATE	PUMPING RATE (l/s)	DURATION (HOURS)	DURATION OF RECOVERY (HOURS)
SO11/6A	TREFIL	8. 9.81	c 2.2	6	6
		9. 9.81	4.3	2	2
		9. 9.81	1	72	24
		14. 9.81	1.5	10	6½
		15. 9.81	2.2	6	6
		16. 9.81	0.66	6	6
SO11/6B	DROS-Y-LYNN	15.10.81	0.8	6	6
SO11/7	RHYDW	10.12.81	1.2,3.4,9	6½	6
		11.12.81	11	6	6
		14.12.81	11	72	24

TABLE 3 - SPECIFIC CAPACITIES

	BOREHOLE	PUMPING RATE (l/s)	DRAWDOWN (m)	SPECIFIC CAPACITY (l/s/m)	DURATION OF TEST (hours)
SO11/6A	TREFIL	1.0	2.46	0.41	72
SO11/6B	DROS-Y-LYNN	0.8	1.17	0.68	6
SO11/7	RHYDW	11.0	7.88	1.42	72

MJB/D/2211
MJD1/113

TABLE 4 - TRANSMISSIVITY VALUES DERIVED BY TEST ANALYSIS (JACOB'S METHOD)

	BOREHOLE	PUMPING	RECOVERY	SELECTED REPRESENTATIVE VALUE
SO11/6A	TREFIL	-	10	
		-	6	
		10	8	10 m^2/d
		4.5	12	
		4.5	10	
		5	5	
SO11/6B	DROS-Y-LYNN	32	41(11)	35 m^2/d
SO11/7	RHYDW	173	158	
		166	134	130 m^2/d
		127	130	
	RHYMNEY	-	-	10-20 m^2/d (1)

(1) Reference 3

3.2 BOREHOLES IN THE TREFIL REGION (TREFIL AND DROS-Y-LLYN)

3.2.1 Trefil Borehole SO11/6A

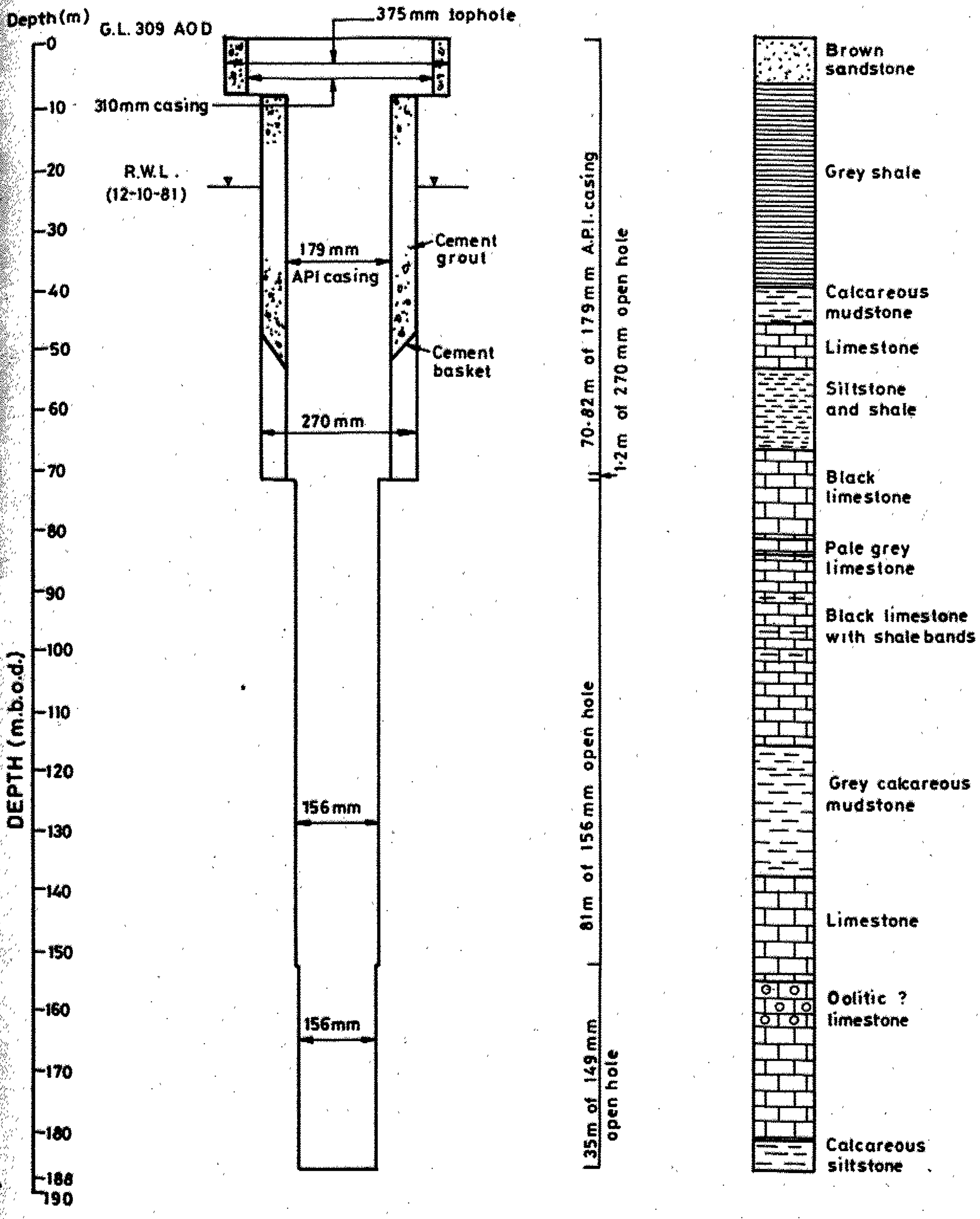
The Trefil site (SO 1236 1255) is immediately adjacent to one of the collapse dolines or sinkholes which pockmark the Mynydd Llangynidr moorland tract. These dolines are evidence of considerable subsurface limestone dissolution and therefore it was thought likely that the borehole would encounter solutional voids. During drilling fissures were met with but most evidently in the vadose zone above the saturated limestone. Drill-foam and cuttings were lost into the rock but apparently above the water-table.

In order to facilitate connections between the borehole and any neighbouring karstic fissure system, the borehole was treated with 10 tonnes of hydrochloric acid (35%). Limestone consists

SO11/6B MTO10/2214 M7O1/113

Figure 3

DROS-Y-LYNN BOREHOLE CONSTRUCTION DIAGRAM



Horizontal scale: 1:10
Vertical scale: 1:1000

SO11/6B

NJD 10/2215
NJD1/113

grouted casing. When drilling resumed for the lower section, the limestones were found to be muddy and these too proved liable to fall in, although no major fissures were encountered. Infalls slowed the progress considerably as the debris had to be cleaned out each morning before drilling could be resumed and often the bit became clogged. After the drilling was completed and the development work was done the instability of the hole within the muddy horizons became progressively worse. The pumping test programme was eventually curtailed by the closure of the hole with infall debris.

The details of construction and lithological log for this borehole are presented in the Appendix B.

3.3 RHYDW BOREHOLE

SO11/7

The Rhydw site (SO 1995 1244) lies some 8.5 kilometres to the east of Trefil, and the drilling was intended to provide information on the limestone aquifer in the East Brynmawr/Clydach Bridge area. As anticipated from the field investigations the limestone in this locality lies much deeper than at Trefil, with its surface about 105 metres beneath a cover of Coal Measures and Millstone Grit strata, which proved to be hard drilling.

The drilling at Rhydw was started by the CF 15 rig, which was later replaced by the 2400-R when it became available from Dros-y-Lynn. At 14 metres, a void was met and drill-foam was lost; cutting samples were not recovered between this depth and 62 metres.

Temporary casing was then installed to support the top 21 metres and this effectively blocked off the superficial voids and fissures so that drilling fluid and cuttings were obtained at the surface once more when the 2400-R commenced drilling.

In the limestone the polymer drilling fluid was lost at 143 metres and the hole was completed to 220 metres using drill-foam. Below about 190 metres the borehole was closed by collapse and in view of the experience at Dros-y-Lynn it was decided not to clean this part out.

MJB/D/2218
MJB1/113

SO11/6A+B

CHAPTER 4 - HYDROGEOLOGICAL ANALYSIS AND INTERPRETATION

4.1 TREFIL AND DROS-Y-LYNN

The pumping test results in the Trefil region indicate that the perennially saturated limestone is poorly permeable, with significant fissure development being restricted to the limestones above the standing water table. Whilst the fissures act as conduits for rapid throughflow to springs and resurgences, they do not provide a water bearing system at depths suitable for exploitation by boreholes. This is disappointing since the karst terrain and the persistence and recession characteristics of the Shon Sheffrey's spring argue for a greater development of solutional fissures and secondary aquifer properties.

The borehole water level at Trefil fluctuates markedly in response to rainfall (Figure 5), the fluctuations being due to changes in the water table rather than the piezometric response recorded at Rhymney Bridge (Interim Report 1979, Figure 13 and page 52).

In the Interim Report it was suggested that a value of about 0.5% was a reasonable estimate of the specific yield (interlinked porosity) of the limestone within the zone of water-table fluctuation. Owing to the absence of observation well data during pump-testing, it has not been possible to determine storage coefficients and the type of storage at the two sites, and hence confirm or otherwise the suggested value. It is to be noted, however, that from observations of the water level response at the Trefil Site (a rise of 9 m following on 130 mm rainfall at Nant-y-Bwch) a value of specific yield of about 1% is indicated. It is to be expected that deeper levels within the limestone aquifer have less solutional voids and therefore a lower effective porosity.. This or indeed the elastic storage coefficient cannot be derived from the existing data..

SO11/6A+B MJB10/2219 MJ01/113

The water level response recorded at Trefil confirms the apparent rapidity of deep infiltration to replenish the aquifer and the subsequent drainage from the uppermost water bearing levels of the limestone. Unfortunately the secondary development of permeability and space available to store groundwater deeper in the limestone has been found insufficient to justify a wellfield in the Trefil region.

4.2 RHYDW BOREHOLE AND EAST BRYNMAWR SO11/7

The pumping test results at Rhydw indicate that the limestone aquifer in the region is potentially productive. The borehole itself is hydraulically efficient, i.e. small well losses (Figure 6), and the aquifer permeability appears moderately high. The borehole was tested to 11 l/s, the maximum delivered by the test pump, although it is estimated that the safe yield of the borehole is 15 l/s. The extrapolations used to estimate this yield are presented in Table 5 and Figure 7, whilst Figure 8 models the pumping water level decline for various pumping rates. It should be noted that these predictions are based on the assumption that the rest water level of 79.7 metres is for a low natural rest water level, and that the predictions utilise pumping rates and periods much in excess of the longest pumping test carried out (72 hours).

TABLE 5 - SPECIFIC CAPACITY DATA FOR RHYDW BOREHOLE SO11/7

PUMPING RATE, Q (l/s)	WATER LEVEL (m)	DRAWDOWN, s (m)	SPECIFIC CAPACITY, Q/s l/s/m
-	79.70	-	-
1.2	80.25	0.55	2.18
3.4	81.35	1.65	2.06
9	84.53	4.83	1.86
11.2	85.72	6.02	1.86
11	85.66	5.96	1.85

(Data for 120 minutes of pumping)

DRILLING AND LITHOLOGY LOG BOREHOLE 2

CLIENT:- WELSH WATER AUTHORITY	PROJECT:- S.E. WALES GROUNDWATER STUDY — COUNTRY:- U.K.
LOCATION:- DROS-Y-LYNN, TREFIL, GWENT	CO-ORDINATES:- SO 1212 1212
GROUND LEVEL:- c. 393m AOD	LOG DATUM:- GROUND LEVEL
RIG:- BUCYRUS-ERIE 2400-R	DRILLING METHOD:- ROTARY WITH DIRECT CIRCULATION
DRILLING FLUID:- WATER TO 28m FOAM TO 153m THEN POLYMER MUD.	CONTRACTOR:- GEO. STOW + Co Ltd.
REST WATER LEVEL:- 23 m (12-10-81)	

BOREHOLE:-

NOMINAL DIAMETER	FROM	TO
375mm	G.L.	9m
270 mm	9	72m
156 mm	72	153m
149 mm	153	186m

TOTAL DRILLED DEPTH 188m.

CASING/SCREEN:-

NOMINAL DIAMETER	CASING OR SCREEN TYPE	SLOT WIDTH	FROM	TO
310mm	JOHNSON	—	GL	8.9m
179mm	API	—		70.82m

GROUTED ABOVE CEMENT BASKET AT 50m.

REMARKS:-

BENTONITE AND HYDROPOL SUPPORTED HOLE WHEN LOGGING ABOVE 72m.

CONTRACTOR DID NOT RUN CALIPER LOG.

LOGS RUN :- ELECTRIC (SP + RESISTIVITY)
GAMMA
16" + 64" NORMAL RESISTIVITY.

DEVELOPMENT : AIR LIFTING, 60 HOURS.

TEST PUMPING : 6 HOURS AT 0.8 l/s, 6 HOURS RECOVERY.

THE MUDDY STRATA WERE UNSTABLE; THIS WAS SO SEVERE THAT NO FURTHER TESTS WERE MADE. COLLAPSE CLOSED HOLE AT 68m.

DROS-Y-LYNN BOREHOLE

DRILLING AND LITHOLOGY LOG BOREHOLE 2

Figure B1

SO 11 / 68

NJ0/10/2224
NJ0/1113

SO 11 SW/76

N 15245

GEORGE STOW CO. LTD.

Waterworks Engineers

READING ROAD – HENLEY-on-THAMES. OXON.

232/159 B

RECORD OF WELL (SHAFT OR BOREHOLE)

DROS-Y-LYNN NO. 2 B.H.

DATE COMPLETED 27 October, 1981

232/159 B

SO 11 SW

All depths to be measured below Ground Level

Work carried out for Welsh Water Authority SO 12 11 12 09

Locality (Exact Site) Trefil, Nr. Tredegar, Gwent. (N.G. Ref. SO.122122) SO 11 SW

Level of Ground Surface above Sea Level (O.D.) .... m.

Depth of Shaft .... m. Diameter .... mm.

Depth of Bore 187 m. 613·55 ft Diameter: At Top 162 mm. 6·37" At Bottom 162 mm.

Details of Permanent Lining Tubes

Diameter	Length Inserted Plain	Slotted	Top At	
162 mm.	72.19 m.	Nil m.	0.50 m	above Ground Level

Water Struck at depth of (in m.) 26.00 metres

Rest Level of Water below Ground Level 24.87 m.

Yield on .... Hours/Days test. Pumping .... litres per sec. .... Date ....

Pump Water level .... m. below Ground Level.

Time of Recovery ....

Remarks Submersible Pump installed and tests of short duration carried out but because of large amounts of sand/silt infall results of any pumping not reliable. Borehole eventually filled to bottom of lining tubes with infall before being abandoned.

See back for Strata Record.

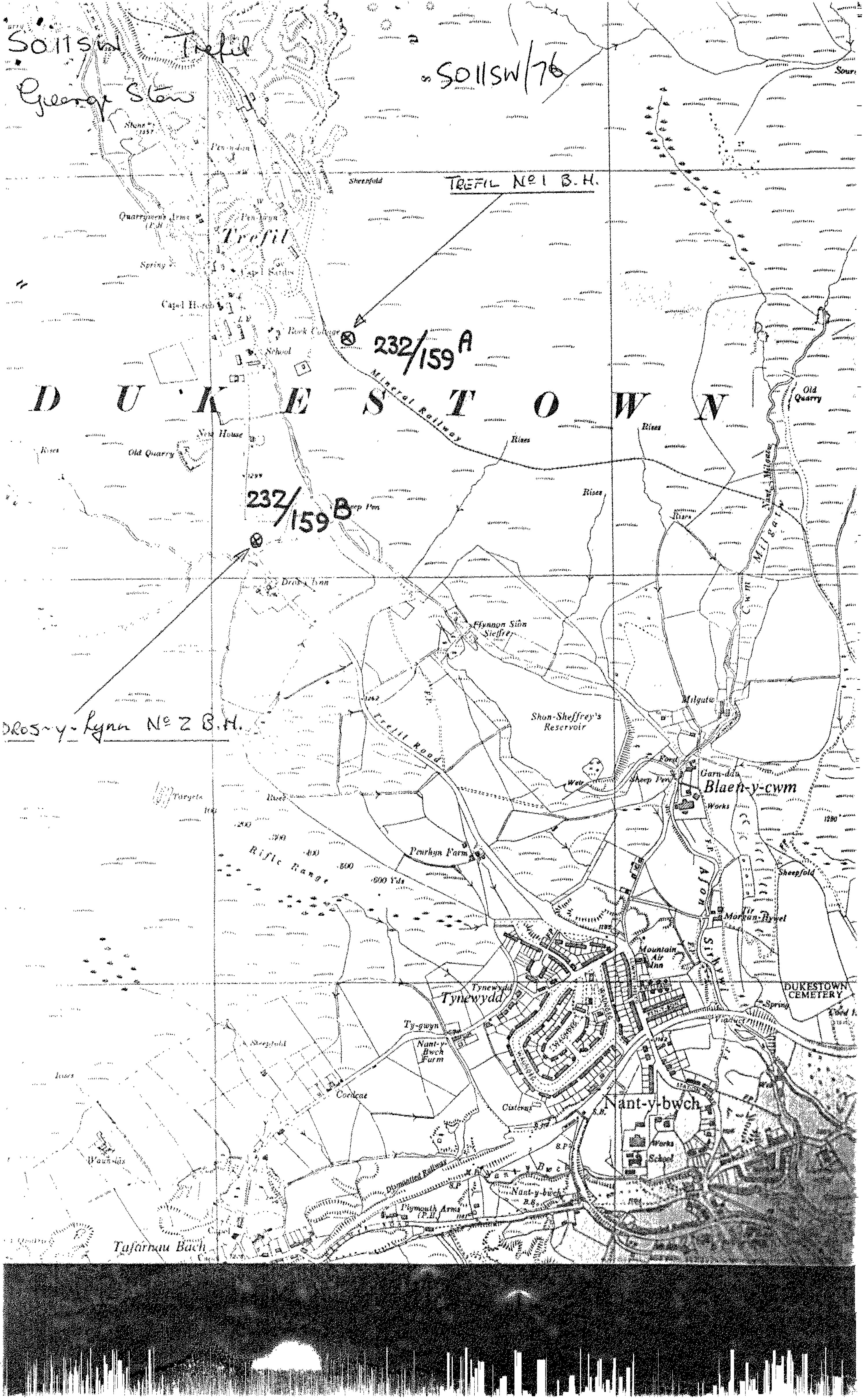
[redacted]

SO11SW/76

DETAILS OF STRATA

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA (and any additional remarks)	THICKNESS METRES	DEPTH METRES
	Clayey topsoil	1.00	1.00
	Brown, fine silty sandstone	5.00	6.00
	Brown, fine to medium sandstone and quartz	1.00	7.00
MILLSTONE	Grey shale	2.00	9.00
GRIT	Dark grey shale	11.00	20.00
	Brown, grey silty shale	2.00	22.00
	Grey, with traces of brown silty shale	12.00	34.00
- - - - - - - - -	Brown quartz sandstone	6.00	44.00
	Grey calcareous sandy mudstone	4.00	48.00
	Buff and grey/buff calcareous sandstone	7.00	55.00
CARBONIFEROUS	Grey calcareous siltstone	5.00	60.00
LIMESTONE	Grey calcareous silty shale/mudstone	9.00	69.00
	Black limestone (Shaley from 91 to 98 metres and pale grey calcareous sandy limestone between 84 and 85 metres).	48.00	117.00
	Grey calcareous mudstone	6.00	123.00
	" " " /oolitic limestone	16.00	139.00
	" " clay/shale	1.00	140.00
	Grey, fine limestone	2.00	142.00
	Pale grey fine limestone	10.00	152.00
	Pale dark grey fine limestone	4.00	156.00
	Very pale grey limestone/oolitic	11.00	167.00
	Medium grain, grey limestone	8.00	175.00
	" " dark grey limestone	4.00	179.00
	Dark grey fine limestone	8.00	187.00

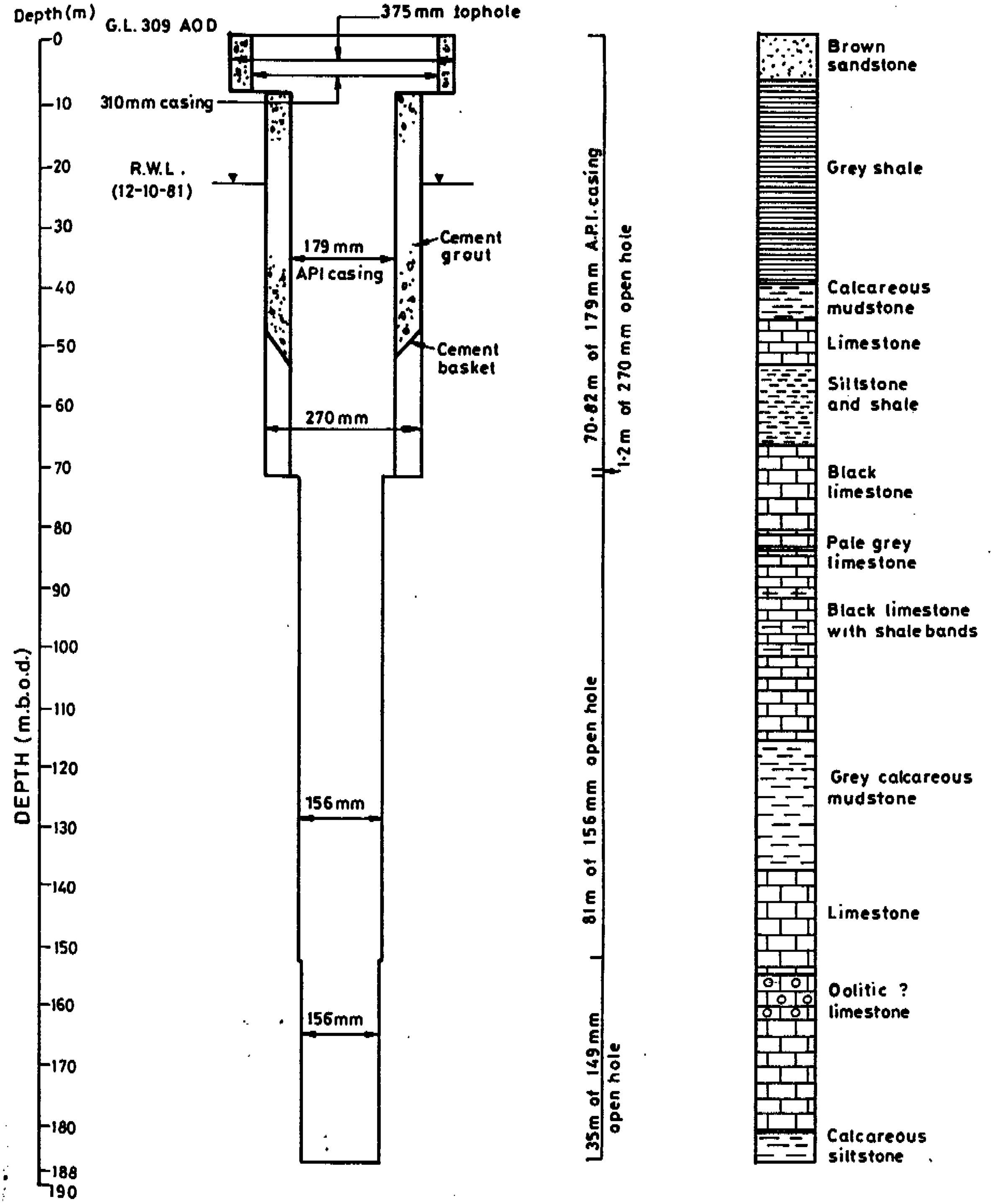
W. J. Barclay
28/5/82.


SO11SW Trefil
George Stow
SO11SW/76
TREFIL No 1 B.H.
232/159 A
232/159 B
DROS-Y-LYNN No 2 B.H.
Sheepfold
Quarrymen's Arms (P.H.)
Pen-gwyn
Trefil
Spring
Capel Horeb
School
D U K E S T O W N
Mineral Railway
Rises
New House
Old Quarry
Sheep Pen
Dros-y-lynn
Ffynnon Siôn Sieffrey
Shon-Sheffrey's Reservoir
Trefil Road
Milgatw
Cwm Milgatw
Ford
Garn-ddu
Blaen-y-cwm
Works
Weir
Sheep Pen
Targets
Rifle Range
600 Yds
Penrhyn Farm
Afon Sirhywi
Sheepfold
Tir Morgan-Hywel
Mountain Air Inn
Tynewydd
Ty-gwyn
Nant-y-Bwch Farm
DUKESTOWN CEMETERY
Spring
Viaduct
Sheepfold
Coedcae
Cisterns
Nant-y-bwch
School
Waun-lâs
Dismantled Railway
Nant-y-Bwch
Plymouth Arms (P.H.)
Tafarnau Bach
Capel
Old Quarry

SO 11 SW/76

Figure 3

DROS-Y-LYNN BOREHOLE CONSTRUCTION DIAGRAM



Horizontal scale: 1:10
Vertical scale: 1:1000

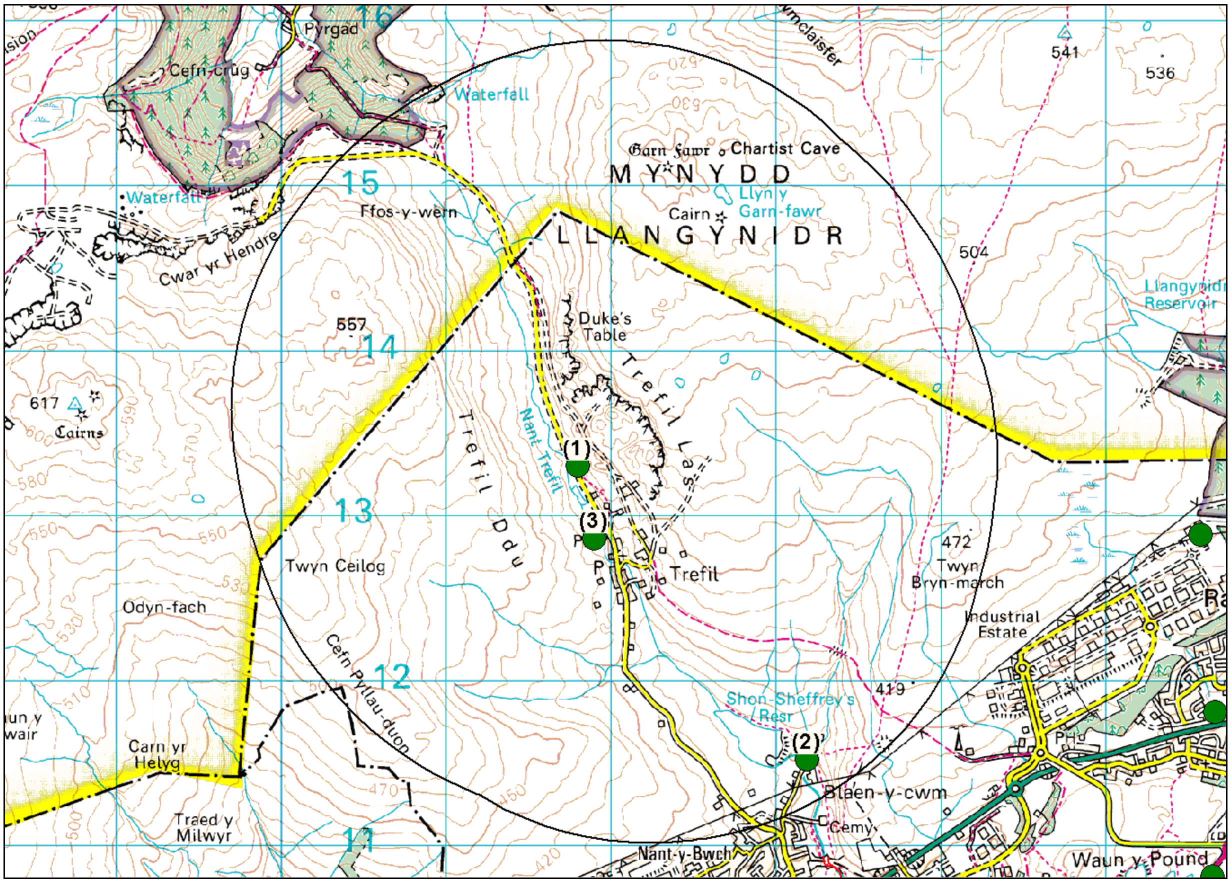
APPENDIX B

Environment Agency data request

Date: 08/03/2022 **Our Reference:** EI11528

Search Details

Map to show the location of Discharge Consents within 2km of the site of interest



One Centimetre = 0.42 Km

Km 0.5 1 1.5 2 2.5 3 3.5 4

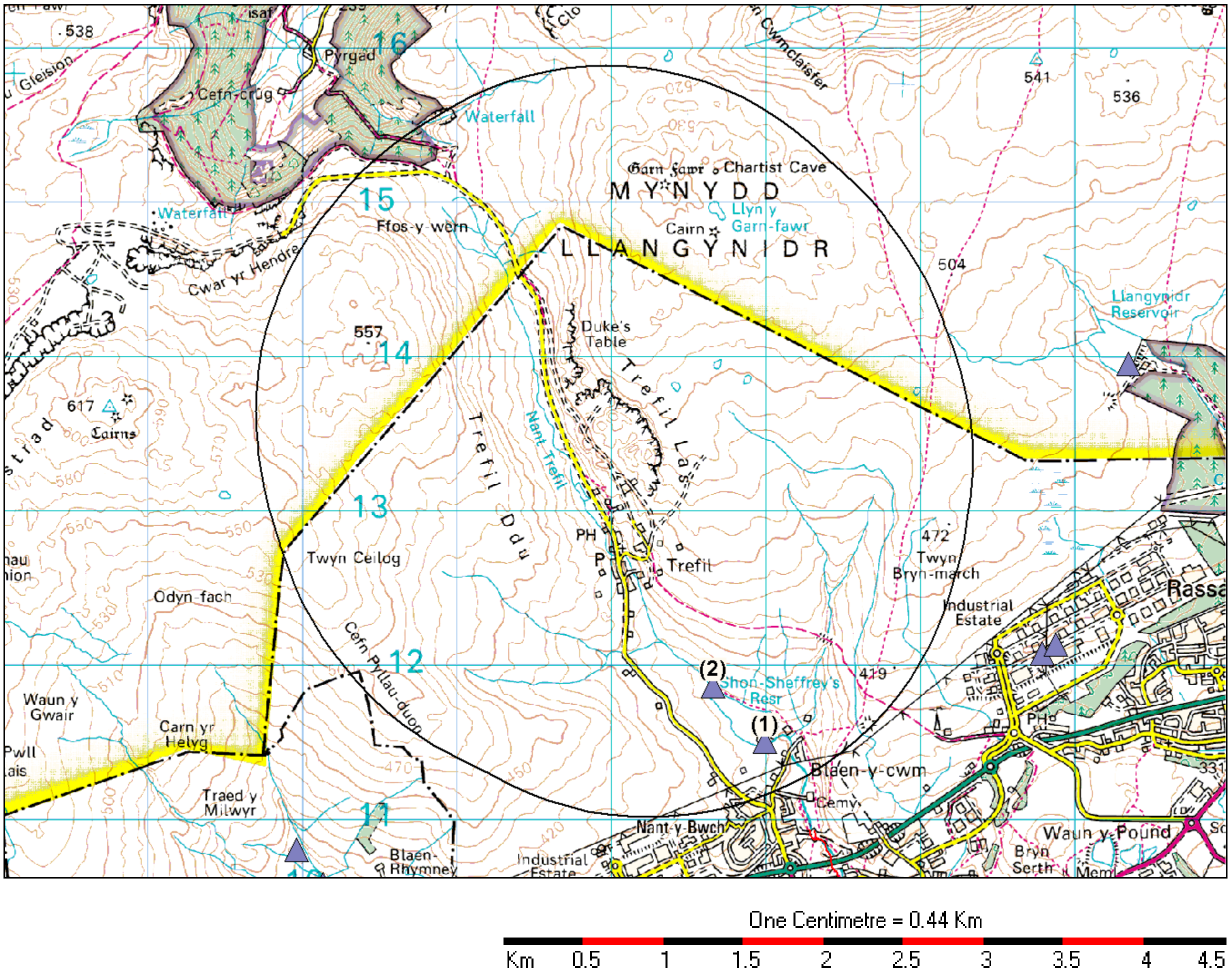
Layer	Key	
Active Discharge Points	●	Active
	•	Not yet effective
Main Rivers	(red line)	

	The following tables contain the results of the search :
	Active Discharge Points
1	Consent No (or Folio Number) : AN0258201 Date Consent Document Issued To Holder(s) : 1995-05-16 Date Consent Becomes Effective : 1995-05-16 Comments : NON - TIDAL WATERCOURSE Long Name Of Site : TREFIL QUARRY TREFIL NEAR TREDEGAR 1st Line Of Address Of Discharge Site : TREFIL QUARRY TREFIL NEAR TREDE 2nd Line Of Address Of Discharge Site : TREFIL NEAR TREDEGAR 3rd Line Of Address Of Discharge Site : NEAR TREDEGAR Ngr Of Site Entrance : SO1180013300 Effluent Dry Weather Flow : 0 Effluent Max Daily Flow : 0 Effluent Max Mean Flow : 0 Effluent Max Flow : 0 Consent status : Active
2	Consent No (or Folio Number) : AB0069201 Date Consent Document Issued To Holder(s) : 1970-01-15 Date Consent Becomes Effective : 1970-01-15 Comments : NON - TIDAL WATERCOURSE Long Name Of Site : GARNDDU FARM NANTYBWCH TREDEGAR 1st Line Of Address Of Discharge Site : GARNDDU FARM NANTYBWCH TREDEGAR 2nd Line Of Address Of Discharge Site : NANTYBWCH TREDEGAR 3rd Line Of Address Of Discharge Site : TREDEGAR Ngr Of Site Entrance : SO1319211519 Effluent Dry Weather Flow : 0.54 Effluent Max Daily Flow : 0 Effluent Max Mean Flow : 0 Effluent Max Flow : 0 Consent status : Active
3	Consent No (or Folio Number) : AC0121201 Date Consent Document Issued To Holder(s) : 1993-11-10 Date Consent Becomes Effective : 1993-11-10 Long Name Of Site : TREFIL QUARRY TREFIL , 1st Line Of Address Of Discharge Site : TREFIL QUARRY TREFIL , 2nd Line Of Address Of Discharge Site : TREFIL , Ngr Of Site Entrance : SO1190012860 Effluent Dry Weather Flow : 0 Effluent Max Daily Flow : 0 Effluent Max Mean Flow : 0 Effluent Max Flow : 0 Consent status : Active

Date:08/03/2022 **Our Reference:** EI11528

Search Details

Report to show the location of Abstraction Licences within 2km of the site of interest.



Layer	Key
Abstraction Licence point data	
Main Rivers	

	The following tables contain the results of the search :
	Abstraction Licence point data
1	Start Date Of This Version Of The Licence (not Necessarily The Start Of The Original Licence). : 17-APR-04 Surname Of Licence Holder, If An Individual; Licence Holder's Full Name, If A Company, Partnership Etc. : Dwr Cymru First Line Of The Licence Holder's Address. : Pentwyn Road Second Line Of The Licence Holder's Address. : Nelson Town From Licence Holder's Address. : Treharris Licence Holder's Postcode. : CF46 6LY Description Of The Primary Purpose Code. : Water Supply Description Of The Secondary Purpose Code. : Public Water Supply Description Of The Use Code. : Potable Water Supply - Direct Start Of Authorised Period Of Abstraction Day / Month. : 01/01 End Of Authorised Period Of Abstraction Day / Month. : 31/12 Description Of The Source Of Supply. : EAW Surface Water Name Of Abstraction Point. : SHON SHEFFREY RESERVOIR (PT A) Code To Denote The Abstraction Point Category. Sp = Single Point, Ar = Area, Rc = Reach And Un = Unknown. : SP Nat Grid Ref : SO13001150 A Unique Number For Each Licence, Which May Include The Catchment And Subcatchment From Which The Water Is Abstracted And An Indication Of The Nature : 20/56/65/0014 The Effective Date Of The First Licence Document With A Particular Licence Number. : 14-APR-66
2	Start Date Of This Version Of The Licence (not Necessarily The Start Of The Original Licence). : 17-APR-04 Surname Of Licence Holder, If An Individual; Licence Holder's Full Name, If A Company, Partnership Etc. : Dwr Cymru First Line Of The Licence Holder's Address. : Pentwyn Road Second Line Of The Licence Holder's Address. : Nelson Town From Licence Holder's Address. : Treharris Licence Holder's Postcode. : CF46 6LY Description Of The Primary Purpose Code. : Water Supply Description Of The Secondary Purpose Code. : Public Water Supply Description Of The Use Code. : Potable Water Supply - Direct Start Of Authorised Period Of Abstraction Day / Month. : 01/01 End Of Authorised Period Of Abstraction Day / Month. : 31/12 Name Of Abstraction Point. : SHON SHEFFREY SPRING (PT B) Code To Denote The Abstraction Point Category. Sp = Single Point, Ar = Area, Rc = Reach And Un = Unknown. : SP Nat Grid Ref : SO12661186 A Unique Number For Each Licence, Which May Include The Catchment And Subcatchment From Which The Water Is Abstracted And An Indication Of The Nature : 20/56/65/0014 The Effective Date Of The First Licence Document With A Particular Licence Number. : 14-APR-66

creu lle gwell
creating a better place

Asiantaeth yr Amgylchedd Cymru
Environment Agency Wales

RECEIVED
18 JUL 2007

Mr Paul Daley
ESI Ltd
New Zealand House
160, Abbey Foregate
Shrewsbury
SY2 6FD

Ein cyf/Our ref: EI11528

Eich cyf/Your ref:

Dyddiad/Date: 12th July 2007

Dear Mr Daily

Re: Hydrological and Hydrogeological Data within a 2 km radius of Trefil Quarry.

Thank you for your enquiry with regards to obtaining hydrological and hydrogeological data for Trefil Quarry.

Please find below comments that should fully answer your request: -

- We do not have any information in relation to groundwater levels within the superficial deposits and bedrock as there are no groundwater level monitoring points within 2km of the NGR provided.

- For groundwater quality, please see the excel spreadsheet on the enclosed CD for springs at NGR SO1265111845 located approximately 1.4km south of Trefil Quarry.

  The springs draw water from the surrounding Carboniferous Limestone and Carboniferous Millstone Grit. The springs rise along a fault line in the Carboniferous strata, and feed directly into Shon Shefry reservoir where they are used by Dwr Cymru for potable supply.

- For Water Quality data for the area of interest, please see the excel spreadsheet on the enclosed CD. Please note that we only have a limit amount of surface water quality data for this area.

- We do not have any information in relation to stream flows within 2km of this location.

- We do not have any record of any Groundwater Abstractions within 2km of this location.

- For Surface Water Abstractions information, please see the excel spreadsheet on the enclosed CD.

- For Discharge Consent information, please see the excel spreadsheet on the enclosed CD.

- The Groundwater and Contaminated Land Team have no record of the land in question being contaminated, or whether it adjoins contaminated land. However this does not guarantee that no land contamination is present at the site, and it would still be prudent to investigate the historical land uses of the site and its surroundings to ascertain whether any past activities which may have caused land contamination to have taken place.

  The Local Environmental Health Department should hold a register of any contaminated land identified within their Local Authority boundaries, and should be contacted for further information.

- Trefil Quarry is located within the 'Shon Sheffry' Source Protection Zone III (total catchment). The quarry is approximately 1.3km north of the springs which feed Shon Shefry Reservoir. The fissured nature of the aquifer makes it difficult to define the total area of the groundwater catchment, and thus only a 'total catchment' exists for this source, rather than a Zone I, II and III.

- Trefil Quarry is located upon Carboniferous Limestone, classed as a major aquifer with high vulnerability. The surrounding area has very thin soils, and karstic features such as sink holes and dolines can provide a rapid pathway to groundwater.

- We do not have any record of Waste Management Licence having been issued within 2km of this location.

- For rainfall data, please see the excel spreadsheet on the enclosed CD. Please note that data has been supplied for 2 stations as they are both approximately the same distance from the site. Also one of the sites goes back about 20 years and the other about 45 years.

I hope this information is of use. Please contact me on 029 2024 5236 if you have any queries.

Yours sincerely

Darren Jones
External Relations Officer

Asiantaeth yr Amgylchedd Cymru
Environment Agency Wales

Notice for the supply of Environment Agency information

(Standard Notice – Commercial) Nothing in this notice will in any way restrict your statutory or any other rights of access to the Information. If you wish to do anything in excess of those rights you may do so in accordance with the following paragraphs only if you agree to all the terms.

2. All intellectual property rights in the documents, data or information supplied to you (referred to as "the Information") whether owned by the Environment Agency (referred to as "Agency Information") or third parties (referred to as "Third Party Information") will continue to be owned by them.
3. The Information has not been prepared to meet your or anyone else's individual requirements. It is your responsibility to ensure that the Information meets your needs.
4. The Environment Agency cannot ensure and therefore gives no promise that the Information in its possession will always be accurate, complete, up to date or valid.
5. The Environment Agency will take reasonable precautions to ensure that we provide you with an accurate copy of the Information from our records.
6. If we have specified that you must pay us for supply of the Information you must pay us before we respond to your request. You will only be able to cancel and request your fee back up to the point when we start work on providing the requested information.
7. If you have asked for the Information to be supplied in an electronic format we cannot guarantee that either the disk or the data file is free of any defects and you should check it for viruses and other items that may affect your computer.
8. Use of Third Party Information, including copying, must be limited to statutory rights. This generally means that you will need to seek permission to copy. Third Party Information may include information from our public registers, which has been supplied to us by a third party, for example the information provided in an application form.

Permitted use of Agency Information

9. As you have paid us our internal commercial usage charge (currently £10) you may take unlimited copies of Agency Information (exactly as it is) for the internal purposes of your business (commercial internal limited use), provided that:
   a) you ensure that all copies are attributed to the Environment Agency;
   b) you do not amend or alter the Information, or merge it with other information;
   c) you do not supply the Information (or any information derived from, or based on the use of it) to others.
10. If you are a professional advisor and you have paid us our internal commercial usage charge (currently £10) you may in addition to the rights in paragraph 9, give copies of Agency Information (exactly as it is) to your client and any other person who reasonably requires a copy (limited professional use), provided that:
    a) any copies you send are in connection with the specific transaction or matter for which you obtained the Information from the Environment Agency;
    b) you make no charge for supplying the Information other than for your actual costs and time incurred;
    c) you attach a copy of this notice and require all recipients to comply with it.

    Recipients of Information under this paragraph do not need to pay any additional fee as long as they use the Information exactly as it is, internally and only for the same specific transaction or matter.
11. Please contact us if you need permission for any other use.

It is important that you also read any additional information or warning we give you about specific Information.

Hysbysiad cyflenwi gwybodaeth Asiantaeth yr Amgylchedd

(Hysbysiad Safonol - Masnachol)

1. Ni fydd dim yn yr hysbysiad hwn yn cyfyngu mewn unrhyw fodd ar eich hawliau statudol nac ar unrhyw hawliau arall parthed mynediad at yr Wybodaeth. Os dymunwch wneud dim y tu hwnt i'r cyfryw hawliau, gallwch wneud hynny'n unol â'r paragraffau canlynol yn unig os cytunwch â'r holl delerau.
2. Bydd pob hawl eiddo deallusol yn y dogfennau, y data neu'r wybodaeth a gyflenwir i chi (sef "yr Wybodaeth"), pa un ai yn eiddo i Asiantaeth yr Amgylchedd (sef "Gwybodaeth yr Asiantaeth") neu i drydydd partïon (sef "Gwybodaeth Trydydd Partïon"), yn parhau i fod yn eiddo'r cyfryw.
3. Ni pharatowyd yr wybodaeth ar gyfer diwallu na'ch anghenion unigol chi na'r eiddo unrhyw un arall. Eich cyfrifoldeb chi yw sicrhau bod yr Wybodaeth yn diwallu'ch anghenion.
4. Ni all Asiantaeth yr Amgylchedd sicrhau y bydd yr Wybodaeth a fedd wastad yn gywir, yn gyfan, yn gyfoes neu'n ddilys, felly na all addo hynny.
5. Bydd Asiantaeth yr Amgylchedd yn cymeryd pob cam rhesymol i sicrhau y'ch cyflenwn â chopi cywir o'r Wybodaeth o'n cofnodion.
6. Os rhagnodasom bod rhaid i chi ein talu am gyflenwi'r Wybodaeth, rhaid i chi dalu cyn yr ymatebwn i'ch cais. Unwaith y dechreuwn ar waith darparu'r Wybodaeth a geisir, ni allwch ddileu'ch cais a gofyn am ddychwelyd eich arian.
7. Os gofynasoch am gyflenwi'r Wybodaeth mewn ffurf drydanol, ni allwn warantu y bydd na'r disg na'r ffeil gwybodaeth yn rhydd rhag unrhyw ddiffygion, a dylech ei archwilio rhag bod ynddo firws neu unrhyw beth arall a allai effeithio ar eich cyfrifiadur.
8. Rhaid cyfyngu defnyddio Gwybodaeth Trydydd Partïon, gan gynnwys copïo, gan hawliau statudol. Yn gyffredinol, golyga hyn y bydd angen i chi geisio caniatâd copïo. Gall Gwybodaeth Trydydd Partïon gynnwys gwybodaeth o'n cofrestrau cyhoeddus a roddwyd inni gan trydydd parti: yr wybodaeth a ddarparwyd ar ffurflen gais, er enghraifft.

Amodau Defnyddio Gwybodaeth yr Asiantaeth

9. Gan i chi dalu inni ein tâl defnydd masnachol mewnol (£10 ar hyn o bryd), gallwch gymeryd faint a fynnoch o gopïau o wybodaeth yr Asiantaeth (yn union fel ag y mae) at ddibenion mewnol eich busnes (defnydd masnachol mewnol cyfyngedig), ar yr amod:

   a) y sicrhewch briodoli pob copi i Asiantaeth yr Amgylchedd;
   b) na newidiwch yr Wybodaeth, na'i chyfuno â gwybodaeth arall;
   c) na chyflenwch yr Wybodaeth (neu unrhyw wybodaeth a ddeillir ohoni, neu a seilir ar y defnydd ohoni) i eraill.

10. Os ydych yn gynghorwr proffesiynol, ac y talasoch inni ein tâl defnydd masnachol mewnol (£10 ar hyn o bryd), yna'n ychwanegol at yr hawliau ym mharagraff 9 gallwch roi copïau o wybodaeth yr Asiantaeth (yn union fel ag y mae) i'ch cwsmer ac i unrhyw un arall sydd ag angen rhesymol am gopi (defnydd proffesiynol cyfyngedig) ar yr amod:

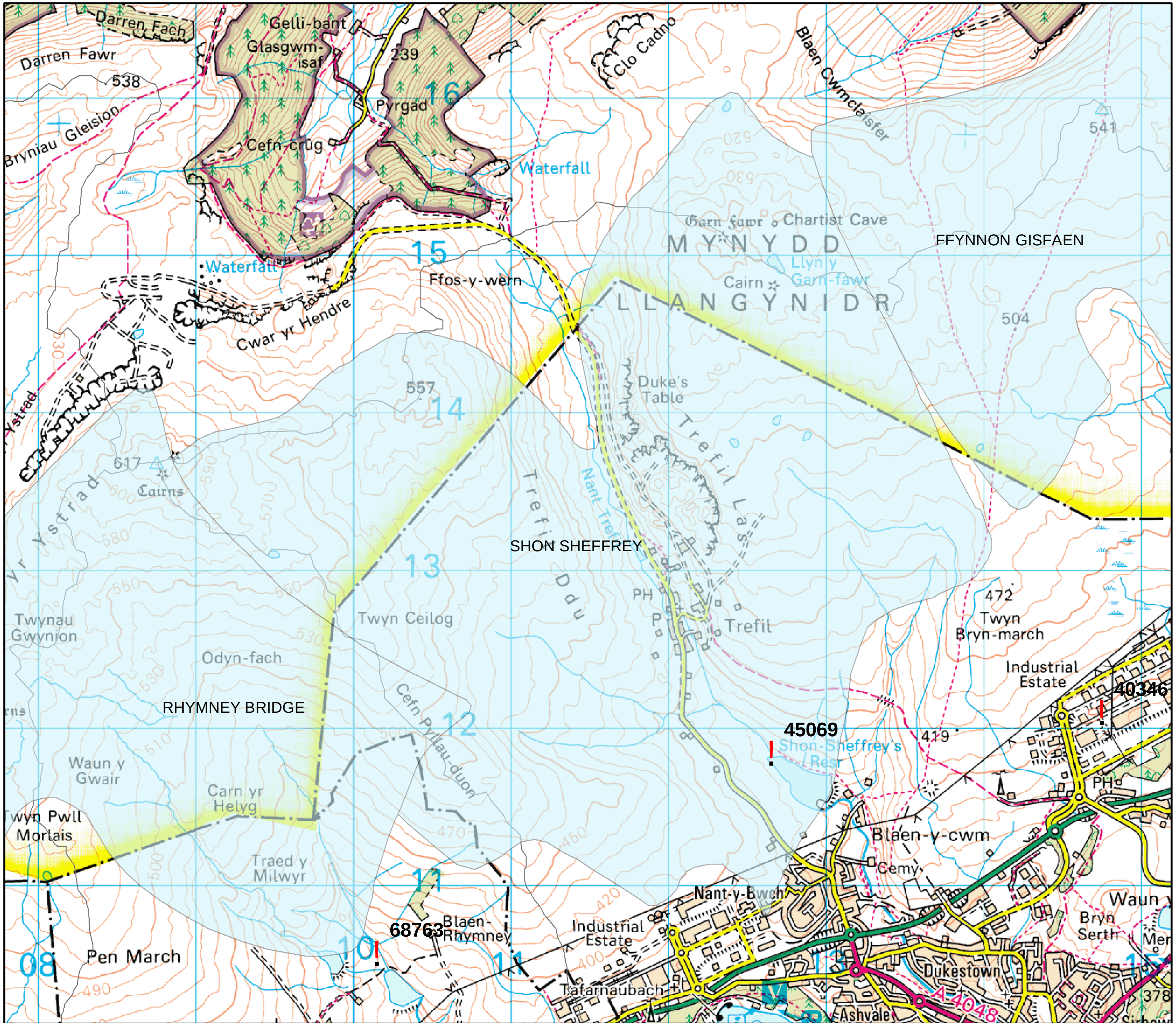
    a) bod unrhyw gopïau a yrrwch yn gysylltiedig â'r gweithrediad neu'r pwnc penodol ar gyfer pa un y cawsoch yr Wybodaeth gan Asiantaeth yr Amgylchedd;
    b) nad ydych yn codi tâl am gyflenwi'r Wybodaeth arall nag ar gyfer eich costau gwirioneddol a'r amser a dreuliwyd;
    c) yr atodwch gopi o'r hysbysiad hwn ac yn mynnu bod pob derbynnydd yn cydymffurfio ag ef.

    Nid rhaid i dderbynwyr Gwybodaeth o dan y paragraff hwn dalu unrhyw dâl ychwanegol, cyhyd ag y defnyddiwn yr Wybodaeth yn union fel ag y mae, yn fewnol ac ar gyfer yr un gweithrediad neu bwnc penodol.

11. Cysylltwch â ni, os gwelwch yn dda, os oes arnoch angen caniatâd ar gyfer unrhyw ddefnydd arall.

Y mae'n bwysig eich bod chi hefyd yn darllen unrhyw wybodaeth neu rybudd ychwanegol a roddwn i chi ynglŷn â Gwybodaeth benodol.

Cysylltwch â: enquiries@environment-agency.gov.uk
08708 506506



Groundwater Quality Monitoring Locations and Source Protection Zones

Gareth Farr 02920466068

Asiantaeth yr Amgylchedd Cymru
Environment Agency Wales

Environment Agency Wales
Ty Cambria House
29 Newport Road
Cardiff CF24 0TP

Tel 029-2077-0088 Fax 029-2079-8555 GTN 7-26 x 1000
www.environment-agency.wales.gov.uk

Title

.

[Delete this text, then add scale bar here.]
[Double-click to adjust properties.]

Date

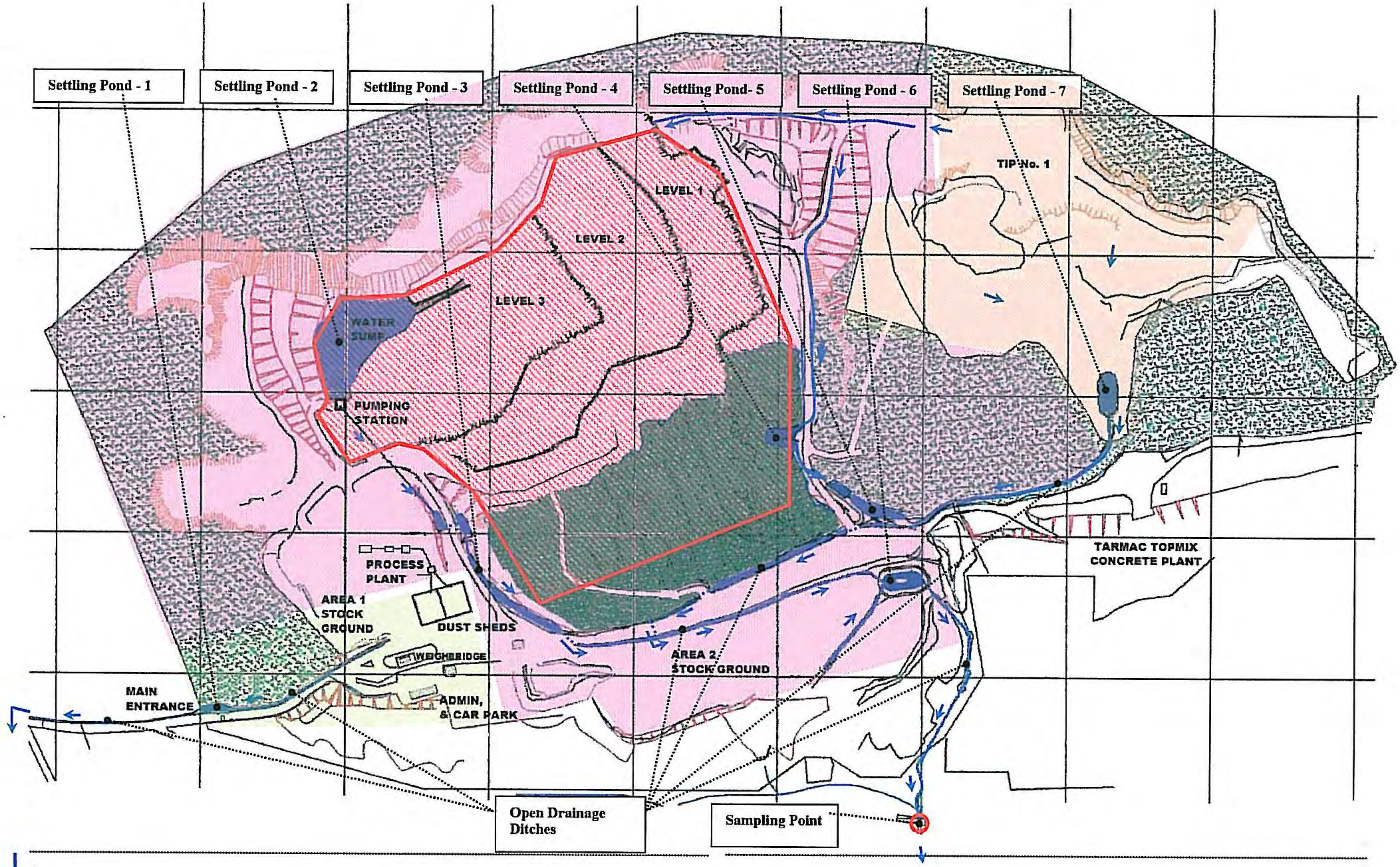
Scale

Dwg No.

APPENDIX C

Site surface water management

TITLE: **TREFIL QUARRY - Water Treatment Systems – (Aide-memoire for section 3.1)**



Flows that discharge from the site leave in a northerly direction travelling in an open drain adjacent to the quarry track. At the most northerly point of this track flows then merge with other flows from the north and travel south parallel to a private tarmac road to the Sampling point where they merge with flows discharging from the final settling pond No. 6

Approx. Catchment Area	Settling Pond No.	Equipment	Notes
North Western Area	1	• Oil boom	• Unlined. • One of two discharge points by which run-off water leaves the quarry boundary. • Flows from this settling pond leave the quarry heading in a northerly direction before then converging with external flows from the north (at junction of tarmac road and quarry track) and then collectively flow south to the sampling point. (See footnote on Plan). • Oil boom installed to absorb any hydrocarbons.
Quarry Complex	2	• Float • 6" Diesel pump.	• Unlined. • This pond acts as a sump in the deepest part of the quarry. • Discharge from the sump is achieved and controlled by the operation or not, of a pump. • The pumps pick-up snorkel suspended from a float, is positioned mid-way in the body of water; below the surface (no floating materials can be drawn in) and away from the bottom (no sediment can be drawn in). • Water is held to allow settlement, before the pump is operated.
Quarry Complex	3	• Oil boom	• Unlined. • Receives pumped water from settling pond No 2 which then flow away via open culvert to the main & final settling pond No 6. • An oil boom is installed to absorb any hydrocarbons.
Quarry Complex	4 & 5	-	• Unlined. • Flows from these ponds are channelled, in a circuitous route via open culvert, to the main & final settling pond No 6
Quarry Complex	6	• Lined. • Oil boom. • 90" elbows at outflow.	• Lined. • The second discharge point by which run-off water leaves the quarry boundary. • The outflow from this pond is fitted with 90° elbows the entrance of which is submerged at high water; this prevents floating debris and hydrocarbons from out flowing the settling pond. • Oil boom surrounds the 90° elbow to absorb any hydrocarbons. • No 6 pond is the main and final settling pond in the quarry drainage system its discharge is channelled via open culvert to the sampling point to merge with flows from the north.
Southern Fill Area	7	-	• Unlined. • Settlement pond for Fill Site; discharge flows from here are channelled in a circuitous route via open culvert, back into the main quarry system where they converge with flows to the main & final settling pond No 6. •
	-	-	• Direction of water flow around system.
	-	-	• Sampling point.
Main Excavation	-	-	• Area of current quarry excavations/extraction