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Initial report on borehole drilling in the Dumfries aquifer

Groundwater Systems and Water Quality Programme

Internal Report IR/02/153

BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/02/153

Initial report on borehole drilling and testing in the Dumfries aquifer

B É Ó Dochartaigh

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Foreword

This report describes work that is part of a 2 year programme of investigation of the Dumfries basin aquifer, and is jointly resourced by Scottish Water, the Scottish Environment Protection Agency (SEPA) and the British Geological Survey (BGS).

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Summary

The Dumfries Aquifer Basin is being investigated in detail on behalf of SEPA, Scottish Water and NERC. As part of this study, four exploratory boreholes have been drilled at three separate sites in order to provide data on the eastern part of the basin. The basic drilling and constructional details are recorded in this report. Further data gathering is proposed, including detailed hydrochemical and down-hole geophysical evaluations.

1 The Dumfries Aquifer Study

The Dumfries aquifer is the largest of the Permian aquifers of southwest Scotland. The basin occupies mainly low-lying ground, and is approximately 25 km in length and 10 km wide. It is surrounded by hills of Silurian sedimentary and metasedimentary rocks, and to the southwest also by the Criffel-Dalbeattie granitic pluton. Most of the basin is covered by glacial and postglacial deposits, but there are several prominent ridges where bedrock is at, or very close to, the surface.

The current programme of investigation of the Dumfries basin aquifer within the context of the overall Nith catchment includes a diverse range of tasks. These range from data collection through drilling and monitoring, to the detailed analysis of hydrogeological and hydrological aspects of the basin and the Nith catchment. The data collection and interpretation will be brought together in a process of conceptualisation of the flow system within the overall catchment, and specifically of the groundwater flow system in the Dumfries basin aquifer. Once the conceptual model has been developed and justified, a numerical model of the system will be constructed with boundaries set within the catchment to allow proper representation of the aquifer. The model will take account of rainfall-recharge relationships, river/groundwater interaction, groundwater abstraction and discharge, groundwater flow paths, hydrochemical evidence and time variant groundwater and surface water level hydrographs. It is envisaged that the model will enable resource development areas to be identified, and provide a management tool to enable groundwater abstraction licensing to be introduced for the aquifer should it be required in the future.

The Permian sandstone aquifer centred on the town of Dumfries has been subject to a number of piecemeal studies since the late 1970s, when the first public supply production borehole (at Terregles) was commissioned. A considerable amount of data on various aspects of the aquifer has been gathered over this time, and numerous interpretations have been presented as reports and contributions to the technical literature (e.g. Ball et al 1987, Robins and Buckley 1988, Cheney and MacDonald 1993, Gaus 1999, Buckley 2000, Gaus and Ó Dochartaigh 2000). Despite these, knowledge of the overall groundwater flow system within the aquifer remains poor, and there are still a number of uncertainties, such as the relationships between groundwater and surface water, between the aquifer and the overall Nith catchment, and between the eastern part of the aquifer and the sea. The current study makes use of previous work and data as a starting point and is undertaking new data collection and interpretation.

The three stakeholders in the project, British Geological Survey (BGS), Scottish Water and the Scottish Environment Protection Agency (SEPA), have slightly different agenda:

- BGS has a mission to survey the UK landmass to enhance the science base and so contribute to national wellbeing. Specifically, BGS is keen to improve understanding of groundwater flow systems in the Nith catchment as part of the National Groundwater Survey.
- Scottish Water needs to protect existing assets and to optimise exploitation of the available resource. Specifically, Scottish Water is keen to maintain its current assets in the Dumfries aquifer and to develop new sources.
- SEPA has a duty to protect and apportion water resources within each river basin and catchment in Scotland. Specifically, SEPA needs accurate knowledge of the resource potential of the aquifer, the abstraction volume, and the pollution risk in order to satisfy the requirements of the Water Framework Directive.

A particular project objective is the determination of the total renewable resource available in the Dumfries basin as a part of the Nith catchment. Further aims include identifying both

development and stressed areas of the aquifer, and defining the principle recharge and discharge zones and the groundwater flow system.

2 Borehole drilling and testing

2.1 DRILLING PROGRAMME DESIGN

During this phase of the project, a drilling programme was designed to allow the collection of new geological and hydrogeological data in the eastern part of the aquifer, where there is currently little information. A drilling specification for 8 boreholes (3 shallow drift boreholes and 5 deep bedrock boreholes) was put out to tender to four drilling companies. Initial quotes from the drilling companies showed that this programme exceeded the available budget, and the specification was revised to allow for 4 deep boreholes. The contract for drilling was let to IPR Drilling of Kilmarnock. Subsequently, geological conditions experienced in the field led to increasing costs, and the programme was further revised, so that in the end only one shallow drift borehole and three deep bedrock boreholes were drilled at three separate sites.

The three sites are at Racks Moss and Ironhirst Moss, both on Forestry Commission land, and at Longbridgemuir Farm (Figure 1). A shallow drift borehole and a deep bedrock borehole were drilled at Racks Moss, spaced approximately 20 m apart. A single deep bedrock borehole was drilled at each of the Ironhirst Moss and Longbridgemuir Farm sites. Borehole details are summarised in Table 1. Detailed borehole logs are presented in Appendix 1.

Borehole reference	Site	OD (m ASL)	Depth (m)	Drift thickness (m)	Summary bedrock geology	Date completed
DF02/1A	Racks Moss	11	26.50	-	-	11/7/02
DF02/1B	Racks Moss	11	100.00	32	Sandstone	24/7/02
DF02/2	Longbridgemuir Farm	20	80.00	5	Sandstone and breccia	31/7/02
DF02/3	Ironhirst Moss	11	100.00	10	Mudstone	15/8/02

Table 1 Summary details of new boreholes in the Dumfries aquifer

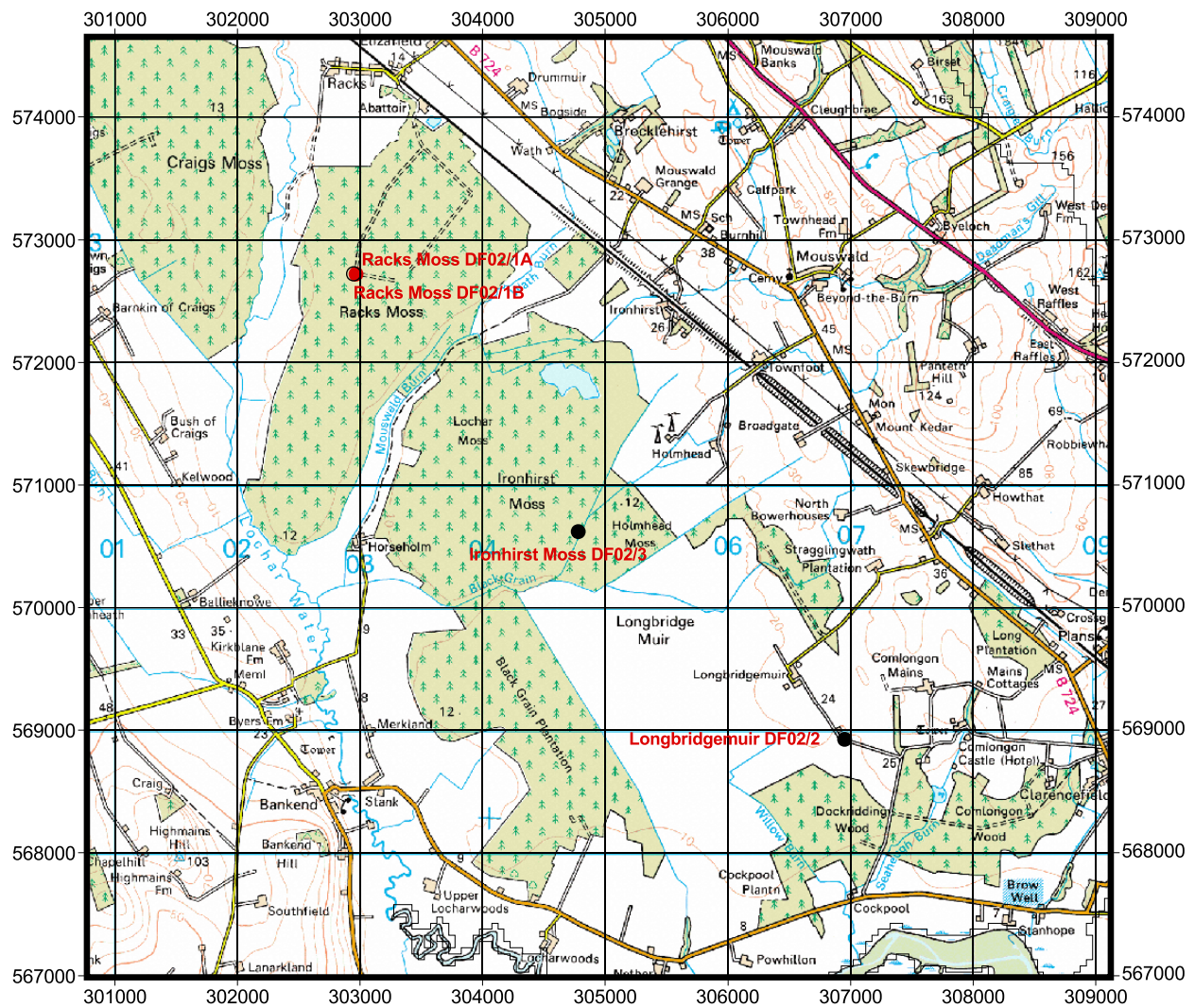


Figure 1 Map showing location of new boreholes

2.2 BOREHOLE DRILLING AND CONSTRUCTION

Borehole drilling began on 8 July 2002 with borehole DF02/1A at the Racks Moss site, using rotary drilling equipment. Temporary casing was installed through the drift during drilling. Prior to drilling, the thickness of drift at Racks Moss had been estimated at 20 m, but drilling proved this to be an underestimate. Drilling continued to 28.85 metres depth, at which point the rotary rig could not advance the hole further. The decision was made to cease drilling at this point and install plastic blank casing with a 3 m slotted screen at the base to provide a shallow drift borehole. Due to collapse of loose gravels at the base of the borehole, the borehole was completed at 26.50 metres depth on 11 July 2002.

A percussion (shell and auger) rig was brought on site and set up approximately 20 m from borehole DF02/1A. Drilling started at borehole DF02/1B on 12 July 2002. Percussion drilling equipment was used to drill through the drift cover and 3 m into bedrock, to 35 m total depth. Plastic casing of 150 mm diameter was installed to this depth and grouted in. Drilling continued through bedrock using rotary drilling equipment. Three core runs were taken during drilling: from 36.10 to 39.10 m, 58.40 to 61.40 m and 79.50 to 82.50 m. The borehole was completed to 100 m total depth on 24 July 2002.

Drilling started at the Longbridgemuir Farm site on 30 July 2002. The anticipated drift thickness at the site was less than 7 m, and the borehole was drilled using rotary equipment from the start. Plastic casing of 150 mm diameter was installed to 2.5 m into bedrock, to 7.5 m, and grouted in with a 2.5 m grout plug. Three core runs were taken: from 8.00 – 11.00 m, 40.00 to 43.00 m and 77.00 to 80.00 m depth. The borehole was completed to 80 m total depth on 31 July 2002.

Drilling started at the Ironhirst Moss site on 6 August 2002. Drift thickness at the site was anticipated to be similar to Racks Moss, and percussion drilling equipment was, therefore, used through the drift sequence. However, actual drift thickness was only 10 m. Rotary equipment was used below this depth. The borehole was drilled 3.5 m into the bedrock, to 13.50 m, and plastic casing of 150 mm diameter was installed and grouted in with a 1.5 m grout plug. Five core runs were taken, as one run produced almost zero recovery due to a faulty core barrel and another run produced very little recovery. The core runs were taken from 14.30 to 17.30 m, 46.50 to 49.50 m (recovery only 0.15 m), 49.50 to 50.70 m (0.20 metres recovery) and 97.00 to 100.00 m. The borehole was completed at 100 m total depth on 15 August 2002.

All of the boreholes were completed with a steel end piece with lockable cover, enclosed by a circular manhole cover flush with the ground surface.

2.3 BOREHOLE TESTING

Immediately following drilling, each of the deep bedrock boreholes was test pumped using an electrical submersible pump. All three boreholes were tested with a 12 hour constant rate pump test. Borehole DF02/1B at Racks Moss was also subjected to an 8 hour step test at 2 hour intervals. A summary of the test details is given in Table 2. Details of the pump tests, with initial analysis of transmissivity (T in m^2/day) are presented in Appendix 2.

Borehole Reference	Site	Pump test description	Length of test pumping (hours)	Flow rate (l/s)	Rest water level (mbdatum)	Maximum drawdown (mbdatum)
DF02/1B	Racks Moss	Step test	8 (2 hours per step)	1.8	2.61	5.64
				3.4	-	10.34
				5.3	-	24.05
				7.6	-	33.90
DF02/1B	Racks Moss	Constant rate	12	5.75	2.62	22.67
DF02/2	Longbridgemuir Farm	Constant rate	12	5.25	7.41	14.79
DF02/3	Ironhirst Moss	Constant rate	12	1.38	1.38	16.67

Table 2 Summary details of test pumping of new boreholes

3 Further primary data collection

The next phase of the project is to undertake further data collection using the newly drilled boreholes and the rock core obtained from the boreholes, by geophysical downhole logging, porosity and permeability testing, and sampling for water chemistry analysis.

Geophysical downhole logging will be carried out on the new boreholes and possibly on selected existing boreholes. This will provide basic information on aspects such as aquifer layering, fracturing, vertical permeability distribution, water inflows with depth, and will help to interpret local and regional groundwater flow systems. Logging may include caliper logging, fluid electrical conductivity and temperature logging, resistivity/spontaneous potential (electric) logging, gamma logging, neutron logging and acoustic logging. Of particular interest will be the depth, size and rate of flow of fractures, and in boreholes DF02/1B and DF02/2, whether groundwater flow is concentrated along the contacts between the interfingering sandstone and breccia.

Water samples will be taken from each of the new boreholes for analysis of major and minor ions. CFC and SF₆ tracers will be used to date groundwaters and provide information to support groundwater provenance and flow path hypotheses. Borehole depth sampling may also be carried out.

Plugs will be taken from the core recovered from the new boreholes and used to measure vertical and horizontal intergranular (primary) porosity and permeability. This is expected to be much lower than fracture (secondary) permeability, but the information will allow the geological units and their aquifer properties in the east of the basin to be compared with those closer to and to the southwest of Dumfries.

During this stage of the project it is also hoped to drill a number of additional shallow drift boreholes in the area to the northwest of Dumfries. It is known that thick glacial and alluvial drift mantles the Permian sandstone aquifer in this area, but hydrogeological data are scarce. Additional shallow boreholes in this area, similarly tested and sampled, will provide information to improve our understanding of the interaction between bedrock and drift, including rainfall-recharge relationships and groundwater chemistry, and of the interaction between the River Nith and both the bedrock and drift aquifers.

The data collected as part of these activities will be combined with existing geological, hydrogeological, hydrological, meteorological, land use and other data. Analysis of these data will lead into the process of conceptualisation of the aquifer system, including the establishment of a catchment-wide water balance.

Appendix 1 Borehole logs

DF02/1A – RACKS MOSS

DRILLED 8/7/02 – 11/7/02
 DRILLED DEPTH 28.85 m
 COMPLETED DEPTH 26.50 m
 REPORTED WATER STRIKES c. 26 m

0 – 7.5	Dark brown peat
7.5 – 12.25	Red-brown fine-grained sand
12.25 – 16.2	Red silty clay with occasional boulder
16.2 – 16.5	Red-brown sandstone boulder
16.5 – 26	Red-brown fine-grained sand, often very fine-grained to silty
26 – 28.85	Coarse gravel and pebbles up to c. 100 mm long

DF02/1B – RACKS MOSS

DRILLED 12/7/2 – 24/7/2
 DEPTH 100 m
 REPORTED WATER STRIKES c. 26 m, c. 80 m

CORE RUNS:

- 1 36.10 – 39.10. Recovery 83%. Most core loss assigned to areas of broken core between 36.43 – c. 37.30 m; and some to c. 37.90 – c. 38.10 m.
- 2 58.40 – 61.40. Recovery 87%. Core loss assigned to c. 59.26 – c. 59.70 m and c. 60.40 – c. 60.55 m.
- 3 79.50 – 82.50. Recovery 42%. Driller reported large voids at c. 80.50 – 82.00 m and most core loss is therefore assigned to this level

0 – 2	Dark-brown peat with some gravel and pebbles (of greenish, coarse grained, very hard sandstone, and buff coloured, coarse grained, very hard sandstone) and much unrotted organic plant matter. Strong organic smell
2 – 3	Mid-brown peat with lots of unrotted organic plant matter, including some pieces of wood
3 – 4	Dark-brown peat with large (50 – 100mm long) pieces of wood
4 – 5	Dark-brown peat with lots of orange-brown unrotted organic plant matter
5 – 6	Steel-grey, stiff, sticky, slightly silty clay with small lumps of peat
6 – 7	Mid-brown fine to medium grained sand with small lumps of red-brown silty clay
7 – 9	Red-brown fine-grained sand to silty sand with red-brown silty clay
9 – 10	Red-brown stiff, silty clay
10 – 11	Red-brown stiff clay
11 – 12	Mid-brown soft silty clay
12 – 13	Lumps of hard (but relatively easy to break) red-brown silt?
13 – 14	Red-brown soft silty clay
14 – 15	Red-brown soft to stiff silty clay
15 – 16	Red-brown soft to stiff clay
16 – 19	Red-brown soft clay

- 19 – 20 Red-brown soft silty clay
- 20 – 25 Red-brown soft clay
- 25 – 26 Grey subangular to subrounded pebbles, 30 – 50mm diameter
- 26 – 27 Poorly sorted coarse sand to coarse gravel and small pebbles (< 30mm) of mixed source: red-brown sandstone, grey (?metamorphic)
- 27 – 29 Poorly sorted coarse sand and coarse gravel (lots < 5mm and lots 10 – 20mm grade) with pebbles/cobbles commonly up to 100mm, rarely up to 150mm. Dominantly well-rounded and grey ?metamorphic rock with some red-brown sandstone.
- 29 – c. 29.6 Blocks of very weathered mid-brown, fine grained to silty sandstone with c. 3% gravel (1-3mm) and occasional grey pebble up to 10mm, easily crumbled by hand to sand; grading to red-brown fine-grained sand with subangular gravel (1-3mm) and occasional grey pebbles up to 50mm long of ?metasandstone
- c. 29.6 Moderately to poorly sorted, angular gravel (1 – 10mm), dominantly a dark-grey fine-grained rock with subordinate red sandstone and quartz
- c. 29.8 – 30.5 Red-brown fine-grained sand (weathered sandstone) with < 3% gravel. Occasional dark-grey, fine-grained, subangular to subrounded cobble (up to 200mm diameter)
- 30.5 – 31.5 Poorly sorted, angular gravel (1-10mm) with well rounded pebbles of medium grained red sandstone and subrounded, smooth dark grey rock up to 50mm
- 31.5 – c. 32 Red fine-grained weathered sandstone with small subrounded pebbles
- c. 32 – c. 32.5 Hard to drill, moderately sorted, angular gravel (2 – 7mm) dominantly dark coloured with subordinate red sandstone and quartz
- c. 32.5 - 36.1 No Samples. Driller reports red sandstone
- 36.10 – 39.10 CORE RUN 1:
- 36.1 – 36.43 Red-brown, fine to medium grained, moderately to well sorted sandstone. Banding c. 20° to horizontal: silty bands c. 10mm wide interbedded with dominant fine to medium grained rock. Relatively intact core pieces 180, 50 and 80mm long; slightly weathered
- 36.43 – c. 37.3 Broken core: pieces up to 50mm long. As above but occasionally a medium to coarse grained red-brown sandstone interval slightly more weathered than the rest
- c. 37.3 – c. 37.9 Fine to medium grained, moderately sorted, red-brown sandstone interbedded with medium to coarse grained sandstone bands 5 to 10mm wide; banding c. 30 ° to horizontal
- c. 37.9 – c. 38.1 Broken core: one piece c. 50mm long, banded red-brown, fine-grained and moderate to coarse grained sandstone. One piece c. 40mm long, moderate to coarse grained
- c. 38.1 – 38.4 Core pieces 50 – 90mm long. Dominantly medium to coarse grained, moderately sorted, red-brown sandstone; occasional fine-grained band c. 20mm wide
- 38.4 – 39.1 Dominantly fine-grained, well sorted, red-brown sandstone; occasional (< 20% of length) medium to coarse grained band 5 to 15mm wide with abundant white quartz
- END OF CORE RUN. BAG SAMPLES TAKEN EVERY 2 M:
- 39.1 – 41 Fine to medium grained, moderately sorted, red-brown sandstone
- 41 – 45 Fine-grained, well sorted red-brown sandstone
- 45 – 49 Fine to medium grained, moderately to well sorted, red-brown sandstone. Abundant white quartz grains 1-2mm long
- 49 – 57 Fine to medium grained, moderately to well sorted red-brown sandstone
- 58.40 – 61.40 CORE RUN 2:
- 58.4 – 59.06 Fine-grained, well sorted, well cemented red-brown sandstone. 2 core pieces: one 550mm & one 120mm long
- 59.06 – 59.26 Fine-grained, well sorted, red-brown sandstone. Core quite broken: pieces 50 – 90mm long

- 59.26 – c. 59.7 Broken core: pieces generally 20 – 30mm & a total of c. 200 – 200mm length recovered. Fine-grained, well sorted, red-brown sandstone.
- c. 59.7 – 60.53 Dominantly fine-grained, well sorted, well cemented, red-brown sandstone; occasional medium grained subhorizontal band 5 – 10mm wide. 2 core pieces: one 190mm and one 640mm long
- c. 60.53 – 60.8 Broken core: one piece 120mm, others 20 – 40mm. Fine-grained, well sorted, red-brown sandstone
- 60.8 – 61.4 Fine-grained, well sorted, well cemented, red-brown sandstone. 2 core pieces 260mm and 340mm long. Occasional natural-looking incipient subhorizontal core breaks – along bedding planes?
- END OF CORE RUN. BAG SAMPLES TAKEN EVERY 2 M:
- 61.4 – 62 Fine to medium grained, moderately sorted, red-brown sandstone. Appears well cemented (chips up to 20mm)
- 62 – 64 Fine to medium grained, moderately to well sorted red-brown sandstone.
- 64 – 66 Fine to medium grained, moderately sorted, red-brown sandstone. Abundant white and light coloured quartz grains 1 – 2mm and occasionally coarser
- 66 – 70 Fine to medium grained, moderately sorted red-brown sandstone. Abundant quartz 1 – 2mm; some black, coarse grains up to 3mm
- 70 – 74 Fine to coarse grained, mod sorted red-brown sandstone. Abundant white quartz and dark/black grains 1 – 3mm
- 74 - 76 Fine to medium grained, moderately sorted, red-brown sandstone. Common white quartz and dark grains 1 – 2mm
- 76 – 79.5 Fine to coarse grained, moderately sorted red-brown sandstone. Abundant white quartz, green and black grains 1 – 3mm. Occasional cemented sandstone pebble 10 – 15mm.
- 79.50 – 82.50 CORE RUN 3:
- 79.5 – c. 79.77 Fine-grained, very well sorted, relatively well cemented red-brown sandstone. Occasional black staining on edges and core breaks. Core pieces 40 – 60mm
- c. 79.77 – c. 80 Fine-grained, very well sorted, relatively well cemented red-brown sandstone. Core pieces 30 – 100mm
- c. 80 – c. 80.38 Fine-grained, very well sorted, red-brown sandstone. Very occasional black staining. Core more broken: 3 pieces 50 – 60mm and the rest 20 – 30mm.
- c. 80.38 – 80.5 Fine-grained, very well sorted, relatively well cemented dark red-brown sandstone. One incipient core break roughly along bedding plane
- 80.5 – 80.55 Broken core: pieces 10 – 20mm. Fine-grained, very well sorted, red-brown sandstone
- 80.55 – 80.75 Fine-grained, very well sorted red-brown sandstone. 1 core piece with 1 vertical fracture showing extensive black staining
- 80.75 – 82.5 No Recovery
- END OF CORE RUN. BAG SAMPLES TAKEN EVERY 2 M:
- 82.5 – 86.5 Fine to medium grained, moderately sorted, red-brown sandstone. Some cemented sandstone pieces 4 – 10mm. Abundant white quartz and dark/black grains 1 – 3mm
- 86.5 – 88.5 Fine to medium grained, moderately sorted red-brown sandstone. 1 piece of cemented sandstone 20mm across. Common black grains 1 – 3mm, occasional white quartz grains 1mm
- 88.5 – 90.5 Fine to medium grained, moderately sorted red-brown sandstone. Cemented sandstone pieces 15 – 40mm. Occasional quartz grains 1mm and green and black grains 1 – 2mm
- 90.5 – 92.5 Fine-grained, well sorted, red-brown sandstone. Occasional black grains 1mm
- 92.5 – 94.5 Fine to medium grained well sorted red-brown sandstone

- 94.5 – 96.5 Fine to medium grained well sorted red-brown sandstone. Common black grains 1 – 2mm; occasional white quartz grains 1mm
- 96.5 – 100 Poorly sorted fine to coarse grained breccia. > 50% of recovered pieces are fine-grained, red-brown sandstone 2 – 5mm. Abundant subangular green, purple and dark grey grains 3 – 5mm. Common rounded white, pink and translucent quartz grains 2 – 5mm

END OF BOREHOLE 100 M

DF02/2 – LONGBRIDGEMUIR FARM

DRILLED 30/7/02 – 31/7/02

DEPTH 80 m

REPORTED WATER STRIKE c. 16 m

CORE RUNS:

- 1 8.00 – 11.00. Recovery 91%. Core loss assigned to c. 10.20 – c. 10.35 and c. 10.80 – 11.00 m.
 - 2 40.00 - 43.00. Recovery 92%. Core loss assigned to between 42.0 and 42.5 m
 - 3 77.00 – 80.00. Recovery 17%. Top piece of core retrieved (77.0 – c. 77.1 m); below this occasional pieces but can't be attributed to any depth.
- 0 – 1 Mid-brown, dry crumbly soil. Some gravel up to 7mm. No cohesion
- 1 – 2 Poorly sorted, red-brown sand and subangular gravel (gravel c. 3 – 15mm). Dominantly dark grey and green rock; occasional piece of red sandstone. Dry
- 2 – 3 Mid to red-brown sand and subordinate gravel and some pebbles up to 25mm. Gravel and pebbles mainly subangular to subrounded, dark grey and green with occasional sandstone piece. Dry
- 3 – 4 Red-brown, poorly sorted clayey sand and gravel/pebbles. Gravel/pebbles are common, poorly sorted, 2 – 40mm, description as above although some pieces more rounded
- 4 – 5 Red-brown, poorly sorted clayey sand and gravel. Gravel is poorly sorted, subangular, 2 – 50mm with pieces of granite/gneiss, green, grey & purple rock
- 5 – 8 No Samples. Driller reports sandstone but probably breccia, as seen in core below
- 8.00 – 11.00 CORE RUN 1:
- 8 – 8.23 Very poorly sorted breccia. Light pink to red-brown, fine to medium grained matrix. Clasts 3 – 15mm, subangular to subrounded, often elongate; purple, grey, green and white. Some grey fine-grained sandstone clasts 40 – 50mm (or areas of reduced matrix?)
- 8.23 – 8.3 Well sorted, fine-grained red-brown sandstone
- 8.3 – 8.34 Moderately sorted breccia; fine-grained red-brown matrix with subrounded clasts 3 – 5mm of white & pink quartz, purple & purple-grey rock
- 8.34 – 8.48 Sloping contact to fine-grained, well sorted, red-brown sandstone with 2 narrow laminae (3 – 4mm) of coarse grained sandstone
- 8.48 – 8.53 Fine-grained, red-brown sandstone with common grey-black grains 1 – 3mm
- 8.53 – 8.62 Moderately sorted breccia with red-brown fine-grained matrix and white and pink subangular to subrounded quartz clasts 3 – 15mm
- 8.62 – 8.83 Fine-grained well sorted red-brown sandstone
- 8.83 – 8.95 Moderately sorted breccia with fine-grained red-brown matrix and white, pink and grey, subrounded to subangular clasts 2 – 4mm
- 8.95 – 9.09 Poorly sorted breccia with fine to medium grained red-brown matrix and clasts 2 – 50mm of purple rock, occasionally red sandstone, white quartz and white and black granite (granite clasts up to > 50 mm)
- 9.09 – 9.8 Fine to medium grained well sorted red-brown sandstone. Occasional horizons with coarser grains/clasts, e.g. between 9.46 and 9.62
- 9.8 – 10 Fine to medium grained moderately sorted red-brown sandstone with occasional clasts 2 – 4mm, mainly white & grey
- 10 – 10.02 As 9.8-10 but with larger clasts of white and black granite
- 10.02 – 10.1 Medium to coarse grained red-brown sandstone with very occasional clast 4 – 10mm of quartz (or granite?)
- 10.1 – 10.2 Poorly sorted breccia with fine to medium grained red-brown matrix and abundant (almost clast supported) clasts of grey/black, purple, white and pink rock

- c. 10.2 – c. 10.35 (Assigned core loss). A few pieces of broken core, up to 30mm, of medium to coarse grained well sorted red-brown sandstone
- c. 10.35 – 10.49 Moderately sorted red-brown fine-grained sandstone with occasional, often elongate clasts 2–6mm of purple, grey, white and pink rock
- 10.49 – 10.6 As 10.35-10.49, but with a higher proportion of clasts to matrix
- 10.6 – 10.8 As 10.49-10.6, but only occasional clasts
- 10.8 – 11 (Assigned core loss). A few pieces up to 30mm of fine-grained, well sorted, red-brown sandstone

END OF CORE RUN. BAG SAMPLES TAKEN EVERY 2 M:

- 10 – 12 Dry, fine-grained, pink-brown sandstone. Occasional clasts generally 3–5mm but rarely up to 10mm
- 12 – 14 Wet, medium grained pinky red-brown sandstone with occasional clast 2–3mm
- 14 – 16 Dry, medium grained, moderately sorted pink-brown sandstone with abundant white grains 1–2mm
- 16 – 18 Dry, medium grained moderately sorted red-brown sandstone with abundant grains 1 – 2mm
- 18 – 22 Damp clayey fine-grained, well sorted, red-brown sand with occasional white and grey clasts 3–5mm
- 22 – 24 Gravel, presumable moderately sorted breccia, with fine-grained red-brown matrix and abundant purple, grey and white/black granite clasts 3-10mm
- 24 - 26 Moderately to well sorted breccia with red-brown clayey/ fine-grained sand matrix and abundant subrounded to rounded clasts 2-5mm, often red sandstone
- 26 - 28 Coarse grained, moderately sorted red-brown sandstone with white, pink, grey and orange grains 1-3mm and finer grained red-brown matrix
- 28 - 30 As 26-28 but also including grains 3-5mm of white/pink and grey/green with fine-grained red-brown matrix
- 30 – 32 Coarse grained, moderately sorted red-brown breccia with fine-grained red sandstone matrix, largely white grains 1-3mm, and subangular to subrounded purple, grey and green clasts 3-10mm
- 32 – 34 Medium to coarse grained red-brown sandstone with occasional grey and purple clast <5mm
- 34 – 36 Coarse grained red-brown sandstone, dominantly white/orange well rounded quartz grains 1-2mm and occasional subangular grey clast up to 4mm
- 36 – 38 As 34-36 but paler pink-brown
- 40.00 – 43.00 CORE RUN 2:
- 40 – 41.28 Dominantly fine grained, moderately to well sorted red-brown sandstone with regular scatterings of rounded grains 1-3mm dominantly white and grey, some green (as for bagged samples above). At occasional horizons are layers c. 5mm of dominantly coarse grained (1-3mm) sandstone Core breaks every 15 – 50 mm. Much evidence of weathering along bedding planes
- 41.28 – 41.37 Moderately sorted breccia with fine-grained red-brown matrix and occasional subangular to subrounded white, white/pink, grey and purple clasts 2-10mm
- 41.37 – 41.75 Poorly sorted, matrix supported pinky coloured breccia with fine-grained pinkish matrix and coarse grains and abundant subangular to subrounded, dominantly white with occasional purple and grey clasts 3-30mm. Becomes more red-brown in colour at 41.7 m
- 41.75 – 41.9 Coarse grained moderately to well sorted red-brown sandstone with some finer grains and occasional clasts up to 15 mm
- 41.9 – c. 42 Poorly sorted, almost clast-supported breccia with subangular green, white, pink, grey, purple and white/black granite clasts 3-50mm
- c. 42 – c. 42.5 Core loss assigned here. 4 core pieces of similar variations to above but pinkish colour: coarse grained sandstone with rounded grains; ditto with clasts up to

- 30mm; poorly sorted, clast supported breccia; fine-grained pinkish-brown cross bedded sandstone with evidence of weathering along bedding planes
- c.42.5 – 42.81 Moderately to poorly sorted breccia. Fine to medium grained pinkish matrix with light grey, dark grey, purple and white/pink clasts 3-10mm
- 42.81 – 42.92 Fine-grained pinkish-brown well sorted sandstone
- 42.92 – 43 Moderately to poorly sorted breccia, as above, with occasional 5mm wide bands of fine-grained pinkish-brown sandstone
- END OF CORE RUN. BAG SAMPLES TAKEN EVERY 2 M:
- 43 – 44 Moderately to poorly sorted breccia with rounded, dominantly white or clear (quartz?) grains 1-2mm and clasts 3-10mm of red sandstone, black, yellow, grey and purple
- 44 – 48 Coarse grained reddish brown sandstone with occasional clast <5mm of red-brown fine-grained sandstone
- 48 – 52 Moderately to poorly sorted breccia with pinkish matrix (red-brown and white (quartz) grains) and subangular clasts 3-8mm of white, black, orange, purple and white/black granite
- 52 – 54 Poorly sorted breccia: coarse grained sandstone matrix with rounded white and clear (quartz?) grains, as above, and subangular to subrounded, often purple and grey clasts 3-20mm
- 54 – 56 Moderately sorted, coarse-grained red-brown sandstone with occasional, dominantly purple or grey clast <5mm
- 56 – 58 No sample
- 58 – 60 Poorly sorted breccia with coarse sand matrix of rounded light coloured (quartz?) grains 1-2mm and abundant dark-purple (sandstone), subangular clasts 2-10mm and some light grey clasts 2-5mm
- 60 – 62 As 58-60 but larger clasts up to 20mm are more abundant
- 62 – 64 As 60-62 but sandstone clasts are subrounded and less purple, more red-brown, and larger clasts up to 40mm are more abundant
- 64 – 66 As 62-64 but very purple-brown, subrounded clasts and sand grains <2mm are less abundant: most grains >2mm
- 66 – 68 As 64-66 but also with some grey (not sandstone) clasts
- 68 – 70 Light to dark purple, poorly sorted gravel-grade pieces with occasional clasts up to 20mm, and NOT sandstone. Some light-grey pieces dominantly 2-5mm
- 70- 74 Poorly sorted breccia: matrix of dominantly subrounded (quartz?) grains 1-2mm; clasts up to 15mm dominantly light grey to purple with occasional red-brown sandstone
- 74 – 76 Poorly sorted breccia: matrix of medium to coarse grained sand up to 1mm; abundant purple-brown (dominant) and red-brown (subordinate) subrounded sandstone clasts 3-7mm, occasionally larger
- 77.00 – 80.00 CORE RUN 3:
- 77.0 - c. 77.1 Medium grained, well sorted, mid-grey sandstone with occasional purple staining (same colour as sandstone clasts in bagged samples, above)
- (?) Fine-grained grey (reduced?) and red-brown sandstone
- END OF CORE RUN
- END OF BOREHOLE 80.00 M

DF02/3 – IRONHIRST MOSS

DRILLED 6/8/02 – 15/8/2

DEPTH 100.00 m

REPORTED WATER STRIKES c. 19 m

CORE RUNS:

- 1 14.30 – 15.80. Recovery hard to estimate (core in pieces) but probably c. 60%.
- 2A 46.50 – 49.50. Recovery c. 5% (problem with core barrel)
- 2B 49.50 – 50.70. Recovery c. 17%.
- 2C 50.70 – 52.50. Recovery c. 94%.
- 3 97.00 – 100.00. Recovery c. 52%. Core loss assigned very approximately to c. 97.25 – c. 98m; c. 98.7 – c. 99m; c. 99.26 – c. 99.6 and c. 99.9 – 100m

- 0 – 1 Dark brown peat or peaty soil
- 1 – 3 Dark brown peat, rich in unrotted organic matter; strong organic smell
- 3 – 4 Mid-grey, silty clay
- 4 – 5 Mid-brown stiff clay with pebbles and cobbles up to at least 50mm, usually grey
- 5 – 6 Extremely stiff, mid brown clay with cobbles of grey rock up to at least 100mm
- 6 – 7 Very stiff, mid brown clay
- 7 – 8 Stiff to very stiff, mid brown clay
- 8 – 9 Subrounded pebbles and cobbles of grey rock up to 100mm, with some mid brown stiff clay
- 9 – 10 Subangular to rounded pebbles and cobbles of grey rock up to at least 100mm, with some mid brown clay
- 10 – 10.5 Broken rock: subangular pieces up to at least 100mm long of very fine-grained purple rock with occasional red-brown veins
- 11 – 14.3 No Sample. Driller reports red/purple rock as above
- 14.30 – 15.80 CORE RUN 1:
- 14.3 – 15.8 Broken core: pieces mainly 20-40mm and subangular; rarely semi-whole core pieces 40-60mm long and 1 piece c. 120mm long. All pieces are very fine-grained, light to dark purple rock. Occasional red-brown veins 1-4mm wide running in any orientation: horizontal; c. 45°; c. vertical. Very occasional white veins only seen at c. 45° or subvertical and crossing the red-brown veins. Red-brown staining spreads over some broken faces. Some black staining evident as 1mm wide veins spread across faces. Some faces look like weathered mudstone: flaking.

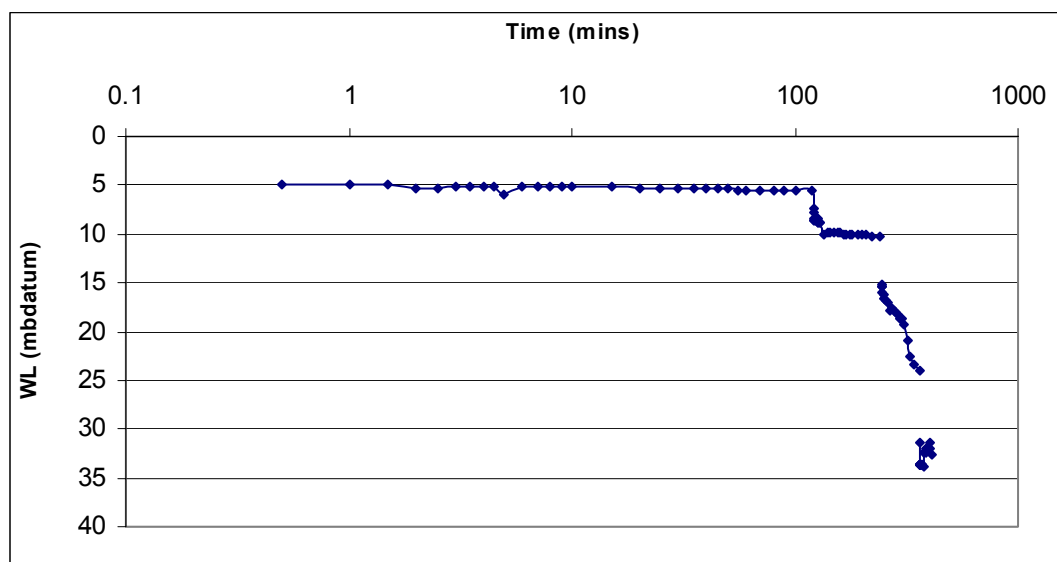
END OF CORE RUN. BAG SAMPLES TAKEN EVERY 2 M:

- 15.8 – 16 No Sample
- 16 – 18 Dark purple, very fine-grained rock: angular to subangular pieces c. 1-30mm
- 18 – 20 As 16-18 but smaller pieces, generally 1-7mm, rarely up to 10mm. Some a pale green colour (looks like reduction spots)
- 20 – 22 As 18-20 but pieces up to c.10-15mm
- 22 – 28 As 20-22 but with rare green spots
- 28 – 30 Mostly mid-grey, very fine-grained rock with some purple and red-brown staining. Angular to subangular pieces 1-c.10mm
- 30 – 32 Dark purple, very fine-grained rock. Angular to subangular pieces 1-20mm
- 32 – 34 Dark grey and dark purple with significant red-brown staining, including veins <1mm. Angular to subangular pieces 1-10mm
- 34 – 36 Dark purple, very fine-grained, angular to subangular pieces with some red-brown staining
- 36 – 38 Dark grey and dark purple, very fine-grained, angular to subangular pieces 1-c.15mm

- 38 – 44 As 36-38 with rare red-brown staining (SAMPLE)
- 44 – 46 As 38-44 with common red-brown staining, sometimes as distinct veins
- 46.50 – 49.50 CORE RUN 2A (recovery c. 0.15 m)/Bagged sample:
- 46.5 – 49.5 As 44-46 and including flakes 2-5mm in size of probably iron pyrite
- 49.50 – 50.70 CORE RUN 2B (recovery c. 0.20 m):
- 49.5 – 50.7 Pale grey-green with red-brown staining and abundant angular core breaks
- 50.70 – 52.50 CORE RUN 2C (recovery c. 1.70 m):
- 50.7 – c.51.3 Pale grey to dark purple, very fine-grained rock with abundant staining in red-brown, orange-brown (iron?) and purple. Some mica visible? Some white inclusions (quartz/calcite?). Abundant core breaks: probably fractures and/or incipient fractures opened during drilling, at c. 30° to vertical with red-brown veins 1-4mm wide and staining on faces; also much rusty (iron?) staining on faces. Fracture faces dominantly smooth and with common black dendritic (manganese) staining up to 10mm high. Some areas of white mineralisation on faces – quartz or calcite?
- c. 51.3 – 52.5 As 50.7-51.3 but more broken. Some rusty-coloured (iron?) staining on broken faces
- END OF CORE RUN. BAG SAMPLES TAKEN EVERY 2 M:
- 52 – 56 Mid-grey angular to subangular gravel c.1-10mm with common purple and red-brown staining
- 56 – 58 As 52-56 but pieces up to 20mm
- 58 – 62 As 56-58 but dark grey to purple in colour with red-brown staining
- 62 – 64 As 58-62 with rare white clasts (quartz/calcite?) (SAMPLE)
- 64 – 66 Dark purple, angular to subangular gravel 1-10mm
- 66 – 68 As 64-66 but some dark grey pieces and some red-brown staining
- 68 – 70 As 66-68 but common red-brown staining and some grey-green staining
- 70 – 72 Dominantly reddish-purple with rare grey rock pieces 2-20mm; rare red-brown staining
- 72 – 74 Reddish-purple rock with some light grey-green staining and some white (quartz/calcite?) pieces 2-c.7mm
- 74 – 76 As 72-74 but more grey-green staining
- 76 – 78 As 74-76 but pieces 2-15mm with some grey-green staining and rare white (quartz/calcite?) pieces
- 78 – 80 Dark purple pieces 2-c.8mm with red-brown staining; rarely grey/grey-green/white (quartz/calcite?) pieces
- 80 – 82 As 78-80 but 2-10mm & rare red-brown staining
- 82 – 88 Reddish-purple and grey pieces, 2-8mm; rare light grey-green pieces
- 88 – 90 As 82-88 with some distinct red-brown veins
- 90 – 92 Dark purple pieces with some red-brown staining
- 92 – 94 As 90-92 with some light grey-green pieces (reduction?), 2-c.8mm
- 94 – 96 Dark purple and light grey-green (reduced?) pieces 2-c.8mm
- 96 – 97 As 94-96 with some white (quartz/calcite?) pieces up to 15mm; subangular to subrounded
- 97.00 – 100.00 CORE RUN 3 (much core loss and impossible to assign core to absolute depths):
- 97 – 100 Dark to light purple, very fine-grained with abundant incipient fractures dominantly at high angles (10 to 30° from vertical) often infilled by white or red-brown veins. One exposed fracture face – smooth, flaky. Some areas of light grey-green (reduced?) colour. One band of horizontal laminae, grey-green with red staining, associated with a core break
- END OF CORE RUN.
- END OF BOREHOLE 100 M

Total Elapsed Time (mins)	WL (mbdatum)	Flow rate (l/s)	Remarks
140	9.88	3.67	
145	9.89	3.67	
150	9.94	3.66	
155	9.9	3.67	
160	9.91	3.69	
165	9.95	3.65	
170	9.97	3.35	
175	10.05	3.98	
180	10.13	3.68	
190	10.08	3.66	
200	10.05	3.67	
210	10.07	3.50	
220	10.21	3.67	
240	10.34	3.67	
240.5			
241			
241.5			
242			
242.5			
243			
243.5			
244			
244.5			
245	15.24		
246	15.38	3.33	
247	15.48	5.00	
248	15.91	6.67	
249	16.19	5.00	
250	16.6	5.00	
255	16.83	5.33	
260	17.07	5.67	
265	17.77	5.33	
270	17.56	5.67	
275	17.62	5.33	
280	17.79	5.67	
285	17.98	5.33	
290	18.28	5.33	
295	18.68	5.67	
300	18.66	5.33	
310	19.23	5.50	
320	20.88	5.33	
330	22.5	5.50	
340	23.39	5.50	
360	24.05	5.25	
360.5			
361			
361.5	31.29		
362	33.55	26.67	
362.5	33.55	3.33	
363	33.58	6.67	
363.5	33.58	10.00	
364	33.58	6.67	
364.5	33.6	10.00	
365	33.6	6.67	
366	33.6	15.00	
367	33.6	3.33	
368	33.6	6.67	
369	33.57	8.33	

Total Elapsed Time (mins)	WL (mbdatum)	Flow rate (l/s)	Remarks
370	33.58	8.33	closing valve
375	33.9	8.00	setting valve
380	32.4	7.33	
385	32.37	7.33	
390	32	7.00	
395	31.9	7.33	flow meter clogged with sand stop test
400	31.29		
405	32.06		
410	32.68		



DF02/1B RACKS MOSS CONSTANT RATE TEST**Borehole DF02/1B****Water levels in borehole DF02/1A (mbgl)**

pre test 1.5

Date 26/07/2002

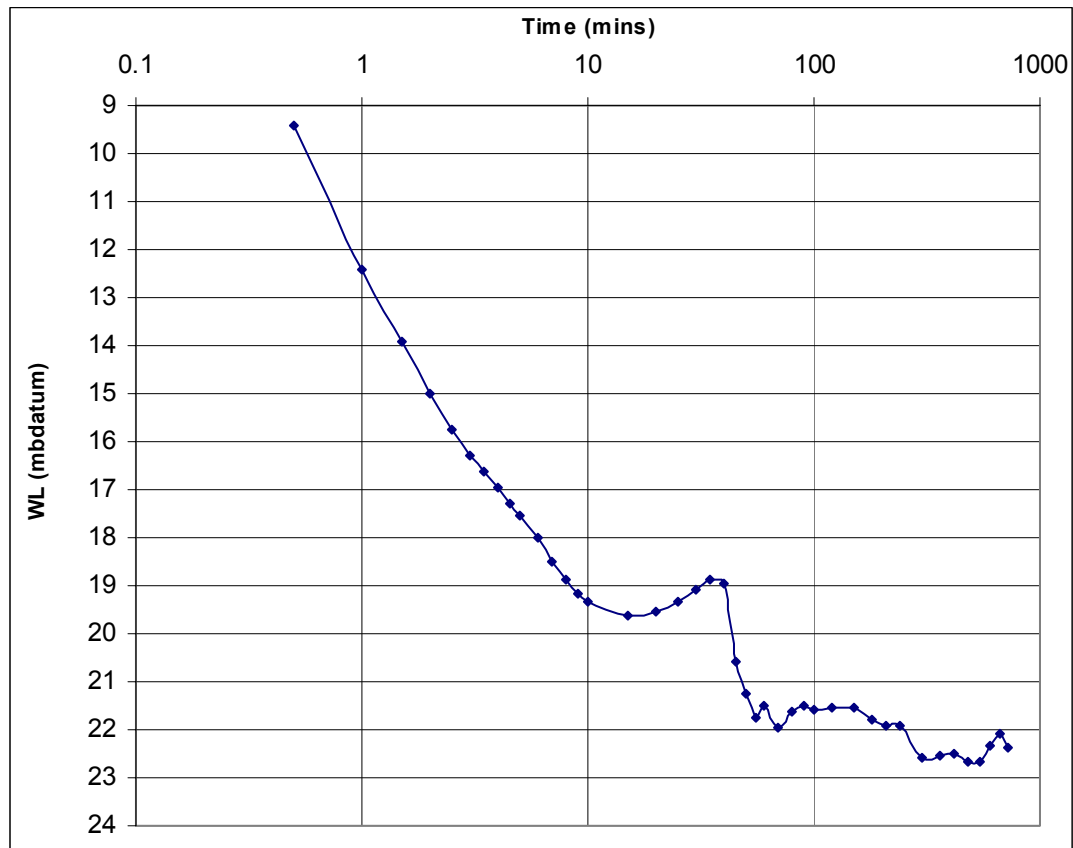
mid test 1.7

12 hour continuous constant rate test - drawdown

end test 1.97

Average pump rate 5.74 l/s

Total Elapsed Time (mins)	WL (mbdatum)	Flow rate (l/s)	Remarks
	2.62		cloudy
0.5	9.42	6.67	
1	12.4	6.67	
1.5	13.9	3.33	
2	15	6.67	
2.5	15.76	6.67	
3	16.29	6.67	
3.5	16.64	6.67	
4	16.97	3.33	
4.5	17.29	6.67	
5	17.53	6.67	
6	17.99	5.00	
7	18.5	6.67	
8	18.88	5.00	
9	19.18	6.67	
10	19.32	6.67	
15	19.62	5.67	
20	19.54	6.00	
25	19.34	5.33	
30	19.1	5.67	
35	18.87	5.33	
40	18.94	5.00	open valve
45	20.6	5.33	water clearing
50	21.24	6.33	
55	21.76	5.67	
60	21.51	5.67	
70	21.97	7.00	
80	21.64	4.83	
90	21.49	5.50	
100	21.6	5.67	
120	21.54	5.75	
150	21.55	5.61	
180	21.78	5.61	
210	21.9	5.56	
240	21.91	5.56	water clear
300	22.6	5.50	
360	22.53	5.53	
420	22.52	5.50	
480	22.66	5.42	water clear
540	22.67	5.64	
600	22.32	5.64	
660	22.1	5.39	
720	22.36	5.53	

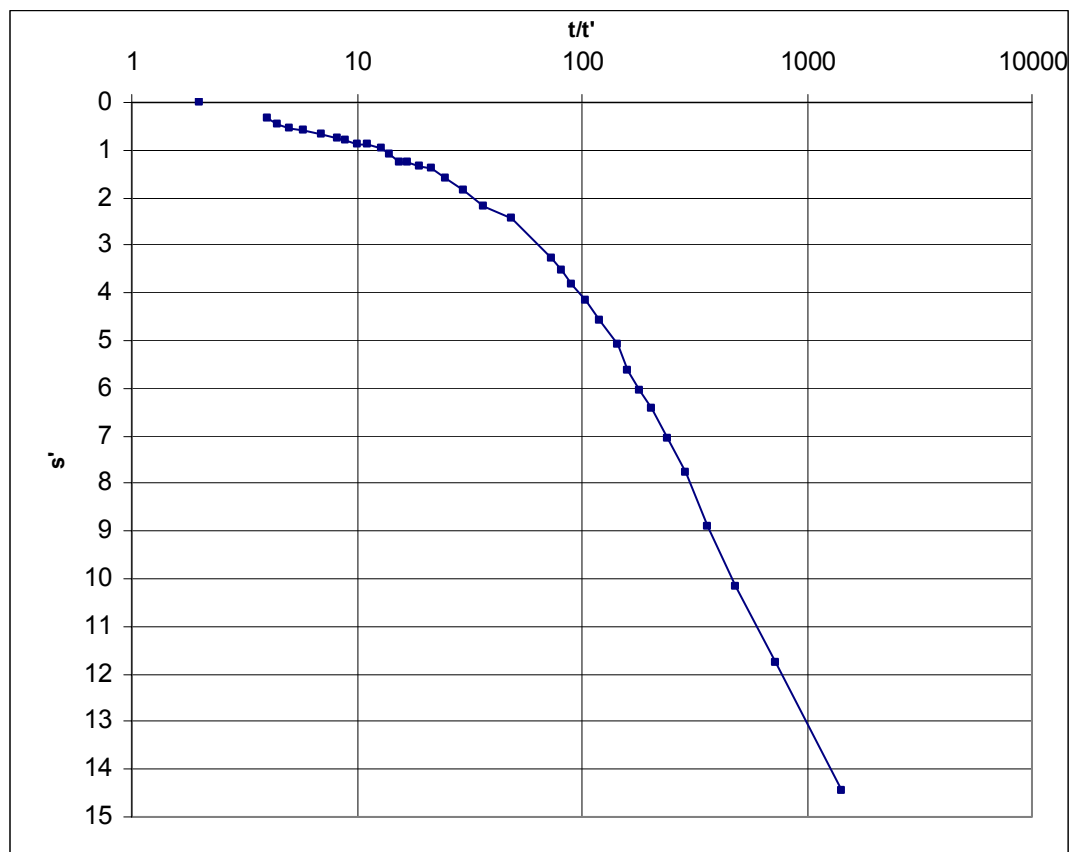


Early	Q (m3)	496.23
	WL t1	12.40
	WL t2	21.25
	WL2-WL1	8.85
	T (m2/d)	10.26

Late	Q (m3)	496.23
	WL t1	19.00
	WL t2	21.20
	WL2-WL1	2.20
	T (m2/d)	41.28

Borehole**DF02/1B****Date 26/07/2002 - 27/08/02****12 hour continuous constant rate test - recovery**

t' (mins)	t (mins)	t/t'	Residual drawdown s' (m)	WL (mbdatum)
	720		19.74	22.36
0.5	720.5	1441	14.44	17.06
1	721	721	11.78	14.4
1.5	721.5	481	10.18	12.8
2	722	361	8.9	11.52
2.5	722.5	289	7.76	10.38
3	723	241	7.06	9.68
3.5	723.5	206.7142857	6.42	9.04
4	724	181	6.06	8.68
4.5	724.5	161	5.65	8.27
5	725	145	5.07	7.69
6	726	121	4.56	7.18
7	727	103.8571429	4.16	6.78
8	728	91	3.82	6.44
9	729	81	3.55	6.17
10	730	73	3.28	5.9
15	735	49	2.43	5.05
20	740	37	2.2	4.82
25	745	29.8	1.83	4.45
30	750	25	1.6	4.22
35	755	21.57142857	1.39	4.01
40	760	19	1.35	3.97
45	765	17	1.28	3.9
50	770	15.4	1.24	3.86
55	775	14.09090909	1.08	3.7
60	780	13	0.96	3.58
70	790	11.28571429	0.9	3.52
80	800	10	0.87	3.49
90	810	9	0.8	3.42
100	820	8.2	0.76	3.38
120	840	7	0.66	3.28
150	870	5.8	0.59	3.21
180	900	5	0.54	3.16
210	930	4.428571429	0.48	3.1
240	960	4	0.35	2.97
300	1020	3.4		
360	1080	3		
420	1140	2.714285714		
480	1200	2.5		
540	1260	2.333333333		
600	1320	2.2		
660	1380	2.090909091		
720	1440	2	0.02	2.64

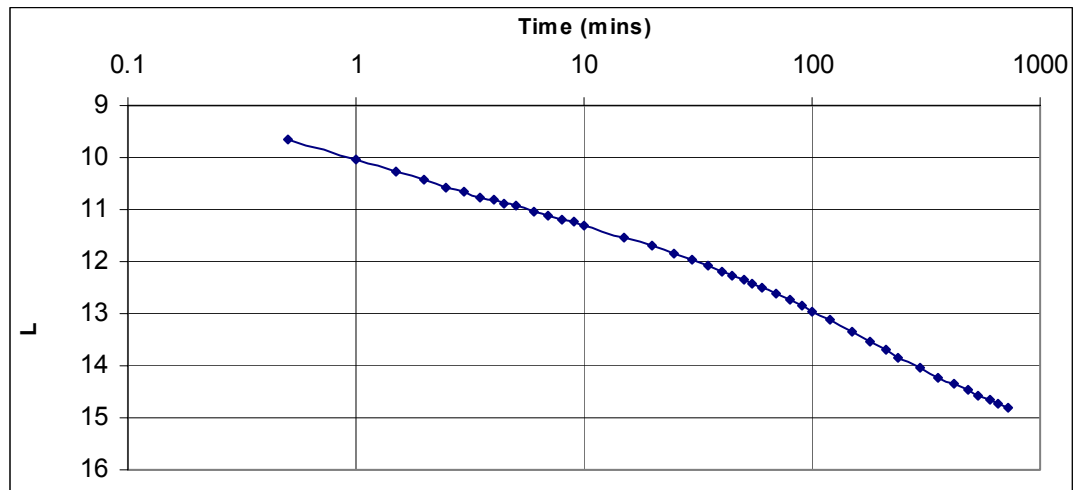


Early	Q (m3)	496.23
	WL t1	0.90
	WL t2	2.20
	WL2-WL1	1.30
	T (m2/d)	69.85

Late	Q (m3)	496.23
	WL t1	3.60
	WL t2	13.00
	WL2-WL1	9.40
	T (m2/d)	9.66

DF02/2 LONGBRIDGEMUIR FARM CONSTANT RATE TEST**Borehole DF02/2****Date 02/08/02****12 hour continuous constant rate test - drawdown****Average pump rate 5.25 l/s**

Total Elapsed Time (mins)	WL (mbdatum)	Flow rate (l/s)	Remarks
	7.41		cloudy
0.5	9.65		
1	10.05		water clear
1.5	10.28		
2	10.43		
2.5	10.58		
3	10.65		
3.5	10.76		
4	10.81		
4.5	10.88		
5	10.93	5.33	
6	11.03	5.00	
7	11.11	5.00	
8	11.18	6.67	
9	11.24	5.00	
10	11.3	5.00	
15	11.54	5.33	
20	11.71	5.33	
25	11.85	5.33	
30	11.98	3.33	
35	12.09	7.33	
40	12.18	5.33	
45	12.27	5.00	
50	12.35	5.33	
55	12.43	5.33	
60	12.49	5.33	
70	12.63	5.17	
80	12.74	5.33	
90	12.84	5.17	
100	12.95	5.33	
120	13.11	5.25	
150	13.34	5.22	
180	13.55	5.78	raining
210	13.71	4.78	
240	13.84	5.33	
300	14.04	5.11	
360	14.22	5.25	raining heavily
420	14.36	5.22	light rain
480	14.47	5.33	rain stopped 14:12
540	14.58	5.14	raining 14:45
600	14.67	5.19	
660	14.74	5.19	
720	14.79	4.50	

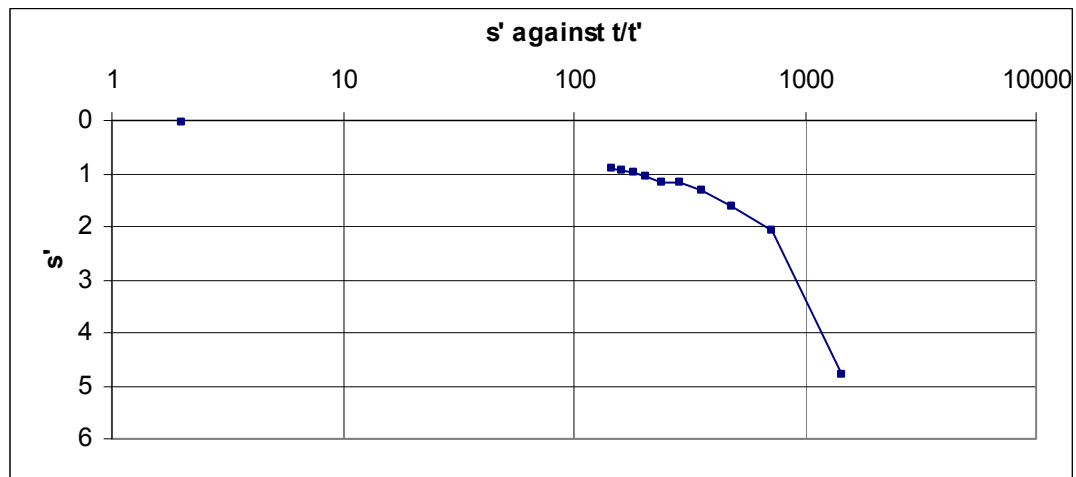


Early	Q (m3)	453.75
	WL t1	10.00
	WL t2	11.30
	WL2-WL1	1.30
	T (m2/d)	63.87

Late	Q (m3)	453.75
	WL t1	13.00
	WL t2	15.20
	WL2-WL1	2.20
	T (m2/d)	37.74

Borehole DF02/2**Date 02/08/02 - 10/08/02****12 hour continuous constant rate test - recovery**

t' (mins)	t (mins)	t/t'	Residual drawdown s' (m)	WL (mbdatum)
	720		7.38	14.79
0.5	720.5	1441	4.79	12.2
1	721	721	2.08	9.49
1.5	721.5	481	1.64	9.05
2	722	361	1.31	8.72
2.5	722.5	289	1.17	8.58
3	723	241	1.16	8.57
3.5	723.5	206.7142857	1.05	8.46
4	724	181	0.99	8.4
4.5	724.5	161	0.94	8.35
5	725	145	0.91	8.32
6	726	121		
7	727	103.8571429		
8	728	91		
9	729	81		
10	730	73		
15	735	49		
20	740	37		
25	745	29.8		
30	750	25		
35	755	21.57142857		
40	760	19		
45	765	17		
50	770	15.4		
55	775	14.09090909		
60	780	13		
70	790	11.28571429		
80	800	10		
90	810	9		
100	820	8.2		
120	840	7		
150	870	5.8		
180	900	5		
210	930	4.428571429		
240	960	4		
300	1020	3.4		
360	1080	3		
420	1140	2.714285714		
480	1200	2.5		
540	1260	2.333333333		
600	1320	2.2		
660	1380	2.090909091		
720	1440	2	0.03	7.44

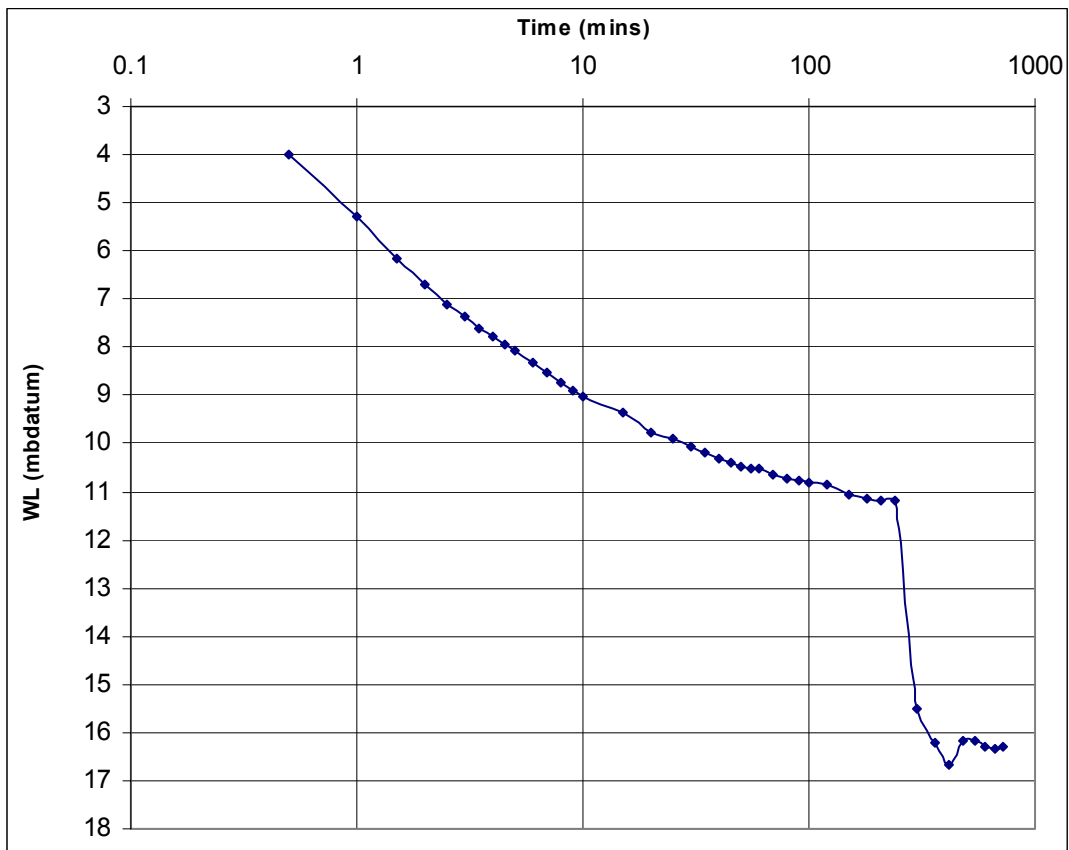


Early	Q (m3)	453.75
	WL t1	0.30
	WL t2	0.80
	WL2-WL1	0.50
	T (m2/d)	166.07

Late	Q (m3)	453.75
	WL t1	3.00
	WL t2	14.00
	WL2-WL1	11.00
	T (m2/d)	7.55

DF02/3 IRONHIRST MOSS CONSTANT RATE TEST**Borehole DF02/3****Date 17/08/02****12 hour continuous constant rate test - drawdown****Average pump rate 1.38 l/s**

Total Elapsed Time (mins)	WL (mbdatum)	Flow rate (l/s)	Remarks
		1.38	cloudy
0.5	3.98	3.33	water clear
1	5.27	3.33	
1.5	6.15	1.00	
2	6.7	1.00	
2.5	7.1	1.33	
3	7.38	1.00	
3.5	7.62	1.00	
4	7.78	1.33	
4.5	7.93	1.00	
5	8.05	1.00	
6	8.31	0.67	
7	8.54	1.67	
8	8.75	3.33	
9	8.9	1.67	
10	9.03	1.67	
15	9.34	1.33	
20	9.76	1.33	
25	9.91	1.67	
30	10.06	1.33	
35	10.18	2.00	
40	10.31	0.67	
45	10.4	1.00	
50	10.46	1.00	
55	10.51	1.00	
60	10.53	1.00	
70	10.64	1.17	
80	10.73	1.17	
90	10.78	1.00	
100	10.83	1.00	
120	10.87	1.00	
150	11.05	1.17	
180	11.16	1.11	
210	11.19	1.28	
240	11.19	1.33	
300	15.5	1.36	
360	16.23	1.44	
420	16.67	1.50	
480	16.17	1.33	
540	16.19	1.33	
600	16.3	1.42	
660	16.33	1.33	
720	16.29	1.28	

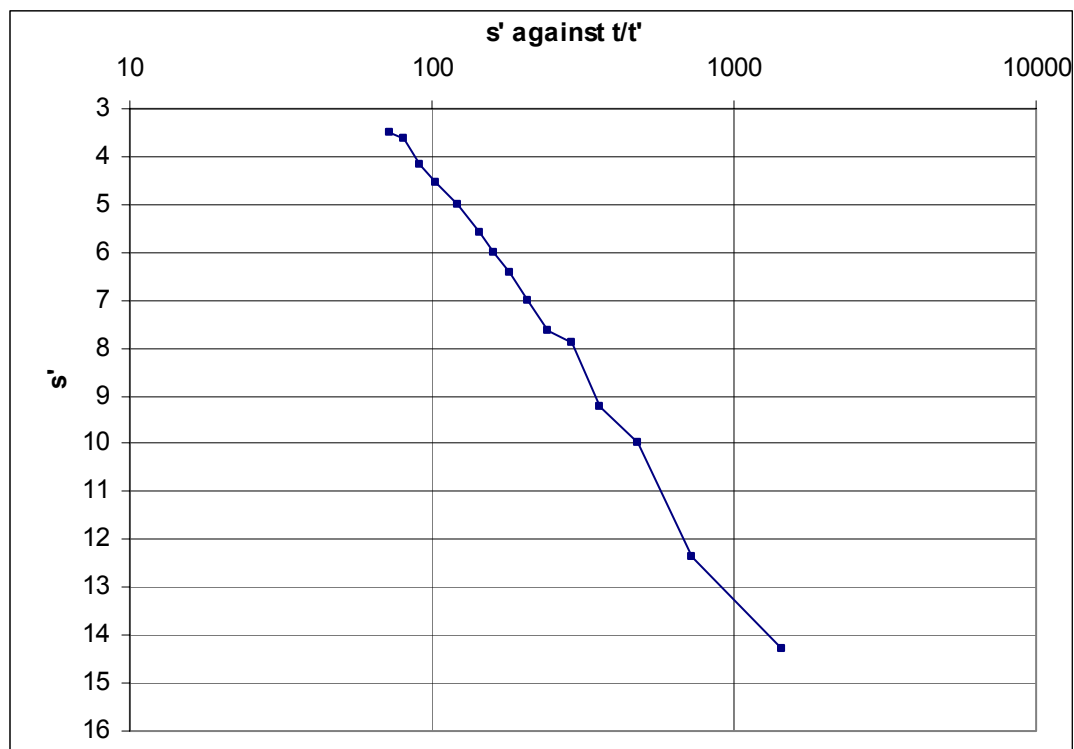


Early	Q (m3)	119.09
	WL t1	5.25
	WL t2	9.75
	WL2-WL1	4.50
	T (m2/d)	4.84

Middle	Q (m3)	119.09
	WL t1	9.50
	WL t2	10.75
	WL2-WL1	1.25
	T (m2/d)	17.43

Borehole DF02/3**Date 17/08/02****12 hour continuous constant rate test - drawdown**

t' (mins)	t (mins)	t/t'	Residual drawdown s' (m)	WL (mbdatum)
	720		14.91	16.29
0.5	720.5	1441	14.3	15.68
1	721	721	12.36	13.74
1.5	721.5	481	9.96	11.34
2	722	361	9.24	10.62
2.5	722.5	289	7.87	9.25
3	723	241	7.62	9
3.5	723.5	206.7142857	7	8.38
4	724	181	6.41	7.79
4.5	724.5	161	5.99	7.37
5	725	145	5.6	6.98
6	726	121	5.02	6.4
7	727	103.8571429	4.53	5.91
8	728	91	4.17	5.55
9	729	81	3.64	5.02
10	730	73	3.5	4.88



Q (m3)	119.09
WL t1	4.40
WL t2	12.10
WL2-WL1	7.70
T (m2/d)	2.83

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Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

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