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The LOCAR Hydrogeological Infrastructure for the Tern Catchment

Groundwater Systems and Water Quality Programme

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The LOCAR Hydrogeological Infrastructure for the Tern Catchment

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Foreword

NERC's LOCAR Thematic Programme aims to improve the science required to support current and future management needs for permeable lowland catchments through an integrated and multidisciplinary experimental and modelling programme. It is undertaking detailed hydro-environmental research in three flagship catchments, the Frome /Piddle in Dorset, the Pang/Lambourn in Berkshire and the Tern in Shropshire. To support the research programme a unique infrastructure of basic data provision and long-term facilities has been established in the three catchments.

The hydrogeological element of this infrastructure represents the largest concerted hydrogeological field programme in the United Kingdom for a number of years. Field work commenced in January 2002 and was essentially completed in December the same year. The Foot and Mouth disease outbreak of 2001 significantly delayed initiation of the field campaign and implementation was further delayed by difficulties encountered in securing land access agreements. In all, a total of 76 boreholes were drilled in the three catchments, resulting in a total drilled length of 2990m of which 976m were cored and tested. A total of 88 piezometers were installed in selected boreholes to allow monitoring of groundwater heads and/or collection of groundwater samples at differing depths. Some 108 pressure transducers have been installed across the three catchments to monitor variations in groundwater head with time.

Acknowledgements

The authors wish to acknowledge the efforts of their colleagues in BGS who were responsible for the success of the fieldwork campaign. They are:

Debbie Allen, Mike Bird, Dave Buckley, Colin Cheney, Jude Cobbing, Irina Gauss, Kate Griffiths, Sarah Hannay, Chris Jackson, Daniel Lapworth, Richard Marks, Magali Moreau, Ilka Neuman, Richeldis, Emily Whitehead, Tyler-Whittle, Peter Williams.

"Water Management Consultants" of Shrewsbury were responsible for the supervision of drilling in the Tern catchment.

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This report describes the hydrogeological infrastructure that was installed in the Tern catchment in Shropshire to support the **Lo**wland **Ca**tchment **R**esearch (LOCAR) Thematic Research Programme. The objectives of the LOCAR Programme are briefly described as are the management structure that was used to achieve those objectives. This is followed by a description of the Tern catchment and a brief overview of the financial support for the whole LOCAR programme. A discussion of the design of the infrastructure precedes a description of what was actually installed and a summary of data that is available through the LOCAR Data Centre as a result. Finally, there is a list of equipment purchased using LOCAR infrastructure funds for use by the Catchment Service Teams and by the LOCAR research community.

1 Introduction

The Natural Environment Research Council's **Lo**wland **Ca**tchment **R**esearch (LOCAR) Thematic Programme was created to improve the science required to support current and future management needs for permeable lowland catchments through an integrated and multi-disciplinary experimental and modelling programme. The Programme supports detailed hydro-environmental research relating to the storage-discharge cycle and groundwater dominated aquatic habitats in three catchments, the Frome/Piddle in Dorset, the Pang/Lambourn in Berkshire, and the Tern in Shropshire with a view to answering the following questions:

- What are the key hydrological processes controlling surface water-groundwater interactions, the movement of groundwater, and material fluxes in lowland permeable catchments?
- What are the key physical, chemical and biological processes operating within the valley floor corridor which affect the surface water and groundwater?
- How do varying flow regimes control in-stream, riparian and wetland habitats?
- How does land use management impact on lowland catchment hydrology, including both water quantity and quality, and wetland ecology?
- How can the hydrological, hydrogeological, geomorphological and ecological interactions resulting from natural or anthropogenic changes be predicted using integrated mathematical models?

In order to carry out its responsibilities for the experimental design, installation and management of the baseline monitoring equipment, the LOCAR Steering Committee established a Technical Expert Working Group (TEG). To support the TEG, a Task Force of CEH and BGS staff was established to develop a detailed understanding of the existing instrumentation and monitoring facilities in the three catchment areas and the needs for additional facilities, the desirable locations for such facilities and an estimates of costs. The Task Force report on behalf of the TEG to the LOCAR Steering Committee formed the basis of LOCAR infrastructure installation strategy. NERC then advertised a contract for the management of the installation of the LOCAR infrastructure. Hydro Logic and Water Management Consultants were made responsible for the administrative side of the work (reporting, financial management, sub contracts, equipment purchase etc) while BGS and CEH were made generally responsible for the design and installation (including field supervision of sub contractors) of the infrastructure. However, Hydro Logic did have particular responsibility for design and supervision of installation of some of the river gauging stations and Water Management Consultants took on responsibility for supervision of drilling subcontractors in the Tern catchment due to their proximity to the field area.

As a result of this activity, a unique infrastructure of long-term facilities has been established in the three catchments. This infrastructure has the dual objectives of:

1. Augmenting the existing monitoring networks within the catchments to provide baseline data to support the current and future research programmes.
2. Providing a range of research facilities.

The purpose of this report is to describe the hydrogeological elements of the infrastructure installed for the LOCAR programme within the Pang/Lambourn catchment to monitor and provide experimental facilities in the saturated and unsaturated zones.

1.1 THE TERN CATCHMENT

The River Tern and its two main tributaries, the Meese and Roden arise on Rhaetic and Liassic clays and mudstones or Permo-Triassic Sherwood sandstones of the North Shropshire Plain. The catchments of these rivers are predominantly rural and the Tern system is free of large urban areas. However, over the years human development pressures have had an impact on the locality. Since the sixteenth century land drainage activity and agricultural "improvements" have led to a loss and degradation of river corridors and a decline in the flora and fauna in areas near the Tern and Strine. Glacial deposits cover much of the low-lying areas and are responsible for many minor topographic features of high conservation interest such as the classic "kettle holes" and peaty mosses, Whixall and Wem Moss.

Groundwater is pumped from the Permo-Triassic sandstone aquifer. Certain areas of the catchment have falling groundwater levels and/or problems of low river flows in summer mainly as a result of licenses being granted in the 1960s that have authorised over-abstraction of groundwater. Generally speaking, most of the severe impacts do not relate to the Tern system.

The Tern catchment was originally proposed for inclusion in the LOCAR programme for two main reasons:

(i) it provides a Sherwood Sandstone dominated lowland permeable catchment

(ii) considerable groundwater and hydrological data are available in the middle reaches because of the development of the Shropshire Groundwater Scheme (SGS).

The Technical Expert group agreed that, for the purposes of the Thematic Programme, the catchment should include all the tributaries of the Tern to its junction with the River Severn. However, for the purposes of infrastructure development and enhanced monitoring it was agreed that the focus should lie on the Middle and Upper Tern north of the confluence with the Meese.

1.1.1 Dominant catchment characteristics

The dominant characteristics of the Tern catchment can be summarised as follows:

- Complex geology. The catchment including the Roden spans many differing lithologies from the upper Carboniferous to the lower Jurassic clays.
- The Sherwood Sandstone (Permo-Triassic) aquifer boundaries are predominantly controlled by faulting, which is not well defined, but very complicated.
- Because of faulting, aquifer thicknesses can vary over short distances from 50 m to 200 m.
- Ill delineated and characterised drift (glacial) deposits, including boulder clays and more granular tills, patchily cover parts of the catchment, influencing recharge.
- With the exception of the upper Tern and the Coal Brook the catchment and tributaries are well gauged.
- The catchment can be split into three characteristic domains: (i) Lower Tern, including the Meese (flat dominated by agriculture, some industry); (ii) Middle Tern, including the Platt and the Potsford Brooks (influenced by pumping from the Shropshire Groundwater Scheme, so well gauged, well investigated, many observation boreholes, good monitoring network, historic and current soil moisture network); (iii) Upper Tern (river corridor springs and seeps, natural ecology and geomorphology, wetlands).

- The Coal Brook is influenced by runoff and soil erosion from the upper Carboniferous mudstones (Keele Beds) with apparent indirect recharge.
- Overbank flooding in the Stoke on Tern to Wolleston area provides the opportunity to monitor the effects on recharge to the Sherwood Sandstone and complex groundwater/surface water interactions.
- Comparative studies are possible comparing a natural (upper Tern) subcatchment with a degraded (pumped) subcatchment (Platt/Potsford Brook).
- There is considerable scope for building on the Environment Agency's infrastructure in the Middle Tern and for joining collaboratively to install new infrastructure.
- Appropriate sites for studies of surface water/groundwater interaction were found in the upper Tern and by extension/development of EA sites in the Potsford Brook.
- The lowest gauge on the Tern is below the confluence with the Roden.
- The catchment is intensively agricultural with land uses including woodland, grassland, root crops, vegetables. Spray irrigation is in widespread use and will have hydrological, water resources and water quality implications
- Industry (dairy, sugar beet factory) is present in the lower catchment with the attendant possibility of pollution and water quality degradation

1.2 BUDGET AND ADMINISTRATION

As noted above, the Pang Lambourn catchment was one of three in which infrastructure was installed. Given the scale of the whole of the LOCAR infrastructure installation (i.e. hydrological, hydrogeological and ecological), it is worth recording the budgetary constraints and the administrative framework within which it was carried out.

The thematic programme had an allocation of £7.75M with the addition of an approved JIF (Joint Infrastructure Fund) bid for £2M for equipment and infrastructure funding for the LOCAR catchments.

The approved JIF-LOCAR funding for all three catchments was initially earmarked approximately as follows:

Hydrogeological (saturated zone) - £1M

Hydrological - £0.66M

Ecological - £0.34M

It was recognised that the JIF funding alone would be insufficient for the required LOCAR baseline infrastructure and equipment requirements. These were estimated at £5M, indicating a further £3M from LOCAR would be necessary.

At the first meeting of the NERC LOCAR Steering Committee held on 29 July 1999, the requirement for LOCAR Thematic funding to support the JIF money was recognised. Also recognised was the separate, but parallel, responsibilities and financial accountability of the JIF consortium and its contractors to the two funding agencies relating to the experimental design, installation and management of the baseline monitoring equipment.

A first draft report produce by the Task Force was discussed at a meeting of the TEG on 20 December 1999. In responding to discussion and feed-back from the TEG, amended proposals were presented for discussion by the TEG on 28 January 2000. Further adjustments to proposals were made as a result of these discussions. The finally agreed proposals were presented in the Task Force Report entitled "Proposals for the Infrastructure and Monitoring on the LOCAR Catchments" dated February 2000. Although the Task Force report was only intended as a working document for the design and installation of the LOCAR infrastructure, it has subsequently been made more widely available (Peach et al. 2004) as a reference document for those requiring information about the design of the whole LOCAR infrastructure.

From the Task Force report it can be seen that the new infrastructure was designed as an integrated whole. The Task Force, in discussion with the TEG, had to design the experimental facilities prior to the award of research grants. Whilst it may be argued that the research grants should have been awarded first so that the Principal Investigators (PIs) could have been directly involved in the specification of the research facilities, it was decided that this would not be done for two reasons:

1. The TEG included representatives from a significant part of the research community.
2. To await the award of research grants would have delayed the onset of the field programme and thus the initiation of collection of additional baseline data and would have added to the overall costs through loss of a summer field season.

Unfortunately the field installation programme was significantly delayed by the outbreak of Foot and Mouth in the UK in 2001-2002.

This report describes only the hydrogeological structure installed within the Tern catchment. There are separate reports for the hydrogeological infrastructure in the Frome/Piddle (Adams et al 2003b) and the Pang/Lambourn (Adams et al 2003a) catchments.

2 Design of the hydrogeological infrastructure

2.1 INTRODUCTION

The purpose of this section is to provide the rationale behind the design of the hydrogeological infrastructure for the LOCAR catchments. Inevitably a number of changes were made to the initial design during the installation for a variety of reasons such as: unforeseen ground conditions; overspend at some sites requiring cutbacks in expenditure at others; revision of overall budgets during the installation phase.

The Task Force identified a number of specific tasks or topics that influenced the design of the hydrogeological monitoring network and instrumentation. These may be summarised as follows: -

- Flow and transport in Triassic Sandstone (and the Chalk in the case of the Frome/Piddle and Pang/Lambourn catchments) aquifer are poorly understood and the relationships between flow and transport properties at different scales (i.e. pore scale, borehole scale and catchment scale) need elucidating.
- Aquifer heterogeneity is a dominant influence on contaminant transport and is not yet adequately characterised. The role of fracture flow in the Chalk and sandstones need particular attention.
- The role of drift deposits in influencing recharge and pollution pathways needs investigation.
- Chemical interactions need an understanding of pore and fracture scale processes (including heterogeneity and scaling properties). The role of, and constraints on, microbial degradation, and hence the scope for natural attenuation of pollutants, require investigation.
- The spatial functioning of the surface water system must be mapped onto an understanding of surface water-groundwater interactions.
- Annual variability in groundwater input into streams is likely to have major ecological impacts and may be strongly influenced by groundwater management. These relationships need investigation.
- Integrated modelling should include improved representation of the interaction between surface and groundwater in terms of both flow and quality, the transfer of pollutants, the impact of land use management change, the linkage of ecological responses to changes in the hydrological regime, catchment management strategies and climate variability.

2.2 AIMS OF THE MONITORING NETWORK AND FACTORS AFFECTING ITS DESIGN

The Task Force identified four principal aims for the hydrogeological component of the LOCAR monitoring networks, namely: -

(i) To provide information on appropriate groundwater parameters to enable a consistent (balanced) model of groundwater flow in each catchment to be constructed.

(ii) To provide instrumentation to enable investigation of groundwater processes, including:

- 3-D flow and transport processes as a function of time and place within each catchment.
- Scale dependence of flow and transport processes.
- Aquifer heterogeneity and its role in contaminant dispersion.
- Flow and transport in fractured aquifers.
- Reactive transport from the scale of pores and fractures to the catchment scale.
- Surface water-groundwater interactions.
- Ecological impacts of groundwater processes and groundwater management.

(iii) To ensure that the hydrogeological monitoring network is fully integrated with other catchment monitoring networks.

(iv) To establish hydrogeological monitoring networks and instrumentation within the budget and timeframe of the LOCAR Programme.

2.3 THE OPTIONS FOR LOCAR HYDROGEOLOGICAL MONITORING STRATEGIES

The aims of the LOCAR research programme constrained the options available for the groundwater monitoring network. If the establishment of hydrogeological instrumentation was to be based on research monitoring objectives, it was important to ensure that the monitoring infrastructure was suitable and addressed the research aims of LOCAR – the reasons for designing and installing the infrastructure prior to the definition of the research projects have already been noted in section 1.2. The following sections indicate the rationale used in attempting to link LOCAR research aims with the type of groundwater monitoring instrumentation required.

2.3.1 Implications for instrumentation

DEFINITION OF GROUNDWATER CATCHMENT BOUNDARIES

Instrumentation needs

- Piezometers and boreholes either side of groundwater divides, at various locations around the margins of the groundwater catchments sufficient to define the groundwater divides.
- Nested piezometers should be used to characterize sub-vertical head gradients throughout the full thickness of the zone of 'active' groundwater circulation either side of the divide.
- Boreholes may be needed to characterize the geological controls on interfluve hydrogeology (e.g. geophysical logs including borehole imaging, flow logs and core analysis)
- Monitoring frequency should be consistent with other data sets used to establish the groundwater balance, e.g. rainfall, surface water and unsaturated zone data. It should also be adequate to provide information on recharge events as well as seasonal variations in the groundwater divides (see section below on recharge processes in the interfluve areas).

- Information on existing boreholes should be used where possible, however, purpose built piezometer arrays would be preferable.
- Consideration should also be given to piezometer arrays to investigate the effects of cover on the position of the groundwater divides.

Linkages to LOCAR research aims

- Integrated modelling of the interaction between groundwater and surface water to produce a water balance at catchment scale.
- Investigation of key hydrogeological processes controlling the movement of groundwater in lowland catchments, including recharge.
- The role of drift deposits in influencing recharge pathways.

RECHARGE PROCESSES IN THE INTERFLUVE AREAS

Instrumentation needs

- Piezometer arrays at representative locations within the catchments (i.e. on interfluves, slopes and valley bottoms), sufficient to characterize the recharge processes.
- The piezometer arrays should be located (i) at sites that have also been instrumented to study the unsaturated zone (matric potential and flow in fractures), and (ii) could use piezometer arrays and/or boreholes that have been developed to define groundwater catchment boundaries (see above).
- The piezometer arrays should provide good vertical head definition through the entire ‘active’ zone of the aquifer.
- Ideally the piezometer array should be associated with a well-characterized borehole to enable geological controls on recharge to be investigated.
- Sites may be chosen specifically to target recharge through drift deposits or associated with perched aquifers.

Linkages to LOCAR research aims

- Investigation of the key hydrogeological processes controlling the movement of groundwater in lowland catchments.
- Investigation of the role of drift deposits in influencing recharge and pollution pathways.
- Investigation of the role of fracture flow.
- Contributing to a better understanding of surface water-groundwater interactions.

3-D DEFINITION OF FLOW ACROSS THE CATCHMENT

Instrumentation needs

- At least three piezometer arrays, penetrating the full thickness of the ‘active’ aquifer, aligned down the hydraulic gradient to characterize the 3-D head distribution. These arrays should ideally be located across a relatively steep section of the hydraulic gradient.

- Cored boreholes should be associated with each piezometric array to provide geological control on the hydrogeology. At one site multiple cored boreholes (vertical and possibly inclined boreholes in fractured sections) should be developed to enable hydraulic and geophysical tests to sample the 2-D and 3-D structure of the aquifer using techniques such as cross-borehole tomography and tracer tests.
- The cored boreholes should be analysed to characterise the matrix and fracture properties of the aquifer to enhance interpretation of the borehole tests.
- The borehole sites may not necessarily need to be co-ordinated with other components of the catchment monitoring network, however, it would be helpful and probably cheaper if the piezometer arrays were located at sites that were also being used for surface water and particularly unsaturated zone monitoring. For example, sites used for studying recharge could also be used in a piezometer transect looking at the 3-D definition of flow.

Linkages to LOCAR research aims

- Investigation of key hydrogeological processes controlling the movement of groundwater in lowland catchments.
- Enhanced mathematical hydrogeological models of catchments.
- Investigation of flow and transport, particularly transport properties at different scales, i.e. pore scale, borehole scale and catchment scale.
- Investigation of aquifer heterogeneity and the role of fracture flow.
- Investigation of chemical interactions and the role of microbial degradation during 3-D flow.
- Investigation of interannual variability in groundwater input into streams.

CHARACTERIZATION OF FRACTURE FLOW

Instrumentation needs

- Development of boreholes on interfluves, within the catchment, and at groundwater discharge points that enable study of the variation in fracturing with depth and across the catchment. The interfluve boreholes should ideally be associated with unsaturated zone monitoring sites to enable the study of recharge through fractures.
- These boreholes will require detailed fracture logging (borehole imaging and core logging), flow logging and hydraulic testing.
- These sites may not necessarily need to be co-ordinated with other components of the catchment monitoring network; however, they may also be used in other studies such as the definition of groundwater catchment boundaries, the 3-D definition of flow, aquifer heterogeneity and groundwater – surface water interactions.

Linkages to LOCAR research aims

- Investigation of key hydrogeological processes controlling the movement of groundwater in lowland catchments.
- Investigation of the role of fracture flow.
- Investigation of flow and transport, particularly transport properties at different scales, i.e. pore scale, borehole scale and catchment scale.

- Investigation of the role of fractures in recharge pathways.
- Enhanced mathematical hydrogeological models of catchments.

AQUIFER HETEROGENEITY AND SCALING EFFECTS

Instrumentation needs

- Fully cored boreholes that intersect the maximum possible thickness of the aquifer to enable the full core characterisation of the matrix.
- Geophysical (borehole imaging) logs, flow logs, and packer tests should be undertaken to characterise the distribution of hydraulically significant fractures.
- Boreholes developed for the characterisation of fracture flow could also be used for the study of aquifer heterogeneity and scaling effects.

Linkages to LOCAR research aims

- Investigation of key hydrogeological processes controlling the movement of groundwater in lowland catchments.
- Investigation of the role of fracture flow.
- Investigation of flow and transport, particularly transport properties at different scales, i.e. pore scale, borehole scale and catchment scale.
- Enhanced mathematical hydrogeological models of catchments.

GROUNDWATER – SURFACE WATER INTERACTION NEAR DISCHARGE POINTS

Instrumentation needs

- Piezometer arrays adjacent to groundwater discharge sites through the full depth of the 'active' zone of the aquifer and within inclined boreholes beneath rivers should be developed to investigate groundwater - surface water interactions.
- The selected groundwater monitoring sites must be consistent with surface water, unsaturated zone and ecological monitoring sites.
- The piezometer arrays and boreholes should be capable of monitoring seasonal variations in head distributions, flow characteristics, storage, water chemistry, and microbiology as well as being amenable to use in monitoring very short term events.
- Boreholes should provide direct and indirect information on geological controls on the hydrogeology (borehole logging, including borehole imaging, and core analysis)
- Instrumentation should have minimum impact on the natural hydrogeological regime.
- There is scope to use piezometer arrays developed to study groundwater – surface water processes to also study 3-D definition of flow across the catchment and fracture flow.

Linkages to LOCAR research aims

- Study of the key physical, chemical and biological processes operating within the valley floor corridor that affect surface water and groundwater.
- Investigation of how varying flow regimes control in-stream, riparian and wetland habitats.

- Study of how land use management impacts on lowland catchment hydrology, including both water quantity and quality.
- Investigation of how the hydrological, hydrogeological, geomorphological and ecological interactions resulting from natural or anthropogenic changes can be predicted using integrated mathematical models.
- Investigation of the spatial functioning of the surface water system.
- Investigation of interannual variability in groundwater input into streams and their likely ecological impacts.
- Integrated modelling of the interaction between surface and groundwater in terms of both flow and quality, linkage of ecological responses to changes in the hydrological regime, catchment management strategies and climate variability.

2.4 EXISTING HYDROGEOLOGICAL INFRASTRUCTURE WITHIN THE TERN CATCHMENT

2.4.1 Geology

The last full field-based survey of much of the catchment was carried out 30-75 years ago. Much new information has become available since then (not least as a result of the Shropshire Groundwater investigation) and advances in geosciences have increased the understanding of both bedrock and superficial deposits in the region. Geological map coverage was complete at 1:10K or 6 inch to one mile scale and at 1:50K and 1 inch to one mile scale, but of variable vintage as indicated in Table 2.1.

Table 2.1 Geological sheet coverage of LOCAR catchment area.

Nantwich 122 1967 (1 inch)	Stoke-on-Trent 123 1994 (1:50K)
Wem 138 1924 (1 inch)	Stafford 139 1927 (1 inch)
Shrewsbury 152 1932 (1inch)	Wolverhampton 153 1929 (1 inch)

At the time of designing the LOCAR infrastructure, revision mapping was planned within the current British Geological Programme for the Stafford sheet (139) starting in 2000/01; the geological database for the Nantwich, Wem and Shrewsbury sheets was deemed to be relatively satisfactory at the last major review in 1989. Since that time a considerable amount of work had been carried out for the Cheshire Basin Project and new borehole and other data had been acquired that indicated revision was required to the geological model presented by the latter three maps. This work fell within the remit of the BGS' Continuous Revision and

Data Acquisition Project. However, no work was currently planned for the Wolverhampton sheet during the initial phases of the LOCAR programme.

2.4.2 Groundwater level monitoring network

The Environment Agency's existing groundwater level monitoring network as at the time of designing the LOCAR infrastructure is indicated in Figure 2.1, only a selected number of boreholes are shown as to include all the boreholes on this scale map would have been counter productive. This extensive network had been developed within the Shropshire groundwater scheme and consequently is concentrated in the central area of the Tern catchment area and is somewhat deficient in the northern and eastern parts of the aquifer.

2.4.3 Groundwater quality monitoring network

The Environment Agency's existing groundwater quality monitoring network is shown in Figure 2.2 .

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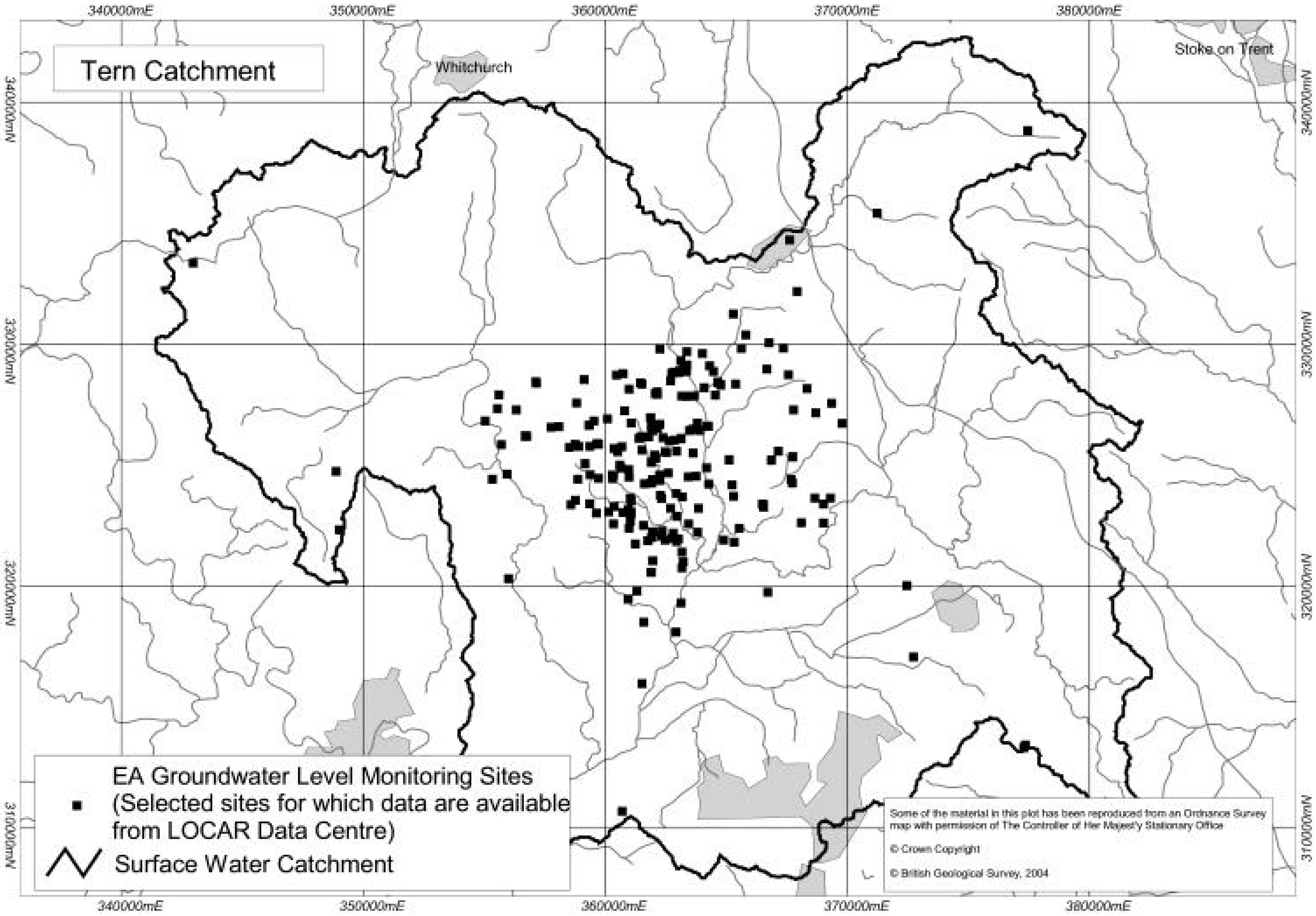

Figure 2.1 The Environment Agency's groundwater level monitoring network in the Tern catchment.

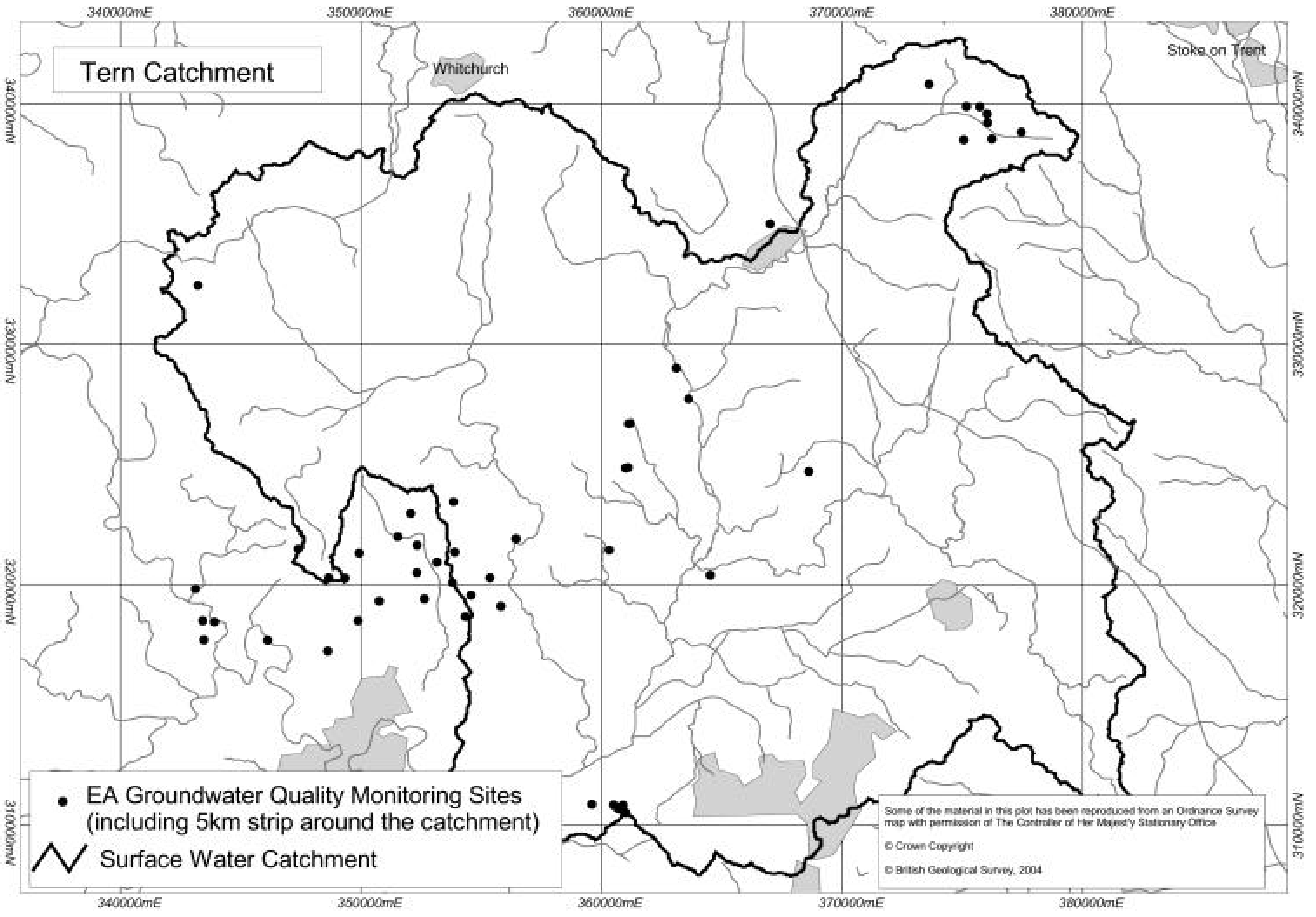

Figure 2.2 The Environment Agency's groundwater level monitoring network in the Tern catchment

2.5 HYDROGEOLOGICAL BASELINE REQUIREMENTS

2.5.1 Introduction

The baseline data requirements required to characterise the catchments for the LOCAR thematic programme were classified into two groups; Time independent data sets and time series monitoring. The time independent data sets are those which are not expected to change frequently with time and include: geology, digital terrain model, river bed levels, borehole datum levels and locations, Ordnance Survey coverage and aquifer parameters. Time series monitoring requirements will include groundwater levels and groundwater quality.

2.5.2 Time independent data sets

As noted earlier, no significant geological mapping has been carried out in this area for the last 30 or more years. Since that time various advances in geological knowledge indicate that significant revision of the geological model was now required; not least for the Drift deposits which overlie parts of the aquifer. This formed an essential component of LOCAR baseline information.

2.5.3 Time series monitoring

Ambient monitoring should potentially be met through the existing networks. However, deficiencies in the groundwater level monitoring network away from the central part of the aquifer have already been noted. Thus additional holes were required in these areas. With regard to groundwater quality measurements, it is recognised by the Environment Agency that their network measurements are not generally carried out to a research standard. Thus monthly groundwater sampling and analysis (at research standard) from a number boreholes throughout the catchment area was required.

2.5.4 Borehole network design considerations

An important factor in the design of the additional network was that the boreholes (both individually and jointly) would significantly assist in understanding the hydrogeology of the Tern catchment. The number of boreholes (of differing designs for different collective objectives) was constrained by a number of factors, some of which could not be evaluated within the TOR of the Task Force (e.g. access). However, the following recommendations were provided, while recognising that such constraints might limit their application:

- As many as possible of all new boreholes and piezometers were to be multi-objective.
- All pilot holes and boreholes to be geophysically logged including detailed fracture logging (borehole imaging and core logging), flow logging.
- The recharge effect of flood events required investigation through monitoring two specially constructed shallow boreholes.
- Surface water/groundwater interaction should be investigated at two sites within the catchment. One would be a new facility. The other would be a development of an existing Shropshire Groundwater Scheme site.
- A single deep borehole was needed to prove the Permo-Triassic sequence at the northern end of the catchment.
- The importance of runoff from the Carboniferous outcrop on recharge to the Permo-Triassic aquifer needed to be evaluated.

- A minimum of four new boreholes were required to augment the existing groundwater monitoring network, particularly in the upper reaches of the Tern and to the south-east of the River Meese. Additional provision of data loggers in existing boreholes should also be considered.
- The structural boundaries of the aquifer needed to be investigated. It was thought that this could be achieved through investigation of existing boreholes in the viscinity of a major fault.
- A minimum of two shallow boreholes were required to investigate the nature and thickness of the Drift cover.

3 The infrastructure as implemented

3.1 INFRASTRUCTURE INSTALLATION

The implementation of the LOCAR infrastructure was fraught with problems due to the scale of the exercise and the lack of appreciation of the time taken to establish land agreements. Naturally associated costs also escalated. Notwithstanding these issues, the outbreak of Foot and Mouth disease caused up to sixth months delay in some cases. At some sites unforeseen ground conditions caused additional delays. It should be noted that as BGS staff were involved in drilling supervision, core description, core sampling and field analysis in all three catchments, delays in the drilling programme in either of the other two catchments had implications for the field programme in the Tern.

3.2 GEOLOGY

As a result of the revision mapping of the Tern catchment that was carried out, the following outputs are now available through the LOCAR data centre:

- Revised digital geological map at a scale of 1:50,000.
- Technical report for the catchment area (Bridge et al 2002) covering 3 major topic areas:
    - structure of the Permo-Triassic aquifer system,
    - description of the Permo-Triassic formations, and
    - characterisation of the superficial deposits.

In terms of the regional geological setting, the Permo-Triassic rocks of the Tern catchment are preserved in a series of north-east – south-west trending half-grabens. Synsedimentary movement on the major faults that define these structures (e.g. Wern Fault, Hodnet Fault) was a major control on deposition and is reflected in the marked thickness variations exhibited by the formations that constitute the lower parts of the aquifer (Bridgnorth Sandstone, Kinnerton Sandstone). Facies variations and unconformities within the sequence are only partially resolved and, in the west of the area, there are clear discrepancies between the geology at outcrop and the interpretations based on the seismic reflection data.

A review of shallow boreholes enabled a complicated Quaternary sequence to be simplified into ten basic Quaternary domains. These domains were distinguished on the basis of their principal surface lithology (sand or clay), and on the total contribution such deposits make to the overall drift sequence. The resulting domain map adds a third dimension to the conventional drift map.

3.3 SURFACE GEOPHYSICAL SURVEYS

In a bid to obtain as much information as possible to allow efficient planning and design of the drilling programme, a contract was let to TerraDat (UK) Ltd. to carry out surface geophysical surveys at selected sites. Table 3.1 shows the geophysical techniques applied at selected sites in the Tern catchment which provide data sets to supplement the borehole information at these sites. The results of these surveys are contained in the TerraDat report (TerraDat December 2002).

Table 3.1 Surface geophysical techniques applied at selected sites in the Tern catchment

Site Code	Site Name	Techniques
T11A	Helshaw Grange	Resistivity Tomography
T21A	Stoke on Tern	Resistivity Tomography
T21B	Stoke on Tern	Resistivity Tomography
T13	Lower Coalbrook	Resistivity Tomography
		Ground Conductivity – EM
T14	Mid Coalbrook	Resistivity Tomography
T16	Norton in Hales	Resistivity Tomography
		Ground Conductivity – EM

3.4 DRILLING PROGRAMME

A framework-drilling contract was established with 6 drilling companies for drilling activities in the three LOCAR catchments. As can be seen from Table 3.2, DrilCorp carried out the all of the drilling in the Tern catchment.

Table 3.2 LOCAR drilling schedule for the Tern catchment

START DATE	END DATE	DRILLING COMPANY	SITES DRILLED (chronologically within package)	
19 March 2002	9 May 2002	DrilCorp	T04	Old Springs Farm
			T13	Lower Coal Brook
			T14	Mid Coal Brook
			T17	Oakley Folly
			T21	Stoke-on-Tern
			T16	Norton-in-Hales
29 July 2002	9 October 2002	DrilCorp	T11	Helshaw Grange
			T08	Helshaw Grange
			T06	Wood Farm
			T07	Crudgington
			T18	Childs Ercall
			T01	Sambrook
			T15	Bearstone

Figure 3.1 is a map showing the locations of the component parts of the hydrogeological infrastructure installed in the Tern catchment which consists of a total of 24 boreholes. Table 3.3 shows the completion details of each hole. The majority boreholes have been equipped with MiniTroll pressure transducers/loggers to enable the monitoring of variation of groundwater heads with time at depths as shown in the table. The table also indicates piezometer diameters and approximate summer water levels; these data enable selection of appropriate equipment for the collection of groundwater samples.

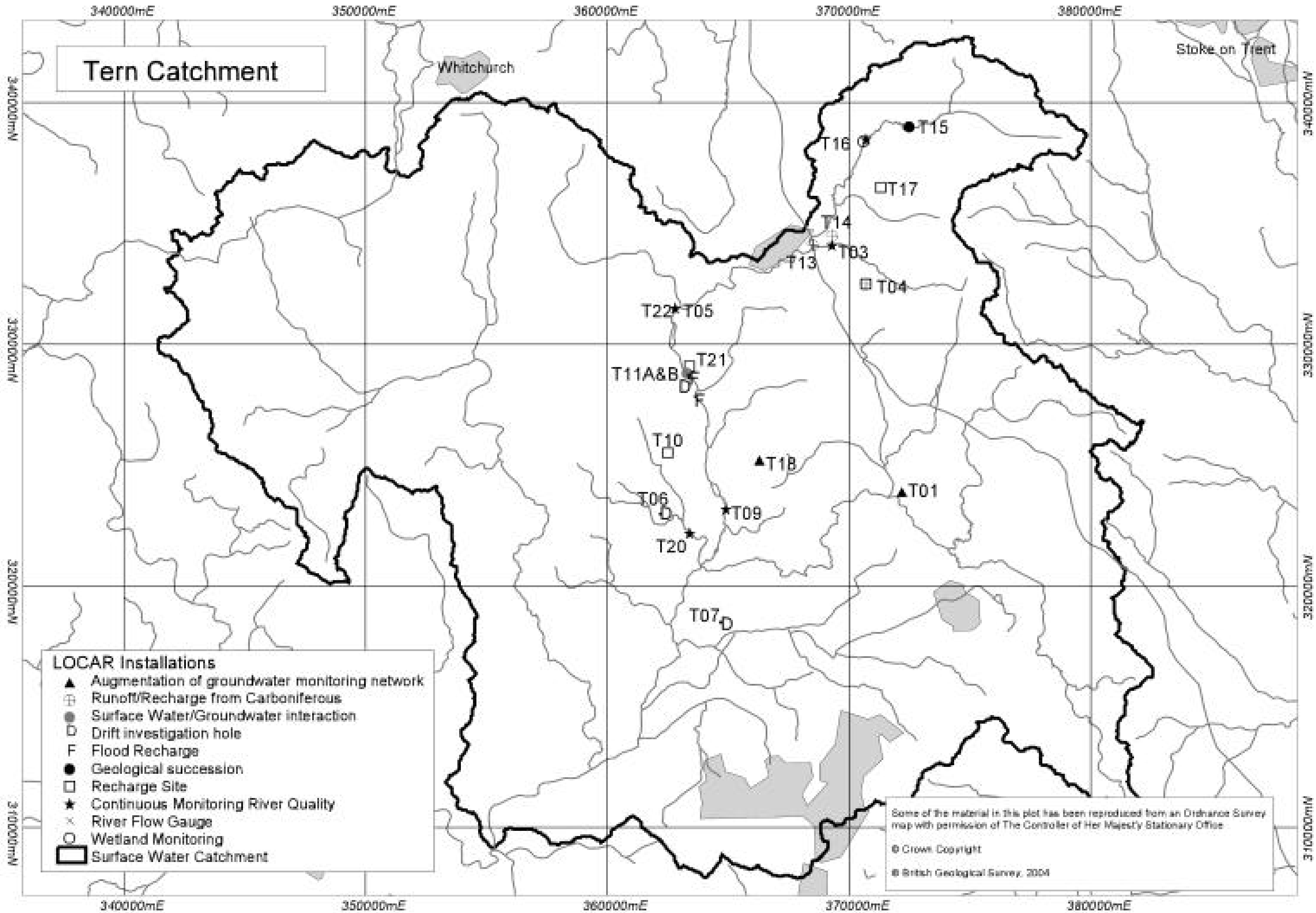

Figure 3.1 Location of the LOCAR infrastructure installed in the Tern catchment.

As noted previously, it was not possible to implement all the Task Force proposals for the hydrogeological infrastructure. At an early stage, the LOCAR capital infrastructure budget was reduced by £400,000, the main part of which came from the provision for hydrogeological infrastructure. Additionally unforeseen ground conditions led to increased drilling costs at some sites requiring cut backs elsewhere in the drilling programme, and access agreements could not be achieved at all planned drill sites.

Selected boreholes were cored during drilling. Each core was hydrogeologically and geologically described (logged) and samples then collected for porewater extraction (by centrifuge) and subsequent chemical analysis and adjacent samples collected for physical property analysis. Following description and sampling the cores were stored in the BGS national core store facility at Keyworth and are available for inspection by the LOCAR community. At some boreholes where cores were not collected, samples were collected from drill returns and these are available for inspection at the core store in Keyworth. Table 3.4 is an inventory of the material available from the Tern catchment at the BGS core store.

Site completion reports were written for each LOCAR infrastructure site and these are held by the LOCAR Data Centre (see chapter 4). These reports are laid out in a consistent manner for each site (see Appendix 1) and reference should be made to these reports for the detail of the installation and for the data collected as part of the installation process (see chapter 4).

Table 3.3 Borehole completion details

Borehole ID	Piezometer ID	Total Depth BGL (m)	Casing Details Top magl	ID mm	OD mm	Material	MiniTroll Depth m	Response zone	RWL mbgl Note 3 below	Comments
T01a			0.4	200		steel				
	T01a-1	90.9			90	plastic	80	84-93.8	c3	
	T01a-2	58	0	200		open hole	20	6.8-58	c3	Annulus
T04a		***26.7***	***0***	***148***		***steel***	***24.8***	***4.5-26.7***	***c20***	***open hole***
T06a		8	0	200		open hole				
	T06a-1	***8***			***90***	***plastic***	***6***	***6.8-8.0***	***c5***	
T07a		15.5	0	200		open hole				
	T07a-1	15.5			90	plastic	10.5	14.3-15.5	c7	
T08a		25	0.6							
	T08a-1	25			90	plastic	23	22-25	c2	
	T08a-2	3			90	plastic	?	1.5-4.5	c3	
T10a									c3	
T11Aa		50.8	0.6	355		steel	none	9.5-50.8	c2	open hole
T11Ab		22.4	0.6	200	250	steel				
	T11Ab-1	21.8			90	plastic	19	19.1-22.4	c2	
	T11Ab-2	2.7			90	plastic	2	wt-2.7	c2	
T11Ac		23.8	0.6	200	250	steel				
	T11Ac-1	***23.8***			***90***	***plastic***	***22***	***21.1-23.8***	***c2***	
	T11Ac-2	***3.5***			***90***	***plastic***	***2.5***	***wt-3.5***	***c2***	
T11Ad		23	0.6							
	T11Ad-1	23			90	plastic	20	20.3-23	c2	
	T11Ad-2	3.5			90	plastic	3	2.45-3.55	c2	
T11Ba	T11Ba-1	?		?	?	?	40		c6	Note 1 below
T11Bb	T11Bb-1	?		?	?	?	30		c5	*Note 2 below*
T13a		***30***	***0***	***150***		***steel***	***25.9***	***19.2-30***	***c5***	***open hole***
T14a										Abandoned
T14b	***T14b-1***	***64.5***	***0***	***75***		***plastic***	***54.3***	***62-64.5***	***c2***	
T14c	***T14c-1***	***30***	***0***	***75***		***plastic***	***26***	***28-30***	***c3***	
T14d	***T14d-1***	***8.6***	***0***	***75***		***plastic***	***4.6***	***7-8.6***	***c3***	
T15a		138.7	0.6	200		steel				
	T15a-1	138			90		100	132-138.7	c15	
	T15a-2	90		200		open hole	35	6.7-90	c15	Annulus
T16a	T16a-1	20	0.6	75		plastic	15	18.5-20	c1	
T16b	T16b-1	10	0.5	75		plastic	6	8.5-10	c1	
T16c	T16c-1	4	0.5	75		plastic	3.5	2.8-4	c1	
T17a		***24.7***	***0***	***152***		***steel***	***20.4***	***6.7-24.7***	***c1***	***open hole***
T18a		42	0.6	200						
	T18a-1	***42***			***90***	***plastic***	***25***	***36-42***	***c5***	
	T18a-2	***27***		***150***		***open hole***	***15***	***19.5-27***	***c5***	***Annulus***
T21a										Abandoned
T21b		26	0.6	200		steel				
	T21b-1	***25.8***		***75***		***plastic***	***22***	***24.5-26***	***c2***	
	T21b-2	***5***		***75***		***plastic***	***3.5***	***3.8-5.2***	***c2***	
T21c		25	0.6	200		steel				
	T21c-1	24.5		75		plastic	20.7	23.8-25	c2	
	T21c-2	5		75		plastic	5.1	3.8-5.2	c2	

Note 1: T11Ba is an existing EA borehole 20m away from the recharge site.

Note 2: T11Bb is an existing EA borehole 100m awy from the recharge site.

Note 3: Rest water levels are given only as an order of magnitude to help decide on sampling protocols.

Note 4: Sites listed in ***bold and italics*** are those proposed for monthly collection of groundwater quality samples – see section.

Table 3.4 Inventory of material from the LOCAR boreholes in the Tern catchment held at the BGS core-store facility, Keyworth.

Borehole	Quarter Sheet No.	SOBI No	Material Type	Top Depth	Bottom Depth
T4A OLD SPRINGS FARM	SJ37SW	18	DLCR	0	6.6
T4A OLD SPRINGS FARM	SJ37SW	18	DLCR	6.6	26.7
T6A WOOD FARM	SJ62SW	131	UWCT		
T7A CRUDGINGTON	SJ61NW	67	UWCT		
T11A HELSHAW GRANGE	SJ62NW	210	DLCR	10.3	22.2
T11A HELSHAW GRANGE	SJ62NW	210	DLCR	23.8	50.8
T14A(abandoned hole)			DCCR		
T14B MID COAL BROOK	SJ63SE	92	DLCR	2.9	30.7
T14B MID COAL BROOK	SJ63SE	92	DLCR	30.7	62
T15A BEARSTONE	SJ73NW	36	DLCR	8.2	48.3
T15A BEARSTONE	SJ73NW	36	DLCR	48.3	106.5
T15A BEARSTONE	SJ73NW	36	DLCR	106.5	138.7
T17A DOWN FARM	SJ73NW	101	DLCR	0.6	57.7
T17A DOWN FARM	SJ73NW	101	DLCR	57.7	82.8
T18A CHILDS ERCALL	SJ62NE	80	DLCR	8.9	33.1
T18A CHILDS ERCALL	SJ62NE	80	BULK	39	41
T18A CHILDS ERCALL	SJ62NE	80	DLCR	41	42

Key to Material Type:		
	CRSM	Core Samples
	DLCR	Drill Core (continuous)
	DCCR	Drill Core (discontinuous)
	UWCT	Unwashed cuttings

3.5 DOWNHOLE GEOPHYSICAL LOGGING

Geophysical logging in the Tern catchment was carried out under a framework contract established with European Geophysical Services. Where possible, the majority of holes were geophysically logged prior to completion. Thus, the field printouts of the geophysical logs were used to design the final completion of the individual holes – this was particularly important in those holes that had multi-piezometer installations. Table 3.5 shows which fluid logs were run at each site in the Tern catchment while

Table 3.6 shows the formation logs run.

3.6 CORE DESCRIPTION AND ANALYSES

Eight holes (T4A, T6A, T7A, T11A, T14B, T15A, T17A and T18A) were cored during drilling which enabled hydrogeological and geological logs of the cores to be written and pore water samples and plug samples for physical properties analysis to be collected

3.7 RESEARCH FACILITIY SITES

3.7.1 Augmentation of existing groundwater monitoring network

Boreholes T1 and T18 were located in cooperation with the Environment Agency to augment their existing groundwater observation network. Their locations are shown in Figure 3.1 and their completion details given in Table 3.3.

3.7.2 Runoff/recharge from the Carboniferous to the Permo-Triassic aquifer

Boreholes at T4, T13 and T14 (see Figure 3.1) provide the opportunity to investigate groundwater/surface water interactions within the Coal Brook. The Coal Brook rises on Carboniferous rocks and flows north-westwards onto the Pero-Triassic aquifer joining the Tern immediately east of Market Drayton. T4 is located on the Carboniferous, while boreholes at T14 and T13 are located downstream on the Permo-Triassic. At site T14 three boreholes (TY14b, T14c and T14d) were drilled adjacent to each other at differing depths (64.5m, 30m and 8.6m respectively) to allow the determination of groundwater head variation at this site. Completion details of all these boreholes are given in Table 3.3. The flow in the Coal Brook is monitored at Market Drayton by a LOCAR hydrological infrastructure flow gauge (site T03).

3.7.3 Drift investigation holes

Boreholes T6, T7 and T8 were drilled to provide detailed information on the drift cover, their locations are shown in Figure 3.1 and completion details are given in table Table 3.3.

3.7.4 Surface water groundwater interaction

Site T11A has been designed to permit the investigation of surface water/groundwater interaction. Figure 3.2 shows the layout of the borehole array which consists of a 51m deep abstraction borehole (T11Aa), and three monitoring boreholes between 24 and 31m deep (T11Ab, T11Ac and T11Ad). Additionally, one of the shallow drift investigation boreholes (T8) is located on the opposite bank of the river and could be used to monitor groundwater levels during any aquifer testing. The completion details of all of these boreholes are given in Table 3.3.

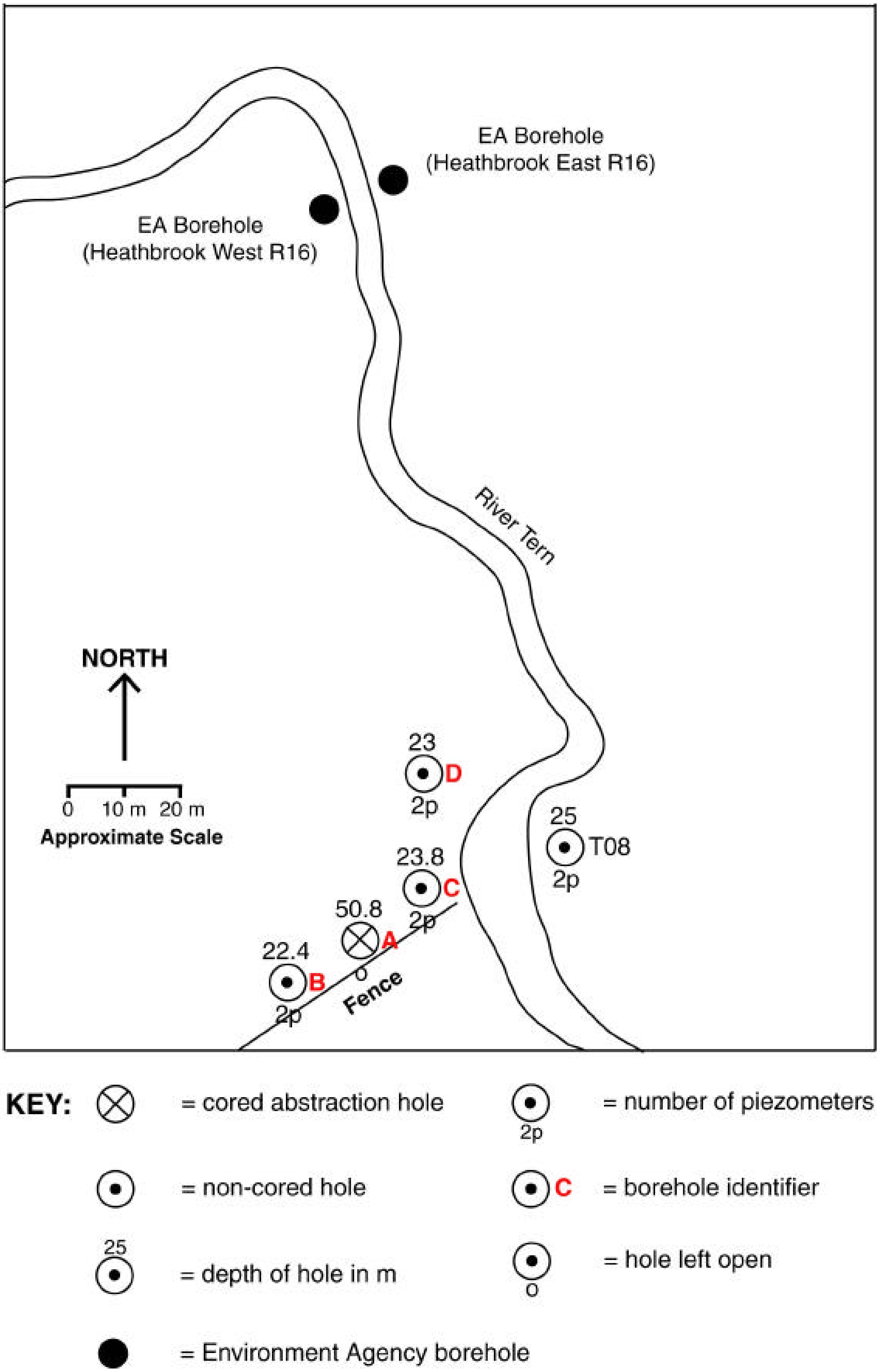

Figure 3.2 LOCAR boreholes drilled at Helshaw Grange, site T11A, in the Tern catchment.

3.7.5 Geological control

Borehole T15 (see Figure 3.1) was drilled and cored to provide detailed information on the Permo-Triassic sequence in the northern part of the catchment. It was drilled on a site owned by North West Water adjacent to an abstraction borehole. Completion details are given in Table 3.3.

3.7.6 Wetland investigation site

Three boreholes were drilled adjacent to each other on the eastern bank of the Tern to the east of Norton in Hales (see Figure 3.1). These holes (T16a, T16b and T16c) were drilled to different depths (20m, 10m and 4m respectively) to allow the determination of groundwater head variations with depth. The completion details for these holes are given in Table 3.3.

3.7.7 Impacts of floods on aquifer recharge

Two shallow boreholes (T21b and T21c) were located on the flood plain of the River Tern near Stoke on Tern (see Figure 3.1) near an outfall of the Shropshire groundwater sheme (SJ 640 280). This is an area that is regularly flooded and the boreholes have been completed with MiniTrolls (see Table 3.3) to record groundwater levels fluctuations in response to flood events.

Table 3.5 Downhole geophysical fluid logs – Tern catchment.

LOCAR Ref.	Borehole Name	Date logged	SWL (mbd)	FLUID LOGGING MEASUREMENTS											COMMENTS
				Fluid TEMP	Fluid EC	Diffntl TEMP	Diffntl EC	Fluid TEMPQ	Fluid ECQ	DiffntlQ	Flowmeter	Flowmeter -Q	Water Quality	Other	
T-01	Sambrook	4-Sep-02	3.2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		Water Quality is TEMP,EC, DO,
T-4	Old Spring Farm	17-Apr-02	17.4	✓	✓	✓	✓	X	X	X	X	X	✓		Water Quality with no pumping only
T-6	Wood Farm Ellerdene Heath	28-Aug-02	?	X	X	X	X	X	X	X	X	X	X		
T-7	Moor Bank Farm, Crudington	28-Aug-02	?	X	X	X	X	X	X	X	X	X	X		
T-08	Helshaw Grange	27-Aug-02	~8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		Water Quality is TEMP,EC, DO,
T-11 ABH	Helshaw Grange ABH	9-Aug-02	~12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		Water quality before and
T-11-P1	Helshaw Grange P1	8-Aug-02	8	✓	✓	✓	✓	X	X	X	✓	X	✓		Water Quality not when pumping
T-11-P2	Helshaw Grange P2	14-Aug-02	~3	✓	✓	✓	✓	X	X	X	✓	X	X		
T-11-P3	Helshaw Grange P3	14-Aug-02	~2	✓	✓	✓	✓	X	X	X	✓	X	X		
T-13	Lower Coal Brook	18-Apr-02	4.5	✓	✓	✓	✓	X	X	X	✓	X	X		
T-14b	Middle Coal Brook	10-Apr-02	2.7	✓	✓	✓	✓	X	X	X	X	X	X		
T-15	Bearstone	26-Sep-02	15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		Water Quality prior to pumping only
T-17	Oakley Folly Farm	25-Apr-02	<1	✓	✓	✓	✓	✓	✓	✓	✓	✓	X		
T-18	Childs Ercall	27-Aug-02	?10	✓	✓	✓	✓	✓	✓	✓	✓	X	X		Flowmeter when pumping only
T-21B	Stoke on Tern	30-Apr-02	2	✓	✓	✓	✓	X	X	X	✓	X	X		

Table 3.6 Downhole geophysical formation logs – Tern catchment.

LOCAR	Borehole Name	Logged	Date	Log	Depth	SWL	Casing	FORMATION LOGGING MEASUREMENTS								
Ref.		by		datum	(mbd)	(mbd)	depth/dia	Caliper	Gamma ray	Resistivity	SP/SPR	Sonic	Neutron	Density	Imaging	Other
T-01	Sambrook	EGS	04-Sep-02	GL	93.8	3.2	0-5.85mbd (8)	✓	✓	16R, 64R,	✓	X	✓	BRD, DNC	opt 2.8-93.6	
T-4	Old Spring Farm	EGS	17-Apr-02	GL	26	17.4	0-4.8m (8)	✓	✓	✓	X	✓	✓	BRD, DNC	opt 4-22m	
T-6	Wood Farm Ellerdene Heath	EGS	28-Aug-02	GL	7	?	0-TD (2 ABS)	X	✓	X	X	X	X		X	
T-7	Moor Bank Farm, Crudington	EGS	28-Aug-02	GL	13.4	?	0-TD (2 ABS)	X	✓	X	X	X	X		X	
T-8	Helshaw Grange	EGS	27-Aug-02	GL	25	~8	0-8.85m (8)	✓	✓	✓	X	✓	✓	BRD, DNC	opt 8-25m	
T-11 ABH	Helshaw Grange ABH	EGS	9-Aug-02	GL	50	~12	0-12m (6)	✓	✓	16R, 64R	X	X	✓	BRD, DNC	opt 12-50.2	
T-11-P1	Helshaw Grange P1	EGS	8-Aug-02	GL	31	8	0-7.9m (10)	✓	✓	16R, 64R	X	✓	✓	BRD, DNC, DPOR	opt 8.4-31m	FWS
T-11-P2	Helshaw Grange P2	EGS	14-Aug-02	GL	24	~3	0-8m (10)	✓	✓	16R, 64R	X	X	✓	BRD, DNC, DPOR	X	CCTV
T-11-P3	Helshaw Grange P3	EGS	14-Aug-02	GL	28	~2	0-8m (8)	✓	✓	16R ,64R	X	X	X	BRD, DNC, DPOR	X	CCTV
T-13	Lower Coal Brook	EGS	18-Apr-02	CT	29	4.5	?0-19m (6)	✓	✓	16R, 64R	X	✓	✓	BRD, DNC, DPOR	opt 19-29.6m	
T-14B	Middle Coal Brook	EGS	10-Apr-02	GL	64	2.7	0-5 (6)	✓	✓	16R, 64R	✓	X	X	X	X	
T-15	Bearstone	EGS	26-Sep-02	GL	139	15	0-4.5m (8)	✓	✓	16R, 64R	✓	✓	✓	DNC, DPOR	opt 4-137.4m	FWS
T-17	Oakley Folly Farm	EGS	25-Apr-02	CT	24	<1	0-6.5m (6)	✓	✓	16R, 64R	X	✓	✓	BRD, DNC, DPOR	opt 6.4-24.2m	
T-18	Childs Ercall	EGS	27-Aug-02	GL	33	?10	0-19.8m (6)	✓	✓	16R, 64R	✓	✓	✓	BRD, DNC, DPOR	X	
T-21B	Stoke on Tern	EGS	30-Apr-02	CT	26	2	0-9m (8)	✓	✓	16R, 64R	X	✓	✓	BRD, DNC	X	

3.7.8 Recharge sites

Sites T4 and T17are located at LOCAR recharge sites which have been installed as part of the LOCAR hydrological infrastructure. The purpose of LOCAR recharge sites is to monitor the movement of water and solutes as they move from the atmosphere, through the vegetation cover, to the land surface and then through the unsaturated zone to the groundwater table. To achieve a representative picture of the behaviour of the catchment as a whole, they are sited on a range of soil types and land use domains and consist of an area of land (of the order of 30 m square) equipped with a variety of instruments including rain gauges, automatic weather stations, neutron probe access tubes, automatic soil water content instruments, equitensiometers, tensiometers, soil water samplers and data loggers. To monitor the impact of the recharge on the water table, each recharge site requires a borehole to allow the measurement of variation in groundwater levels with time. Thus boreholes at these two sites allow collection of this information for their respective recharge sites. There are two other LOCAR recharge sites within the Tern catchment, T10 and T11B. These both use pre-existing Environment Agency boreholes to provide relevant groundwater data.

4 Data

4.1 INTRODUCTION

The LOCAR Steering Committee has delegated responsibility for its data and implementation of its data policies to the Centre for Ecology and Hydrology and the British Geological Survey. They established the LOCAR Data Centre, as part of the National Water Archive to be responsible for all LOCAR data. It is important to distinguish the Data Centre's responsibility for data from actual data custody itself. In some cases data will be physically transferred to the Data Centre, for example, the results of the field programme, while in others, the Data Centre will keep records of where data are held.

The aim of the Data Centre is to create an integrated, quality controlled, quality assured database readily accessible to LOCAR scientists by all appropriate contemporary means and which appears seamless to the outside user.

Data held by the Data Centre can essentially be divided into four groups:

- Existing time independent data sets from other agencies.
- Data collected as part of the LOCAR Infrastructure installation exercise.
- Monitoring data. This includes historic and current data collected by other agencies (e.g. the Environment Agency) and data collected by the relevant Catchment Service Team following installation of the LOCAR infrastructure.
- Data collected as part of individual LOCAR research projects.

The hydrogeological data sets collecting during and/or as a result of the infrastructure installation exercise are discussed below. The storage of and access to these and all LOCAR data sets are governed by the LOCAR data policy which can be found at:

http://www.nerc.ac.uk/funding/thematics/locar/datapolicy.shtml

4.2 DATA SETS

4.2.1 Collected during the infrastructure installation phase

Table 4.1 shows the various data sets collected during the infrastructure installation phase.

4.2.2 Monitoring data

GROUNDWATER HEADS

Table 3-3 shows the depths at which MiniTroll recorders are installed in the Tern infrastructure boreholes. These MiniTrolls were initially set up to record heads at 60-minute intervals and it is intended that they will be downloaded on a monthly basis. However, they are capable of storing up to 30,000 data points and have a reported minimum battery life of 1.5 years.

GROUNDWATER QUALITY

In order to provide regular groundwater quality data from the catchment, budgetary provision has been made for 13 groundwater samples to be collected and analysed on a monthly basis. Recommendations for sample sites have been made and are currently under discussion with the Catchment Service Team (CST) who will be responsible for collecting the samples. The CST are considering the proposed sample collection regime and the amount of time required to complete it. The main factors involved are the time involved in accessing the individual sites with the appropriate sampling equipment and the time required to purge the boreholes/piezometers before a representative sample can be collected. Table 3-3shows those sites proposed for groundwater sample collection.

Table 4.1 Data sets available for LOCAR boreholes in the Tern catchment

	T1A Sambrook	**T4A Old Springs Farm**	**T6A Wood Farm**	**T7A Crudgington**	T8A Helshaw Grange	**T11A Helshaw Grange**	T11B Helshaw Grange	T11C Helshaw Grange	T11D Helshaw Grange	T13A Lower Coal Brook	T14A Mid Coal Brook	**T14B Mid Coal Brook**	T14C Mid Coal Brook	T14D Mid Coal Brook	**T15A Bearstone**	T16A Norton in Hales	T16B Norton in Hales	T16C Norton in Hales	**T17A Oakley Folly**	**T18A Childs Ercall**	T21A Stoke on Tern	T21B Stoke on Tern	T21C Stoke on Tern
Drillers daily sheets	√	Ö	Ö	Ö	√	Ö	√	√	√	√	√	Ö	√	√	Ö	√	√	√	Ö	Ö	√	√	√
Supervisors logs	√	Ö	Ö	Ö	√	Ö	√	√	√	√	√	Ö	√	√	Ö	√	√	√	Ö	Ö	√	√	√
Borehole completion forms	√	Ö	Ö	Ö	√	Ö	√	√	√	√	√	Ö	√	√	Ö	√	√	√	Ö	Ö	√	√	√
Downhole geophysical logs	√	Ö	Ö	Ö	√	Ö	√	√	√	√		Ö			Ö				Ö	Ö		√	
Surface geophysics						Ö	√	√	√	√	√	Ö	√	√		√	√	√			√	√	√
Transducer installation	√	Ö	Ö	Ö	√	Ö	√	√	√	√		Ö	√	√	Ö	√	√	√	Ö	Ö		√	√
Geological core log		Ö	Ö	Ö		Ö						Ö			Ö				Ö	Ö			
Hydrogeological core log		Ö	Ö	Ö		Ö						Ö			Ö				Ö	Ö			
Physical properties analysis		Ö				Ö						Ö			Ö				Ö	Ö			
Pore &/or depth chemical analysis		Ö	Ö	Ö		Ö						Ö			Ö				Ö	Ö			

Bold lettering indicates cored boreholes

5 Equipment

A limited amount of equipment was purchased using LOCAR infrastructure funds to both enable the Catchment Service Teams to collect groundwater samples at regular intervals at selected sites within the catchments and to provide a central pool of specialist equipment for use by researchers within the LOCAR community. The following is a list of that equipment:

- DIPMETERS
  - 3 x 100M dip meters
  - 3 x 8m pocket dip meters
  - 1 x 60m logging dip meter with associated software and connection cable
- MICROPURGE GROUNDWATER SAMPLING EQUIPMENT
  - 1 x Sample Pro Pump Consultants Kit (¼" and ¼" Push In fittings) with controller, hose, hose-reel and portable petrol air compressor.
- WATERRA GROUNDWATER SAMPLING EQUIPMENT
  - 1 x Power Pack PP1/ backpack & SA
  - 3 x hand operated groundwater sampling systems (32mm OD and 21mm ID) with 3 x 60m hose each system and necessary ancillaries.
- ARCHWAY PACKER EQUIPMENT
  - 2 x 88-185mm double packers with ancillary equipment
- GRUNDFOS GROUNDWATER SAMPLING PUMP
  - 1 x MP1 monitoring/sampling pump with 80m cable, generator and power converter.

The dipmeters and groundwater sampling equipment are primarily for use by the Catchment Services Teams (who are also purchasing additional groundwater sampling equipment) and can't be considered as being available to individual research projects. However the packers can be accessed through the Catchment Service Teams and it is recommended that requests for its use are made with as much notice as possible due to the possibility of demands from several researchers at the same time.

6 References

Adams B., Peach D.W., and Bloomfield J.P. 2003(a). The LOCAR hydrogeological infrastructure for the Pang/Lambourn catchment. British Geological Survey Internal Report, IR/03/178.

Adams B., Peach D.W., and Bloomfield J.P. 2003(b). The LOCAR hydrogeological infrastructure for the Frome/Piddle catchment. British Geological Survey Internal Report, IR/03/179.

Bridge D. McC., Humpage A. J., Sheppard H., Lelliott M. and Garcio-Bajo M. 2002. Lowland Catchment Research (LOCAR) geological framework study River Tern catchment, east Shropshire. British Geological Survey, Commissioned Report, CR/02/138.

Peach D.P., Adams B., Hudson J., Leeks G. and Armitage P. 2004. LOCAR/JIF proposals for infrastructure and monitoring on the LOCAR catchments. British Geological Survey Internal Report, CR/04/131N.

TerraDat (UK) Ltd. 2002. Surface geophysical surveys in three British catchment areas – the Frome/Piddle, Tern and Pang/Lambourn. Contribution to Lowland Catchment Research (LOCAR), carried out for NERC.

Appendix 1 Contents of the LOCAR Site Completion files held by the Catchment Service Teams and the LOCAR Data Centre.

1. Site Summary

   This includes a brief site description, a summary of the land agreement and any other relevant information (e.g. name of the landowner and any neighbours who may have an interest in activities on site)

2. Maps & Diagrams

   Details of site layout.

3. Photographs

   Some before and after installation shots.

4. Land Agreement

   A copy of the land agreement between NERC and the landowner.

5. Health and Safety

   Site risk assessment, a copy of the catchment hazard identification matrix (i.e. a table of a range of hazards and sites at which they exist)

6. Specifications

   Specifications of equipment installed at the site.

7. Manuals

   Generally equipment manuals will be held separately by the Catchment Service Teams.

8. Calibration

   Calibration details of installed equipment

9. Variables

   Details of the variables recorded by the installed equipment.

10. Appendices

    Data sets collected during infrastructure installation. Where appropriate will include:

    - Indication of downhole geophysical logs that were carried out
    - Results of the site levelling survey carried out using Trimble GPS RTK equipment.
    - Chemical analyses of water samples collected during drilling.
    - Lithostratigraphical log – the geological description of the core.
    - Indication of any surface geophysical surveys carried out.
    - Borehole completion details.
    - Site Audit sheets summarising casing and piezometer completions and installation depths of MiniTrolls.

- MiniTroll and cable Quality Inspection reports.
- Cross Hole Tomography electrode installation details.
- Description of drilling samples.
- Hydrogeological log of core.
- Physical properties of core samples
- Chemical analyses of pore waters collected from core samples.
- Drillers’ day sheets.