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NATURAL ENVIRONMENT RESEARCH COUNCIL

# The LOCAR Hydrogeological Infrastructure for the Frome/Piddle Catchment

Groundwater Systems and Water Quality Programme

Internal Report IR/03/179



BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/03/179

# The LOCAR Hydrogeological Infrastructure for the Frome/Piddle Catchment

B Adams, D W Peach and J P Bloomfield

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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. 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.

This infrastructure was installed during a field campaign lasting from January until December 2002. 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.

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## Summary

This report describes the hydrogeological infrastructure that was installed in the Frome and Piddle catchments in Dorset to support the **Lowland Catchment Research (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 Frome and Piddle catchments 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 **Lowland Catchment Research (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 FROME/PIDDLE CATCHMENT**

The relative paucity of ecological data in the two lowland catchments first proposed by the LOCAR working group (i.e. the Pang/Lambourn and the Tern) led to the consideration of the Frome catchment. The presence of the Rivers Laboratory of the Institute of Freshwater Ecology within the catchment and the fact that the Frome is the last natural Chalk salmon stream in the UK, and the consequent focus of a considerable amount of ecological research over the last 20 years, resulted in its inclusion as a catchment within the LOCAR programme.

The Frome catchment suffers from a scarcity of groundwater monitoring whereas the Piddle catchment to the north, which is similarly underlain by Chalk and Tertiary deposits, has had considerable attention paid to it in recent years. These studies have been carried out as a result of its designation by the National Rivers Authority (now the Environment Agency) as a river requiring Alleviation of Low Flows (ALF) (Scott Wilson Kirkpatrick, 1993). The Piddle discharges into the Poole Harbour estuary very close to the Frome and appears to provide a good scientific parallel to the Frome in its behaviour. It was, therefore, included with the Frome for the LOCAR programme. In contrast to the Pang/Lambourn Chalk catchments, it is large and demonstrates greater diversity of geology and geomorphology. It incorporates a subcatchment (South Winterbourne) which is similar to the Pang/Lambourn and others of very different physiography, geology and soil cover.

The Frome/Piddle river system is generally noted as being of high amenity value due to its visual, sporting (angling), faunal and floral attractions. This historical situation has been largely due to the maintenance of its rural character, and the lack of industrial development. The naturally high water quality is maintained in a system highly buffered from acidifying influences. There is also a lack of pollution in the sea entry to the catchment through Poole Harbour, which allows migratory fish to enter. The flood plain areas are managed to maintain suitable water levels in riparian meadows and wetland areas. The rivers have therefore remained clean enough to support thriving populations of brown trout and salmon, yet have the habitat characteristics in their lowland reaches to also sustain a healthy population of coarse fish. However, in recent years a number of changes have conspired to move the status of the rivers towards a trophic threshold that, if exceeded, could significantly change the ecology in future.

Generally, the Frome offers opportunities to study many complex and interesting sediment dynamics questions. Sediment transport pathways are likely to show great variety with regard to links between the catchment slopes and channel and, given the scale of the catchment, there are many opportunities for within-channel storage of sediments. The variety in channel form and histories of human intervention (and current abstraction and compensation waters management issues) present interesting linkages between geomorphology, sediment routing and surface/groundwater interaction.

Particular characteristics of the Frome/Piddle are set out below in summary form. These have influenced the infrastructure development and monitoring strategies for the whole three-catchment programme and the particular design of the Frome/Piddle.

### **1.1.1 Dominant catchment characteristics**

The dominant characteristics of the Frome/Piddle catchment can be summarised as follows:

- Complex geology. Flow contributions may be received from Jurassic limestones, Upper Greensand, Chalk, sands of the Tertiary deposits, superficial sands or gravels and clay with flints.

- The solid geology is affected by extensive faulting which is likely to provide controls or constraints on groundwater flow and influences on surface contributions or outflows.
- The interfluvium between the Frome and Piddle shows many karst features on the Tertiary and superficial deposits indicating extensive karst development in the underlying Chalk aquifer.
- Extensive superficial sands and gravels provide the likelihood of large groundwater storage, particularly in the lower catchment.
- Both rivers could be subdivided into hydrological domains, i.e. chalk stream (South Winterbourne), headwater streams with perched water in upper chalk, flood plain areas on gravels, subcatchments with considerable clay cover.
- The Frome is a braided river in parts of the middle and lower reaches.
- The upper Frome and Piddle offer steep slopes through the less permeable Middle and Lower Chalk with hills capped with Upper Chalk.
- There appears to be considerable sediment transport even in the upper reaches of the Frome and Piddle systems.
- Geomorphological/ecological interest can be found in the middle to lower reaches of the Frome.
- Wetlands can be found on the Frome floodplain (e.g. East Stoke)
- Considerable data on the ecology and water chemistry of the Frome and Piddle exists, generally focussed on specific sites and tributaries.
- The Frome and its tributaries are predominately well gauged but have a poor groundwater monitoring network.
- The Piddle is well gauged with an extensive observation borehole network.
- Land and facilities at East Stoke occupied by the IFE provide an excellent and secure environment for integrated experimentation across all disciplines in unconsolidated flood plain deposit environment.
- The Piddle offers opportunities for new collaborative studies with the Environment Agency, where the consequences of low flows and their alleviation require investigation.
- The extensive access to the River Frome and its side channels with associated fishing rights provide ideal opportunities for setting up boreholes and other long term environmental observations.

## **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 produced by the Task Force was discussed at a meeting of the TEG on 20 December 1999. In responding to discussion and feedback 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 Frome/Piddle catchment. There are separate reports for the hydrogeological infrastructure in the Pang/Lambourn (Adams et al 2003a) and the Tern (Adams et al 2003c) 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 the Chalk (and Triassic Sandstone in the case of the Tern catchment) aquifers 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 interfluvial 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 interfluvial 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 FROME AND PIDDLE CATCHMENTS**

### **2.4.1 Geology**

At the time of designing the LOCAR infrastructure, the Geological Map sheet 328, Dorchester covering the lower end of the combined Frome/Piddle catchment area had recently been surveyed and published incorporating the new Chalk stratigraphic nomenclature (Bristow et al 1998). Major structural features and geomorphologic features such as solution hollows had been identified. However, the western part of the catchments and the 5km buffer zones cover extensive areas of structurally complex geology that fall on the Bridport (327) and Yeovil (312) sheets, which were last resurveyed between 1931 and 1946 and neither of which were due for resurvey.

### **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 shown in Figure 2-1. The network consists of 23 boreholes in the Piddle catchment (8 of which are logged every 15 minutes, the remainder being manually dipped) and 7 sites in the Frome catchment all of which were currently manually dipped.

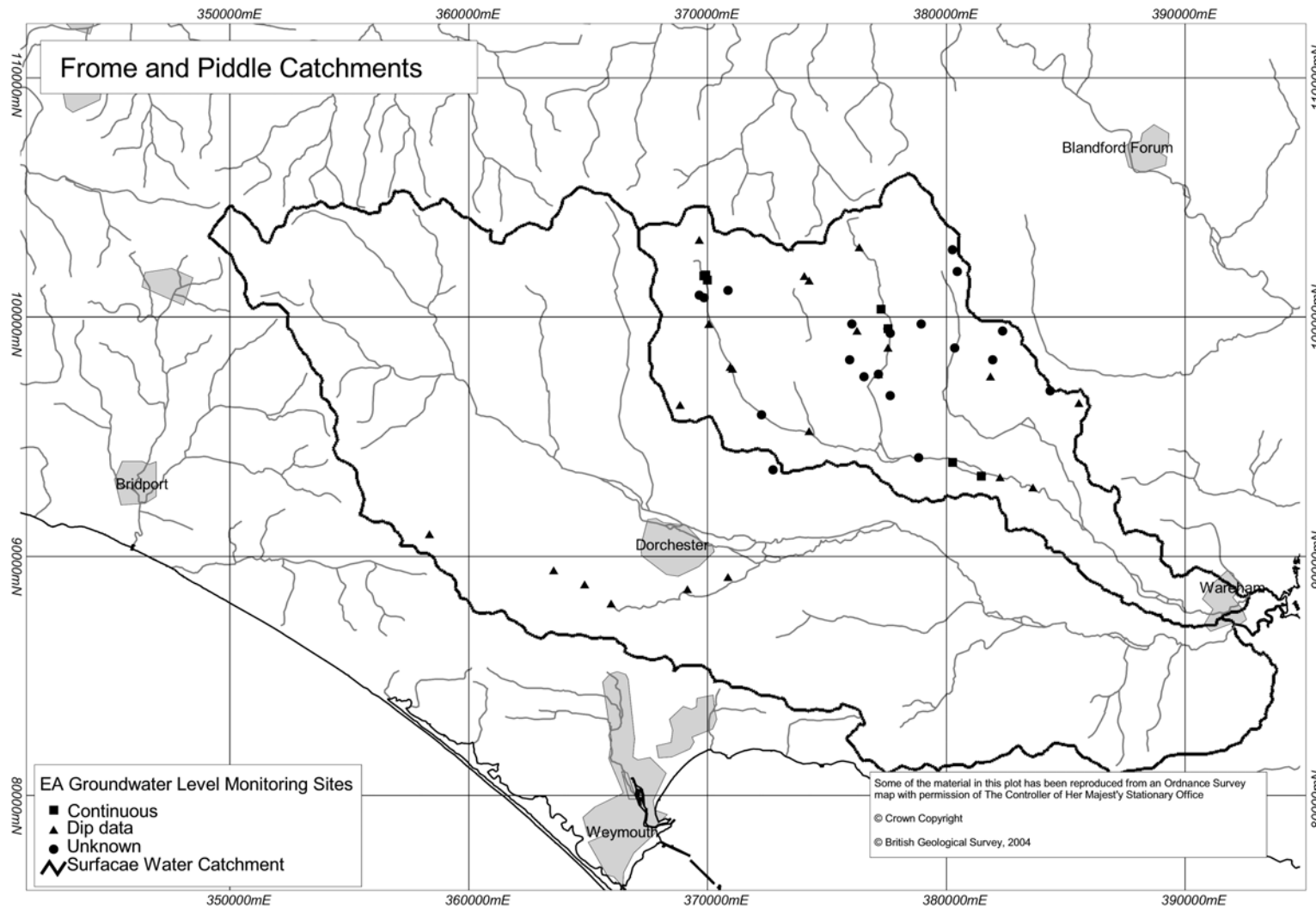


Figure 2-1 Map of the Environment Agency's groundwater level monitoring network in the Frome/Piddle catchment.

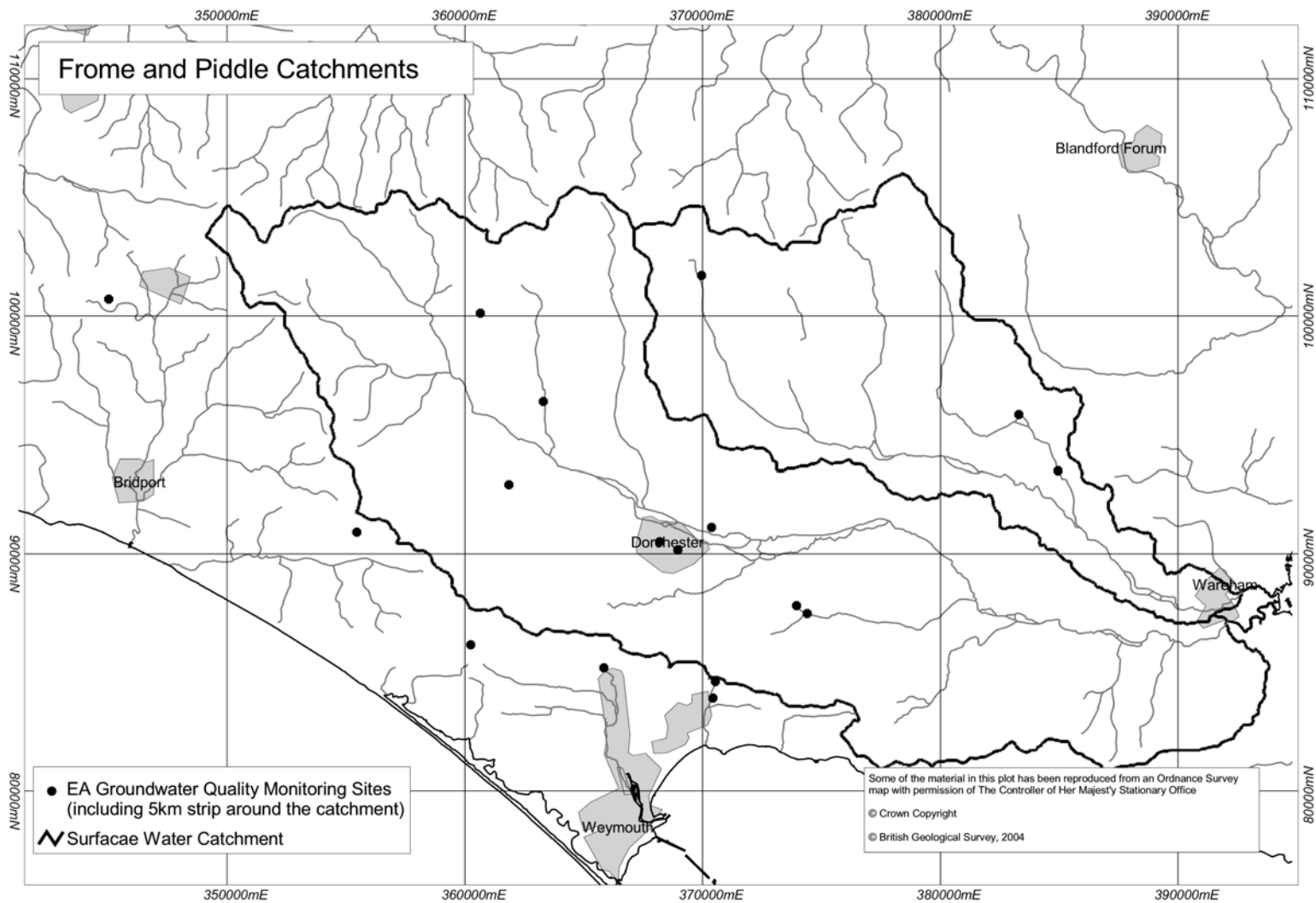


Figure 2-2 Map of the Environment Agency's groundwater quality monitoring network in the Frome/Piddle catchment.

### 2.4.3 Groundwater quality monitoring network

The Environment Agency's groundwater quality monitoring network, again at the time of designing the LOCAR infrastructure, is shown in Figure 2-2. There are five sites within the Piddle catchment and seven within the Frome. Each site had been sampled between 40 and 70 times since 1996. Determinands from analyses include inorganic major, minor and trace constituents including nitrogen species plus additional measurements of organic carbon, temperature, conductivity and dissolved oxygen.

## 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

A good understanding of the geology of the catchment area is fundamental to the hydrogeological conceptual model. Recent developments in the understanding of the lithostratigraphy of the Chalk aquifer highlight the relationship between the stratigraphy and certain topographic features. Whilst the new stratigraphy had been applied to the recently re-surveyed area included on the Dorchester 1:50,000 geological map (sheet 328), it had not yet been applied to the western part of the catchments and the 5km buffer zones which are covered the Bridport (327) and Yeovil (312) sheets, neither of which were due for resurvey. It was important that the new stratigraphy is applied to these areas because of the recognisable relationship between the stratigraphy and certain topographic features. Additionally, some members of the newly defined members of the succession have distinctive geophysical log signatures. Identification of these stratigraphic horizons (particularly those which act as preferential flow horizons) is essentially to understanding the groundwater flow within the catchment areas. Thus it was recommended that revision mapping of the geology of the western part of the Frome/Piddle catchments should form a fundamental part of the JIF/LOCAR baseline knowledge for future research initiatives.

The distribution of marls and hardgrounds throughout the catchments will affect the nature of fracturing. Many small faults exploit weaker horizons such as marls and so fracture porosity would be enhanced at the intersection of faults and marls. In addition, both faulting and jointing intensity may be greater in hardgrounds than in normal soft chalk. So the intersections of faults with hardgrounds may also lead to an increase in fracture porosity.

Geological survey of the catchments was essential to provide aquifer/rock characterisation through: -

- location and characterisation of the distribution of marls and hardgrounds.
- determination of the distribution of fracturing in the catchments over a range of scales:
  - at the catchment scale by mapping the size and displacement on the largest fault zones,

- at the outcrop scale by obtaining data on joint distributions and bedding fracture frequency,
- and at the borehole scale through the correlation of fracture data with geophysical and hydrogeological observations.

### **2.5.3 Time series monitoring**

The LOCAR infrastructure boreholes were designed to provide experimental facilities and/or to augment the Environment Agency's existing groundwater level monitoring network. As can be seen from section 2.4.2, the groundwater level monitoring network was particularly deficient in the Frome catchment. With regard to groundwater quality measurements, it was recognised by the Environment Agency that their network measurements were not generally carried out to a research standard. Thus monthly groundwater sampling and analysis (at research standard) will be collected from 10 LOCAR boreholes throughout the catchment.

### **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 Frome/Piddle 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 should be multi-objective.
- All pilot holes and boreholes to be geophysically logged including detailed fracture logging (borehole imaging and core logging), flow logging.
- A minimum of five new boreholes were required to augment the existing groundwater monitoring network in the Frome catchment. They would be cored at narrow diameter (cores being logged, pore waters sampled and analysed, and remaining core to be stored), and then reamed to required finished diameter. All of these boreholes would be equipped with 3 nested piezometers.
- A number of existing boreholes needed to be equipped with data loggers to provide additional enhancement of the existing groundwater monitoring network.
- A minimum of three boreholes were required to investigate surface water/groundwater interaction within the Frome valley corridor. Again these should be cored and logged and each equipped with 3 nested piezometers.
- Investigation of surface water/groundwater interaction at a floodplain wetland site was afforded by access to land at the IFE River Laboratory at East Stoke. This facility required an initial "central" borehole to prove the local geological conditions and an inclined borehole below the river corridor. A series of shallow piezometers would characterise the flow regime in the river gravels.

## 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. Unforeseen ground conditions (for example the difficulty in drilling through the Tertiary cover at Culpeppers Dish – PL05) caused delays at individual sites. 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 Frome/Piddle.

### 3.2 GEOLOGY

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

- New digital geological map at a scale of 1:50,000.
- Technical report for the catchment area, including structural analysis. Some of the lithostratigraphical terms used on the 1:10 000 base maps had been superseded and the report includes a table indicating the current terminology (Newell et al 2002).

In terms of regional geological setting, the catchment lies at the centre of the Wessex Basin, a post-Variscan sedimentary depocentre that extends across central southern England and adjacent offshore areas. The geology of the catchment has been shaped by a history of Mesozoic extension and a phase of Cenozoic folding and structural inversion of basin-bounding and intra-basinal faults. The present day structure is dominated by the effects of this basin inversion that in turn have important influences on the form of the Frome/Piddle drainage basin.

The Frome/Piddle catchment is underlain by solid geological units ranging in age from the Middle Jurassic Fuller's Earth Formation to the Palaeogene Bracklesham Group. However, it is the Cretaceous Chalk and Palaeogene formations which dominate the solid geology of the catchment. In terms of gross lithology, chalk underlies around 65 % of the catchment, sand and sandstone around 18% and argillaceous rocks 11%. The balance of 6% comprises predominantly Jurassic interbedded limestone, sandstone and clays. Drift deposits cover about 268.2km<sup>2</sup> (41%) of the catchment and include clay-with-flints, alluvium and river terrace deposits. The general structural dip of strata within the catchment is to the ESE and the depth of present day erosion increases toward the WNW. As a consequence, the surface geology of the Frome/Piddle catchment comprises three distinct geological zones: the headwaters of the Frome and Piddle cut into Jurassic limestones and mudstones, the middle reaches flow across chalklands, and the lower reaches traverse the Palaeogene deposits of the Wareham Basin before discharging into Poole Harbour. The southern margin of the Frome-Piddle drainage basin broadly corresponds to the southernmost limit of the Chalk outcrop, which itself is controlled by major faults.

### 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. Of the three sites surveyed in the Frome/Piddle catchment, only one (FP08) was the subject of subsequent drilling activity. Table 3.1 shows the geophysical techniques applied at selected sites in the Frome/Piddle. 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 Frome/Piddle catchment

Site Code	Site Name	Techniques
FP08	East Stoke	Resistivity Tomography Ground Conductivity – EM
<b>FP19 – site subsequently abandoned due to difficulty in obtaining land agreement</b>	Maiden Newton	Resistivity Tomography Ground Conductivity – EM
<b>This site NOT the one eventually used for FP04</b>	Winfrith UKAEA	Resistivity Tomography

### 3.4 DRILLING ACTIVITIES

#### 3.4.1 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, Foundation and Exploration Services carried out the majority of the drilling in the Frome/Piddle catchment, the only exceptions being at the recharge sites FP25 and FP04 which were drilled by CEH.

Table 3.2 LOCAR drilling activity in the Frome/Piddle catchment.

START DATE	END DATE	DRILLING COMPANY	SITES DRILLED (chronologically within package)
9 January 2002	25 February 2002	Foundation and Exploration Services	FP13 Higher Came Farm FP17 Down Farm FP34 Fordington Down FP05 Cull Peppers Dish
19 June 2002	26 June 2002	Foundation and Exploration Services	FP16 Oakers Wood
25 July 2002	25 July 2002	Centre for Ecology and Hydrology	FP35 Lower Wraxall
30 September 2002	24 October 2002	Foundation and Exploration Services	FP08 East Stoke FP29 Cattistock FP37 Frome Whitfield

Figure 3-1 is a map showing the locations of the component parts of the hydrogeological infrastructure installed in the Frome/Piddle catchment which consists of a total of 17

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.

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, for example no inlined boreholes were drilled under rivers. Access agreements could not be achieved at all planned drill sites thus, for example, it was not possible to drill at the planned site near Maiden Newton which had been designated as FP19.

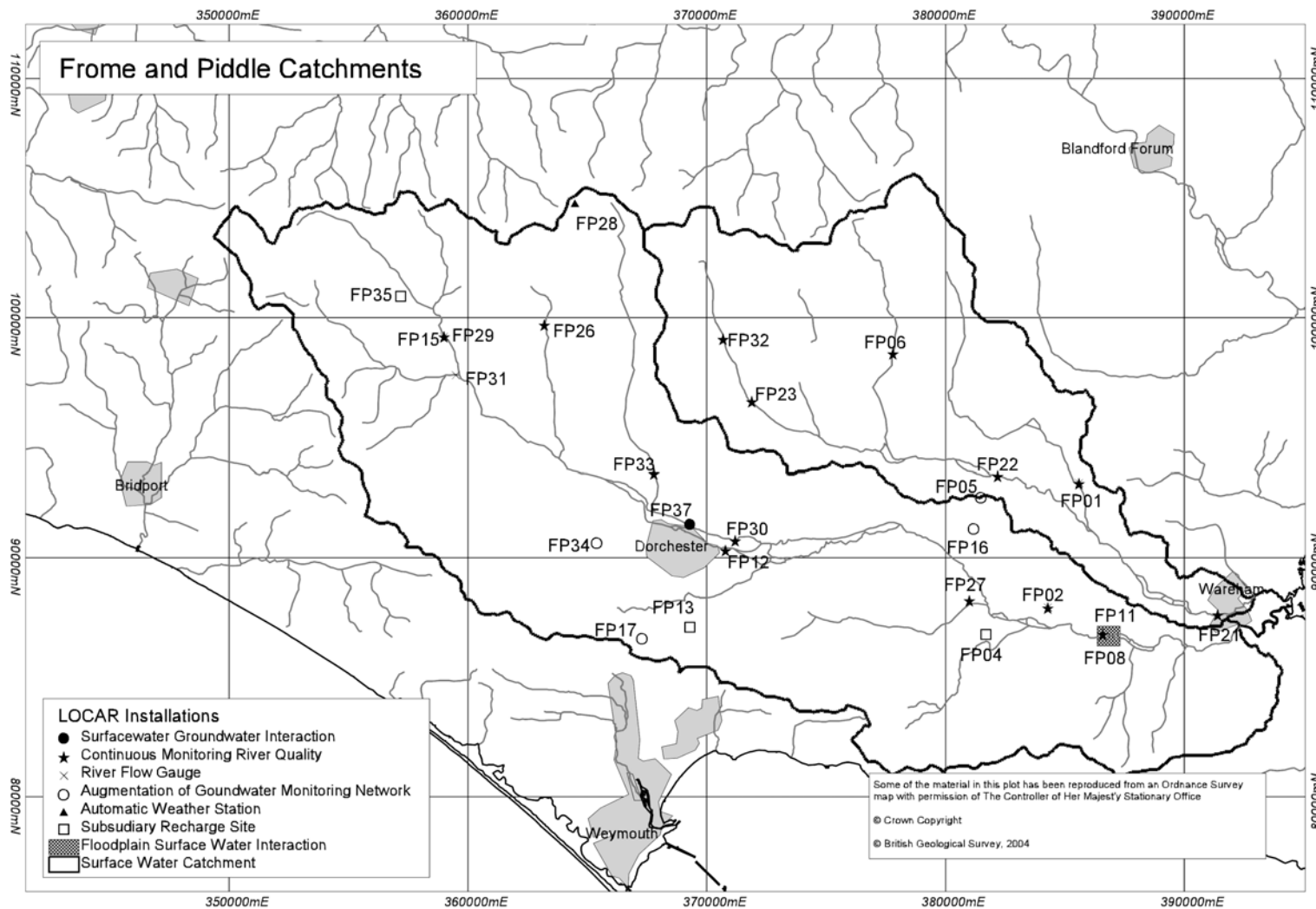


Figure 3-1 Location of the LOCAR infrastructure installed in the Frome/Piddle catchment

### 3.4.2 Coring

Where boreholes were to be cored it was planned that air flush rotary core drilling or U100 percussion drilling without the addition of water would be used. This was because interstitial porewaters from the cores were to be sampled and it was felt that the addition of fluids (other than air) to assist the drilling process could contaminate the porewaters being sampled. At the first site drilled (FP13) the drillers were unable to progress through the chalk using just air as the circulating fluid; they found that the chalk balled-up around the drill bit effectively preventing penetration. By adding small quantities of water to the circulating air, to give an air-mist drilling fluid, drilling rates were significantly enhanced. As FP13 was not being cored it was agreed that the hole could be completed by the air-mist method.

The next hole to be drilled was FP17a which was to be cored, and once more it proved impossible to progress with the air flush method. It was agreed that the air-mist approach could be used as long as the quantities of water used were kept to an absolute minimum. It was also decided to “spike” the added water with Lithium Bromide. Knowledge of the groundwater chemistry from the Wareham area (i.e. downstream of the Frome/Piddle catchment) suggested that natural Li content of groundwaters in the region could be expected to be of the order of 0.01 mg/l and the Br content would also be naturally low. By using a concentration of the order of 10mg/l of Lithium in the water used for the drilling mist any invasion of the drill core by the drilling fluid would be indicated by a significant increase above background levels of both Li and Br.

The water used for the air-mist was supplied from a bowser and the Lithium Bromide was added to this water. Water samples were collected from the mixed bowser water and analysed for Li and Br content at the same time as the pore waters collected from the core samples. The results of the analyses indicated that at most depths there was an increase in both Li and Br concentrations above the expected background levels; apparent mixing of the water from the drilling circulation fluid with the pore water ranging from 0 to nearly 5%. It was concluded that contamination when drilling chalk using water (even in small amounts) must be taken into consideration when looking at the pore water chemistry.

Where boreholes were cored, the 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 Pang Lambourn catchment at the BGS core store.

Table 3.3 Borehole completion details

Borehole Completion Details - Frome Piddle Catchment											
Borehole ID	Piezometer ID	Total drilled/inst'd. depth BGL (m)	Depth @ time of inst. MiniTroll (m)	Casing Details				MiniTroll (Depth if known) m	Response zone m bgl	RWL mbgl <i>Note 1 below</i>	Comments
				Top magl	ID mm	OD mm	Material				
FP05a		15		n/a							
	FP05a-1	71.23			81	90	plastic	Yes	20.2->71.23	?	
FP08a				0.97	204	223	steel				
	FP08a-1	15.18	12.04		34	40	plastic	11	D12.4-15.18	c1	
FP08b		15		0.92	204	223	steel				
	FP08b-1	15	15.07		34	40	plastic	14	13.0-15.0	c0	
FP08C		15		1.1	204	223	steel				
	<b>FP08c-1</b>	<b>15</b>	<b>14.94</b>		<b>34</b>	<b>40</b>	<b>plastic</b>	<b>14</b>	<b>13.5-15.0</b>	<b>c1</b>	
	<b>FP08c-2</b>	<b>2.65</b>	<b>1.84</b>		<b>34</b>	<b>40</b>	<b>plastic</b>	<b>2.5</b>	<b>1.0-2.65</b>	<b>c1</b>	
FP08d		15		1.02	204	223	steel				
	FP08d-1	14.7	14.7		34	40	plastic	13.5	13.3-15.0	c1	
	FP08d-2	2.95	3.08		34	40	plastic	3.5	1.5-3.65	c1	
FP08e		15		1.07	204	223	steel				
	FP08e-1	15	6.16		34	40	plastic	6.5	12.4-15.0	c1	
	FP08e-2	2.5	2.58		80	90	plastic	3	1.0-2.5	c1	
FP08f		15		1.05	204	223	steel				
	FP08f-1	15	14.99		80	90	plastic	14	12.2-15.0	c1	
	FP08f-2	3?			34	40	plastic	Yes	1.5-3.4	c1	
FP13a		69.25	66.01	-0.36	152	not known		Yes	3.65-TD	c20	
FP16a		21.35		c.grnd.lvl.	204	223	steel				
	<b>FP16a-1</b>	<b>21.23</b>			<b>80</b>	<b>90</b>	<b>plastic</b>	<b>19</b>	<b>16.2-21.35</b>	<b>c1</b>	
FP16b		8.33		c.grnd.lvl.	204	223	steel				
	<b>FP16b-1</b>	<b>7.69</b>			<b>80</b>	<b>90</b>	<b>plastic</b>	<b>6.5</b>	<b>3.5-8.33</b>	<b>c1</b>	
FP17a		109.7	93.72	n/a							
	FP17a-1	93.72			84	90	plastic	Yes	79.0-109.7	c50	
FP17b		70.8	70.7	n/a							
	<b>FP17b-1</b>	<b>69.3</b>			<b>84</b>	<b>90</b>	<b>plastic</b>	<b>Yes</b>	<b>61.7-70.8</b>	<b>c50</b>	
FP29a		15.4		0.84	204	223	steel				
	<b>FP29a-1</b>	<b>13.8</b>	<b>12.93</b>		<b>80</b>	<b>90</b>	<b>plastic</b>	<b>12</b>	<b>3.0-13.8</b>	<b>c2</b>	
FP34a		80.07		-0.15	204	223	steel	yes	8.7-80.07	c55	
FP35a		6.29			68	75	plastic				
	<b>FP35a-1</b>	<b>6.11</b>			<b>24</b>	<b>33</b>	<b>plastic</b>	<b>5.5</b>	<b>2-6.29</b>	<b>c5</b>	
FP37a		30		0.85	204	223	steel				
	<b>FP37a-1</b>	<b>30</b>	<b>30.07</b>		<b>80</b>	<b>90</b>	<b>plastic</b>	<b>29</b>	<b>15.0-30.0</b>	<b>c1</b>	
	<b>FP37a-2</b>	<b>10</b>	<b>9.77</b>		<b>34</b>	<b>44</b>	<b>plastic</b>	<b>9.5</b>	<b>5.5-10.0</b>	<b>c1</b>	
	<b>FP37a-3</b>	<b>4</b>	<b>4.25</b>		<b>34</b>	<b>44</b>	<b>plastic</b>	<b>4.5</b>	<b>2.0-4.0</b>	<b>c1</b>	
FP37b		30.3		0.96	204	223	steel				
	FP37b-1	24.5	24.54		80	90	plastic	23.5	23.0-25.0	c1	
	FP37b-2	16.1	16.12		34	44	plastic	15	14-18.5	c1	
	FP37b-3	4.5	4.52		80	90	plastic	4.8	3.0-5.0	c1	

Sites listed in **bold and italics** are where it is proposed that groundwater samples should be collected on a monthly basis for chemical analysis.

It is also recommended that samples be collected at FP04 (Winfrith recharge site) when constructed.

*Note 1* Rest water levels given only as an order of magnitude to help decide on sampling protocols

Note 1: Rest water levels are given only as an order of magnitude to help decide on sampling protocols

Note 2: Sites listed in **bold and italics** are those proposed for monthly collection of groundwater quality samples – see section

It is also recommended that groundwater samples should be collected from FP04 when it has been completed.

Table 3.4 Inventory of Frome/Piddle core and drilling samples held at the National Core Store, BGS Keyworth.

Borehole	Quarter Sheet No.	SOBI No	Material Type	Top Depth	Bottom Depth
FP08			UWCT		
FP16A OAKERS WOOD	SY89SW	222	CRSM	0.6	11.5
FP16A OAKERS WOOD	SY89SW	222	DLCR	0.9	3.9
FP16A OAKERS WOOD	SY89SW	222	DLCR	6.2	21.4
FP16B OAKERS WOOD	SY89SW	223	DLCR	0.6	4.7
FP16B OAKERS WOOD	SY89SW	223	BULK	4.7	5.3
FP16B OAKERS WOOD	SY89SW	223	DLCR	5.3	8.3
FP17A DOWN FARM	SY68NE	101	DLCR	0.6	57.7
FP17A DOWN FARM	SY68NE	101	DLCR	57.7	82.8
FP29A CATTISTOCK	SY 50SE		U100 tubes		
FP37A FROME WHITFIELD	SY69SE	79	U100 tubes		
FP37B FROME WHITFIELD	SY69SE	80	U100 tubes		

Key to Material Type:

CRSM	Core Samples
DLCR	Drill Core (continuous)
DCCR	Drill Core (discontinuous)
UWCT	Unwashed cuttings

Table 3.5 Downhole geophysical fluid and formation logs – Frome/Piddle catchment

LOCAR Reference	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		
FP-5		22-Jan-02	48											X		
FP-13	Higher Came Farm	22-Jan-02	~24	✓	✓	✓	✓	X	X	X	✓	X	X	X		No pumped fluid logging
FP-16	Oakers Wood	12-Jun-02	7.7	✓	✓	✓	X	X	X	X	X	X	X	X		
FP-17	Down Farm	24-Jan-02	48.40	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X		Pumped. PWL when pumping higher
FP-29	Cattistock	23-Oct-02	?	✓	✓	✓	X	X	X	X	X	X	X	X		
FP-34A	Fordington Down	12-May-02	~50	✓	✓	✓	X	X	X	X	X	X	X	X		
FP-37A	Dorchester	23-Oct-02	1.3?	✓	✓	✓	X	X	X	X	X	X	X	X		No pumped fluid logging
FP-37B	Dorchester	23-Oct-02	4.2?	✓	✓	✓	X	X	X	X	X	✓	X	X		Flowmeter down+uplog when pumping

LOCAR Reference	Borehole Name	logged by	Date	Log datum	Depth (mbd)	SWL (mbd)	Casing depth/dia	FORMATION LOGGING MEASUREMENTS								
								Caliper	Gamma ray	Resistivity	SPR/SP	Sonic	Neutron	Density	Imaging	Other
FP-5	Culleppers Dish	BEL Geophysical	27-Nov-02	IST top	63.8	48		X	✓	Induction RES	X	X	X	X	X	
FP-13	Higher Came Farm	BEL Geophysical	22-Jan-02	GL	66.7	~24	0-3.5m (6)	✓	✓	16R, 64R,LAT	✓	X	X	X	X	
FP-16	Oakers Wood	BEL Geophysical	6-Dec-02	GL	21	7.7	none? 3.5m?	X	✓	✓	X	X	X	X	X	
FP-17	Down Farm	BEL Geophysical	24-Jan-02	GL	109	48.4	0-4.4m (8)	✓	✓	16R, 64R, LAT	✓	X	X	X	X	
FP-29	Cattistock	BEL Geophysical	23-Oct-02	GL	13	?	0-TD (ABS)		✓	✓	X	X	X	X		
FP-34A	Fordington Down	BEL Geophysical	12-May-02	GL	81.3	~50	0-8.6m (8)	✓	✓	IndRES, IndCOND	X	X	X	X	opt 8.3-51m only	
FP-37A	Dorchester	BEL Geophysical	23-Oct-02	TGL?	29	1.3?	0-7.7m (3)	✓	✓	✓	X	X	X	X		
FP-37B	Dorchester	BEL Geophysical	23-Oct-02	TGL	30	4.28m	0-12.6m (3)	✓	✓	IndRES, IndCOND	X	X	X	X		

### **3.5 DOWNHOLE GEOPHYSICAL LOGGING**

Geophysical logging in the Frome/Piddle catchment was carried out under a framework contract established BEL Geophysical, a division of Alluvial Mining Ltd. 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 and formation logs were run at each site in the Frome/Piddle catchment.

### **3.6 CORE DESCRIPTION AND ANALYSES**

Six holes (FP16A, FP16B, FP17A, FP29, FP37A, FP37B) 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 FACILITY SITES**

#### **3.7.1 Inter-catchment flow**

Although the surface water catchments of the Frome and Piddle rivers are clearly separate, previous studies (Paolillo, 1969; Merrin, 1999) have suggested that there may be some transfer of groundwater from the Piddle to the Frome. As a means to investigate the possibility of such transfer through the karstified Chalk underlying the Tertiary cover in the south-east of the catchment, boreholes were drilled at two (FP05 and FP16) to enable the determination of Chalk groundwater gradients in this region (see Figure 3-1).

At FP05 (adjacent to the major collapse feature of Culpeppers Dish) significant problems were encountered during drilling. With no positive identification of Chalk in the drilling returns it is thought that the 69.25m (drilled depth) borehole probably encountered a cavity in the Chalk which was filled with Tertiary sediment – the final full depth of the installed piezometer was 71.23m (i.e. greater than the drilled depth). The completion details are given in Table 3.3 and it is believed that the MiniTroll installed will be monitoring groundwater levels from the Chalk aquifer. Fuller details of the problems encountered in the drilling process can be found in the LOCAR site completion report held by the LOCAR Data Centre (see chapter 4).

At FP16 two boreholes were drilled (FP16a and FP16b) to two different depths (21.35 and 8.33m respectively) to permit the monitoring of groundwater levels in both the Chalk and Tertiary cover. This site is prone to surface water ponding following heavy rain falls and some problems with flooding of the well head chambers was initially encountered – this was overcome by extending the chamber walls to give above ground surface completions.

#### **3.7.2 Floodplain surface water-groundwater interaction**

On the floodplain of the River Frome, between the River Frome and the Mill Stream at the IFE River Laboratory at East Stoke (see Figure 3-1) 6 holes were drilled (FP08a-f) to permit monitoring of groundwater levels at differing depths and at different locations across the site (see Figure 3-2). The completion details of each hole are given in Table 3.3.



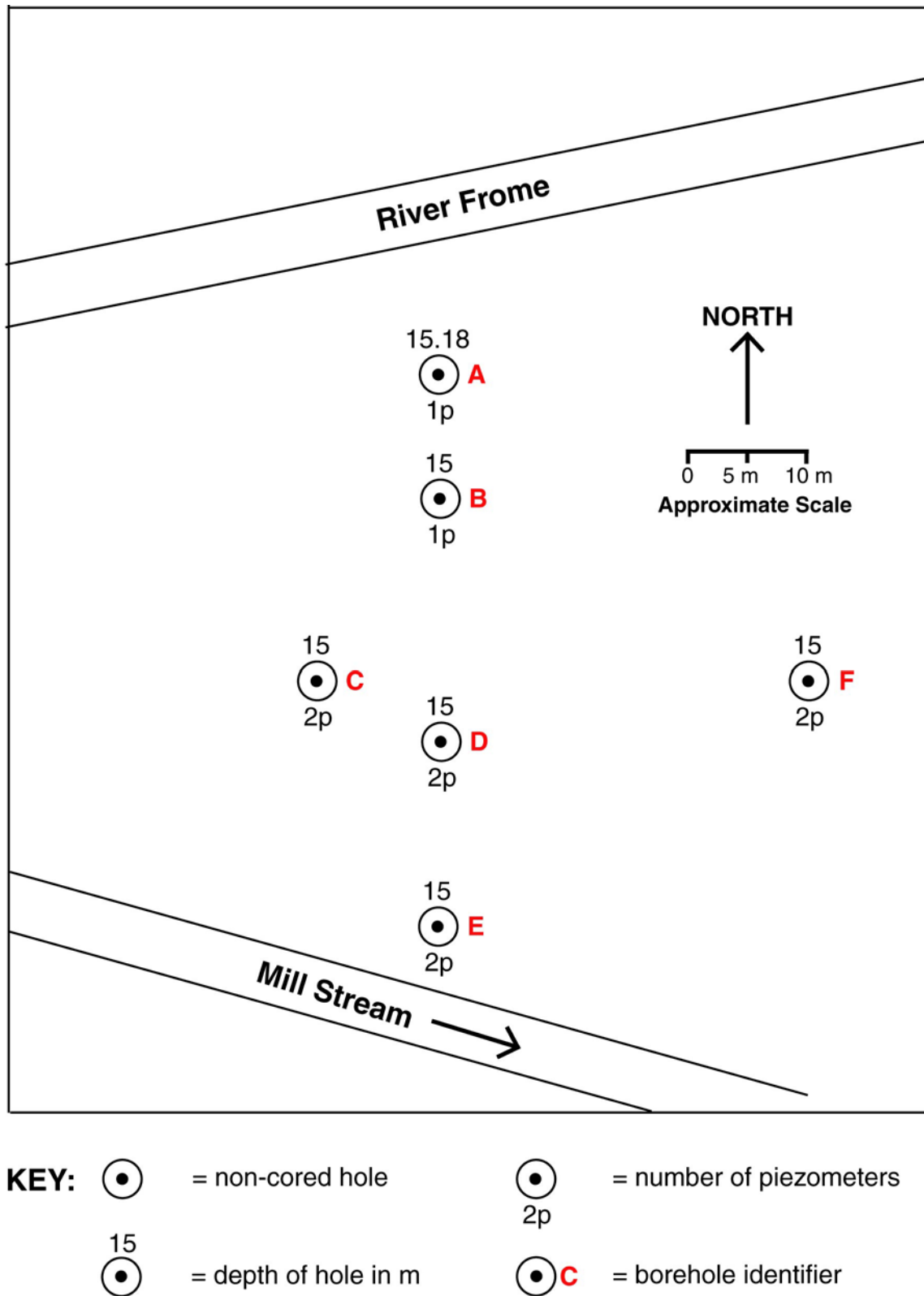


Figure 3-2 The LOCAR investigation boreholes located at East Stoke – site FP08

A single hole has been drilled on the floodplain of the upper reaches of the River Frome at Chilfrome (FP29) in the Upper Greensand. Again completion details are given in Table 3.3. Located approximately 27m from the river bank it provides the opportunity to investigate groundwater-surface water interaction, there being a LOCAR hydrological infrastructure flow gauge (FP15) installed some 70m upstream near the road bridge.

At site FP37 (Frome Whitfield) two boreholes, FP37a and FP37b, were drilled on the north bank of the River Frome to depths of 30m and 30.3m respectively into the Chalk. Each hole has two piezometers at differing depths (see Table 3.3) to enable the monitoring of heads in the Chalk at approximately 10m and 40m away from the river.

### **3.7.3 Recharge sites**

Sites FP04, FP13 and FP35 are located at LOCAR recharge sites which have been installed as part of the LOCAR hydrological infrastructure. The purpose of 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, equitensimeters, 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 three sites allow collection of this information for their respective recharge sites.

### **3.7.4 Augmentation of groundwater monitoring network**

At sites FP17 and FP34 boreholes were drilled to augment the Environment Agency's existing groundwater monitoring network. At FP17 two holes were drilled (FP17a and Fp17b) two differing depths (110m and 70.8m respectively) to allow monitoring of groundwater heads at differing depths. FP34 was drilled open hole to a total depth of 80.07m. The completion details of these holes are given in Table 3.3.

## 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 Pang/Lambourn 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 10 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 3.3 shows those sites proposed for groundwater sample collection.

Table 4.1 Data sets available for LOCAR boreholes in the Frome/Piddle catchment

	FP5A	FP8A	FP8B	FP8C	FP8D	FP8E	FP8F	FP13A	FP16A	FP16B	FP17A	FP17B	FP29A	FP34A	FP35A	FP37A	FP37B
	Cull Peppers Dish	East Stoke	East Stoke	East Stoke	East Stoke	East Stoke	East Stoke	Higher Came Farm	Oakers Wood	Oakers Wood	Down Farm	Down Farm	Cattistock	Fordington Down	Lower Wraxall	Frome Whitfield	Frome Whitfield
Drillers daily sheets	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Borehole completion forms	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Downhole geophysical logs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Surface geophysics	✓	✓	✓	✓	✓	✓	✓	■	✓	✓	■	✓	■	✓	✓	✓	✓
Transducer installation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Geological core log	■	■	■	■	■	■	■	■	✓	✓	✓	■	■	■	■	✓	■
Drill cuttings log	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Hydrogeological core log	■	■	■	■	■	■	■	■	✓	✓	✓	■	■	■	■	✓	✓
Physical properties analysis	■	■	■	■	■	■	■	■	■	■	✓	■	■	■	■	■	■
Pore &/or depth chemical analysis	■	■	■	■	■	■	■	✓	■	■	✓	✓	✓	■	■	✓	✓

## 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 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

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- 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.