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by

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ABSTRACT

The Water Supplies and Related Structures of Roman Britain

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Information is provided on the remains of aqueducts, wells, Roman baths, drains, pipes, springs and tanks, from 807 sites in Roman Britain (fortresses, forts, towns, small towns, settlements and villas). The introduction of running water supplies and baths had considerable social implications, for urban and rural communities. Aqueducts are the most intensively researched water-related structure of Roman date; evidence from Britain is presented in detail. Particular attention focuses on unresolved structural problems (Leicester, Lincoln). Wells were also important for water supply at all site types, especially for domestic use; possible religious aspects are also discussed. The layout of bath buildings is reviewed, and the provision of drains and sewers. Distributions of all the various water-related structures, based on the archaeological record, are evaluated. Several points emerge from this analysis, i.e. a number of settlements should be reclassified based on their possession of public baths or running water supplies.

Generally, these systems are poorly understood, partly through concentration of past fieldwork on monumental and domestic structures (areas outside buildings have rarely been investigated in detail). Britain's high annual rainfall has tended to diminish the importance attached by scholars to water-related features. There has been a general reluctance to discuss water supply and baths in studies of urban and villa development. These factors have tended to obscure their relevance both socially and technically, resulting in a lack of appreciation of the complexities surrounding water supply. An attempt is made to quantify the labour organisation and costs of well and aqueduct construction, to show the impressive scale of some Romano-British ventures.

It is concluded that water-related features are generally under-represented in the archaeological record, compared to the number of known sites. This can only be corrected by considerable additional fieldwork and re-evaluation of existing information.
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CHAPTER 1.
THE BACKGROUND: HISTORICAL CONTEXT OF WATER SUPPLY

1. INTRODUCTION
With the introduction of aqueducts to Rome in the late 4th century BC the Romans had developed a desire to have unpolluted water for drinking and domestic use. As the empire expanded, water supply was given a high priority wherever the Romans established themselves. The Roman army introduced into the new province of Roman Britain organized water supply at their fortresses and forts. Where towns and new settlements developed under Roman rule, organized water supplies were also introduced. Amongst the many remains of structures that have been found in Britain dating to the Romano-British period, aqueducts, wells and baths are common in the archaeological record. These were features which were either new to Britons following the conquest or which were constructed on a wider scale than hitherto.

Organization of water supply is of course fundamental to all human settlement but improvements on nature, especially when water engineering is involved, constitutes a characteristic of civilization. The improvement of water supply must be one of the basic means developed by man to enhance the quality of life. Baths and bathing derive their origin from the ability of man to bring water to their homes or to specially constructed public bathing facilities.

2. OBJECTIVES
In this thesis I shall bring together much of the available evidence from the archaeological record for Roman Britain on water-related features and discuss the possible impact they had on British society. The thesis is also about the mechanics of water provision and drainage, and their distribution at Romano-British sites. It also seeks to address the social and economic impact of water supply and its use. In the discussion I shall look at:

1. the sites where water-related structures have been found;
2. the type of water-related structures;
3. the inter-dependence of these structures upon each other;
4. the distributions of different water-related features at different categories of sites.
Arising out of this information some questions are relevant, such as:
(a) how reliable are the data?
(b) how representative are the data for all the Romano-British sites known from the archaeological record?
(c) are current interpretations of some of the Romano-British aqueducts and wells acceptable?
(d) how to reconcile older and more recent excavation reports on water-related structures such as aqueducts, baths and wells?
(e) what is the relevance of water supply to a community?

This thesis will not give detailed descriptions of each site or structure associated with water supply, rather it will examine broader problems related to the water supply systems. I shall discuss the wider social implications associated with the provision of the facility, its administration, financial implications and maintenance. The site categories used in the database are legionary fortresses, forts, fortlets, and chartered towns (municipia and coloniae), civitates, small towns, settlements and villas. There are definitional problems with the latter three categories which I shall discuss in chapter 2. The categories of water-related structures recognized for the Romano-British period are aqueducts, baths, wells, waterpipes, drains, sewers, springs and tanks.

This thesis owes its genesis to a short research visit I made in 1993 to the Ashmolean library to collate information on the water-related structures of Roman Britain. I soon realized there was a much larger project to be done gathering widely scattered information from the existing archaeological record, and developing a new framework for its analysis. Three months research then turned into a three year project.

The hope is to have the database published in a gazetteer format to provide easy reference to the data set on the water-related structures of Roman Britain. Although the database is not claimed to be a complete collection of all available data on such structures, it is considered that most of the known ones have been included.
3. DATABASE

The database is effectively a large gazetteer of the data on the remains of water-related features at Romano-British sites I have been able to trace in the archaeological record. I have to date assembled a database of more than 800 archaeological sites from many records dating from the 17th to the 20th centuries. It is not claimed that all the available water-related sites have been processed. The structure of the database is discussed in detail in Chapter 2.

Problems arose over the definitions of some categories of sites and water-related features, such as:

1. Site types - for instance, how to categorize small towns, settlements and villas. Scholarship is generally not in agreement with the category of some sites, mainly because of definitional problems of those sites. I shall discuss some aspects of these problems in Chapter 2. For fortresses, forts and fortlets, there seems to be reasonable agreement. Large towns such as the four chartered towns of coloniae and two agreed municipia seem straightforward. Some civitates were larger than others, but these do not seem to present problems of category either. Since John Wacher's seminal book *The Towns of Roman Britain* appeared in 1974, there has been an intense debate on how to define settlements, towns, and particularly 'small towns'. In the papers from a 1992 conference on Romano-British small towns almost every author refers to the lack of acceptable definitions. The authors analyse their development, morphology, function and the economic implications surrounding their activities in both the agricultural and non-agricultural fields, and what the social and religious implications were for the communities. Water supply does not seem to form part of the discussions of the development or morphology of the settlements. Burnham and Wacher, in the first five chapters of their book on 'small towns', discuss the above aspects of towns, but have little to report on water supply or wells. As an example, Neatham is shown to have had no less than eleven wells, but despite the fact that there were so many wells for the single community, there is negligible discussion on the water supply of the site (1990, 264-9, 272).

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1 Brown (ed.) 1995. It is striking how the nineteen authors of articles agree on the lack of a definition, but that they turn up with almost as many definitions as there are authors.
2. **Data types:**

2a. *Aqueducts*, for instance, were constructed in or with different materials and the archaeological record is not always clear what was the form of the aqueduct. Uncertainty often exists whether a stone channel was, in fact, the aqueduct or whether it only carried a wooden or some other pipe. Aqueducts usually originate from outside the most commonly excavated area of a site, providing obvious inequalities in the evidence.

2b. *Baths* varied tremendously in size, both at legionary forts, at forts, at towns, settlements and villas. The functions of small baths were different to those of public baths. Often the presence of baths is only inferred from token evidence.

2c. *Wells* were used for water supply, but also served as features for cult purposes. Sometimes they are referred to as shafts, and it is not always clear in what context, whether for water supply, ritual purposes, or for production of lime, or some other use. When wells have been excavated they have often been recorded primarily for the small finds found in them.

2d. *Drains* and *sewers* are often confused with each other.

2e. *Tanks* are sometimes only inferred from a base that has been identified.

These are problems which revealed themselves as the database was assembled. The definitions of categories of both sites and water-related features will be looked at in greater detail in Chapter 2, and where relevant, in the chapter for each site or feature type.

4. **WATER SUPPLY**

The different types of water-related features will be presented in a series of chapters: *aqueducts and springs* (Chapter 3), *wells and rain water catchment* (Chapter 4), *baths, drains and sewers* (Chapter 5).

4.1 **Chronology.**

Water supplies from antiquity came in a variety of forms. The earliest forms of water sources were likely to have been springs as there is a body of evidence relating to sacred springs. Later, people constructed wells, aqueducts, dams and the so-called dew-ponds. Man-made drainage and sewer systems are known from the classical period. In some settlements, and in towns, drainage and sewers formed part of a system to remove excess water from a continuously running water supply brought in by aqueducts and to remove human and animal waste products.
Man-made wells was also an early form of water supply, as for instance, in the book of Genesis it is mentioned that Abraham dug wells (c. 3000 BC), or the religious wells from the Indus civilization about 2500 BC. Water was also piped by conduit from adits in the side of mountains for considerable distances from as early as the later Bronze Age. The palace-temples of the Bronze Age such as at Knossos, Phaistos and Mallia and the palace of Nestor, developed elaborate water supply and drainage distribution systems. At the Island of Samos, Herodotus informs us that a tunnel-aqueduct water supply was constructed through Mount Kastro during the reign of the tyrant Polycrates in the early part of the 6th century BC. In other instances tunnels were dug to allow water to be brought to a city by water carriers.

There are many remains of magnificent aqueducts built by the Greeks dating from the 7th to the 4th centuries BC (Crouch 1993, 43) and by the Romans (Winslow 1963, 171-6) dating from the 4th century BC through into the 4th century AD (Hodge 1992, 92). Many of these Greek and Roman remains have become national monuments in the modern countries where they are situated. Yet, modern scholarship gives scant discussion of water supply systems dating from the pre-Roman and Roman periods in Britain, probably because none of the Romano-British aqueducts incorporated large bridge structures as found elsewhere.

Water is a prime social need and the search for water supplies must have been of great importance to ancient communities, both during the prehistoric period and later. Food could be obtained from remote sources, but in antiquity water was obtained nearly always from local sources such as a nearby stream, a spring, or from a purposely sunk well (Clark 1944, 1; 1957, 152-8). There are several reported cases from the Bronze Age of spring-heads being specially adapted for ease of obtaining water and these would appear to have often developed as religious shrines. A possible Neolithic site was recently found at Abercynafon, Wales, by a local forest ranger.

2 Genesis 21.15, 26.15, 21.18-21. Abraham had wells dug in the Negev desert and so did his son Isaac, who had reopened the wells which were destroyed by the Philistines.
3 Mackay 1935, 40-2, 55-8, 85.
4 Bromehead 1942, 183-96.
5 Mathioulakis 1966, 32.
6 Castleden 1994, 23.
7 Report prepared for the open day of the Clwyd Powys Archaeological Trust, in conjunction with other interested groups held during the summer of 1995. In a personal letter to me Dr. Caroline Earwood, the leader of the excavation team has indicated
Manley comments that prehistoric hillforts in Britain did not have a natural water supply, but that it was most likely that clay-lined ponds within the forts must have been used as cisterns to collect rainfall (1989, 121). Such a supply, he says, would have been supplemented by human or animal carriers with water transported from springs or rivers in pottery vessels or leather containers. Although this seems to be the most feasible explanation from studies of detailed excavation reports of hillforts, there are reports of wells and shafts from the pre-Roman period (see wells, chapter 4).

A number of hillforts around Britain have been identified as having Neolithic origins. Examples are at Crickley Hill (Dixon 1994), Gloucestershire (SO-32-927161 - on the Cotswold scarp), dating from the Neolithic to Bronze Age; Breiddin Hillfort (Musson 1991), Montgomeryshire (SJ-33-292114), with evidence of habitation from the Neolithic to Late Bronze Age, and Danebury (Cunliffe 1995, 91), Hampshire (SU-41-323376). Each of these sites had water supplies some distance away from the hillforts themselves and it seems certain that water was carried either from spring or pond or river sources. In the case of Breiddin Hillfort, the pond appeared to have become overgrown with flora over a long period and a cistern was constructed later during the Late Iron Age, probably between 300 and 200 BC (Musson 1991, 89). Some of these pre-Roman hillfort inhabitants migrated down to the valleys to work the land where water also was more abundant. By the time the Romans arrived there were already many established British settlements all over Britain.

At their third attempt in AD 43 the Romans obtained a foothold in South East England. There is a growing perception that far from seeing the invasion just as conquest, some of the southern tribes of Britain welcomed the invader for protection against aggressive neighbours. The Romans also introduced order and stability to the region, a local form of Pax Romana. They also introduced expertise in architecture and engineering construction of buildings, (especially baths), roads, bridges, aqueducts and wells. Among all the real or that the findings will not be completed for a few years as they are having extensive dendrochronology tests done on wood recovered from the site. Letter to A Burgers from Dr Caroline Earwood, dated 5 February 1996. Another example is the Budsene spring on the Danish island of Moen which was enclosed in a hollow alder wood (Brøndsted 1958, 2.202). The figure shows the tree trunk which was inserted into the springhead, and also the relics which were deposited by worshippers of the spring goddess.

8 Dating from pottery indicators were from before the 4th century BC, but it is thought that habitation might have been from the Neolithic period, though the main activity dated to the 4th c BC and later.
supposed 'benefits' that the Romans brought to the Britons, the improvements in the provision of water must have ranked high. Yet water provision at Romano-British sites has not received the attention it warrants. Richmond (1968, 2.87) said that "in the literature it is one of the necessities of life so much taken for granted as to be little mentioned".

The native British must have been profoundly intrigued by the Roman baths which were constructed in the wake of the conquest. It would appear from recent literature that they came to accept bathing as a norm, because from about the mid 2nd century many British towns, settlements and villas seemed to have included bath complexes. The cult of the bath was probably one of the most significant non-political aspects of the so-called romanization of the Britons.

At some stage after the conquest the Britons were introduced to Roman features such as aqueducts for obtaining water for their towns and to bathing. Suddenly to be confronted with this foreign concept of having water virtually on-the-tap must have been something of a culture shock. The profound effect that the provision of running water for domestic use could have had on such prehistoric societies has been observed time and time again during modern colonization. Whether or not individual Britons had access themselves to such supplies, water supply was no doubt viewed as a symbol of Roman power. Both colonial powers, Britain and France, having occupied many African and Far Eastern countries for economic and political reasons during the late 19th and early 20th centuries, made attempts to improve the lot of the indigenous inhabitants of their new colonies. Provision of running water for these people was a prime facility that was introduced, often accompanied by celebrations on the part of the recipients. The same may well have applied to the indigenous British when they were provided with improved water supplies.

The Iron Age nucleated communities assimilated a new cultural awareness under Roman rule. New settlements developed as Roman style towns along main roads and military communication routes. The Romans built or encouraged the construction of houses, streets,

9 I was involved with a project through my firm working for a municipality in the Cape Province of South Africa, drilling for water in a remote rural area in order to provide drinking water to the African community. When the scheme was completed and communal water points laid on in the area, celebrations lasted for a week to thank the Inkosis for this wonderful gift.

10 Frances Condron provides an extensive bibliography in her PhD thesis, 1996, on the development of settlements and towns in Britain after the Roman invasion.
hospitals, granaries and roads. Drainage systems were also provided, sometimes in the form of elaborate sewers, as at legionary fortresses such as at York (Whitwell 1974, 4 and Fig.2.), Exeter (Bidwell 1980, 32 Fig.18) and Caerleon (Boon 1972, 25 and Fig.10) and at the Roman colonia at Lincoln (Wacher 1995, 138, and my Fig.3.9), and at Colchester. Impressive public buildings were erected - fora, temples, theatres - and abundant water provided - aqueducts, wells, baths and fountains. Dams were also constructed in some locations.

The data collected in this thesis, although biased towards water-related structures, show that for four centuries from the conquest period onwards, the British landscape was transformed as fortresses, forts and chartered towns were built by the Romans, and the Britons transformed their settlements into towns and villas with these facilities, which improved the quality of life. For the Britons it was especially a stage of improvement from their own more primitive type wattle and daub huts. Although some of the earlier structures were built with timber, during the 2nd century most of those structures were replaced with stone-built buildings, both in forts, towns, other settlements and villas. The indigenous British had little or no prior experience of many of these facilities. It can only be guessed at how the Britons responded to these new living conditions and how improved availability of water supply impressed itself on the people.

The provision of water supplies was an important aspect of the new material culture for the Britons. The data shows that many towns, settlements and villas acquired water supplies to support large communities. However, based on the archaeological record, there are still many sites which do not show any remains of these facilities. Can one conjecture from the data available that all or most of the forts, towns, settlements and villas actually had these water-related structures, but that they simply have not been found, or that they have been destroyed during the passage of time? From the excavation reports of many sites I gain the impression that many more excavated sites than are indicated in my database, in fact, did have water-related features. Comparing descriptions of sites (stratigraphy, materials, smallfinds) where no water-related features have been explicitly recorded with sites where they have, it seems likely that many of the former group could also have had aqueducts, wells and baths.

4.2 Roman Britain.

In Britain, aqueducts were often of the leat type, a specially designed ditch dug along contours of uneven ground from a source to the delivery point. Examples are the leats at Dorchester (Dorset), Great Chesters, Winchester and Wroxeter. At Lanchester three aqueducts of the stone channel type served the fort, constructed along contours of the land between the source and fort. Elsewhere wooden pipes were used. At Chester (Hanson 1970, 185) and at Lincoln (Lindum) (Thompson 1954) earthenware pipe-lines were constructed as the water supplies. At York the suggestion is that it may have been supplied with a lead pipe encased in concrete (Hanson 1970, 192). Both wells and shallow tanks also were important water supplies during Romano-British times and they were probably the most important forms of water supply for most communities.

I think that much of the evidence pertaining to the ancient water supplies in Britain has become lost through a combination of lack of interest, natural decay and the activities of industrial and property development during and after the industrial revolution. Circumstantial evidence seems to indicate that water supply in the form of wells and aqueducts were much more common than present excavation evidence would suggest for forts, towns, settlements and villas.

5. DISTRIBUTION OF WATER-RELATED FEATURES

In Chapter 2 I shall define the types of sites and structures as I intend to use them in the thesis. In Chapters 3, 4 and 5 the evidence of the database will be presented giving the information on which an assessment can be made of the features and their distributions. Then in Chapter 6 I shall look at the distributions of both sites and the features found at them. The issues that will be addressed will be:

a) the geographical distribution of site types;
b) the distribution of features at different site types;
c) the distribution of types of features within a site;
d) the assessment of the evidence of a-c;
e) the problem of who paid for the amenities which were provided to forts and to other communities;
f) the aspirations of private benefactors and those who sought public office within a community.

To assess the evidence given in Chapters 3, 4 and 5 the issues listed above will be considered as will the associations between the site
types, their distributions and the different categories of water-related structures. The tables and distribution figures show that there are patterns in the distribution of site types across the country with water-related structures, but that at some sites where there is an expectation of particular features, they are absent. The question is, why? In particular, why would a site have an aqueduct, and/or wells, but no bath? Conversely, why will a site have a bath complex but no water supply? In part at least this must be due to lacunae in our archaeological knowledge, but some of the gaps may be genuine incongruities. The remains of some water-related features in older excavation reports, are often susceptible to new interpretations, for example the Dorchester Roman aqueduct. There are other instances, such as the problem of the water supply for the fort at Housesteads. Many indications within the fort suggest that it must have had a running water supply. Why is there not even the smallest physical evidence to indicate that there was such an aqueduct? Similarly, the aqueducts at both Chester and Lincoln leave many unanswered questions about how they functioned. Similarly there are divergent interpretations as to the functions of certain deep wells/shafts: were they dug as water supplies or for ritual purposes, or did they function as one and reverted to the other at a later date? Why did some settlements or villas (usually not large communities) have an unusually large number of wells, such as the settlement at Stonea Grange with 13 wells, the villas at Stanwick with 12 and Thetford with 10? At the small town of Tiddington 14 wells are recorded and the fort at Derby had 6 wells. These numbers are not the norm for recorded water-related features when compared with most of the other sites. I shall discuss these questions, but answers to them are not obvious.

An important question to consider is, why are there these disparate distributions amongst similar site types?

6. SOCIAL CONTEXTS

6.1 The Romanization debate.
The so-called romanization of conquered peoples by the Romans is complex. It is my belief that there was some intention by them to influence the material culture of the conquered people. It may have been more successful in Italy itself or even parts of Gaul, but whether romanization of the British was as successful is debatable. I do not want to enter into a profound discussion of the romanization process, but will consider in Chapter 7 Burnham's comment on the
subject of water provision of water related features in this regard (1995, 121). The native British experienced many new things under Roman rule - new ways of construction, changes in domestic architecture, the provision of major buildings such as fora, basilicas, amphitheatres and running water supplies. The perception of the power motive could not have escaped the Britons, but did it romanize them? Even before towns or villas were built many Britons would have come into contact with the new way the Romans built their forts and with the amenities they provided for themselves. I shall examine this aspect in relation to water supply and baths.

6.2. Organization and administration of water supplies.
There is no extant literature from antiquity to inform or guide us on the topic of water supply administration, or of any of the other public structures, in Britain. It would appear that during the early 2nd century and the 3rd century the people of Britain experienced prosperity and wealth, and tremendous expenditure took place on construction of buildings, housing, water supplies, baths and other amenities. Places like Dorchester, Leicester, Lincoln, London, Silchester, Wroxeter, York, and many other British towns grew in population, and with the wealth that accompanied this growth, these centres embarked on extravagant building projects such as temples, fora, public baths and amphitheatres, and water supplies. How successful was this extravagance? Were the tribal authorities able to sustain this progress? How long did it last? Did urban development costs exceed the available wealth? To what extent was provision of running water a contributing factor? I shall look at these problems (in chapter 7) as they affected the water related features in Roman Britain.

For an understanding of the Roman approach to the decision-making processes for the construction of new amenities or how they were subsequently constructed and administered, it is necessary to look at how the Romans set about creating their major towns and also the civitates for the local tribes (in Chapters 2 & 7). This process seemed to have had its beginnings already before the invasions of Julius Caesar, with increasing trade between Britain and Gaul (Liveridge 1973, 3). An important question is whether there was an

13 Julius Caesar invaded Britain during 55 and 54 BC in two separate expeditions. A number of scholars have written on the subject, such as Bruun (1981), Ward-Perkins (1970, 1-19), MacMullen (1974), Duncan-Jones (1974 and 1990), and others.
intention to control spending by the civitates? The complex problem of who paid for public spending will be discussed in Chapter 7.

There is no indication in the ancient literature for the costs of structures in Roman Britain. However there are some statistics of costs of structures from elsewhere in the Empire and, through two case studies, an aqueduct leat and a well, I shall arrive at some order of cost for such structures. Such studies have certain limitations as we have to make many assumptions about conditions existing in Britain at the time, of which we have no actual evidence. We can use some labour costs that are known for services such as agriculture or the army, and the quoted or estimated costs of structures from antiquity.

The performance of service structures is always problematic and their efficiency is generally directly proportional to their regular maintenance. This applies now as it must have done in antiquity. Funding for maintenance purposes in antiquity is difficult to assess, but that the need was there and provision made cannot be disputed. Pliny the Younger, in his letters to Trajan, several times draws the Emperor's attention to the need for the maintenance and repairs of structures that had deteriorated during service, or had gone wrong during construction, or after a period of negligence, and that additional funding would be required. From the archaeological evidence some assessment can be made of what maintenance was likely to have been carried out and will be discussed in Chapter 7.

6.4 Religious aspects.
Water in antiquity had far wider implications than its use for drinking, bathing and other domestic or industrial uses. Religious ritual also played an important part in the interaction with water supply, especially at spring sources. In Celtic religion the importance of water is indicated by the representation of river gods such as the Tyne river god found at Chesters and a sculpture of the Tamesis river god discovered at the mithraeum of London (Jones and

14 Gaius Plinius Caecilius Secundus, Pliny the Younger, AD 72?-113?: Pliny, Letters and Panegyricus, in two volumes, tr. by Betty Radice, Loeb Classical Library, 1972, (1969), letters 37, 38, 39, 40, 41, 42, 61, 62, 90, 91, 98 & 99. All these letters refer to some technical problem related to water or construction and the finances for the projects. It would appear in the case of the province of Bithynia Trajan had given Pliny the authority to allocate funds for spending on construction projects without reference to a higher authority.
Mattingly 1990, 264). An important Celtic water-related goddess of the sacred well found at Carrawburgh, is that of the nymph Coventina, also found elsewhere in Britain (Allason-Jones & McKay 1985), another indication of the importance of water in the Celtic religion. There were a number of spring sources in Britain which were modified to include a well and were ornamented with temples and altars. Often these religious spring sites had a Celtic background, but, true to the Roman ethos, they romanized a number of these.

Springs, rivers and wells were associated with Celtic religious functions and became focal points for their cult practice and ritual long before the coming of Rome. The pre-Roman Celtic Britons appear to have adopted the concept of the sacred well similar to their Gallic counterparts. Together with its religious function, the well also would have served the purpose of providing the community with water and some of the early wells were probably dug by these early Britons.

Rivers were important because they were associated in Celtic tradition with fertility and with deities such as the divine mothers and sacred bulls. The Celtic mother-goddesses, who frequently also functioned in the role of war-goddesses and prognostication (foretelling the future), have wide association with water (Ross 1967, 20). There was a connection with fertility which could be likened to the life-giving powers of water and this was exemplified in the naming of rivers after goddesses. In Gaul there are several rivers so named, as for example the river Marne, which derived its name from 'Matrona', or 'Divine Mother', probably because at one time there was a cult legend associating the mother with the river (Ross 1967, 20). Ross reports that "in 1963, some 140 carvings of a cult nature in wood were recovered from the marshes at the source of the river Seine... This find adds weight both to the importance to the Celts of sanctuaries associated with the sources of rivers and to the association of the human head with sacred springs" (1967, n.2, p.21).

Ross reports other cult object finds found in rivers and at springs. Some finds in rivers are images of deities which probably were related to the cult practices, but others are often ordinary items like swords and Celtic metal artifacts. Although Jane Webster indicates that one has to be careful in the interpretation of evidence of early finds used for cult practices (1996, 1, 5), there seems to be no reason wholly to abandon the conventional view of the religious associations of water in Celtic society.
In Britain a similar pattern is found in the naming of rivers after goddesses (Rivet and Smith 1979, 22-47, such as the river Dee, the "holy one", or Celtic Deva "the goddess" (22), the river Clyde after the Celtic Clota name the "washer, the strongly flowing one" (45), the Severn (Sabrina) (457), and both the Braint from Anglesey and the Brent of Middlesex from "Brigantia" a river goddess (278-9). The archaeological evidence for temples at sources of rivers in Britain is lacking, but Ross says that "the siting of the Lydney temple makes it clear that the wide estuary of the Severn (Sabrina) was of first importance, while the actual cult objects recovered from the temple to the god Nodons strengthens the connection between the cult and the water itself" (Ross 1967, 22). There are other shrines associated with aquatic cults in the region of the Severn estuary and adjacent areas (p.22).

There is other direct evidence for the cult of wells, pools and lakes in the British isles. From Europe the two prime examples for the veneration of lakes come from the La Tène phase of Celtic culture found in Lake Neuchâtel. Strabo, quoting Posidonius, reported "that the treasure found at Toulouse...and part in the sacred lakes...", seems to indicate that there was a practice of using the lake at Toulouse as a cult centre. (Strabo IV, I, 13: Tierney, 262). Fox (1946) reports that Celtic metalwork was found in the small lake Llyn Cerrig Bach, in Anglesey, and that the manner in which it was deposited strongly suggests a ritual deposit (Ross 1967, 24). Fox (1958) also reports discovery of "the finest pieces of La Tène art in rivers, such as the Witham in Lincolnshire and the Thames...and the most likely reason for their presence here is...of the placing of precious objects in water for religious purposes" (Ross 1967, 24). On the evidence quoted above it seems clear that early religious practices were important in pre-Roman times, but in view of the comments by Webster it would seem that a new assessment of the original interpretations is necessary.

It would seem that the Celtic religion was highly developed amongst Britons at the time of the Roman conquest. The Romans, in the tradition of romanization, also influenced the Celtic religion, often naming the gods and goddesses of the Celts after their own.
7. CONCLUSION

In the chapters that are to follow I shall look closer at the aspects that have been presented above. I outline the methodology of collecting and collating the material. I shall discuss some problems, issues and questions that have emerged from my study of the archaeological data. A simplified presentation of the database material will be given. The main gazetteer database is incorporated in summary form in Appendix 2. An attempt will be made to establish patterns of water facilities and how much can be gleaned from the analysis of this data. The extent to which the provision of water facilities contributed to the romanization of the British and the success of that provision will be discussed. Finally, there will be a concluding section reviewing the analysis that has been presented with some comments on possible future research.
CHAPTER 2.
METHODOLOGY, DATABASE, ROMAN HYDRAULIC ENGINEERING
IN ANCIENT TEXTS

1. GENERAL
After trying several databases, Microsoft ACCESS version 2.0 was adopted for creating a database and the other type tables to record the information on water-related structures from the archaeological record of Roman Britain.

2. PURPOSE OF THE DATABASE
There is no comprehensive gazetteer summarizing the available material on water-related structures for Roman Britain for easy reference. For this reason I have produced a gazetteer database of information on water-related features at Romano-British sites.

The information used in the database covers archaeological remains reported in many sources and includes sites reported up to the end of 1995. An attempt has been made to cover most of the available reports on Roman water type structures, but inevitably some publications might have been overlooked. A primary motive for the research presented here has been the need to bring together information spread out in many publications. Also important in the study is the inter-relationship of the various features, and their significance in the romanization process, and in their social and religious contexts. The data can never be complete as new excavated sites are continually reported in the literature and a vast number of sites remains unpublished.

3. DATA COLLECTION
The most important previous work on water supply and drainage in Roman Britain is the unpublished thesis of Julie Hanson, which summarizes data available up to 1970. She discussed in detail aspects of aqueduct types, the types of channel and piping used and some details about the sites. Her primary purpose was to look at the known

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1 At the present time there is no comprehensive summary for the water supplies of the empire or even for the various provinces, though one may note the work of Geell (1902) and Birebent (1962), both for Algeria in North Africa. Research is currently in progress to summarize information on water supplies for the Mediterranean area. The Germans have done some work in collation of water supplies through the Frontinus-Gesellschaft in three volumes Die Wasserversorgung antiker Städte edited by Garbrecht et al, 1986, 1987, 1988. For this reason I have produced a gazetteer type database of information on water supply features at Romano-British sites.

aqueduct water supplies for military and town sites, and inevitably there are some omissions in her work and in the light of recent investigations and new excavations, her discussion of many sites requires updating. Not all the sites she discussed had remains of aqueducts, but because of other circumstantial evidence she conjectured that such sites may have had an aqueduct-type water supply.

Stephens discussed sites with civic and military aqueducts in his two 1985 papers, but he did not go into the sort of detail that Hanson covered. Both authors in a few instances make comments on technical detail that require some re-interpretation, which I shall attempt to do in the sections of this thesis where it is appropriate.

The features discussed by Hanson and Stephens are summarized in Tables 2.1a and 2.1b as follows:

**Table 2.1a: Water supply features cited by Hanson**

<table>
<thead>
<tr>
<th>Total record entries:</th>
<th>76</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sites entered twice*:</td>
<td>-9</td>
</tr>
<tr>
<td>One site entered 3 times**:</td>
<td>-2</td>
</tr>
<tr>
<td>Actual number of sites:</td>
<td>65</td>
</tr>
</tbody>
</table>

* different periods, or once for fort and once for town.
** Corbridge i) Flavian, ii) Severan, iii) 4th century

<table>
<thead>
<tr>
<th>Distribution of water supply features:</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>Military: (certain/conjectured)</td>
</tr>
<tr>
<td>Towns (+1 villa):</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AQ = aqueduct; BA = baths; WP = waterpipe; SP = spring; TA = tank.</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 5 baths were reported as being external to the forts.</td>
</tr>
<tr>
<td>** 7 of the pipes shown by collar remains within forts were conjectured to indicate that forts had aqueducts.</td>
</tr>
</tbody>
</table>

**Table 2.1b: Aqueduct features cited by Stephens**

| Military: | 55 |
| Civil: | 31 |
| Total: | 86 |

3 Stephens 1985a, 197-207; 1985b, 216-36.
4 Hanson 1970, 358-74.
For comparison, I have recorded a total of 135 sites with aqueducts (see Chapter 6, Table 6.1). Neither of these two authors dealt with the wider range of archaeological sites with water-related features that have been reported on during the past 200 years.

I have collated information on water-related structures for 7 types of sites. Military sites are divided into fortresses, forts and fortlets. This evidence includes aqueducts (with a variety of conduit types), Roman baths, wells, and cisterns or tanks. The presence of baths would generally indicate the probable existence of a reasonably effective water supply, either of wells or aqueducts or a water source such as a spring or clean stream close to the site. Smaller baths, such as found in or near forts and in settlements and villas could have been provided with water from wells, or some other source, by soldiers or slaves carrying water to the baths. Baths are generally reported in detail in structural terms, but for some reason their water supply has not often been investigated or commented on.

In the next section, the typology of water-related features and the typology of sites are defined for the purpose of this thesis.

4. DATABASE RECORDING

The procedure used for compiling the database was to record information obtained from the libraries for each site on index cards with as many bibliographic references as possible, and then to transfer it to a computer database.

The types of sites are given in the records of the ‘site type’ field. The database consists of fourteen fields as follows:

Field one: site name
Field two: site type
Field three: Roman name (where known)
Field four: eastings, and
Field five: northings, in International Grid format
Field six: location, in National Grid format
Fields seven to fourteen give the following eight data types:
  aqueduct, bath, well, drain, pipe, spring, tank and sewer.

6 The database table was originally headed by fifteen fields of which the last eight represents the actual typological features data. The 7th field was the ‘Reference’ memo field, but the large size of each memo record made it impractical to handle within a database, and was transferred as a table to Appendix 2.
The initial two fields provide the site name and category of site (for simplicity I defined nine types: fortress, fort, fortlet, colonia, municipium, civitas capital, small town, settlement and villa). Field three gives a Roman name for the site name where it is known. The fourth and fifth fields give the location of each site in the International Grid format in terms of the 'easting' and 'northing' coordinates based on 100km (100,000m) grids. The sixth field provides the location for each recorded site using the Ordnance Survey National Grid system for Britain, with the two-letter notation for each 100 square kilometre grid area. Fields seven to fourteen give the water-related features of the database which represent the archaeological remains discussed in the text. Query tables have also been produced based on the database table which gives the location of sites in the International Grid format based on eastings and northings for 100km square grids. Plots have been produced showing locations of sites for specific water-related feature types based on the International Grid pattern. The database is presented in this thesis as a series of specialized tables because the format is too wide for all the fields to be given together in a single table. These are divided into three basic divisions:

a) a single table (Appendix 1) gives all the data for the eight types of water-related features;

b) the reference memo field is now given as a separate table with each record headed by the site name (Appendix 2);

c) site names and types with their locations and the category of feature under discussion, (Appendix 3);

One of the problems with the typological data was to decide what to include without making it completely unwieldy. Originally it was my intention to include the dates of the various structures in the fields for each type of structure, but as the dates of so few of the structures are known it was decided not to include it at this point. Inclusion of a date field adjacent to each structural type would have doubled the number of fields and would have made printing of meaningful tables a difficult task. Date information is usually given in the references of Appendix 2. The typology of water-related features does not include agricultural drainage features and Fen-type drainage.7

7 Areas such as Wentlooge Level (Gwent) show Roman expertise in this type of hydraulic engineering. On Wentlooge Level, the Romans used many drains to lower the water table in order to reclaim land which was affected not only by surface flooding, but also by erosive attack from usually violent sea waves. At Romney Great Wharf alone more than
All reference material will be in Harvard format and details will be given in the bibliography. I have added pertinent notes about some of the water-related features for information and to clarify aspects about them. Also, the three references CSIR and TIBRS and TIRCGLL always are given at the end of a reference record where they apply. It is also to be noted that many of the references in the database and the bibliography are dated in the last and previous centuries. These authors give descriptions of structures which they have actually seen or had first hand knowledge of and many of which may have disappeared since. For many water-related features the older references are the only ones that I could trace. However, early archaeological reports often did not give sufficient details for the precise location of sites or for features such as wells or aqueducts at particular sites. Nevertheless the reports can provide visual testimony of the existence of specific structures at sites where the evidence is now lost.

The database provides a reasonably extensive sample of water-related structures for the Romano-British period (Appendix 1). Many references are included in the table of Appendix 2, and I have endeavoured to make these as complete as possible. Where the literature mentions that, for example, wells were found at a site, they are indicated in the field as W1+. Where the specific number is given it would be indicated.

The inclusion of structures such as baths or piping or drains is assumed to indicate the presence of some form of water supply by implication. Large public baths would most likely have required some form of constant running water supply such as an aqueduct. Baths in some forts, villas or homes may have been small enough for them to have been filled by water carriers. Many of the sites listed in the database show only a bath or a drain or piping, without also showing a water supply. It is to be inferred that such sites had some form of a water supply source. A number of these may have had running water supplies of which the structures are now no longer visible, or they

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40 drainage ditches have been found and also protective dikes to protect the land from the sea. Britannia 17, 1986, 91-117; 19, 1988, 191-2; 25, 1994, 175-211.

8 CSIR: Corpus Signorum Imperii: Great Britain (Oxford).

TIBRS: Tabula Imperii Romani: Britannia Septentrionalis.

may have been filled from water in a tank or cistern, or water carried from a well or spring.

Many sites mentioned in the literature have yielded items such as hypocaust tiles, which could have originated from the hypocaust of a bath, but since rooms other than baths were also heated, it cannot be assumed every such tile would indicate the presence of a bath. Although some such isolated tiles could have been part of a bath complex, I have not included such sites in the database unless some additional information indicates that it is warranted to assume that the site had a bath.

It is also likely that many Roman settlements and towns had wells which have not been found or recorded during archaeological investigations. This could equally apply to other water-related structures. Many archaeological excavations, especially of the last 30 years of rescue archaeology, remain unpublished and this necessarily affects the completeness of the data set available for my thesis. Where available, the more recent excavation reports, such as at Colchester (Crummy 1984 Report 3 and 1992 Report 6) and Caerleon (Zienkiewicz, et al, 1986), are more thorough in their descriptions of features such as water supplies.

The database of archaeological sites used in this thesis is thus by no means a complete gazetteer, representing a sample of excavated Roman period sites which has provided evidence of water-related structures. The reason for this limitation is that there is a dearth of information about such structures at many other Romano-British sites. For instance, study of the Nene valley, south-eastern England, or the Cotswolds area, areas where there were numerous Roman period settlements, reveals many details of water supply for some sites, but there are many more which have shown none. This seems to apply throughout Britain. The ‘missing’ information was either not recorded during excavations, because they had been completely destroyed beforehand or the excavators were not particularly looking for that category of structure, or of course, the site might genuinely not have had water-related structures. One is led to the tentative conclusion that the fairly extensive sample of sites in the database could be a reasonable indicator that many, if not most, of the remaining sites must have had access to water supplies that were quantitatively or qualitatively different from the traditional supplies used at the pre-Roman British settlements.
What are the chances that the sites that had no record of having had water structures, did in fact have them? I am conscious of my lack of archaeological experience and of the problems involved during excavation of sites. However I find myself asking whether archaeologists have paid enough attention to those factors that allow a community to thrive. There were so many factors which influenced the location of settlements, whether it was to establish a fort, a town or a villa. One constant factor must have been: could they subsist at those sites, and for this the two prime requirements were food and water. Defence was also important, but under Roman rule defence was of less significance to the 'new' Briton and for them their livelihoods and commercial prosperity became the motivating forces.

Since water was vital to existence it can be assumed that they gave it some priority in their planning. Scanning some of the standard works on Roman Britain it is difficult to find the word 'water' mentioned and even more so 'water supply'. This seems to indicate some reluctance concerning this important social requirement and one which would surely have demanded early attention when establishing a household or a community. When reports do mention a well, for instance, it might be merely to describe the small finds found in it, with less concern about identifying the length of time the well may have been in use. That the well in itself was of importance to that site in its own right is usually ignored. This, it can be argued, may account for the fact that many sites have been reported on and no water-related structures recorded. It may also be because interest in water or the technical aspects of what made a site viable as a place to live at was outside the ken or interest of the investigating archaeologist. It is possible that little attention has been given to the details of the remains of aqueducts or wells in Britain precisely because of the relative abundance of water in this country, leading scholars to underestimate the significance of water supply. An abundance of water in nature is not the same as a sufficiency on site.
5. TYPOLOGY OF WATER-RELATED FEATURES

The database presents information on 807 archaeological sites and data records of eight water-related features: aqueducts, baths, wells, drains, pipes, tanks, springs and sewers. A brief definition is given of each feature as it will be used in this thesis.

1. **An aqueduct** is any type of conduit which conveys water from a source to a distribution tank (castellum divisorium).

2. **Baths**, a place for bathing. From the 1st century BC they were generally heated by a hypocaust system which warmed the floors from underneath and walls built with flue pipes to heat the rooms, and almost invariably had a hot room (caldarium), a tepid room (trepidarium) and a cold room with plunge baths (frigidarium).

3. **Wells** were shafts sunk into a water-bearing layer (aquifer) of permeable rock, gravel or sand, or to below the top of the water table where ground is permanently saturated.

4. **Drains** consisted of ditches, stone- and wood-lined channels, and occasionally pipes, to convey rainwater, water from baths, waste material from kitchens and latrines, and stormwater along streets, away from the buildings on a site.

5. **Pipes** were made of wood, lead, ceramic materials and stone.

6. **Tanks** were receptacles in which water was stored, usually constructed with stone and lined with mortar. It is likely that there were also many wooden tanks, but these are less visible archaeologically.

7. **Springs** were sources of water which issued from the ground fed by an aquifer in the form of a perched water table, usually along the slopes of hills or mountains.

8. **Sewers** were stone-built structures, generally arched and usually underground, which were conduits into which drains discharged waste materials from kitchens, latrines, baths, and also rain water from stormwater drains.

Each one of these features had particular characteristics, which were often dependent on where they were situated on a site, and also on the materials from which they were manufactured. A brief discussion of each feature will be given below.
5.1 Aqueducts

These consisted of the following types:

1a. Leats: open ditches cut into soil or rock.

1b. Stone channels: usually lined with clay or lime-based mortar to render them impermeable to seepage; on more elaborate aqueducts the channel (specus) is usually an arched structure tall enough for cleaning purposes, popular in the rest of the Empire; sometimes they are covered with ashlar slabs. Another issue concerns whether a stone channel was open, as at Lanchester, or covered.

1c. Wooden pipes: usually bound, with iron rings at joints. Wooden pipes varied in length from about 1m to 3.5m, with bores of about 50mm to 90mm diameter. The outside of one end was tapered so that it could fit into an enlarged opening at the thick end of an adjacent pipe, which was bound with an iron collar. These iron collars are often the only remains which indicates the line of such wooden pipes. Roger Wilson discusses the wide use of wooden pipes as aqueducts, and in particular refers to them also being used in inverted siphons (1996, 22).

1d. Lead pipes: were either round, triangular, oval or pear shaped (see Chapter 3, Fig.3.2); they were mostly used in an aqueduct system where inverted siphons were necessary, or in intra-site distribution systems.

1e. Ceramic pipes: were made from terracotta (earthenware) and were either cased in concrete, or uncased. They were hollow, conically-shaped, with a small diameter end which could fit into the large end of the adjacent pipe. The sizes varied considerably, depending on the expected amount of water to be delivered. At Lincoln the diameter of the large end of the earthenware pipe was about 140mm reducing to about 90mm at the smaller end. Ceramic distribution pipes found at Wroxeter were about 70mm at the large end and 35-40mm at the small end. Pipe lengths varied from about a half metre (as at Chester), to one metre (as at Lincoln). Joints were sealed with a specially prepared lime mortar.

1f. Stone pipes: made from bored-out stone were used in several places in the eastern part of the Empire, but are rarely attested in Britain.

In the database I have used the classification aqueduct and the symbol AQ to indicate it at a site, and where possible have indicated in the field column what the aqueduct feature consisted of, but this was not always possible. Aqueducts are more fully discussed in
Chapter 3 and a case-study of the Dorchester aqueduct is analyzed in Chapter 7.

5.2 Roman baths
Baths developed a standard pattern consisting of the hypocaust system for heating, which provided graded temperatures to generally two heated rooms (lb above) and the larger baths also included a dry-heat sweating room (sudatorium). Within each one of the first two hot rooms there were pools fed with hot water from tanks associated with the heating system (Nielsen 1990, 14-8). There were also many other rooms used for dressing, scraping, massaging and other activities in the larger bath complexes. The public baths of towns usually had a basilica attached to them, where exercise activities were available, and where food and other commercial products could be obtained, which at the same time provided a social community centre associated with the baths. There were also private baths which were run as commercial enterprises, particularly in places like Rome, Pompeii and Ostia (Nielsen 1990, 122-7). It is not known if there were any commercially run private baths in Britain. Baths varied tremendously in size across Britain and the large ones usually were architecturally very elaborate structures. At fortresses, baths were usually large as they would have been used by large numbers of soldiers (Zienkiewicz 1986). A number of towns also had large baths such as Leicester and Wroxeter. The smaller baths in settlements and villas often consisted of two or three rooms only, as at the villa of Cosgrove (App.2), with three rooms for a caldarium, a tepidarium and a frigidarium with a small plunge bath attached (Quinnell 1991, 8-11). In Chapter 6 I shall discuss the status of some settlements with baths. Some other villas had quite elaborate baths such as at Northleigh and Rockbourne (App.2). I have not given a classification of Roman baths (designated as BA) in the database table, but in the text (Chapter 5) have discussed their classification and where appropriate, referred to their sizes and other attributes. Baths have been comprehensively treated in the literature, mostly baths outside Britain.9

5.3 Wells
These were an important source of water for all site types. They were dug into both soil and soft fractured rock, and, where necessary, were lined to prevent internal collapse of the walls. Water-bearing rock, usually limestone and sandstone formations, is widely spread

over Britain. Wells varied in diameter from about 1m to 2.5m, and also were made in square format, particularly when they were steined (lined) with wooden planks. Some wells were steined with used barrels, and also with masonry or brick. Wells could be as shallow as 2m when they were sunk in gravel or sand layers close to the surface (as at London and Silchester) (App.2), and others could be as deep as 30m and more. Some wells were also used for cult purposes and in the literature there sometimes is confusion between shafts used only for religious purposes and wells used primarily as a source of water. Clarke (1996) discusses the overlap between these two functions, with particular reference to Newstead.

Wells generally have not been studied as a special construction feature except in a few cases, such as the Wilsford shaft (30m) (App.2) and the wells/shafts at Rushmore (40m and 51m) (App.2) and the details of some selected wells relating to their lining as a means of protection against collapse, as at London, Lancaster and Scole (App.2). Mostly they have been discussed in the archaeological record for the contents of their finds, or their importance to cult practices. I shall look at selected aspects of wells such as their construction features including lining (Chapter 4) and their social and religious significance (Chapter 7). Wells are not sub-classified in the database.

5.4 Drains
Drains varied tremendously typologically, having been constructed as open soil type ditches, pipes of various kinds and channels in stone, some open and others covered. Many excavation reports show drains of several kinds for some town sites. At forts they generally seem to be timber or stone-lined. It would appear that drains were often allowed to deteriorate, or were blocked up as new development took place at sites. Baths usually had an elaborate drainage system such as at the baths of Leicester (Chapter 3, 94), (App.2). Many towns had systems of drainage from private homes which discharged into larger drains or directly into sewers such as at Lincoln or York (App.2). They have not been classified in the database (shown as DR).

5.5 Pipes
These were used in aqueduct systems, water distribution systems within urban areas and occasionally in drainage systems. Wooden pipes

10 In the literature drains are sometimes referred to as culverts, a term in modern terminology implying a drain passing underneath a structure.
were used more often than either lead or earthenware pipes, whether as aqueducts (as at Cirencester, Caistor-by-Norwich, Carpow and Fendoch), or in distribution systems (found at Caerwent, Colchester, Gloucester, London, Silchester, Verulamium and Wroxeter) (Hanson 1970, 419). Wood was cheaper and more accessible than either lead or materials for ceramic pipes, and they were easily repaired. Where inverted siphons were necessary either lead or earthenware pipes were used and they were usually encased in concrete when used for that purpose, though wooden pipes are recorded as having been used as inverted siphons (see Chapter 3, section 3.4), as at Caerwent (Hanson 1970, 85) and as recently found at Gosbecks near Colchester (Wilson 1996, 22). This is an unusual use of wooden pipes, probably working only under quite low pressures, and as repairs to wooden pipes at Caerwent shows, they were prone to burst under pressure (Hanson 1970, 85). There seem to have been no standard wooden pipe diameters or lengths, these depending probably on the boring equipment and lengths of trees available to a pipemaker. Iron collars used at the joints of wooden pipes were found at many sites but surprisingly were not used much at military sites as at Birrens, Brough-on-Humber, Fendoch, Pen Llystyn and South Shields, although they were used at the legionary fortresses of Caerleon and Carpow (Hanson 1970, 421). Pipes are indicated in the database as WP.

Lead pipes were mainly used in distribution systems in Roman Britain. A lead pipe inverted siphon was used in a portion of the earthenware aqueduct at Chester (Stephens 1986, 60) (App.2). Lead was also used in pipelines as at Caerleon, Corbridge (an 18.5m length was recovered), Inchtuthil and York (App.2). Hanson suggests that lead may have been used more readily at military sites because the cost of expensive lead was paid for by the State, whereas towns had to finance their use of materials from their own funds, so would therefore have used the cheaper wooden pipes rather than lead or earthenware pipes (Hanson 1970, 419).

The use of earthenware pipes as aqueducts in Roman Britain is recorded only for Chester and Lincoln, whereas they were used widely in distribution systems at many sites. When they were used as a rising main in an aqueduct as at Lincoln, they had to be encased in concrete in order to withstand the water pressure. Their diameters varied over their lengths for different sites from about 30-50mm (Wroxeter) to 90-140mm (Lincoln) (Hanson, 1970, 423-4) and 130-170mm (Chester), (Stephens 1986, 60), and their lengths from about 0.3m to
0.7m. The military supply depot at Holt was a probable supplier of earthenware pipes to Chester fortress and probably also to the colonia at Lincoln (Hanson 1970, 423). Pipes have been classified in certain instances in the database.

5.6 Tanks
Tanks were widely used in all categories of sites to store water. Many excavation reports have recorded tanks, some of which were filled with rainwater run off from roofs and others were placed where it was most convenient to fill them, or at places from which water could be conveniently drawn from them. They varied in size depending on whether they stored water from an aqueduct supply such as the tank at the north wall of the colonia at Lincoln, or were a source inside a building for internal use. An elevated tank is postulated for the bath at Leicester (Wacher 1995, 350, Fig.10) but there is uncertainty as to how it was filled. Similarly, an elevated tank is proposed for the hypothesized inverted siphon of the aqueduct at Lincoln (Thompson 1954, 117). Usually tanks were at floor level in buildings and of modest size (capacity about 1.5m³ to 3m³). In private homes they usually were below floor level in a convenient place where they can receive water from rooftops. Tanks are not classified, even in the existing literature, because so little of the upper part of tanks has survived.

5.7 Springs
These were the preferred source of water for aqueducts, though sometimes aqueducts tapped the headwaters of streams. It must have been a constant worry whether a spring would supply sufficient water all year round. At Winchester it is reported that several springs were tapped at Itchen Stoke. A puzzling situation existed at Caerleon where there was a spring within the fort which seemed not to have been utilized as a water supply, but that a ‘culvert’ was used to remove the water from the site (Hanson 1970, 179). Although there were springs along the route of the aqueducts for the Lanchester fort, the northern aqueduct was extended further west, where two dams were built across a stream to provide the source of water. Springs are not classified (shown as SP).

5.8 Sewers
Sewers are some of the best preserved structures from the Roman period, primarily because they were always constructed below ground level. As new construction took place over demolished buildings they
became covered to greater depths. The remains of twenty sewers have been recorded in the database, of which half are from military sites. Sewers were used in Roman times for the removal of foul waste, stormwater or excess water from a running water supply. They were usually wide and high slab-covered structures such as at Lincoln (Wacher 1993, 46, 138) and arched structures such as at York (Whitwell 1976, 1-55), to be discussed in Chapter 5. They are not classified in the database (shown as SE).

The table of Appendix 1 gives all the data for the 807 sites showing the distribution of the water-related features, and shows the incompleteness of the information about the type of structures that one would expect to find at sites. For instance at a site that has a bath one would expect to have some form of water supply. If the bath is large the expectation would be that it was serviced by a running water supply, such as at Caerleon or Wroxeter. However it often happens that a town may have a public bath, but no water supply of any kind has as yet been found, as at High Wycombe. I shall be discussing this anomalous aspect in greater detail in Chapter 6.

6. TYPOLOGY OF SITES
The term ‘site’ in modern archaeology, it is suggested, must be avoided because it is considered an "artificial concept invented in the present with no meaning in the past" (Greene 1995, 53). However, Greene suggests that archaeologists should continue to use the term as a "descriptive label for a place where... artifacts and/or features occurs" (ibid. 53). It may be a problem to refer to a region, or the route of an aqueduct as a site, but usually such features are not referred to as sites. Aqueducts are referred to by the site name of the town or other site they serve. A ‘site’ in this thesis is taken to be a place where people lived, such as a fort, a town, a settlement or a villa.

The nine site types used in the database are given on p.19 and below follows a brief statement about each type.

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11 There is no doubt some logic behind the reasoning why the term ‘site’ as a notion should not be used, but if qualified with a name that gives the location of a supposed site it provides a practical means of referring to a locality. The word site comes under the category of generic words like 'love', 'war' or 'object', each of which have been analyzed etymologically and philosophically, without specific acceptable definitions. Yet they are read, in spite of Duneill's statement that 'site, as an archaeological concept, has no role to play in the discipline...In spite of the technical problems its abandonment will cause, the concept of archaeological sites should be discarded' (1992, 36-7, quoted at Greene 1995, 53).
6.1. Forts.

In the database tables I have used three categories of forts namely fortresses (legionary), forts (auxiliary/cavalry), and fortlets. These categories are based on the functions they served. All three types varied considerably in size, even within each category. Their function and size were determined by the number of soldiers that each housed during its active existence. I have not included military camps as a category, because they did not have permanent status, and did not generally have permanent water supply features, water most likely being obtained from springs or clear small rivers.\(^\text{12}\)

1. **Fortresses** were of two kinds: **legionary** (c. 20-25ha) and vexillation (c. 6-12ha). The legionary forces were the protectors of the frontiers of the Empire and their fortresses had to house as many as 5,000 to 6,000 military personnel. The legions were composed of Roman citizen soldiers; vexillation fortresses may have housed mixed brigades of legionary and auxiliary troops. Wilson lists ten legionary fortresses and twelve vexillation fortresses (1980, 92-3), but the military disposition of fortresses and forts was very fluid through the conquest period (c.AD 43-68), the Flavian (AD 70-96), the Trajanic-Hadrianic (AD 97-138) and the Antonine periods (c.AD 142-63). Often both fortresses and forts were deployed during these periods to serve particular military needs, so that they may not all have been occupied at the same time. Jones and Mattingly (1990, 88-101) show in a series of maps (Map 4.23, 4.24, 4.31, 4.32) the complicated changes of disposition of military sites over that period of about 120 years, indicating that it can be misleading to mention all the known military sites for the period from AD 43 to AD 168. In the database I have listed nine legionary and four vexillation fortresses with water-related structures, without taking into account their period of deployment. In Table 6.2 where I have given the summarized information for all site and feature types, I have classed all military sites together as forts, for the purpose of analysis.

2. **Forts** are continually being added to the list of known remains as new ones are discovered. The areas of auxiliary forts were generally about 1 to 5ha in extent, depending on many factors, and they were usually manned by auxiliary infantry and cavalry units, consisting of between 500 to 1000 soldiers. Towards the later first century unit

\(^\text{12}\) However, some anomalous, semi-permanent structures were erected during the construction of major sites, as with the officer’s compound at Inchtuthil. (Pitts and St Joseph 1985, 215).
numbers at some forts were increased to about double the former unit size (Breeze 1983, 15). Their duties were in general to keep lines of communication open and preserve the peace in conquered territory. During the 3rd century the north of Britain was relatively peaceful (Welsby 1982, 8), but in the south-east of Britain there were indications of trouble from the European continent and this resulted in the construction of the so-called forts of the Saxon Shore (Johnson 1979). These forts differed in some respects from the type of forts described above, but I have not listed them separately. They have been listed as ordinary auxiliary/cavalry forts. Holt is listed as a fort, but was actually a supply base to other forts of special products such as pottery tiles and ceramic pipes.

3. **Fortlets** were usually small forts (generally less than 0.5ha) and manned with a detachment of about a centuria. They were often used as outposts for the purpose of protecting an installation such as a bridge, river crossing, or a road (Breeze 1983, 43). Milecastles I have referred to as fortlets. In the database 10 fortlets are listed which had water-related features.

Many of these military installations were not permanent, and some could be abandoned for a period and, when military circumstances required it, be re-established at a later date.

6.2. Coloniae, municipia and civitas capitals.

Coloniae, municipia and civitas capitals seem reasonably well defined as large urban centres or major towns, each serving specific functions within the province. The three initial coloniae were built for the specific purpose of housing large populations of discharged soldiers, as at Colchester, Gloucester and Lincoln. York, on the other hand, was raised to that status in the early 3rd century during Severus' reign (Salway 1993, 391-2). The water-related structures for coloniae were usually an integral part of their planning at the inception of their development. The coloniae would have been established with the approval of the Emperor and the colony would have been governed by a council known as an ordo with a constitution modelled on that of republican Rome. Officers would have been elected by the council as executive magistrates, who would have been responsible for the planning of the city's development including its water supply (Frere 1974, 206).
When the word 'town' is used in this thesis it has meaning only in the broadest sense applied to major towns. Distinctions are drawn between chartered towns (the _coloniae_ and _municipia_) and non-chartered towns (the _civitas_ capitals) and more particularly between the latter and 'small towns'. Verulamium is the only town in Roman Britain for which there is evidence that it was granted a charter as a _municipium_ (Wacher 1993, 18). The status of Roman London seems to be uncertain; however, I have designated it a chartered town in that as the provincial capital it was almost certainly promoted either to municipal or _colonia_ status (Frere 1987, 193).

1. _Coloniae_ were chartered towns specially created for retired army veterans and their families. These towns had a certain amount of autonomy in their administration and were able to raise capital for their development, including construction of public buildings, baths and water supplies. In Britain the four _coloniae_ were at Colchester, Gloucester, Lincoln and later York. All four initially started as fortresses.

2. _Municipia_ were often pre-existing towns that were promoted to Roman municipal status, also with some form of self-government, but they did not have the full administrative powers vested in the _coloniae_ (Frere 1967, 200). Verulamium was a _municipium_ (probably from the AD 50s) and London may have achieved that status soon after the Boudician revolt in AD 60 (Frere 1967, 93-4). However, London is a problem with regards to its status. Morris argues that it was created as a wholly Roman town not associated with a tribal centre, with early Roman citizens already living on the site (1982, 104). It was not a _colonia_ or a _civitas_ and its probable status from its inception, c. AD 48, was the rarity, a _municipium civium Romanorum_, a Roman citizen borough" (104). Clearly London must have had some status more than that of a mere settlement or ordinary town, especially considering its importance as the capital of the Province and as a major commercial centre and as a major harbour.

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13 Morris 1982, suggests that Leicester was also a _municipium_, based on "The diploma of M. Ulpius Novantico (CIL xvi, 160), a Coritanian/Corieltauvian auxilliary soldier, gives his origo as Ratis, not Coritanus, implying that Leicester had risen from the status of _civitas_ to that of _municipium_ by AD 106. For the contrary view see Frere 1978, pp.235-6" (Morris 1982, '71, n.31 p.354). Frere's view is that since Novantico "was already a Roman citizen as a result of a special grant in the field...", it has no bearing on the status of Leicester. This is an historical opinion, but one cannot but wonder why so few towns in Britain had _municipium_ status.
There may have been other towns with higher status, particularly because of "their evidence of intense romanization", such as Canterbury, Leicester, Wroxeter and probably Cirencester, but there is uncertainty about it (Frere 1967, 206).

3. Civitates were based on the pre-existing tribal territories which centred around newly created civitas capitals. They did not have the same self-governing powers of the chartered towns, but they did function on the model of Roman towns with an ordo who elected magistrates responsible for the running of the civitas (Millett 1990, 7, 66).

The civitates in Roman Britain were centres of local government based on 17 tribal areas. These tribal areas were the artificial partitioning of Britannia by Rome in order to facilitate government and regularize relations with the different British tribes.

Millett lists 16 civitas capitals (1990, 106, Table 5.1; 154-6, Table 6.5), which is three less than the number of tribal areas which he shows in Fig.16, (p.67). The two tribal areas, the Ordovices and the Degeangli in Wales, do not seem to have had civitas capitals, nor does he refer to the civitas capital of the Trinovantes.

Table 2.2: Civitas capitals.

<table>
<thead>
<tr>
<th>Civitas capitals</th>
<th>Tribe</th>
<th>Modern town</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caileva Atrebatum</td>
<td>Atrebates</td>
<td>Silchester</td>
</tr>
<tr>
<td>Caesaromagus (or attached to Camulodunum)</td>
<td>Trinovantes</td>
<td>Chelmsford (or Colchester)</td>
</tr>
<tr>
<td>Corinium Dobunnorum</td>
<td>Dobunni</td>
<td>Cirencester</td>
</tr>
<tr>
<td>Durovernum Cantiacorum</td>
<td>Cantiaci</td>
<td>Canterbury</td>
</tr>
<tr>
<td>Isca Dumnoniorum</td>
<td>Dumnonii</td>
<td>Exeter</td>
</tr>
<tr>
<td>Isurium Brigantium</td>
<td>Brigantes</td>
<td>Aldborough</td>
</tr>
<tr>
<td>Noviomagus Reginorum</td>
<td>Regini or Regni</td>
<td>Chichester</td>
</tr>
<tr>
<td>Ratae Corieltauvorum</td>
<td>Corieltauvii</td>
<td>Leicester</td>
</tr>
<tr>
<td>Venta Belgarum</td>
<td>Belgae</td>
<td>Winchester</td>
</tr>
<tr>
<td>Venta Icenorum</td>
<td>Iceni</td>
<td>Caistor-by-Norwich</td>
</tr>
<tr>
<td>Venta Silurum</td>
<td>Silures</td>
<td>Caerwent</td>
</tr>
<tr>
<td>Verulamium</td>
<td>Catuvellauni</td>
<td>St. Albans</td>
</tr>
<tr>
<td>Viroconium Cornoviorum</td>
<td>Cornovii</td>
<td>Wroxeter</td>
</tr>
<tr>
<td>Suggested civitas capitals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durnovaria</td>
<td>Durotriges</td>
<td>Dorchester (and Ilchester)</td>
</tr>
<tr>
<td>Luguvalium</td>
<td>Carvetii</td>
<td>Carlisle</td>
</tr>
<tr>
<td>Moridunum</td>
<td>Demetae</td>
<td>Carmarthen</td>
</tr>
<tr>
<td>Petuaria</td>
<td>Parisi</td>
<td>Brough-on-Humber</td>
</tr>
</tbody>
</table>
Civitates perigrinae had a similar constitution to that of the coloniae but without quaestors and servi Augustales. The elected magistrates serving in local government could acquire Roman citizenship if the town received a charter. The prestige of these positions attracted some wealthy members of the community to participate in local government and so to enhance their power and wealth.

They would have been responsible for the collection of taxes for the state, but also for the planning of the development of the town and raising the funding for buildings. It was expected that they would become generous benefactors to city development projects. By the middle of the 3rd century it became a problem to find enough wealthy persons to take on these duties because they were expected to give ever more donations (Frere 1974, 207).

They seem to have been released from military control becoming self-governing civitates peregrinae (Wacher 1993, 21) and had their own constitutions modelled on the Roman type of towns elsewhere in the Empire (Salway 1993, 391). Based on the evidence only 11 civitas capitals have been directly attested and 3 further sites are also suggested (Table 2.2). The civitas of the Catuvellauni was probably administered from the municipium of Verulamium. The suggestion is that the Trinovantes were administered from Caesaromagus (Chelmsford) or Colchester, but opinion seems to differ on this (Wacher 1995, 207). The formation of the civitates is complex (Haselgrove 1984, 31-43), but generally was based on prior Roman experience in Gaul. In Britain, the civitas territories generally had a loose relation with earlier ‘tribal’ boundaries (Haselgrove 1989, 34; Birley 1988 11, 24ff).

6.3. Small towns, settlements and villas.

I have used the following simple approach in my database for the listing of lesser settlement sites: 1) small towns, 2) settlements, and 3) villas.

6.3.1. Small towns were ‘settlements’ that developed the characteristics of urban centres with some order in their layout and probably had some kind of industry or centres of attraction such as temples for cult practices. However, the definition of a small town
is contentious with little agreement amongst scholars. Burnham (1995a, 7-17) gives a detailed analysis of settlements and what attributes they should have in order to acquire the status of a small town. I have used Burnham’s list of 97 small towns (1986, 186-7, Fig.1) to identify the small towns mentioned in my database.

Small towns are problematic and scholars still disagree on certain aspects of definition. I generally accept Barry Burnham’s definition of small towns (1995a, 7-17). Frances Condron has synthesized Burnham’s approach (Burnham 1995a, 7-17) to the classification of small towns and suggested some modifications (Condron 1996, 57-8). However even here things are not straightforward. In his early work (1986) Burnham listed some 97 sites, but in later work he has cited in texts variously 52 sites (1987, 187), and 60 (1988) and 54 (Burnham and Wacher 1990, 2). Rodwell and Rowley (1975, 3) list 78 sites, and Millett (1990, 154-6) lists 117 ‘small towns’ but complicates the issue by including the four coloniae, 16 civitates and a municipium with Burnham’s listed 97 sites. Whether from this it is to be assumed there are as many as, or only, 97 small town sites I have not been able to confirm. However, where the sites collated by me coincide with any of Burnham’s lists, I have used the title of ‘small town’. Other nucleated sites I have called ‘settlements’ unless they are specifically known by a different category such as civititates or municipia.

6.3.2. The term settlement, as it will be used in this thesis, denotes minor nucleated sites, where small groups of families lived with no apparent indication of urbanization. Such settlements would have been hamlets and small villages consisting of a few farmsteads, but not operating as a unit with an organized urban structure. Often they would be near forts, towns or villas, but seemed to have had an independent existence. They could have been farmers, but also had other economic interests such as pottery and iron workings. Some ‘settlements’ dating from the Iron Age developed during the Romano-British period into villas or towns, such as Boreham or Somerfield Keynes.

Ultimately, Eleanor Scott says, everyone must decide for themselves what is the distinction between a settlement and a villa (Scott 1993, viii).\(^\text{14}\) It is not always easy to know how to interpret a site if the

\(^{14}\) Scott gives a detailed analysis of the problems of analyzing the classification of villas, indicating some of the confusion created by scholars when particular attention
original excavator did not provide sufficient information, which of course may not have been available at the time of excavation. Even the name 'town' which has become synonymous with settlements in Roman Britain as 'fortified places with a civilian character' (Wacher 1993, 19), can create confusion when it is applied to some specific sites. The confusion about settlement classification is compounded as shown in the Britannia index (1995, 184-5) where many settlement sites are listed, of which 17 are included in Burnham's list of small towns (1986, 187). Hingley (1989, 2-3) acknowledges the historical framework for the archaeological evidence of settlements, small towns and villas, but he stresses the dissatisfaction and criticism with this approach in recent times.15

Frances Condron (1995, 103) seems to have provided a sensible approach to the question when she says that "The use of the term 'small town' here is taken as a modern label applied by archaeologists to the identified sites, rather than a meaningful description of the settlements themselves". This seems to be a crucial issue in the debate: when archaeologists describe the remains of buildings on a site there is seldom discussion on what made that site function as a dynamic entity in which people lived. It is a difficult problem because we rarely have any knowledge of who lived in the buildings, but when there are public buildings and services, the site cannot easily be considered as a simple settlement. For the most part these are larger than simple farmsteads and typically it is these larger and more complex rural settlements which have yielded information for water-related features. The existence of such features presupposes an infrastructure controlled by some group of individuals, and probably by the more affluent and powerful members of the community.16 I have listed as settlements in the database any nucleated sites which are not classed as towns of any type mentioned above, or as villas.

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15 Hingley 1989, 2-3, cites Burnham & Johnson 1979; M Jones and D Miles 1979; Reece 1982 and Cunliffe 1984 who is critical of the historical approach. Since 1989 a number of scholars have reconsidered the basic approach and assumptions to settlement classification.

16 Burnham 1993, 99-110; Condron 1995, 103-18; Rodwell & Rowley (eds.), 1975. The authors of the articles mention the disagreement over details of some aspects of definitions of small towns and by implication also on settlements, which are of necessity discussed by them.
6.3.3. Villas and non-villa rural settlement.

There seems to be general agreement on what constituted a villa, although there are variations within this category, which I will mention where it is important in the treatment of their water-related structures. I have not distinguished between different types of villas, whether they were of 'corridor' or 'courtyard' villas, or of any other type. Although they varied in their layouts, this did not seem to have any bearing on the type of water supply they used. There are problems with interpretation however, as pointed out by Jones and Mattingly. To quote one example, although the Lydney example is recorded as a villa, the abnormally large size of the baths would suggest that the site might have been 'a bigger enterprise than normal for a villa' (1993, 193). This type of situation is likely to be common and could be usefully researched, but it was beyond the scope of this thesis to investigate whether the sites could be differently classified.

Usually the excavation reports refer only to the site comprising the structures within the villa's built-up area. Actually the villa consisted of the home, out-buildings and the surrounding land which form the villa estate (Hingley 1989, 100-9, 121-3). When it comes to the other occupied areas, that is Hingley's non-villa settlements, the situation is very complicated, particularly within the context of his discussion of 'settlement' economics.

These non-villa settlements were the simple homes of people who did not become 'highly romanized' and therefore the buildings do not show the characteristics of Roman type buildings, that is, the linear features associated with Roman construction or being built with stone. Hingley refers to these widely spread settlements over the province as ranging from 'extensive village-type communities to single upland farmsteads' (1989, 23). The farmstead settlements are not confined only to the uplands. Non-villa settlements are often associated with villas and Hingley (1989, 100-9, 121-3) indicates some relationship between them and the villas. On the other hand many non-villa settlements were not associated with villas or other nearby communities and Hingley (1989, 100-9, 127-8) speculates that these could have been the homes of absent landlords. He also suggests that there may have been families living in simple settlements but also had some contacts with more sophisticated urban communities (Hingley 1989, 24-25). It seems to me that the exact form of dependency between different kinds of estates in these rural areas is not
clearly established. How the 212 settlements I have recorded in my database will fit into Hingley’s classification I have not examined, but whatever the type of non-villa settlement, 20 had some form of an aqueduct, 49 had baths and 135 had wells. It would seem that there is a need to investigate these so-called settlements in relation to the small town and villa categories. In Chapter 6 I shall discuss the classification of 41 settlement sites and reappraise their present status.

Hingley (1989, 133-44) also refers to more isolated non-villa communities not seemingly associated with any other community. These were probably the poorest classes who occupied and were the owners of land traditionally inherited from generation to generation from before the conquest. In the absence of definitive evidence of the relationship between different communities, it seems unnecessarily restrictive to assume that a non-villa type settlement had to belong to some more established estate, villa or urban centre. My primary interest in these sites is whether they possessed water-related features and how their presence affected the status of the so-called settlement. It is therefore not possible to adopt Hingley’s criteria for what constitutes a settlement for the purposes of this thesis. I have simply grouped all the sites which are not forts, major towns, small towns or villas as settlements in the records of the database. The dispersed minor dwellings that dominate the Romano-British landscape are certainly drastically under-represented in my database, but they have also tended to be far less explored archaeologically, with academic priorities more focussed on upper levels of the settlement hierarchy.

7. SITES WITH SPECIAL FUNCTIONS AND STATUS

Some sites were difficult to classify because of limited information in the literature about their status. A number of sites seem to owe their existence to some industrial activity. For instance it would seem that the settlements like that at Alice Holt, Hants., and Cantley, West Yorkshire (see App.2), owe their existence to the very extensive potteries that developed during the late 2nd and 3rd centuries. The case is similar for mining sites of Roman date, many of which continued on from the Iron Age period. The gold mine at Dolaucotthi (App.2) and the lead mine at Linley (App.2), were both dependent on aqueducts for water supply. There are many Roman iron mining and iron working sites but only at Lydney (App.2) have I been able to trace an aqueduct. Beauport Park (App.2) is referred to in
the literature as an iron mine\textsuperscript{17} or processing site, which could be classified as a settlement (or even a villa). It is situated in the iron-rich area of the Weald in Sussex and boasts a bath-house\textsuperscript{18} built during the 1st century (abandoned in the mid 3rd century), but no indication of what water source it may have had. Walton-le-Dale (App.2) had two wells and was classed as a settlement, and is described also as having the function as a military supply base. This does not fall within my criteria of what a settlement is.

\textbf{8. SITES WITH NO WATER-RELATED FEATURES}

From a first glance at the limited information on some sites I formed the opinion that they might have had water features. But on closer reading of several references for those sites I came to the conclusion that no water-related features were actually reported. These sites are referred to in the database as 'falsus' sites, because it is likely that other people may form the same impression as I did that water-related features have been found. That is not to say that they did not in their hey-day have these features, but merely to put on record the fact that they have not yet been found - contrary to the impression one can form.

Many reports of sites incorrectly imply that they did have water-related structures, especially baths. For instance in describing the features of a site with a bath, usually the bath had an hypocaust, drains, special kinds of tiles and \textit{tibuli}, mosaics and often painted walls.

A number of sites are described in the literature referring to such type of finds, and the expectation would be that the sites may have had baths, but none have been found. Similarly from descriptions of certain sites the expectation is that they may have had other water-related features, but again none have been found as yet.

\textsuperscript{17} Britannia 10, 1979, 139-56; 19, 1988, 217-74.
\textsuperscript{18} Britannia 19, 1988, 217-74.
Examples of sites without water-related features are given in Table 2.3.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Site type:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ardoch</td>
<td>fort (large)</td>
</tr>
<tr>
<td>Limestone Corner</td>
<td>fort</td>
</tr>
<tr>
<td>Neath</td>
<td>fort</td>
</tr>
<tr>
<td>Whichham</td>
<td>fort</td>
</tr>
<tr>
<td>Coldharbour</td>
<td>settlement</td>
</tr>
<tr>
<td>Brantingham</td>
<td>villa</td>
</tr>
<tr>
<td>Frampton</td>
<td>villa</td>
</tr>
<tr>
<td>Kingscote</td>
<td>villa</td>
</tr>
</tbody>
</table>

Sites not included in database:\textsuperscript{19}:
- Brancaster: fort
- Bowness-on-Solway: fort
- Lidgate: villa

The sites mentioned in the table have the typical characteristics of other similarly classified sites, but no water-related features have been found yet. The following three sites (not included in the database), would seem to have all the requirements to have had water-related structures. Brancaster in Norfolk, a fort (3.1ha) with a 'large civil settlement' (23ha), \textit{(EAA 23, 1985)} has no reported water-related features. Bowness-on-Solway (refs), the terminal fort on Hadrian's Wall, a largish fort (c. 2.77ha) and with a large civil settlement, has no reported water-related structures. In the light of evidence for elaborate baths and water supplies to some of the other forts associated with Hadrian's Wall it is surprising that this site has not yielded any evidence of their existence. Lidgate in Suffolk, a large winged corridor type villa with 20 or more rooms, has no reported water-related structure \textit{(Antiquity 45, 1971, 224-5)}. One can add further examples, Kingscote(App.2) in Gloucestershire, is a villa, referred to in at least ten volumes of \textit{Britannia}, but with no mention of water-related features, and the villa is situated in a county where they were usually well provided with a bath and water supply system. Frampton (App.2), a villa in Dorset is another site where the expectation would be for some water-related features to have been part of the complex, but none have been found. This negative list is extensive, especially when one considers the 2000 or

more reported villas and many more settlements of various kinds. Some may have been too poor to afford such luxuries, but there seems to be too large a number without those features. They may of course not have been found yet or have been irretrievably destroyed. In general therefore, when the reported archaeological evidence of sites with and without water-related features for Roman Britain is compared, the evidence seems to indicate that many more sites had water-related structures than have been reported.

8.1. Problems of the archaeological data.
The partial list given above of sites where water supply features would be expected but none have been found, stresses the problem of some archaeological data. There are some detailed reports on aqueducts and wells, but very few in comparison with the number of sites that have been excavated and which would obviously have had some sort of a water supply. The reports of the Colchester (App.2) excavations pay particular attention to water supply and other water-related structures. For many sites it would appear that amateur archaeologists were the excavators most interested in aqueducts or wells.

Historically, archaeological investigations started as a result of the interest antiquarians (Aubrey, Camden, Leland, Stukeley) had in the past. These antiquarians had no particular background in archaeological excavations and indeed their initial interest was almost entirely confined to recording what they observed of remains or heard about what others have noticed. Gradually a better approach developed and by the second half of the nineteenth century antiquarians like Pitt Rivers and others in Europe, had developed methodical approaches to excavation of remains. Greene states that "the requirements of 'scientific' excavation were finally met when Pitt Rivers approached recording...with a clear perception of the significance of stratification..." (1995, 62). He quotes the excavation of Corbridge as one of the sites where the "aims and techniques of archaeology" were developed into the modern scientific science that archaeology has become (1995, 69-76). Leonard Woolley commented that the early 20th century excavation work at Corbridge would have scandalized any British archaeologist of today (Greene 1995, 70). The remains of the aqueduct at Corbridge are still visible within the confines of the excavated site, but its course outside the

main site is not well reported. From my study of the reports on the remains of water-related features it seems that there was a limited interest in these features during early archaeological work and it was more by chance observation that features like leats were reported when they were still visible during the 17th to early 20th centuries. Most of the physical evidence of leat-type features seem to have been irrevocably lost as a consequence of intensive ploughing and is not easily identified even on aerial photographs. The exceptions are the leats at Dorchester, Great Chesters, possibly Winchester and the leat at Wroxeter (App.2). At all four of these sites the courses of the leats are known only along certain sections, the rest being completely destroyed by agricultural activities.

The number of known archaeological sites where water supplies and baths have been found is surprisingly small in comparison with the number of sites where it would be expected that such features should have existed. Eleanor Scott reported in 1993 well over two thousand villas (though, of which, many entries are likely to be other types of settlement). Nonetheless the villas with a proven water supply in my database amounts to only about 5% of these postulated 2000 villas. This seems to be an anomaly and can be attributed to several different factors.

1. wells have often not been found because of the limited area of excavation at many of the sites;
2. wells may have been covered with so much overburden that ordinary physical excavation techniques have not uncovered them;
3. excavators working before archaeology became a strict science during this century have not been interested in wells unless small finds were found in them;
4. wells have collapsed or been irretrievably destroyed;
5. where leats were the water supply system these have most likely been destroyed by continued cultivation on former estates;
6. where water supply consisted of water-mains in the forms of wooden, lead or earthenware pipes, they have been robbed out, weathered or destroyed over the centuries, particularly during the Anglo-Saxon and Medieval periods;
7. tanks would have suffered the same fate as water pipes.

To what extent tanks were a significant factor in the water supply of sites is difficult to say. It would have been expected that at the less romanized types of sites, such as farmsteads, round houses,
etc., where there is no apparent evidence of wells or aqueducts, that
at least tanks may have been an obvious source of water supply filled
by rainwater or water brought in from another source to fill them.
This aspect will be commented on in Chapter 6.

Although the volume of the archaeological record is large for Roman
Britain, there is nevertheless a limited amount of evidence on water-
related features. Much of archaeology in Roman Britain is presently
devoted to rescue archaeology and this severely limits the area over
which excavations are carried out. For many sites excavation reports
still need to be published and this also limits the available
information. For many other places in the Empire more inscriptive
and literary evidence is available, which complements the
archaeological evidence. Probably the most significant reason for the
lack of information for Roman Britain, not only for water-related
features, is the poor evidence from ancient literary sources.
Recently valuable evidence has become available from the many writing
tablets found at Vindolanda, (Bowman 1994a, 1994b), but they appear
to be concerned with accounts, materials and the army, and are not
likely to provide new evidence about what was built in Britain during
the Roman period. Four inscriptions (RIB 430, 1060, 1049 and 1463 -
discussed in Chapter 3) are the only epigraphic evidence that refer
to water supply in Roman Britain.

Directly related with water supplies are the ancient water supply
sources: springs, (rivers) and dams. Floods were also a problem the
ancients had to consider. I discuss these briefly below.

9.1. Floods.
We have limited knowledge of flood control measures in antiquity.
However several ancient authors refer to the flooding of Rome by the
Tiber river during periods of high rainfall. Livy reports that in 193 BC
storms were the cause of flooding of the lower city (Livy 35.9.2; 35.21.5). During 60 BC serious floods destroyed the pons sublicius, the
wooden bridge over the Tiber river, and also in 54 BC and 23 BC when the
pons sublicius was again destroyed (53.20; 53.33). In 22 BC the floods
created a food crisis in Rome, resulting in Augustus appointing a praefecti frumenti dandi (Dio 54.1; 54.14; 54.17). Suetonius mentions
continued flooding in spite of precautionary measures (Sue., Aug. 30.1; 37; 40). He reports further floods in AD 36 (58.26.5) and in AD 69 the
reconstructed pons sublicius collapsed again due to flooding by the
Tiber (Tac. Hist. 1.86; Suet. Otho 8.3). Pliny the Younger tells of
considerable damage due to flooding of the Anio and Tiber rivers, despite Trajan's efforts at flood control (Ep. 8.17). Further major floods are mentioned during Marcus Aurelius' reign (AD 217) and again in AD 374 (Sha. M. Ant. Aurelius 8; Dio 79.25; Ep. de Caes. 32.3; Ammianus 29.6.17-18). Olivia Robinson discusses the administration and officers who were appointed by different emperors to deal with the flood problems in Rome (1992, 3, 85-9).

In modern times agencies concerned with water hydrology generally provide some flood control facilities to prevent severe flood damage. These often take the form of major dams in major catchment areas, but even these are not always adequate for very severe floods. The Romans usually constructed dams as a source for the supply of water to an aqueduct. There does not seem to be evidence that they constructed dams for flood control.

The reason why flood control dams were not built by the ancients, was that the reservoir walls had to be very high in order to impound sufficient water to be effective as a control measure against floods.21 The ancients did not have the understanding of the problem, nor the knowledge to construct such high dam walls to contain large volumes of water. We therefore cannot be sure that they did construct dams for the purpose of flood control. However, Hodge suggests that dams may under certain circumstances have been constructed with flood control in mind (Hodge 1990, 86), but it seems to me doubtful. The Proserpina dam at Merida, Spain, had a capacity of 10 million m³, (with a wall height of 12m) which was large by Roman standards, and could well have served as a flood control reservoir, but is small compared to modern flood control dams, such as the High Aswan dam in Egypt, or the Kariba dam in Zimbabwe (both in excess of 10,000 million m³). Hodge lists 13 Roman dams dating from the first century BC to AD 284 (1992, 82). They mainly served as sources of water supply for aqueducts and he suggests that some may also have been intended for flood control structures, and others as irrigation dams and for soil retention control, a technique practiced by the Nabataeans (Smith 1971, 21-2), and also in North Africa (Hodge 1990, 86). The few dams that have been suggested for Roman Britain now would be classed as weirs across streams to form the intake of an aqueduct.

One can only wonder how often flood disasters affected the water supply systems in antiquity. The floods of February 1995 reported in Britain

21 Many large dams that have been built this century both for water supply and flood control have wall heights of the order of 100m.
and continental Europe along rivers such as the Clad, the Clyde, the Tyne, the Rhine, the Seine and the Danube, had their counterparts in antiquity. The forts along the Rhine and Danube must have been particularly at risk. This would possibly have applied to many of the settlements along rivers such as the Nene, Trent, Severn and Thames, and others, where there were high concentrations of settlements. Ramm (1971, 181) refers to floods which caused the silting up of a Roman wharf at Hungate near York as a result of flooding during the late 3rd and mid 4th century AD. On his Fig.28 (p.180) he shows flood levels along the banks of the river Foss. Richardson (1959, 56), who excavated the Hungate area, shows the levels of silting of more than a metre (Fig.3) that occurred during the Roman period into the Medieval period as a result of flooding (1959, 56). Flooding also seemed to have occurred during the late 5th to early 6th centuries on the Hatfield Moors and also in the Humber area during the Dark Ages (Ramm 1971, 183). No doubt similar floods took place elsewhere in Britain during Roman times, which probably resulted in erosion and instability of the embankments of leat aqueducts, but we have no record of specific instances of such damage.

No study of flood damage to structures seems to have been carried out for the Romano-British period. What, may be asked, was the impact on Roman water supply systems and how did the communities and the Roman authorities deal with the potentially devastating effects of such floods? It would seem that, from Ramm's report, nothing was done to repair the flood damage at the wharf in York and this could have been the situation at many places in Britain. Usually flood damage is of such proportions that for the period under discussion it would have been easier to start anew elsewhere rather than repair the damage. When facilities like leats were severely damaged they were most likely abandoned. It is likely that baths which were dependent on such running water supplies may then also have stopped operating.

Archaeological evidence indicates that some water supply systems suddenly stopped operating. It is not clear whether they failed because of some form of local instability in the structure, or because of some natural disaster such as floods or earthquakes. The latter may have applied to regions of earthquake activity, but this was not a likely cause in Britain. So some water supplies in Britain could have became inoperative as a result of flooding, which could have triggered embankment failures (called slope failures in soil mechanics terms), and also caused silting up of the conduit, erosion of embankments, cracking as a result of desiccation during periods of drought. Negligence in cleaning out silted aqueduct channels could be the start of incipient
failure conditions as water would have overflowed the sides causing erosion of the embankments. Hodge (1992, 124) reports on the mounds of silt removed from aqueducts such as the Anio Novus and from the settling tank of the Aqua Virgo, indicating that maintenance was a regular practice. For a city like Rome with specific departments responsible for such work it would have been a normal practice, but in Roman Britain the local town administrations may not have had specific maintenance units to do regular maintenance. However, we do not know what the maintenance practice was in Roman Britain for any of the urban centres.

10. LITERATURE AND ARCHAEOLOGY

Archaeological information is generally recorded in journals, excavation reports, or magazines (such as the now discontinued 'Gentleman's Magazine'), and books, which are often specific to particular counties or even parishes. Much of this literature is available only in some of the country's specialized copyright libraries, or in the county and parish records and the National Monuments Record office at Swindon and their several regional sites. In recent years some specialized books on water supplies and aqueducts in particular have become available, of which the most detailed general books are those of Trevor Hodge (1992) for Roman aqueducts and Dora Crouch (1993) for Greek aqueducts. Neither pretend to be exhaustive, but Hodge's book is likely to remain a standard work for some time. Other books on water supply have been written by technical people, such as Robins (1946), Bromehead (1942) and Smith (1971, 1976), usually engineers who covered the history of water supplies from antiquity to the present. Scholars such as Bruun (1991), Birebent (1962), Gsell (1902) and Landels (1978), describe specific aspects of water supplies. Two pioneer books on the remains of the aqueducts of Rome are by Thomas Ashby (1935) and Esther van Deman (1934). Much specialist literature has recently become available on excavations of water-related structures at sites around the Roman Empire, but there has been no comparable literature on the water supplies of Roman Britain.

Trevor Hodge's book is a treatise on Roman Aqueducts and Water Supply (1992) covering the Empire with some reference to Britain on topics such as wells and lead pipes, but only in passing on the actual aqueduct/leats. Hodge makes an important comment: "The real argument comes from the fact that the Roman aqueducts were not built to provide drinking water, nor to promote hygiene. Nearly all Roman cities grew up depending for their water on wells or cisterns in the
individual houses, and some cities (such as London) got through their entire history without having had an aqueduct at all. In most, when the aqueduct arrived, it came belatedly and only as a result of imperial or other munificence (or a concerted municipal effort), long after the city had grown up and already existed without one for decades, even centuries, in apparent health and prosperity" (p.5). I am not sure that this is the whole story, but it has some element of truth in it and I shall return to it in Chapter 3. His treatment of the subject is wide ranging, providing much detail on the technicalities of construction of aqueducts and their administration, and of water supply and distribution in general at Rome and elsewhere in the Empire. He has also provided some information on the calculation of water-flow in channels and the type of distribution systems used by the Romans. His bibliography is particularly useful in that it is divided under headings of the type of subject that is covered by water supply systems and a geographical survey of Roman aqueducts throughout the Empire.

The most recent information on aqueducts and water supply in the English language is given by Roger Wilson (1996, 5-29), providing an overview of the state of current knowledge. In his review of the existing literature he stresses many areas where there are major deficiencies in detailed knowledge, in particular the dating of some of the well-known aqueducts (12-18), such as the aqueduct from Uzès to Nîmes with the famous Pont du Gard bridge and the very long Carthage aqueduct. Dating information is also not available for many of the water-related structures in Roman Britain. Wilson's comment on the lack of information on villa aqueducts "because the line of the conduit has not been traced outside the excavated area of the villa' (p.25) is particularly significant, because I believe that also applies to other site types in Britain. Although Wilson points out that aqueduct studies have advanced considerably in the last decade (p.26), it seems to me that not much new information has become available on Roman aqueducts in Britain during the same period.

Similarly Dora Crouch has produced a study on Water Management in Ancient Greek Cities (1993) with an excellent discussion on karst formations and of limestone geology in general over the Mediterranean basin. It was in these type of formations that people looked for their water supplies from pre-classical times. Crouch describes some important sites in detail, which give a good insight into how the development of water supplies was planned and constructed by the
Greeks, and how they were managed. However she is not too clear on some technical detail.

Long before engineers seriously studied the history of early water supply archaeologists had already discovered many remains of the ancient evidence dating from the Bronze Age through to the aqueducts of the Roman and later periods. Classicists and ancient history scholars tried to interpret the two perplexing major literary texts on Roman hydraulic technology, Vitruvius (late 1st c. BC) and Frontinus (AD 90s), with amplifications by Faventinus (c. 4th c.) and Palladius (c. 5th c.), (Plommer 1973, 1-2). One of the problems with the studies by scholars from the different disciplines is that classicists, historians and archaeologists often do not understand the hydraulic principles involved and the architects and engineers are not familiar with the language of literary sources and archaeological evidence. This problem is compounded by the fact that neither of the first two ancient authors was clear on some of the technical aspects they discussed, thus making it difficult now to understand the exact meaning of some of their statements.

11. ROMAN HYDRAULIC ENGINEERING: THE ANCIENT TEXTS

In order to understand the development of Romano-British aqueducts and other structures, it seems appropriate to briefly discuss aspects of the complexity of ancient technology, and in particular Roman engineering, hydrological knowledge, surveying, and the training of engineers and architects.

The modern study of ancient technology and specifically Roman engineering, has come from classicists22, ancient historians, archaeologists, architects and engineers23. The interests of the latter two groups are usually concerned with the history of the technology relating to the construction of ancient structures, and in particular ancient engineering. About the Roman engineers and their engineering knowledge we know nothing, except for the remains of how they applied it. Aqueducts are one such manifestation, which includes the simple aqueduct leat used on a wide scale on different types of sites in Roman Britain. But, even for leats, we can only conjecture how they went about surveying and constructing them. No records have survived to indicate if the engineers had drawn plans, recorded survey data or how they planned

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22 Examples in the English language literature are: Blake 1959; Landels 1978; White 1984. There are others and also in other languages.

the quantity of materials needed for the construction of structures, which Vitruvius assures us they must have done. Parts of the Forma Urbis Romae have been found (Grewe 1985, 14), but few detailed plans for the construction of structures in that or other ancient cities seem to be extant. The collected work of ancient surveying manuals, the Corpus Agrimensorum, published information by Roman surveyors and how they set out certain land survey projects, but they did not describe how engineering surveying was actually carried out.

The development of the physics of hydraulics related to the practical applications of water in motion as applied to ancient water supplies were of particular interest to the engineering profession during the nineteenth century. This theoretical interest developed out of the planning of healthier and more abundant water supply which became imperative as the populations of the major cities of Europe and America strained existing supplies (Smith, 1976b, 93). The example of the extensive aqueduct system of Rome became a model for the supply of clean water for modern aqueducts over long distances from the cities. Thus interest in the technology of ancient water supplies was brought into focus, particularly Roman hydraulic technology and the applications of the technologies that preceded it.

We do not have detailed information on Roman engineering practices. Vitruvius, in his book on architecture and engineering, comments on a number of aspects relating to these topics, but in a general way. He makes it clear that the architect/engineer produced a plan (ichnographia) to show the elevation (orthographia), "the vertical image of the front, and a figure slightly tinted to show the lines of the future work..." (1.2.2). Clearly it must have been the practice, even before his time, to produce plans for the design and construction of structures, especially by the Greeks from whose sources he draws much of his information. It is a salutary experience to read what Vitruvius has to say about professionalism and how one needs to acquire that all-round liberal background which makes an individual a rounded person in order

24 Vitruvius, 1st c. BC, De Architectura, Books 1-10.
25 Vitruvius comments on what was expected from architects and engineers while practising their professions. Most technical training was obtained while men served in the army, he himself being army trained. He gave his views on what the educational background of architects and engineers should be. He gives criteria for an architect/engineer's liberal educational background in order to understand the technical, social and spiritual implications of his profession (1.1.3) and the need to appreciate the social issues in practicing his profession and his responsibility as an advisor and designer to his client (6, Pref.6). He emphasizes the need to rely on the experience of others (7, Pref.6) and gives his reasons for producing a manual on architecture and engineering techniques (7, Pref.18).
to practice his particular expertise successfully, in spite of the problematical technical knowledge he sometimes gives.

Although he acknowledged that flow in a channel was related to the size of a conduit and to the rate of flow, Frontinus only quantified the volume of flow of water in terms of size of a conduit. It is important to take into consideration flow rate, size of conduit and friction during flow to arrive at an empirical formulation for volume of flow. Similarly Vitruvius gave a vague explanation for the operation and construction of the so-called inverted siphon (he does not give it a name). He comments on the function of the horizontal part of the conduit at the bottom of a valley, the venter, and also on water as it flows down hill and the supposed swelling of the water as it is forced up the opposite slope. He says "stand-pipes are to be made in the bend, by which the force of the air may be relaxed" (8.6.5-6), which is unnecessary for the system to work. These misconceptions by those authors have been misinterpreted from as far back as the 16th century. Modern engineering scholars have tried to make some sense of what Vitruvius was trying to say in terms of the physics involved, both with regards to the standard siphon and the incorrectly named inverted siphon.

The physics and mathematics of a liquid flowing in an a U-tube configuration are well understood, but the Romans did not have the theoretical background to base their designs of inverted siphons on such knowledge. Roman engineering was primarily empirically based. By trial and error, and from the knowledge they gained from other societies, they were able to produce complex engineering structures and perfected the use of inverted siphons. Unfortunately no written evidence or drawings are extant from antiquity indicating how this knowledge was adapted for the improved constructions. Hodge (1992, 428, n.43) lists 18 aqueducts with attested so-called inverted siphons, correctly referred to as pipe pressure systems. The inclusion of the Lincoln aqueduct in this list as having such a pressure system is premature, since the existence of a pressure system in the aqueduct has not yet been proved, although it has been suggested. There is circumstantial evidence that points to the possibility that it was feasible, but nothing certain.

Another area where the Roman engineers (and other civilizations before them) had an imprecise understanding of a specific technology concerned the way calcined lime, when combined with certain admixtures, hardened into the strong cementing agent used in concrete. It is only during this
century that the chemistry of lime-based hydraulic cement has become, to date, partially understood, and empirical application is still important in concrete technology today. A recent TV film on the construction of the Colosseum in Rome showed a lack of understanding of the part 'pozzolana' soil, derived from volcanic action, had on the development of hardening of calcined lime used as a cementing agent. Vitruvius refers to a "kind of powder which, by nature, produces wonderful results", found in the neighbourhood of Baiae and Mount Vesuvius (2.6.1). The Romans by empirical observation in the harbour works of Misenum, and a break water at Puteoli, found that concrete made with lime admixed with pozzolana was stronger than concrete that had only clean sand mixed with the lime. It is this improved concrete quality which allowed Roman engineers to build the amazing domed roof of the Pantheon (Smith 1976a, 49), the dome for the Bath of Mercury in Baiae (McKay 1978, 48-9), and vaulted roofs for many structures, and the cores of masonry dams.

Other aspects of ancient and Roman construction are similarly poorly understood. NAF Smith, a civil engineer, has written a penetrating article on the "Problems of Design and Analysis" as it relates to ancient engineering and especially to Roman aqueduct bridge design and construction. He suggests that, since for maintenance purposes, the cross-section of the aqueduct had to be large enough to accommodate workmen, "in that case a size based on flow may not have been the issue at all" (1991, 122). Considering the variety of aqueduct channel sizes it seems to be a fair comment on the ultimate design approach of Roman engineers to channel sizes. This practical non-technical approach did not necessarily apply to the actual bridge design, for which strength parameters would have been important to consider. How these were arrived at would be most interesting to know.

There has been a lack of recent studies on water supply as it applies to the different site types, which may have created a certain amount of misunderstanding of its importance to Romano-British archaeology, and needs urgent research to bring into focus the relevance of water supplies in Roman Britain.

I shall treat the eight types of water-related features in detail in the following three chapters, followed in Chapter 6 by their distribution in Britain.
CHAPTER 3.
WATER SUPPLIES: 1) AQUEDUCTS, SPRINGS AND DAMS

1. WATER SUPPLY SOURCES
Location of suitable water sources was one of the important duties of the Roman engineer wherever a military site was to be established. The Romans had a long tradition of searching for water sources for the aqueducts they built all over the Empire. The sources of water supply used by them consisted of:
1. water from springs, streams and dams; transferred in aqueducts in the form of various kinds of stone channels, leats, wooden and earthenware pipes;
2. rainwater, stored in a variety of cisterns/tanks, pottery vessels, water buckets and other containers;
3. groundwater, recovered by sinking wells into perched aquifers or into the watertable of water bearing gravels, sands and rock formations.

One of the purposes of my thesis is to examine the evidence from the archaeological record confirming that all three methods were used in Roman Britain. For this reason, it was necessary to collate the evidence in gazetteer format in order to discover what type of water supply or water structures were used at different kinds of sites. Many of the aqueducts were in the form of leats dug as an earth channel in soil or rock. There are no apparent high bridge structures from the Romano-British period that carried the channel of an aqueduct over deep valleys as are found in so many other parts of the Empire.

Many settlements and towns in the Empire had only wells as water supplies. As the population grew in the different parts of the Empire, in particular in urban areas, greater volumes of water were required, especially to serve the public facilities such as fountains from where the general public could draw water. Large volumes of water also were required for public baths as the ritual of daily bathing became an integral part of romanized social custom and for this the aqueduct was the obvious solution. Running water was also needed for the flushing of public latrines, sewers and the streets of towns, usually obtained from the excess over-flow from fountains. Even with the large number of slaves available to use as water carriers it was not possible to rely on wells alone as a water supply in large volumes, mainly because in many areas they were not able to yield sufficient quantities of water, whereas aqueducts delivered large volumes. Springs were the preferred source of water for aqueducts and dams were often built in the vicinity
of springs to ensure that unpolluted water reached the cities (see Section 3).

2. SPRINGS

Vitruvius, in Chapter 1 Book 8, gave advice on how to locate a water source if springs were not obviously visible. The engineer had to lie flat on the ground and looking at the horizon would see in the distance, if the circumstances were right, where vapours rose from the ground, indicating a source of underground water. If he then dug there he would encounter a water source.¹ This is a misinterpretation of a natural phenomenon, because the apparent vapour so observed is merely the mirage of heat radiation creating turbulent air flow upwards from the warm ground. He does qualify this procedure with advice on the type of trees and plant growth which could also indicate that there were underground streams in the vicinity. Vitruvius made comments on springs and the quality of water derived from them, which were a mixture of practical advice and often interspersed with comments which have no physical truth. His views on many technological aspects, often unsound, particularly related to water engineering, seemed to have influenced technical thinking until about the 18th century.

Springs emerge at the surface of sloping ground as water flows by seepage from a perched water table or aquifer, which is relatively easily observable. From great antiquity such springs have been the source of water supplies for humans and animals. In time, cults developed round such springs, probably because their source seemed to indicate a supernatural origin and and the supply was without limit. The practical value of such clean water sources was realised very early and a number of ancient communities obtained water from springs channeled along conduits to their cities. When the water of the Tiber became polluted during the 4th century BC, the consul Appius Claudius of Rome built the first aqueduct in 312 BC, 16km long and all underground, with its source from springs about 9km east of the city (Winslow 1963, 171). A number of the other aqueducts to Rome had their sources as springs.

For Roman Britain there are a number of sites where the water source is from springs, for example, the aqueduct to Winchester had as its source several springs near Itchen Stoke (Fasham & Whinney 1991, 5-11); the villa of Chedworth had a spring water source and so did the palatial

¹ A woodcut illustration from an edition of Vitruvius published in 1522 in Florence illustrates his conception of how a spring source could be detected (Bromehead 1922, 145).
villa of Fishbourne (Britannia 25, 1994, 289). In the database 47 sites are listed as having spring water sources in Roman Britain and there are likely to be more not yet identified.

3. DAMS

Often dams were built below springs, or across streams to ensure a constant supply of clean water to an aqueduct. The dams also functioned as a means to control the flow into the aqueduct, such as the second dam (masonry and concrete, 49m high) at Subiaco, constructed under Nero to serve his pleasure resort, and from Trajan’s time used as a source for the Aqua Anio Novus (Smith 1970, 58-68). Several aqueducts in Spain also had dams as their supply source, notably the dams at Alcantrilla (Toledo) and Proserpina (Merida), both so-called masonry dams, and at Cornalvo (Merida), an earth dam. These dams, built across streams, had fairly large capacities: the Proserpina with a capacity of 10 million m$^3$ of water. This is a large dam for its low height of 12m. Hodge lists 13 Roman dams built during the 2nd and 3rd centuries AD (1992, 82). Schnitter (1987) records many dams from antiquity which served as water supplies to cities, of which a number were built by the Romans.

Roman dam building probably represents the acme of their empirical hydraulic engineering knowledge. They may not have had an understanding of the theory involved in the design of masonry and earth dams, but their perception of basic hydraulic principles allowed them to construct a variety of dam types. The stability of dam walls is subject to low factors of safety, which the Romans compensated for by building the down stream sections at slopes as flat as 1:3 to 1:5. If one considers the spectacular and tragic failures of some modern dams, it is even more to the credit of the Roman engineers who built their long-lasting dams. No doubt they had failures too, but the Subiaco dam only failed in 1305 (Smith, 1970, 65) after 12 centuries of service. The Prosperina dam, with a down stream slope of 1:5, is reported as still being in use today (Hodge 1992, 89). The dams at the source of the Lanchester aqueduct are said to have been almost intact during the early 19th century (Steer 1938, 210-34), but now hardly visible.

For Britain I have been able to trace only two dams which served as the source of water for aqueducts. These were built as sources of supply for one of the aqueducts to the fort at Lanchester (Steer 1938, 210-34; Reed & Austin 1976, 214, 216, Fig. 36) (App.2). The lower dam (A) was built over a small stream that had a spring as its source. About 0.25km higher up the slope there was another spring at which a dam (B) was
constructed, which discharged into the lower dam. It is not known how
the system worked between the two dams, but it is possible that the
supply from the lower spring into its dam did not supply sufficient
water, so it was decided to complement the supply with an additional
upper dam.

It has been suggested that the Saughy Rigg Washpool was the source for
the Great Chesters aqueduct (App.2), but it is not certain (Mackay 1990,
285)². I saw no evidence of a likely place at this position where the
aqueduct could have obtained water from the river or evidence of dam
remains when I visited the site, nor could I see any indication of the
source on the relevant aerial photographs held at RCHM(E) archives at
Swindon. Putnam has suggested that the Dorchester aqueduct may have had
as its source of supply a 4m high dam, which was built across the
Steppes Bottom stream near Littlewood, (Putnam & Hewitt 1996, 1, Fig. 2,
interim report). There may have been other Roman dams in Britain which
have now completely disappeared.

4. ROMAN SURVEYING

In my judgement, one of the most significant feats of Roman surveying
and construction is that of the aqueduct from Ucetia (Uzes), the source,
to Nîmes and that beautiful aqueduct bridge structure, the Pont du Gard.
From the surveying point of view, a standard of levelling was achieved
that would do a modern surveyor proud, providing a route through rough
and mountainous country with a fall of 17 metres in 51km, that is, a
fall of one third of a metre (1 foot) in 1 km (Hauck 1988, 78-84). This
quality and skill of surveying, done with the crudest of instruments,
can only be appreciated if one has tried to do surveying over similar
distances. Many of the other Roman aqueducts of Gaul (Nîmes, 51km;
Cahors 'Divona', 31km), Germany (Köln, 95km), Spain (5 major aqueducts),
North Africa (Carthage, 132km) and several in the eastern part of the
Empire, attest to the skills of the Roman surveyors. This skill in
precision surveying had special significance for Roman Britain as
demonstrated by the examples of the Dorchester, Great Chesters and
Winchester leat aqueducts because of the small difference in elevations
between the source and delivery points.

These surveying skills were important aspects of Roman technology
brought to Britain, whether surveying of fort, town, building, aqueduct,

² Bruce 1884, 225-8, Pl.xvi; JRS 35, 1945, 80-1. There is uncertainty about the
source, a suggestion being that a dam was constructed at Saughy Rigg Washpool, but no
evidence of it has been found.
road route, or agricultural plots. The army had a corps of surveyors (agrimensores, land surveyors, and libratores, surveyor levellers using water-levels such as the chorobate and cross-pieces) controlled by a mensor (Dilke 1971, 51). Most of the ancient writings on surveying were based on accounts by Vitruvius, Hero and the Corpus Agrimensorum, which described surveying for agricultural and land purposes, and not for engineering, for which little research has been done (Smith 1990, 59-61). The Roman surveyor (librator) achieved a surprising degree of accuracy in surveying with the most crude and elementary instruments, the groma and chorobate and probably also the use of Hero's dioptra. By the middle of the 1st century the dioptra had probably improved sufficiently for more accurate measurements to be made of slopes than with the simple chorobate or with the A-frame (Mathews 13(1) 1970, 9).

The groma is a device with which linear sightings can be made along right angle directions; the chorobate is an awkward levelling device and the dioptra can do both leveling and angle measurements including angles less than right angles. Smith believes that the A-frame levelling device (Fig. 3.1) should not be ruled out as having been used by the Roman surveyors in establishing relative levels for aqueduct routes (Smith 1990, 61).

![Diagram of levelling with an A-frame level](image)

Fig. 3.1: Levelling with an A-frame level, (Butler 1933, 73, Fig. 5).

However, Roman surveyors were not infallible. A prime example of 'How Not to Build an Aqueduct' discussed by Nicholas Horsfall, is the Saldae aqueduct in Algeria which was intended to bring water from the spring of El Anseur, 21km away. A Roman engineer, Nonius Datus had made the original plan, and carried out the initial survey. But it took a long time, something like 15 years, from the start of the project (c AD 137) until water eventually flowed. When construction had progressed for some short distance, the contractors realised they had a problem constructing the aqueduct over the valley of El Hanai‘at. Datus’ services were again called for and the aqueduct was placed on arches along the valley. But progress was slow and he was required elsewhere. He was recalled again
four years later, because it turned out that the two units who were constructing the aqueduct worked from both the source end and from Saldae at the same time. One of the construction sections included a long tunnel of 428 metres and the two units did not meet in the centre. In his words "It was apparent that the digging had strayed from the line, so much so that the upper tunnel (source end) turned right, to the South, and likewise the lower tunnel turned North, to its right. So the two ends were out of line and had gone astray". Nonius Datus had recorded this information on an inscription found at Lambaesis (modern Lambese), dated to pre-AD 153. Datus was recalled to survey a connecting link, which was eventually successfully constructed for delivery of water to the city (Horsfall 1987, 40-1).

One wonders how many mistakes like that occurred in antiquity. I suspect that the aqueduct at Lincoln did not function as it was originally planned to operate. Examination of the interior of the earthenware pipe encased in Roman concrete does not show the encrustation of sinter as do many pipes and channels which operated in similar limestone environments, which could imply that water did not in fact flow in the pipe for any length of time. There are other uncertainties about this aqueduct, in particular its source of water and the delivery of water from the source to the town (see section 9.3, p.87).

5. TYPOLOGY OF WATER SUPPLY CONDUITS AND STRUCTURES

Specially constructed artificial aqueducts are very characteristic of the Roman approach to water supply. Aqueducts that were used specifically for irrigation water supplies, as in parts of North Africa for instance, contributed to the local economy. However, the same cannot be assumed for aqueducts used as purely domestic water supply and there does not seem to be any evidence to support this possibility. Their contribution to society seems to have been of the same order as that of temples, Roman baths or the larger and richer villas found all over the empire. None of these structures directly generated wealth for the communities where they were situated. However all three were indicators of wealth and power - whether of the State, of the community or of individuals. Each type served specific functions within the communities where they were located: temples for religious and cult practices, baths for bathing and as public social centres, and the great villas for the pleasure of their wealthy owners.

There do not appear to be aqueducts constructed specifically for irrigation purposes in Roman Britain. Because of the over-abundance of
water in Britain in some low-lying areas, such as the Fens and at Wentlooge in Wales, channels were constructed for draining of water-logged areas. Some aqueducts were constructed for industrial use such as those at Dolaucothi where three leat aqueducts were constructed for the purpose of hydraulic mining (Jones, et al, 1962, 71-84). On a lesser scale, at the pottery works of Cantley (Doncaster) two very short aqueducts provided water for the manufacturing process, which indicated an economic use of water. At Holt, where the army at Chester had pottery and tilery works, the aqueduct may also have served some economic purpose. The small town of Wilderspool had a pottery industry, but it is not certain that water from its aqueduct was used in the industry.

Across the empire there were many Roman aqueducts, often involving high and aesthetically beautiful bridge structures, that served two very important functions. Firstly, they conveyed one of the necessities of life, water; secondly, they were an expression of the ability (power) of Romans to create such impressive structures. However, aqueducts were not a necessity for survival. People would have been able to get water, albeit with some effort, from other sources. Although there were alternative water supplies, people developed many different kinds of facility for comfort and pleasure, and these, in part at least, depended on the construction of aqueducts to make running water available.

In Britain there are none of the magnificent arched bridge remains carrying the aqueduct conduits to urban centres. The Romans utilized various forms of aqueduct conduit that are also found in other parts of the Empire. Where there were no problems with valley crossings which could not be effectively circumnavigated by following contours, the preferred method was to use simple leat channels, ditches dug into soil and rock forming the water conduit. Other conduit types are listed below.

5.1. Typology of conduits.

5.1.1. Leats.
Leats are open ditches dug in soil with sloping sides. It would seem that when the channels had to be deeper than one metre, the general slope of the walls was about 45 degrees, which in certain circumstances would have been too steep a slope and may have been unstable. Evidence has been found of slumping of the sides of the leat at Dorchester (Dorset) where it was in a high side-cut.
5.1.2. Stone channels.
These are of two kinds. The first kind is channels cut in rock in order to maintain the desired flow grade of a leat. They usually followed directly along the line of the leat where it traversed rock, as at Dorchester. The second kind are channels made from dressed stone cut for the purpose of forming channels with two vertical sides and a floor. These channels could either be sealed with a lime-based mortar to render them impermeable to leakage, or be the carrier of some form of pipe. Remains of both these channel types are found at several sites in Britain. The remains of three aqueduct channels were still intact as late as the mid 19th century, originally built to provide water for the fort at Lanchester, but have subsequently been destroyed by opencast coal mining (Steer 1938). Vitruvius advises that such a channelled aqueduct should be "arched over to protect it from the sun" (VIII.vi.1). No mention is made of protection for health reasons. Many stone channel aqueducts were below ground level, firstly, for protection against pollution, and secondly, to ensure that the supply could not easily be cut off by an enemy.

5.1.3. Pipe lines.
Pipes consist of four types: a) wooden, b) ceramic (terracotta), c) lead, and d) stone pipes.

a) Wooden pipelines are usually indicated by the remains of iron rings or collars which have been found in situ, mainly within the confines of the enclosure of sites. In Britain, the wooden pipes were as a rule carried in a channel of stone, but not invariably so. The iron collars associated with wooden pipes vary in size from different sites. More than 20 collars were found at Wroxeter with a diameter of about 63mm and pipe lengths of the order of between 1.5m to 1.8m (Atkinson 1942, 121-6), whereas at Silchester and Verulamium the collars were of the order of 110-155mm in diameter (Archaeologia 55, 1896(2), 422-4). Although evidence for wooden pipelines were found at some forts such as at Birrens, Fendoch, Pen Llysten and South Shields, no iron collars have been traced (Hanson 1970, 421). Instead two pipes were fitted together and the join then "solidly packed with clay" to prevent leakage (Arch. J. 125, 1968, 125). Collars were found at the legionary fortress sites of Caerleon and Carpow.
a) pouring lead and forming the joint

b) cross-section of Roman lead pipes and soldered seam

c) forming pipe and showing soldered and lap joints

d) methods of jointing pipes to each other

Fig. 3.2: Construction of lead pipes and making of joints (Hodge 1992, 309 Fig. 215, 312 Figs. 216 & 217, 314 Fig. 219).
b) In Roman Britain the major ceramic pipe aqueduct is that of the Lincoln colonia, at least part of which was encased in concrete. It is not clear whether the pipe was buried when constructed. When discovered it was below modern ground level. It seems to have traversed ground from the vicinity of the Roaring Meg for about 2km to a tank in the north of the upper part of the colonia, into which it is speculated it would have discharged, but the route of the last half kilometre of the aqueduct has not yet been traced. An earthenware pipe is also reported for the fortress at Chester as part of its water supply (Stephens 1986, 60).

c) Remains of Roman lead piping have been found at several sites in Britain for distribution of domestic water, such as at Bath, Lincoln and York. At York, during excavations at Wellington Row, a 180mm diameter (external), 18m long lead pipe was found, “which seemed to have carried water across the bridge and down the centre of the widened road” (Wacher 1995, 175; Britannia 21, 1990, 325). This is the largest known Roman lead pipe found in Britain. Lead piping was extensively used elsewhere in inverted siphons, and for this use the thickness of the pipe has been reported as being from 19 to 25mm. Several techniques of forming lead pipes were developed and an elaborate technique of soldering the joint was one method of sealing the pipe, this being the main procedure used for inverted siphon pipes. Pipes were also formed on a circular mandrel, then bending the two edges of lengths of pipe over on themselves and forcing the edges tightly against each other making a lap joint. This type of joint would not have been able to take the internal pressure of inverted siphons. Other joints were also made for specific purposes. Sketches of lead pipe making and forming of joints are shown above (Fig. 3.2, p.60).

d) Stone piping were used mainly in the eastern Empire such as at Patara and Aspendos (Grewe 1985, 76, 80-81). Piping bored in stone must have been extremely costly to produce in terms of both time and money. It was not used in Britain as far as I can ascertain.

5.2. Tunnels.
Tunneling was not used in Britain as it was in the rest of the Empire. Tunnels were constructed through both soils and rock, of which the Köln aqueduct is an example. There is the famous tunnel of Eupalinos on Samos island (Rihll & Tucker 1995, 403-31), and the tunnel section described by the Roman army engineer who left an inscription describing the problems with the tunnel section of the aqueduct at Saldae (Horsfall
1987). The aqueduct from Vers to Cahors in France had a short length constructed as an arched channel in a soil tunnel (de Garros, 1989).

**5.3. Bridge structures and arcades.**

There are many famous remains of aqueducts carried on stone bridge structures and arcades, and they are some of the most magnificent stone constructions produced by the Romans. Long arcades with elaborate arches over land and as bridges over rivers and roads are found all over the Empire, some of the most conspicuous being those at Aspendos, Carthage, Köln, Pont du Gard, Segovia, and Rome’s own contribution of many remains. The channel (specus) is carried on top of the masonry structure and was always covered, either by an arched roof or ashlar slabs. Usually channels were large enough for a person to walk in so that repairs and maintenance could be carried out.

Four minor bridge structures have been suggested: at Beckfoot fort, at Henk Bridge on the Great Chesters aqueduct, the bridge that carried the aqueduct into Exeter, and the controversial bridge structure suggested for the Lincoln aqueduct. Thompson reported foundation slabs (1954, 114-7, Fig.3) for piers which most probably would have carried a substructure for that portion of the aqueduct. At Beckfoot, Joseph Robinson reported in 1880 the discovery of "a very curious structure" and "leading out of this space was a hewn channel, apparently intended for water". Collingwood thought "it to have been the end of an aqueduct leading into the fort at that corner", (Collingwood 1936, 38, 76-84, Fig.1). From the 1:25,000 OS map of the area it would appear that the aqueduct would have had to be carried on a raised structure to enter the fort as Collingwood suggests, but the evidence is inconclusive. In a new survey of the Great Chesters aqueduct by the RCHM(E), it is suggested that at the crossing of the valley at Benks Bridge, which is about 6m below the course of the aqueduct, a bridge would have been necessary to carry the aqueduct across the valley and the river. It is likely to have been of wood construction, but its length and actual height is not known and no surface remains survive (Britannia 21, 1990, 288). The aqueduct originally serving the fortress and later the town at Exeter, was carried on an elevated timber bridge structure where it entered the town defences, but it is not clear how long this structure was (Britannia 14, 1983, 322). Perhaps there are other sites where aqueducts have been suggested which would have required bridge structures, but this would need special investigation to confirm it.
5.4. Inverted siphons.

This is a most unfortunate name for the type of aqueduct which conveys water from a high point on one side of a valley to the opposite bank. Such an aqueduct is correctly classified as a pressure system for which the elevation of the downstream side of the pipeline has to be lower by a small amount in relation to the level of the upstream end (Fig. 3.3). The difference in height need not be great, but in practice will depend largely on the resistance to flow in the pipe. The Roman engineers did not have the knowledge to calculate exactly the flow in pipes or channels, or the necessary difference in level to allow flow to take place. They are likely to have relied on their experience and observations of existing inverted siphons to decide on an effective difference in level. The actual pipes for inverted siphons were usually made of lead, but there are some where stone piping was used, such as at Aspendos (Ward-Perkins 1955, 119, Fig.2). One of the main problems would have been to prevent leaking at joints of a pipeline at the bottom of a valley because of the high pressure which is generated, anything from 5 to 20 atmospheres, depending on the height between the delivery aqueduct and the pipe in the valley. Pipes used in inverted siphons appear always to have been encased in concrete. The Lincoln aqueduct must have operated as a pressure system, with an inverted siphon because the upward slope of the pipe, but evidence for the source end of the aqueduct has not been found to confirm this. Suggestions have been made by Thompson, Wacher and Lewis for possible sources, but so far no source has been identified. Since the earthenware pipe encased in concrete has been traced near the Roaring Meg, the postulated piers at the Roaring Meg could have supported a low bridge structure as proposed by Wacher (see Fig. 3.7b) carrying the pipes southwards towards the town. However, such an interpretation is dependent on identifying its actual water source. The purpose of the foundations have not been satisfactorily explained.

Figure 3.3 shows that for water to flow in an inverted siphon the intake of the conduit must be higher than the discharge end at the castellum, indicated by the differences in levels \( h_1 - h_2 \). The amount of this difference, \( \Delta h \), will depend on a number of factors, including the friction in the conduit, the shape, the roughness of the internal surface, viscosity, and others. The bends where the sloping sides

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3 Hodge lists 14 inverted siphons (1992, 428, n.43); Wilson (1996, 8, and n.24) mentions 11 additional inverted siphons. The inverted siphon at Beaunant on the Lyon aqueduct had a depth of 123m compared to the suggested one at Lincoln which had a depth of about 22m. The pressure at the bottom of the Beaunant inverted siphon would have been 1230kPa (12.1 atmospheres), a high pressure for a pipe.
meet the bottom section of the conduit will bear the greatest thrust and is usually anchored.

![Diagram of inverted siphon](image)

Flow will take place when \( h_1 - h_2 = \Delta h \), when \( \Delta h \neq 0 \).

**Fig. 3.3: Illustration of principle of the inverted siphon (AB).**

Because the pressures in inverted siphons can be very high, depending on the height \( h_2 \), the conduit was usually encased in concrete, or in some instances the walls of lead pipes would be abnormally thick. In the case of the Lincoln aqueduct the delivery end would have been either at the east gate or the north gate tank, a height \( h_2 \) above the suggested low bridge structure near the Roaring Meg. The source, wherever that was, would have had to be higher by a distance \( \Delta h \), for water to flow in the pipe. Neither of these two heights are known.

### 6. TECHNICAL ASPECTS OF AQUEDUCT CONSTRUCTION

Adam (1974) discusses in some detail the construction of structures during Roman times, especially as practiced in Rome, Spain and other parts of the Empire. He does not discuss the construction of leats. Although Vitruvius mentions bridges and aqueducts and other structures, the information given is often too general and not detailed enough for us to know exactly how it was done at that time. Some visual evidence in the form of sculptures has survived; so, for example, the well-known representation of a crane (Smith 1990, 79).

#### 6.1. Stability and instability of aqueducts and maintenance

It is important to appreciate that Roman engineers were confronted with problems relating to the stability of aqueduct structures, even though they did not have the theoretical understanding of instability. Any form of channel, whether of the open leat type or stone-lined types, is subject to either erosion, instability, or cracking, with consequent loss of water, which can often compound problems. In modern construction
of aqueducts, reinforced concrete pipes (minimizing cracking) and steel conduits are used, and even they have a limited life span. The non-uniform appearance of surfaces of the remains of exposed Roman walls seems to suggest that repairs must have taken place at intervals over a long period and this is likely to have applied to all the other structures (Bruun 1991). Evidence from excavation reports often suggest that reconstruction took place on parts of a site and this could well have been within the period of normal decay of structures, suggesting that it was easier to reconstruct rather than to repair. Although many ancient structures have survived, the evidence of their decay is obvious and their active use as serviceable structures led to their abandonment. The ancient aqueduct structures would have been prone to instability and cracking due to shrinkage of concrete over time, leaching of lime out of the concrete, thus reducing their tensile and compressive strengths, which rendered them unserviceable and led to their abandonment, because of cost of repairs. For leat type aqueducts, the swelling and shrinkage of clayey soils in which they were constructed would have been the source of instability. Modern soil mechanics have shown how the stability of earth embankments is affected by different construction techniques and moisture control. It is probably not unfair to say that many Roman structures must have failed because of poor foundation control. Avery (1993, 1-10, Figs.117-124) gives a good basic account of the theory of stability analysis that can be used to assess the stability of ancient structures if appropriate soil and rock strength parameters are measured in situ or in a laboratory. Avery quotes extensively from soil mechanics literature.

It may be conjectured that some of the aqueducts (and wells) could have become inoperative during their lifetimes due to some structural inadequacy or due to the original poor construction, or subsequent unstable development as a result of saturation of soils during flood periods. Similarly aqueducts constructed in clayey soils would likely have failed in places due to wetting and drying resulting in cracking of its embankments, or due to erosion during flooding. The regular maintenance of such service structures must have been a major problem for both public bodies and private owners, as it is even today in our much more sophisticated repair-conscious age. The total maintenance costs of long linear features were possibly prohibitive. This is probably one of the reasons why a number of the aqueducts of Rome and elsewhere fell into disuse.
One wonders to what extent that was an issue in Britain, where the problem would have been somewhat different, given the predominance of leat type structures. Silting up and embankment erosion would probably have been the main in-service problems. Neglect of the leats may also have been responsible for them becoming inoperative, resulting in blockages and other breaches that might have impeded their proper functioning. There is nothing in the archaeological record to indicate how long the known leats in Britain carried water, whereas for a number of the known aqueducts elsewhere there is evidence of how long they supplied water, particularly those in Rome. For the Dorchester aqueduct there is evidence that a slip failure had occurred along a section on Whitfield farm and that it was repaired, but it was not clear when this would have taken place.

Pipe aqueducts used on many sites (as at Cirencester, Caistor-by-Norwich, Chelmsford, Fendoch and Carpow) and internal distribution pipes (as at Bignor, Birrens, Colchester, Caerwent, Gloucester and Wroxeter) would have required regular maintenance, especially wooden pipelines, which could crack if allowed to dry out and burst if under high internal pressure. The seals at joints between individual pipes could have deteriorated over a period of use and would have needed repairs. The joins of stone channels would have been potential weak points subject to leaks, because the sealing mortar would have been very sensitive to even slight lateral and vertical movements in the individual channel blocks. It is reported that several sites had stone channels that carried wooden pipes, which may be the result of experience with leaking joints of the original supply channels. Hence the need to support wooden pipelines for their joints not to be disturbed. I would suggest that on certain sites the stone channels were the original water conduits, but because of problems with the integrity of the joints of the channel blocks to hold water, it was belatedly decided to use wooden pipes and support them on the channels. It could not have been cost effective from the beginning to build a channel and use a wooden pipe to carry the water.

7. SITE TYPES

Owens observes that "An adequate supply of water was one of the major factors in deciding the location of a new city, and many cities were so situated as to take advantage of naturally occurring supplies of water from springs, wells and even rivers" (Owens 1992, 158). It is likely that many urban centers did not start with an aqueduct as the initial source of water supply.
Aqueducts have been used to deliver water to all the listed site types in Roman Britain as shown in Table 3.1.

<table>
<thead>
<tr>
<th>Site type</th>
<th>Aqueducts</th>
<th>Percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>forts/fortresses</td>
<td>66</td>
<td>48</td>
</tr>
<tr>
<td>coloniae</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>municipia</td>
<td>1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>civitas capitals</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>small towns</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>settlements</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>villas</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td>Total sites</td>
<td>135</td>
<td></td>
</tr>
</tbody>
</table>

7.1. Water supply data.

All the data recorded in the database is given in the table in Appendix 1. The sites where aqueducts have been found are listed in Appendix 1 from which their distributions have been extracted and are given in Figures 6.1 (forts), 6.2 (civitas capitals), 6.3 (small towns), 6.4 (settlements), 6.5 (villas) in Chapter 6.

There are biases in the archaeological record data for Roman Britain as represented in the table in Appendix 1. As excavations continue, the number of known Roman settlements increases over the time span. However, the number of sites where the water supply features have been reported comprises a small percentage.

The rescue context of many excavations is a further factor affecting the details of the archaeological record and some water-supply features (pipes of lead or wood) may be poorly represented as a result of decay or ancient reuse. Clearly, the information obtained by me for any specific site may not be complete, so that the presence of one type of structure and the absence of another may not necessarily reflect the true archaeological potential of the site. Hence, during the analysis of site data these shortcomings in the data set and therefore the biases they introduce must be borne in mind.

In Table 3.1 it is shown that forts registered half the number of aqueducts listed in the database, showing that the army had a preference for aqueduct water supplies compared to any other supply. The reason for this may have been that there were usually a large number of troops
concentrated in a confined space, so that large quantities of water would have been used daily, and it would have been preferable to have a running water supply than having to have it carried to the site or drawn from wells. It is not clear why many of the other forts also did not have aqueducts, but this could have been due to lack of excavation outside the fort area, or to their destruction over time, or genuine absence. However, it is considered that aqueducts were more widely used at forts and other type sites than indicated by the archaeological record. For instance, at forts, assuming the daily consumption and other uses of water per person was 20 litres per day, then for a contingent of troops of say 500, at least 10,000 litres of water would have been necessary. To carry or draw that amount of water each day would have been a costly activity both in time and personnel. The problem is even greater for the larger forts and fortresses and those with cavalry units. Seven fortresses are listed as having had aqueducts, excluding those originally at the coloniae. The lack of aqueducts at more small towns may indicate that they also have not been found for a variety of reasons. At sites which were not urbanized, wells and springs are likely to have been the preferred sources of water supply, if for no other reason than an economic one.

Initially it was the military who, as they advanced from south to north and from east to west, introduced water supply and drainage systems not previously used in Britain.

8. AQUEDUCTS

8.1 General.

There must be a number of factors which relegated aqueduct construction in Roman Britain to the expedient based mainly on leats, simple channels at ground level, or pipe conduits. Comparing the lengths of aqueducts (many over 30km long) in the Mediterranean world with those in Britain (all known ones are less than 25km), may suggest that the relative availability of suitable water sources was easier to find in Britain. Topography may have been a factor, but cost may have been more significant in the decision to build the cheaper type structures. Generally, where aqueducts were required in Britain, the countryside did not have deep valleys surrounded by mountains, so the need for elevated bridge structures and long arcades did not arise. Leats could be

---

4 The assumption of 20 l/d would include water for drinking, cooking, personal washing, and for washing of clothes. If a person carried 10 litres at a time, at least 1,000 daily trips would have been necessary. This would have required about 83 trips per hour for a 12 hour working day, which could imply that about 10 people or more were drawing water every day for 365 days a year. The occupation of drawing water from wells would have presented similar work load problems.
constructed to follow and cross contours to obtain the desired gradient to permit reasonable flow rates. But even so, the construction of simple leats, that is, channels cut into the soil or into rock, were major undertakings. Even their relatively lower costs would have been considered carefully, because towns had to generate their own revenue for public facilities, whereas the province financed its own expenditure on capital public works.

8.2. Leat aqueducts.

Examples of leats for which evidence exists are Bowes, Dolaucothi, Dorchester, Great Chesters, Haconby, Haltonchester, Hardknott, Tomen-Y-Mur, Winchester and Wroxeter. Dolaucothi is the only known gold mine in Britain, worked from pre-Roman times, and further developed by the Romans, that was served by three aqueducts of leat construction. Unfortunately the leat-type aqueducts have been eroded or destroyed over the centuries, primarily because of agricultural activity. The routes of the aqueducts of Dorchester, Great Chesters, Winchester and Wroxeter can be traced with difficulty on the ground.

Leat aqueducts were constructed across contours in such a way that the flow could be controlled within the gradient limits set by Vitruvius (1:2,000 min. and 1:200 max.), or what was expedient for the topography of a particular region. For only a few of the leats that have been recorded in the database is there sufficient information to trace them along the ground. Where they were cut into soil, leats have been vulnerable to natural erosion or eradication by agricultural activities over a very long period, so that many have completely disappeared and their traces are unlikely to be discovered. Where such leats have been cut into rock they seem to have been silted up, as for instance for long lengths of the Dorchester aqueduct in Dorset (Putnam 1995, 128-31) (Fig. 7.3), and portions of the Dolaucothi aqueducts, that is, the Cothi (A), Annell (B), Gwenlais (C), and the Nant Dâr (D) (Fig. 3.4) (Jones and Mattingly 1990, 182, Map 6.3).

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6 This may not be entirely correct, as apparently even if a site has been extensively ploughed, if the light and the time of the year when the growth of the crops is just right, a cropmark may show up and reveal a structure that is invisible at the surface.
Fig. 3.4: Routes of the Dolaucothi aqueducts (after Jones and Mattingly 1990, 182, Map 6.3).

Only minor excavations have been carried out on the Great Chesters aqueduct (Fig. 3.5), but it has been surveyed twice, the first time in 1850, and again in 1988 by the RCHM(E) (Mackay 1990, 285-7). Several sections have completely disappeared, but sufficient lengths of the aqueduct have survived to show its general route. It has been suggested that the source of the aqueduct may have been a dam at Saugby Rigg washpool (A), of which there is now no evidence. At Benks Bridge (B) it has been suggested there was a bridge structure carrying a pipe conduit across the stream, but no remains have been found. The aqueduct discharged into a tank near the baths at the fort (C).
Present surveys of these aqueducts usually consist only of a line on a poorly contoured map, making it difficult to visualize their spatial impact on the landscape. For instance, a preliminary survey of the course of the leat aqueduct of Winchester (Fig. 3.11) was published as recently as 1991 (Fasham and Whinney 1991, 6-11). Future work on it could include plotting it so that its 3-dimensional aspect can be illustrated.

Although some work has been carried out on the British leat aqueducts, there is no published information showing cross-sections of their complete routes. It would be helpful for future studies if the known leats can be plotted in a format which will show them in the context of the local topography. These two aqueducts (Dorchester and Winchester) offer the opportunities to have them mapped to standards which modern computer 3-dimensional plotting can now achieve.

Stone channel aqueducts appear to have been constructed only at military sites such as at Birdoswald, Birrens, Catterick, Glenlochar, High Rochester, Lanchester and Stanwix. There may have been a stone-channel aqueduct at the villa of Well.
The three stone-channelled aqueducts of the Roman fort at Lanchester are an example of this type of construction. The Rev John Hodgson reported and provided a plan of the aqueducts in 1822 (Hodgson 1822) "when the channels were apparently as 'visible as the day they were made'" (Reed & Austin 1976, 214). By 1938 it was difficult for KA Steer (1938, 210-34) to locate the route during a geometric survey of the channels (Fig. 3.4). Reed and Austin state that destruction was due to "Three different forms of land-use - agriculture, new housing and opencast coal-mining - (and these) can be identified as the main agencies which threaten archaeological sites". Natural erosion by the elements has also contributed to this process, but not to the extent and at the rate at which human agencies have caused damage. A prime cause of wanton destruction was opencast coal-mining, since "as a result of deforestation during the last war and the succeeding two decades, some previously protected archaeological remains, such as the dams and aqueducts of the Roman fort, were destroyed" (Reed & Austin 1976, 213).

Fig. 3.6: Lanchester fort aqueducts (Reed & Austin 1976, 215, Fig. 37).

9. INSCRIPTIONS

There are no ancient literary reference or epigraphic information for any of the known leats in Britain, but four inscriptions have been found, one about the repairs to an aqueduct, and three refers to the provision of new aqueducts, all four referring to forts.

7 The article discusses the early discovery of the three aqueducts to the fort and its subsequent deliberate destruction.

8 A recent case of continued destruction of archaeological sites has been the three medieval bridges at Hemmington on the Trent, (Current Archaeology 12(8), 1994, 316-21).
In addition to the four inscriptions from forts (Collingwood & Wright, 1965)\(^9\) the only information we have about aqueducts in Britain is from the archaeological record. At any rate, the epigraphic evidence shows that the leat type water carriers were considered by the Romans as aqueducts. The inscriptions are as follows.

9.1. The four known inscriptions.

**RIB 430 (143):** Caernarvon, AD 198-209.

\[
\text{[Imp(eratores) Caesa(rius) L(ucius) Sept(imius) Seuerus Pius Per[tinus et M(arcus)] Aurelius Antoninus | Pius Augustus] et [P(ublius) Sep(timus) [Geta no]b(bilissimus) C(aes(ar) |rium a]queductivm uetus|tate conia]bs(os) co[orti] I Sunic(orum) restit(uerunt) | [...ARE...|...NL...}
\]

'The Emperor-Caesars Lucius Septimius Severus Pius Pertinax Augustus and Marcus Aurelius Antoninus Pius Augustus and Publius Septimius Geta, most noble Caesar, restored the channels of the aqueducts fallen in through age for the First Cohort of Sunicians....'.

Interpretation of the inscription based on morphological grounds, mentioned by Stephens (1985b, 228-30), suggests that there may have been more than one aqueduct channel; one supplied the fort and the other the extramural baths. It is not clear whether these were channels that carried water pipes. Wheeler, (1924, 110-11) says the fort could only have been supplied by pipelines.

**RIB 1049 (348-9):** Chester-le-Street, AD 216.

\[
...e[qu(itum)] | [a]lae ...Antoni]nianae | ... t]erri-to[rrium ... a]quam induxit | [balneum ... a s]olo in][struxit sub cura ...]diani leg(ati) | Aug(usti) pr(o) pr(aetore) Sabin(o) II et An]ullin(o) con(n)s(ulibus)
\]

'... of the troopers of the Cavalry Regiment ... Antoniniana ... domain-land ... brought in a water supply, and erected a bath-building from groundlevel under the charge of ... emperor's propraetorian legate, in the consulship of Sabinus for the second time and of Anullinus.'

---

\(^9\) Collingwood & Wright 1965, (RIB) Inscriptions for aqueducts have been identified as follows: Caernarfon - RIB 430; Chester-le-street - RIB 1049; Chesters - RIB 1463; South Shields - RIB 1060.
It would seem that the work was done during the reign of the Emperor Caracalla, for which a comparable inscription was found at High Rochester (RIB 1279). This aqueduct is known only from the inscription, as there is no archaeological evidence for it. The fort has a sewer and the baths mentioned in the inscription also suggest that there was a running water supply. Limited excavation or loss of the remains of the aqueduct account for it not having been found.

RIB 1060 (354): South Shields, AD 222.

Imp(erator) Caes(ar) diui Seueri / nepos diui Magni Antonini
fil(ius) | M(arcus) Aurel(ius) Seuerus Alexander | Pius Felix
Aug(ustus) pontif(ex) max(imus) | trib(unicia) pot(estate) p(ater)
p(atriae) co(n)s(ul) aquam / usibus mil(itum) coh(ortis) V
Gallo(rum)
induxit curante Mario Valeriano / leg(ato) eius pr(o) pr(aetore)

'The Emperor Caesar Marcus Aurelius Severus Alexander Pius Felix Augustus, grandson of the deified Severus, son of Antoninus the Great, pontifex maximus, with tribunician power, father of his country, consul, brought in this supply of water for the use of the soldiers of the Fifth Cohort of Gauls, under the charge of Marius Valerianus, his propraetor legate.'

This is one of the most complete inscriptions in Britain relating to the provision of a water supply amenity. It indicates that there may have been two aqueducts at South Shields, the original aqueduct that went out of commission and the new one provided by the emperor Alexander Severus, some time during AD 222-35.

RIB 1463 (354): Chesters, AD 181-5 (Haverfield), AD 217 (Birley).

Aqua adducta / alae II Astur(um) | sub Vlp(io) Marcello / leg(ato)
Aug(usti) pr(o) pr(aetore)

'Water brought for the Second Cavalry Regiment of Asturians under Ulpius Marcellus, emperor's propraetor legate.'

It is uncertain whether the inscription refers to Ulpio Marcellus who was the governor in Britain from AD 181-5, or the governor with the same name dated to AD 217 (Birley 1988, 36, 174). Haverfield (1897, 179) favoured the earlier date, whereas Birley (1988, 174) assigns the inscription to the later date. In the note to the inscription, it is pointed out that the ala II Asturum was a 3rd century garrison of
Chesters, and since the posting of garrisons to Hadrian's Wall was rare at the end of the 2nd century, it was unlikely that this unit was present at the fort in Commodus' time (AD 181-92) (Collingwood & Wright 1, 1965, 472). However Birley also points out that a certain Q. Baienus Blassianus, a prefect, "had commanded an auxiliary unit in Britain, in his case the cohors II Asturum, which was his first commission." He is reported in a papyrus to have been in Egypt in AD 168, and was active from c.AD 140-168 (1988, 51), so he is unlikely to have been with the cohors II Asturum in Chesters in AD 217. To reconcile these two persons' dates it would seem that the inscription refers to the earlier governor. This inscription is also complete, brief and concise. Birley has pointed out that during the 2nd and 3rd decades of the 3rd century there were many examples of the provision of this kind of amenity (Collingwood & Wright 1, 1965, 472, RIB 1463).

There are other inscriptions which attest the provision of, or repairs of baths, e.g. RIB 605, 730, 764, 1091, 1212 and 1912 (Collingwood & Wright 1983, 87).

10. HYDROLOGY AND HYDROGRAPHIC DATA

Scholars have tried to make estimates of flow and several estimates have been published. Hodge (1990, 346-8) gives some of these discharge statistics for a number of aqueducts over the Empire, though none for British aqueducts. These statistics should be treated simply as orders of magnitude because of the many variables that are involved in calculating flow in channels or pipes. In Roman Britain, some calculations have been done for the Dorchester aqueduct and those at Dolaucothi. However there is very little hydrographic data of measurements of flow and mapping of leats which can assist in their descriptions.

Jones et al., (1962, 78-9) calculated flow quantities for the aqueducts at Dolaucothi at Pumsaint in Wales. They used standard formulae for calculating the rate of flow in open channels for two depths (0.381m and 0.305m) to arrive at quantities of flow of 16.2 and 11.7 million litres per day. The Cothi leat discharged into a tank with a capacity of about 14,300m³ (14.3 million litres). Water was used from this and other tanks on the site for hushing of the ore to be processed for its gold. In the RCHM(E) article on the Dorchester aqueduct a flow quantity is given

10 The formulae on which they based their calculations are simplified versions of hydrological calculations, but provides adequate orders of flow quantities. Hodge also gives these formulae in his appendix (349-55), explaining in some detail for the non-technical person, how they are to be used.
(using the same formulae) of 58.9 million litres per day. (I have not found any other flow data for the other known aqueducts from Roman Britain.) The quantities quoted are enormous. I suggest that these flow rates are based on the maximum height of flow anticipated for the aqueducts, which would probably have been the flow rate during flood periods. For the Dorchester aqueduct, I calculated, based on the dimensions provided in the RCHM(E) article (p.587), that for one quarter of the depth of flow given, the flow yield would have been one fifth of that at the suggested depth of 61cm (2ft). Even so the yield would have been nearly 12 million litres/day.

Provision of overflow facilities for discharge of excess water was common in Roman water engineering. Such facilities were generally available to discharge water after it serviced public baths, homes, fountains, latrines and washed street drains, before it was allowed to flow into a river or out of the town. At Dorchester there is evidence of a conduit which removed excess water from the main aqueduct to the river Frome.

11. SOME CASE STUDIES OF AQUEDUCTS IN ROMAN BRITAIN.

11.1. The Dorchester aqueduct.
I discuss the Dorchester aqueduct in detail in Chapter 7. There I give an overview of the finding and modern surveys of the remains of the aqueduct, and then discuss a possible background to its original construction. I then advance a series of hypothetical assumptions about the leat-type aqueduct, in order to give a picture of what would have been the engineering implications of its construction. Bill Putnam has discovered that parts of the Dorchester aqueduct channel were in rock-cut (Putnam 1995, 128-31). He mentions that many of these rock-cuts have been silted up with deep overlying layers of soil (see Fig. 7.4) as at Fordington Bottom (B)(SY 6692 9109), at Muckleford (E)(SY 6397 9343) and at Penns Plantation (D).

11.2 The Lincoln aqueduct
Part of the Lincoln aqueduct route was published in 1954, and little additional information has been added since Thompson reported the structure in 1954 (Fig. 3.7a). In his paper on the Lincoln aqueduct, he refers to the eight ‘piers’ that must have stood on the bases shown in his Figures 2 and 3 (positions D to E)(1954, 112, 115). The figure also shows a projected dashed line from the known position of the aqueduct pipe, giving the relative elevations of suggested piers above the foundations that were found.
Fig. 3.7a: Route of Lincoln aqueduct (after Thompson 1954, Fig. 3).

Fig. 3.7b: A possible restoration of the aqueduct bridge (Wacher 1981, 300, Fig. 18).
Wacher (1995, 141, Fig. 60) gives an elevation plan of "a possible restoration of the aqueduct bridge on the south side of the Roaring Meg". The form of the latter is highly speculative (Figs 3.7a & 3.7b). Nevertheless, the evidence of the 'pier' bases indicates that piers and a super-structure may have been constructed above them, possibly 3-6m high. Various proposals have been put forward to justify the existence of a bridge structure near the Roaring Meg, which would have carried a portion of the aqueduct system (section 9.3).

The implied source of the aqueduct as indicated by Wacher's possible restoration across the Roaring Meg stream (OD c. 40m) is unproven, though Wacher has suggested an alternative source for the aqueduct at a spring some 30km away in the Lincolnshire Wolds at Otby Top north-east of Lincoln, at an elevation of about 152m OD (1981, 297-300, Fig. 17). He said that this source "would have provided a more than adequate head of water to make the aqueduct work on a siphon principle". If the elevation at the tank on the North Wall was at OD 67m, the difference in elevation (Δh of Fig. 3.3) between the source and the discharge point would be 85m, and would have provided a more than adequate head for the actual siphon portion. From the contour map (Fig. 3.8) it would appear that there were several places where the valley elevations were lower than the delivery point, which would require that a very long section of the aqueduct would have been an inverted siphon raising the water to the final required level. If evidence should turn up to confirm this route, it would be the longest inverted siphon built by the Romans and would be unique in ancient hydraulic engineering. Wacher also shows a proposed restoration drawing of the aqueduct bridge across the Roaring Meg (Wacher 1981, 300, Fig. 18), but it is not clear whether this formed part of his extended aqueduct. By implication the bridge would have extended further north than the Roaring Meg for some distance, about which he gives no comment.

Since no evidence to date has been found of the aqueduct beyond the Roaring Meg or the superstructure of the suggested bridge and arcade structure this remains an unproven theory, until new evidence can confirm the existence of the aqueduct continuing northwards. Wacher's suggestion of an extended aqueduct is nevertheless an attractive solution and his route needs to be looked at in much detail to provide archaeological evidence before it can accepted.

11 Wacher 1981, and discussion, 297-304.
12 It is noted that he has not included this reference in the second edition (1995) of his book though he included the discussion on the extended aqueduct.
The Lincoln aqueduct was first referred to in 1700 by a Yorkshire antiquary in a letter to the Dean of York, commenting that "a small canal, or Roman aqueduct or pipe" was discovered. By 1781 "the aqueduct was apparently well known to the local inhabitants" (Thompson, 1954, 108). At that time certain substructures of the aqueduct were apparently still visible, but by 1806 Gough (1806, ii, 366) says that there was only "a mound where some traces of a tower or some building, supposed the place of a reservoir", which he marked on an accompanying map as
being circular\(^{13}\) (Thompson 1954, 109). Thompson describes the details of
the aqueduct from the Roaring Meg towards Lincoln along the Nettleham
Road, based on excavations undertaken during 1951-52 (1954, 106-28), the
direction being revealed on air photographs taken in 1951. The aqueduct
was an earthenware pipe encased in concrete and its route is shown on
Fig. 3.7a.\(^{14}\)

Lewis refers to a short section of earthenware piping encased in
concrete which was found in 1857 towards the east of the lower town
above the spring line, beside Greestone Stairs (Lewis 1984, 71, Fig.
11). Since it was also encased, he suggests it could have been a
pressure main from the south, either from beyond the Witham river, or
from somewhere along the spring line at about the 50m contour. It would
seem there is not sufficient evidence to be more positive about what the
purpose of this short section of pipe-line was, and where it entered the
Roman town. If it was a second aqueduct, it could only have served the
lower part of the \textit{colonia} below the 50m contour line, since most of the
upper \textit{colonia} lay above the 55m contour. He points out that other pipes
found in Lincoln indicate that some running water supply was available.
However, there seems to be no direct evidence of how the aqueducts (if
there were two) did provide water to the upper and lower parts of the
town.

Thompson (1954, 106-28), suggested that the Roaring Meg was the water
source for the aqueduct from the north (Fig 3.7a, position F). It was
about 21.2m (70ft) below the highest point of the rising main aqueduct
along Nettleham Road, where it is assumed to have reached the Roman town
at the water tank just north of the East Gate. For water to flow upwards
along the pipe, Thomas Sympson in the 18th century\(^{15}\) suggested that a
tower was erected with a reservoir tank at the top, near the Roaring
Meg. Its level would have had to be greater than 21.2m above the stream
in order to function. From this tank, water could be discharged into the
aqueduct through a down-pipe, thus forming a closed inverted siphon
system. Excavation during 1951-2 revealed eleven foundation slabs for
piers (shown in Thompson’s Figures 2 and 3), on which it was suggested
the inverted siphon pipe would have been supported. Two proposals for
lifting of water to the top of the tank have been made by Thompson,

\(^{13}\) Camden’s \textit{Britannia} (ed. Gough, 1806), ii, 366, and Pl.X. Presumably the map
Thompson refers to is Camden’s Pl.X.

\(^{14}\) There seems to be some vague evidence of piping which brought piped water to the
lower \textit{colonia} site, with a suggestion that its source may have been along the Witham
river valley (Lewis 1984, 71).

\(^{15}\) Sympson T, 18th c., \textit{Itinerary Curiosum}, i, 88 and his \textit{Adversaria}, see \textit{Lincoln. Notes
and Queries}, ix, 65-90, mentioned by Thompson 1954, 108.
including an endless chain bucket system, or the use of a Roman type force-pump. Thompson favoured this latter solution (1954, 121-2), but the quality of force pumps at that period is not considered to have been of a standard that could have raised sufficient water for the needs of the Colonia (Smith 1991, 125-6).

FT Baker, who was involved in the original excavations, suggested to me in 1995, that he is of the opinion that the aqueduct crossed the Roaring Meg and followed a line towards the left of the main road to the north (B), along the Lincoln Cliff, the Jurassic ridge above the 61m (200ft) contour, where apparently there are springs. However he says, this has not been looked into. Lewis refers to this ridge in his discussion of Wacher's route for the aqueduct (Lewis 1984, 68), but he does not mention the possibility of the aqueduct having its source in this formation. If Baker's suggestion is a possible solution and a spring source was available on the ridge above the 61m contour, then the height to which water would have had to be raised into a tank would have been much less, in order for the inverted siphon to have functioned.

Wood (1981, 107-10) reported that the furthest south the earthenware aqueduct has been located is at a position a distance of 860m from the north-east corner of the Roman city (his Fig 13 p.108). As no evidence has been found of the aqueduct along the proposed line by Thompson beyond point X (Fig. 3.4), it "leads to the speculation that it may have turned from the presumed line". Unfortunately the article provides no spot heights of the last few places where it has been found. However, the 1:10,000 OS map contours indicate that Thompson's line would continue along an upward grade (to about OD 215ft, (65.5m) as suggested by Thompson), whereas, as suggested by Wood, it veered off to the south-west in the direction of the north wall of the colonia towards the Roman bath, or the castellum, which is at a lower elevation. It thus would seem reasonable to conjecture that the Roman engineers were aiming for a different entry point to the colonia than the one suggested by Thompson. The 1:10,000 Ordnance Survey map shows there is a valley (now filled in and built over, carrying a road) between point X and the bath of the colonia, which would imply the possible need of another siphon, not mentioned by Wood. At the present time this last portion of the aqueduct's route is still not resolved.

16 Jones (ed.), 1981, 83-114, with subarticle by Wood K F, Sect., 6, 'The Roman Aqueduct at Lincoln: Recent Investigations', Fig 13, pl.XXIa, b, 107-110.
At Lincoln, Thompson states that, from some point not far from the Roaring Meg source, OS surveying shows "that the pipe may have lain 1.3m (4ft) below the Roman period surface at this point. It then follows that there is a rise between source and supply-point of some 21.2m (70ft), attained over a distance of approximately 2km (1¼ miles). It is thus clear that, between point C and the upper Roman colonia the aqueduct constituted what water-engineers term a 'rising main'; the method of construction, in lengths of earthenware pipe heavily sheathed in waterproof concrete, indicates the measures taken to withstand the resultant pressure which must have been considerable" (Thompson 1954, 121). Thompson's suggestion would indeed have required a high pressure. No comment seems to have been made about the condition of joints when the lengths of pipe remains were recovered during excavation. From the few lengths of pipe in the Lincoln County Council Museum, I could not see any obvious problems at joints.

11.2.1. The tank solution.

Thompson suggests two possible methods of filling the tank: in the first of these, water would have been lifted into a tank at least 21m\(^{17}\) above the source by mechanical means using an endless chain and bucket arrangement. Water would then be allowed to flow by gravity along the down-pipe and under pressure along the rising main on the principle of the 'inverted siphon'. Alternatively, they could have employed a force-pump, such as the type found at Silchester (1954, 112-22). He discusses the two possible solutions in detail, but each one presents technical problems. The tank solution invokes the concept of the inverted siphon system with a reservoir tank raised on a platform providing the water source (Thomas Sympson's original suggestion). Lewis (1984, 65, Fig.6) shows some possible suggestions of how the tank arrangement would have provided water to the aqueduct.

In order to calculate the amount of water that could be made available using Thompson's suggestions I have produced a schematic diagram (Fig. 3.9) of the tank solution based on Thompson's descriptions and measurements. Some of the features of the superstructure shown, are my own schematic representations, merely to illustrate the principles involved. They are not meant to indicate what the Romans constructed, if, in fact, they did use this as a solution. Gough (1806) apparently reported the tank as being circular. The size of the tank is not known.

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17 The height should be more to function as an 'inverted siphon'.
I have assumed that it is rectangular and similar to the dimensions of the foundation platform for ease of calculation purposes (Thomson's foundation No.VIII, p.120, Pl.XI). The size of the foundation was about 4.88m long by about 2.9m wide, giving an area of about 14m². It would have been adequate to carry a tank of similar area. The tower, on top of Pier VIII, may have been of wood construction as suggested by Thompson because of many nails found around the foundation bases, but it is not certain. Lewis, in his drawing, implies a masonry type structure supporting the tank and the down pipe towards the intake of the aqueduct.

If the outlet of the tank at its base was at least 21.2m above the water supply level (the Roaring Meg) relative to the highest point of the aqueduct near the colonia, the choice of height of the tank would have been important depending on how quickly it could be filled. For instance, if the tank height was 2m, then water would have had to be raised from ground level to a height of 23.2m, or 24.2m if the tank was 3m high. Table 3.3 gives some statistics related to the tank supply configuration and the aqueduct as given by Thompson.

It is necessary to know the heights of such a tank to provide sufficient quantities of water. The Table 3.2 below gives height and capacity in litres:

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>Volume (m³)</th>
<th>Capacity (litres)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>14,000</td>
<td>14,000</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>28,000</td>
<td>28,000</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>42,000</td>
<td>42,000</td>
</tr>
<tr>
<td>4</td>
<td>56</td>
<td>56,000</td>
<td>56,000</td>
</tr>
</tbody>
</table>

The minimum head of water between the tank and where the suggested down-pipe enters the aqueduct is 16.3m (OD 61.2m-44.9m) giving a water pressure at Pier V of 163 kPa.¹⁹

¹⁸ The tank with a height of 4m would have exerted a pressure on the foundation of between 400 to 500kPa, which would have been well within the bearing capacity of the foundation.

¹⁹ A head of water of 16.3m is equivalent to 16.3m x 1000kg/m³ = 16,300kg/m² = 163,000kgf/m² = 163kPa.
Table 3.3: Statistics for tank and aqueduct (Thompson 1954, 112-22).

Heights above sea level are given as Ordnance Datum - OD.

Letters A-F and X are given on Thompson's Fig.2 (p.112) (my Fig.3.9), which are pertinent to his discussion in the text.

E-F: OD of Roaring Meg pool, and top of foundation VIII at 39.9m.
D: OD of foundation I at 42.4m.
C: OD at 43.6m.
B: OD at 44.0m.
A: OD at 44.5m.
X: OD at 45.4m.

Top of pier on foundation VIII at OD 42.9m.
Suggested point where down-pipe enter aqueduct pipe, at OD 44.9m.
Bottom of tank at OD 61.2m, also the delivery level at the Colonia bath(?).
Top of 3m high tank at OD 64.2m.

The relative levels of the bottom of Piers I-VIII and 1, 2 and 3 south of pier I, resting on the foundations discovered during the 1951-2 excavations, are shown on his Fig. 2 and I have reproduced them on Fig. 3.9.

Thompson (1954, 121) suggested that the tank could have been filled with an endless chain carrying bronze buckets (Vitruvius De Arc. x, 4.4), which I have depicted diagramatically in Fig.3.9. Whatever the means of generating power to work this system, it must be assumed that it could fill the tank at a reasonable rate. If a bucket held 5 litres and say the chain system had 20 buckets, each complete revolution would have delivered 100 litres of water to the tank. If a revolution took say two minutes to complete, the system would have raised 72,000 litres of water per day. This would have provided about 14 litres per person for a population of 5000 inhabitants. If a bucket could hold 10 litres the system could have delivered about 140,000 litres per day. Also, if there were two sets of chain and bucket systems the delivered water could have been doubled, and it also would have been insurance against breakdown of one of the systems. The assumptions suggested are speculative and is intended merely to provide an order of delivery of water at the colonia. The suggestion is that the aqueduct was directed towards the bath (Wood 1981, 107-10), which means most of the water would have been used for that facility. Of course, in a week the system would have delivered about half a million litres of water, part of which could have been distributed to the rest of the town.

20 The height of the installation would have been of the order of 25m, suggesting a bucket every 2m.
The amount of water involved is low compared to what calculations show other aqueducts delivered. No remains of a tank or a chain and bucket system, or a pump, have been found in the vicinity of the Roaring Meg.

The outlet from the tank would be connected to a down-pipe (here assumed to have been a lead pipe, and may have been encased) delivering water into the aqueduct at its lowest point (Vitruvius' venter). This section would have been carried on the proposed bridge piers that would have stood on the foundation platforms which were found by Thompson.

For water with an average density of 1000kg per cubic metre at a head of 16.3m, the pressure in the pipe at its lowest point would have been 163kPa (kilo-Newton per square metre), for which in modern times we would use either steel pipes or reinforced concrete piping. Very good quality concrete today would be 400-600kPa (in tension) concrete with compressive strengths of about 1200-1800kPa. Lamprecht gives some typical compressive strengths for concrete from various structures in the Empire of 800-1700kPa (1988, 36). From tests of a short length of the pipe Wacher (1995, 141) quotes a bursting pressure of 6.3kg/cm² (630kPa) at which the pipe jacket cracked, indicating that the concrete had adequate strength (assuming that the concrete sample was representative). Based on this strength and assuming that this would have been the order of strength of the pipe at the bottom of the siphon, the pipe would have been able to withstand the water pressure generated by the siphon. Some of the more well-known inverted siphons such as at Gier in France and the one at Pergamon seem to have had much thicker concrete casings round lead pipes where the pressures were generally also higher to cope with higher pressures in their siphons.

11.2.2. The pump solution.

Thompson's second suggestion of a pump, would probably have operated at a level of OD 42.9m, so that the head of water would have been 18.3m, giving a pressure on the pump of 183kPa. With this system the pump would have forced water directly up the pipe and the full pressure of the water would have been exerted on the pump piston. I doubt whether a Roman pump of the 1st century could have provided a pressure that would have been necessary to force water up the aqueduct against that back-pressure in the pipe. With the technology available to the Romans it is inconceivable that they could have produced pumps with packing between

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21 If the rate of flow in pipe is assumed to have been 1m/sec the pipe would have delivered about one million litres of water per day, indicating that with the proposed tank scheme it would have been delivering water well below its capacity.
the cylinders and pistons that could hold a pressure of that magnitude. Today special O-rings are used in pressure pumps with close tolerances between cylinders and pistons in order to transmit high pressures and the casings would be made of steel or special aluminium alloys. The Romans used bronze in the late first and second centuries, whereas earlier they used wooden cylinders. I estimate from replicas of reconstructed Roman force-pumps that they could lift water at most about 4.5m, provided there are reasonably close tolerances between the cylinder casings and the pistons, the surfaces are smooth and the pistons have good quality packing like strong leather to provide a seal between piston and cylinder. Lewis (1984, 64-6) also comments on the use of a pressure pump by the Romans at Lincoln, indicating that the pressure on the piston would have been of the order of 255kPa (37 lbs/in²), which is a load of nearly half a ton. It would have required enormous leverage to lift that amount of water load along the pipe. He concludes that it all seems very unlikely.  

Thompson suggests delivery quantities by pump of the order of 5 gallons/minute, or 22.5 litres/min. The volume of the aqueduct pipe of 2km length and nominal diameter of 0.12m would have been 22.65m³, a capacity of 22,650 litres. As he pointed out, to provide water for 5000 inhabitants would have taken 16 hours continuous pumping, but it would have taken more than 11 hours merely to fill the pipe. He also suggested that two pumps would have provided the colonia inhabitants with double the daily amount of about 5 litres per day. Assuming the pump(s) did not break down and never stopped the water delivered for such an ambitious project does not seem to have been typical of Roman engineering planning. Based on these arguments the proposed pump system seems unlikely to have been an alternative solution.

Lewis (1984, 63-72) discusses the implications of the various proposals by Thompson and Wacher for the water supply to Lincoln, indicating that these were fraught with problems and that Lincoln’s supply was still unresolved in 1984. No further work has been done on this since 1980 (personal communication, Mike Jones). Of the two suggested methods by Thompson I would prefer the chain and bucket/tank solution, provided more information can become available about the elements of the system as proposed and evidence of some remains of the equipment used. However, the two proposed solutions would have been very inefficient ways of

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22 Lewis 1984, 57-73.

23 Thompson mentions allowance for leakage of 50%, which would require no stoppage in the pumping cycle to prevent filling the pipe again, a vicious circle.
providing a running water supply to a deliberately planned large colonia.

If the earthenware pipe sections that have been recovered are examined they appear clean with no apparent deposits of calcium carbonate. Pipes carrying water from geological limestone environments similar to that of the Lincoln area usually are encrusted with lime deposits. An obvious investigation that should be carried out is to examine other pipes in the same area in which it is positively known that water has flowed to note whether they show any marked deposition of calcium carbonate. Dr Graham Morgan tested the interior of the portion of the Lincoln aqueduct in the possession of the School of Archaeological Studies, Leicester, for any lime deposit. The test showed no lime reaction, from which it could be inferred that lime-rich water did not flow in the pipe. However, more extensive tests will have to be done to be positive that water did flow in the aqueduct for any length of time and that it did function as intended.

11.3. The Raw Dyke, Leicester.
The Raw Dykes is mentioned by John Nichols in his 1810 ‘History of Leicester’, referring to "the army of King Charles that was drawn up (‘in these famous vestiges of Roman labour’) when preparing to storm the Town of Leicester in 1645" (Nichols 1810, II(2), 505-6). A slightly different version appears in the Victoria County History, Leicester (I, 1907, xxxi, 14, 252, & 273) where it is stated "that the 'Raw Dykes' are the remains of the oppidum of 'King Leir'". The first reliable information of the occupation of Leicester is from the Roman period. Kathleen Kenyon (1948, 40-1) discussed the possibility that the Raw Dykes (Fig. 3.10) might have been an aqueduct after dismissing the interpretation of the earthworks as a defensive rampart. This was first suggested by William Keay, a consulting engineer, who was on the excavation committee for the Leicester Roman Forum during the early 1930s. He originally presented a paper to the British Association, Archaeological Section in 1933, where he gave his opinion that the Raw Dykes was a likely aqueduct supplying the town of Roman Leicester (Ratae) with running water. He commented that no wells have been located for the Roman period in Ratae (several have been found since) and with a population of the order of 5,000, an external water supply was essential. The SMR records have some details of his work on the subject of
the Raw Dyke, including a brief report on his opinion and a plan showing
details of the so-called aqueduct site, with survey details.24

Fig. 3.10: The Raw Dyke, Leicester, (after Wacher 1995, Fig.58).

The conjectured construction of the Raw Dyke consisted of a leat type
excavation from the Knighton Brook (A) along the 61m contour for about
2.4km to the Roman town, entering the Ratae town walls through the south
gate (B)(Fig.3.10). A portion of this ditch (leat aqueduct) still
survives in the town near the junction of Aylestone Road and Saffron
Lane (C). At Saffron Lane the ditch was cut along this contour and the
material from the east side was dumped along the west forming an
embankment. At the top the ditch was about 15m wide and 4m at the
bottom, and about 2.4m deep (Wacher 1995, 350). William Keay prepared a
plan showing the route of the aqueduct, suggesting that it was fed from
the Knighton Brook and that there may even have been a dam constructed
across the stream west of the intake of the aqueduct.

Kathleen Kenyon said there were several problems with relative levels
relating to the channel and the baths, as it skirts past the baths into
the town centre. She suggests that as a theory it is "not entirely
satisfactory, but the best that can be put forward on present evidence" (1948, 41). At a door-sill of the Jewry Wall, she points out the level
is at 62.3m and the channel bottom is at 57.1m, about 5m too low to
provide water directly to the baths (1948, 41). She then says "when
experience showed that the level was too low, an effort was made to

24 A copy of this report and the plans, together with a copy of a statement he wrote
for the Leicester Mercury of 27 May 1938, 'Leicester's Roman Aqueduct', is held in the
SMR records at the Jewry Wall museum.
correct it by raising the bottom 6ft 6in" (2m) (1948, 41), but she does not show how this was achieved.

At the Knighton Brook end Keay also shows a length of about 320m (A-C) of the Dyke as being conjectural. The 1888 OS map showed a length of 740m (C-D) of the Dyke south of the short length of the Dyke still visible near Aylestone road. In 1804 a portion of about 300m (D-E) was reported to be still visible. Keay’s firm did a tachy survey of the remains of this surviving length of the Dyke and from city plans of the area produced the line for the rest of the Raw Dyke.25 Keay mentions on his plan that Dr Stukeley reported the length of the dyke as being 1,904 feet (580m), which is considerably shorter than his plan shows, that is 2.4km to the south gate.

The interpretation of the Raw Dyke as an aqueduct raises several questions.

Firstly, was it an aqueduct, and was it constructed by the Romans, or was it constructed at a later date? There appears to be no literary or archaeological information to confirm any of these questions, except for Nichol’s unsatisfactory reference given above. Secondly, assuming it was of Roman construction, then they must have been aware from the start that it would not be able to serve as a supply for the baths (F), which were at an elevation about 5m higher. That would not have deterred the Roman engineers. I think, if the structure was an aqueduct, the supply of water to the baths became a secondary issue, the main purpose being to bring water to at least the lower parts of the town. It would be reasonable to assume that the aqueduct would have provided a good constant flow of water, the reason for it being built. If so, it must have been purposefully built to supply a large number of inhabitants, other public buildings and probably fountains. Some of the public buildings were, like the baths, at a higher elevation level than the 61m contour, so to supply water from the dyke to these public buildings would also have been a problem. This seems to raise the issue of where the majority of people lived in Ratae who could have benefitted from the aqueduct. Thirdly, assuming that the dyke was the Roman aqueduct and there was this problem about elevation, would it not have been sounder engineering practice to have built a central tower with a raised tank near the south gate and distributed water from there to the various buildings including the baths and inhabitants rather than have the tower

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25 Wacher in his book used this basic plan to provide his Figure 158 of the line of the aqueduct.
within the precinct of the bath? Kenyon suggested that a tower was built in the courtyard of the baths and water raised from the river below (Fig. 5.6). The River Soar was another 8m below the level of the Raw Dyke at the east gate, requiring water to be lifted to the raised tank on a tower to a height of about 15-18m. It was not the policy of the Romans to draw water from main rivers for towns. It would seem to me that if the Raw Dykes was indeed the water supply of Roman Leicester, then a raised tower in a more central place would have been the Roman solution, for which there are many precedents, such as at Pompeii. Such a tank would have had similar problems to the one assumed for Lincoln, except that an inverted siphon would not have been part of the supply system. So far there has been no evidence for such a structure.

Kenyon suggested that the Raw Dyke as an aqueduct was a failure, implying that the town did not have a running water supply until the 4th century when a tank supply was provided in the south-west corner of the baths (Wacher 1995, 349). It would seem that there is no physical evidence for such a tank; only Kenyon’s attempt to justify the anomalous situation of a large bath needing plenty of water and an aqueduct of doubtful use or even existence. Wacher comments on the large drains virtually round three sides of the bath-building, which seem to indicate that plenty of water was freely available at the baths, and which had to be disposed of (1995, 349). He mentions that a ditch was found on the east side of Southgate street northwards away from the Raw Dykes (352). Belairs (1899, 40-4) described a sewer which started from the vicinity of the baths, then discharging into the river. This would imply that from somewhere excess running water was being drained, which must have somehow reached the bath. The meagre evidence certainly supports the existence of an illusive aqueduct and distribution system.

However, recent archaeological investigations have not been able to confirm the presence of an aqueduct in the vicinity of the supposed south gate. R J Buckley of ULAS (personal communication April 1997), mentioned to me that excavations outside the defences of Roman Leicester on either side of Oxford street did not show any evidence of the Raw Dyke having reached as far as the south gate. The Raw Dykes was also not found during recent investigations near the Royal Infirmary Hospital. Also, between the River Soar and the Jewry Wall baths no evidence of the Dyke has been found, nor has any evidence been found of any water-related features around the semicircle of Keay’s suggested loop towards the east gate. There is possible evidence of a fountain base with a draining pipe, which has been found in the south-west corner at the
junction of the Roman road coming from the east and passing south of the forum on the south-north road between the forum and the baths. Based on this evidence it would seem the solution to the water supply of Roman Leicester is far from resolved.

Neither of the two aqueducts discussed above has provided satisfactory answers to the question whether they actually functioned as intended during Roman times. If they were intended to do so but did not actually deliver water as planned, it would indicate poor planning, ingenuity and surveying on the part of the Roman engineers. However, lack of archaeological evidence in these two instances leaves that verdict about their engineering planning still to be determined by future work.

11.3. The Winchester aqueduct.

Until the 1980s only the terminal end of the Winchester aqueduct was known (Stephens 1985a, 203-4), although it was suspected that its source must have been the river Itchen near its headwaters. During 1983, the watching brief and rescue archaeology whilst the M3 motorway was being reconstructed, revealed the presence of the aqueduct on Grace’s Farm (A) (SU 5060 3286, Fig.3.11) along the route of the motorway. The Trust for Wessex Archaeology, through the M3 Archaeological Rescue Committee, then did a geophysical survey of a portion of the aqueduct near Grace’s Farm, and an airphoto study of the whole route. The importance of this recently discovered aqueduct is that it is the longest aqueduct so far known in Roman Britain. Its length is reported to be 23.75km (p.8) (Fig. 3.11), following a winding route along and across contours to maintain an acceptable flow grade. The source is at several springs above the Manor Farm near Itchen Stoke (B) (Fig.3.11) some 6 kilometres in a direct line from the delivery point at the north-west corner of the Winchester defences (C) (Fasham & Whinney 1991, 9, Fig.7).

The report on the structure so far can only be considered as an interim one. There would have to be a more detailed examination of the aqueduct over its full length to establish its exact route and the profile of the structure along its length. The geophysical work was done on sections along its assumed route based on detailed 1:10,000 OS maps and from this information a complete route has been provided. The report mentions several problems with the location of the route, but is not clear on the details. Further investigation of the structure will be necessary to

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confirm whether, like the Dorchester aqueduct, it also needed to be dug into the underlying rock along parts of its course.

Fig. 3.11: Route of Winchester aqueduct (after Fasham & Whinney 1991, 9, Fig. 7).

11.4. London's water supply.
London obtained most of its water supply from springs and wells. However, Wacher suggested on the evidence of wooden pipes found near the Temple of Mithras and on the forum site that it implies "some form of distributive system for running water" (1995, 101, 110). Wilmott rejects Wacher's suggestion that an aqueduct must have supplied the baths (1974, 48-51, and reiterated in his 1995 edition, 90, 95). The Billingsgate and Huggin Hill baths (with one of the largest caldaria in Roman Britain, Marsden, 1980, 103-4) were situated along the spring line above the Thames river front, and the Cheapside bath was in a high water table area, from which Wilmott concludes there was therefore no apparent need for an aqueduct type supply and none has been found (1982, 16). It is probably correct that an aqueduct did not supply water from an external source. This cannot rule out the possibility that water may have been tapped from the abundant springs reported in the literature (including
Wilmott's reports), from within the walls of Roman Londinium, and distributed to places in the town along pipes. This type of situation may not evoke the idea of an aqueduct in the accepted sense of bringing water from a distant source, but technically such a system would still be classed as an intra-mural aqueduct supply.

At any rate it is possible that part of London had a running water supply, discussed in Chapter 4. Evidence of Roman wooden piping has been found in five places in London (Wilmott 1984, Fig. 1).27 Even though the first two baths referred to above were along the spring line, it cannot be ruled out that conduits of some kind were used to provide their water supply. Wacher makes the interesting observation that "as seems likely,..., a diminishing in the number of wells could simply indicate that the supply of running water, perhaps to street fountains, was being used more efficiently..." (1995, 110); however, no system supplying fountains has been found.

12. CONCLUSION
Leat aqueducts were a common form of water supply in Roman Britain, but pipe-type aqueducts are also well represented. Stone channels were also used, but the evidence seems to indicate that because of leakage problems, wooden pipes may often have replaced them, the channels then being used as supports for the pipes. Sites with aqueduct water supplies, based on the archaeological evidence, represented only a relatively small number of sites with running water supplies and I believe that the number should be considerably higher. In the archaeological literature reference is often made to the likelihood of sites possibly having had aqueduct water supplies, but that they have so far not been found. For a better understanding of the wider issues relating to the internal distribution of water at urban centres, clarity on their external water supplies requires urgent further research. Progress on water supply and internal distribution at many sites like Cirencester, Colchester, Gloucester, Leicester, Lincoln, Verulamium and York, cannot be made without further study of where their running water supplies came from.

27 Home 1948, note 2, p.170, 'From the Bank of England site have come lengths of squared oak, 7¼ x 4½ inches, with circular piercing ⅛ inches in diameter. These wooden pipes seem to indicate one of the various forms of supply'. Marsden P. 1980, 23, reports 'a wooden pipe made from interconnecting links joined by iron collars or rings ran alongside the front of the building, ensuring a supply of running water to at least some of the tenants.... and it was through the end wall of this room that a wood-lined drain emptied waste water into the area beyond'. Merrifield 1965, at pages 73, 148, 219 item 170 and Fig. 29, confirm the two sites where water piping have been found.
Other issues such as who constructed and surveyed leat aqueducts is completely unknown for Roman Britain. For instance how often were inverted siphons used in Britain? Except for Lincoln, inverted siphons are usually only suggested as possibilities, such as at Chester and Colchester, but no firm archaeological confirmation has been provided. The subject is in need of specific research.

Wooden pipes were a very popular means for distribution of water. The evidence for lead and ceramic pipes is more difficult to trace. Lead pipes may have been used more widely than presently acknowledged in the record.

Water sources were generally from springs, or the head waters of streams. Dams were often built at stream heads as sources for water, but evidence for them in Britain is scarce. Many sites relied on wells for their water supply, and other less secure systems such as tanks collecting rainwater. The next section will discuss these alternative means of water supply, and attempt to assess whether aqueducts were a substitute to the standard form of well water supply.
CHAPTER 4.

WATER SUPPLIES: 2) RAINWATER CATCHMENT AND WELLS

1. GENERAL
Rainwater catchment will be discussed first, because the main part of this chapter will be about wells.

2. RAINWATER CATCHMENT
Storing of rainwater, such as at hillforts, was probably the earliest form of man-made water supply. Although water could be carried in skin bags and pottery vessels, the quantities would have been limited, so that ponds would seem to have been a solution. In ancient Babylonian, Minoan and Mycenaean palaces there were structures found which appeared to have been used as storage tanks, including the very large urns found at Knossos. Tanks as a storage structure in Britain were introduced by the Roman army in their fortresses and forts, and thereafter they were features found in all the different site types.

In the typical Roman houses in Roman Italy the atrium usually had a tank below floor level where water was drained to from the roof of the house. Houses in Britain did not seem to have a principal room with a tank, but provision was made for storing of rainwater in specially constructed tanks. Tanks were constructed with materials of wood, lead and stone. Wooden tanks were not large because of the problem of containing the planks so that they would remain waterproof. Barrels usually had a truncated oval shape because it was found that this added to their strength and improved the sealing between staves, but this was not possible with larger vessels used for water storage. The one redeeming factor about wood is that when it is kept wet it self-seals as it swells. Lead tanks were used, but lead was an expensive commodity; they generally seem to have been round. Several lead tanks are reported, including some used for Christian religious purposes. Stone tanks were the most popular water storing facility in forts, public buildings and private homes. They generally were rectangular in shape and the walls were constructed on a plinth usually made of ashlar slabs. Various means of water proofing of stone tanks were used: wood-lined, lead-lined, clay-lined and lime mortar-lined. I would think that stone-lined tanks must have required constant maintenance, especially the clay- and mortar-lined ones. The clay must have been a specially heavy clay with a high plasticity in order to stick to the walls. With the elapse of time the clay would have become completely saturated and would have slaked from the wall, thus requiring resealing. Mortar-lined stone walls would
have been very sensitive to minor movements which could have been caused by constant buffeting by buckets and being bumped by humans or animals, or settlement of the foundation slabs. The mortar across a joint between stones has no tension strength, so that the slightest movement caused either by an external agency or temperature variation, could have created leaky joints.

A number of villa houses have been reported with such tanks such as at Gatcombe (metal-lined?), Halstock (stone), North Leigh, North Fleet (clay-lined) and West Wickham (wood). At the small town of Ashton a lead tank is reported. Tanks at forts were generally of stone construction, even at the Lunt fort, where most of the buildings were of wood construction.

I have recorded the remains of 102 tanks at all site types, but there must be many more not recorded, or they have not been found. Table 4.1 gives the distribution of sites with tanks (and lists the total number of sites included in the database below).

<table>
<thead>
<tr>
<th>Table 4.1: Sites with tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forts</strong></td>
</tr>
<tr>
<td>32</td>
</tr>
<tr>
<td>24%</td>
</tr>
<tr>
<td>135</td>
</tr>
</tbody>
</table>

2.1. Sites with tanks.

2.1.1. Forts.

The number of fort sites recorded to have had tanks is unrealistically low, because most forts must have had a water storage feature, even if there was a well on the site. With many soldiers being around much of the time, easily available water would have been a necessity. The remarks relating to wells and the number of fort sites recorded in the database compared to the total number of forts known, applies to tanks as well. Even the small fortlets would have required more water storage than could be stored in amphorae alone.

The cavalry fort of Lunt at Baginton had 15 tanks, some of them used for drinking water for horses, although they possibly could have been taken to the River Stowe to drink. It had 6 wells which would have been the water supply for the tanks.1 Housesteads had 5 tanks made of stone slabs and lined with mortar, including the still well-preserved remains of the

---

1 There are three excavation reports for the Lunt fort, but I have only had access to the first two.
one north-east of the latrine near the South Gate. How these tanks were filled is not clear, although a few of the possibilities of how water was supplied to the fort have been mentioned in Chapter 3.

Some tanks were filled from the roofs of buildings that had gutters with down-pipes, but how general this would have been in forts is not known. Storing water obtained from rain water could have been only a supplementary source of water and is unlikely to have been sufficient for auxiliary forts, but could have been useful in emergencies when the other sources were temporarily out of action.

2.1.2. Other sites with tanks.

Tanks were recorded at all the site types other than the two municipia. However, Table 4.1 shows that the number of sites that had tanks for the sites recorded in the database is low, which makes it even worse when considered for all the known sites of the Roman period. It is most probable that tanks would have been used at these sites but have not been discovered yet, or have been completely destroyed. In Frere's extensive reports on Verulamium no mention is made of tanks or shown on any of the plans, although many other water-related features are shown, such as drains and pipes (1972, Vol.1; 1983, Vol.2). In London, the remains of three tanks have been found. A tank is associated with the Billingsgate baths south of the frigidarium. A large timber tank preceded the 3rd century bath-building. At the Cheapside baths the remains of a timber-lined 28m³ tank (Fig.4.1 below) was found, situated to the north of the baths. It was not revealed how water was transferred from the tank to the baths or how the tank was filled. The tank was partly sunk into the gravel layer and it had no bottom, so it may have filled by seepage from the bottom, since the water table was high and ground water was abundant in the area (Wilmott 1982b, 239). At Silchester only one tank is recorded, but this also seems unrealistic, considering there were 76 wells. The villas at Keston and Whitebeech had 6 and 5 tanks respectively, and the settlement at Sibbington had 4. These are the highest number of tanks recorded for non-military sites. Generally one or two tanks is the norm for the other sites.
Obtaining water from the roofs of buildings other than at forts was probably also a common practice, but the evidence would be difficult to substantiate, unless guttering can confirm it and has been found attached to fallen down roof structures. I have not come across such evidence, but it would be surprising that rainwater catchment was not a general practice in Britain during Roman times, since it was a common practice elsewhere.
3. WELLS

3.1. General.

Wells were a common form of water supply for both public and domestic use in many parts of the world from the early Bronze Age. It was important to have well water supplies even if a community had a running water supply because of possible droughts, attack by an enemy who could cut an aqueduct supply, or because an aqueduct became inoperative. In dry climates like North Africa and the Near East wells were an important means of water supply because of the short rainy season. In many parts of Africa it is still a basic form of water supply. Wells were used as water supplies in Britain until the early part of the 19th century, when boreholes increasingly replaced wells, which continued the principle of winning water from underground sources.

For wells of about one metre in diameter one person usually had to do all the work of digging the soil or chiselling the rock material and filling the containers. Wells of about 2m diameter and larger could be dug by more than one person at the same time. As the depth of a well increased from about 10m the problem of fresh air became important and diggers would have had to be relieved more often than at shallower levels. I have personal experience of this; once when inspecting a dry pit 12m deep I had to be hauled up after 20 minutes at the bottom because of dizziness due to foul air. In modern engineering practice, fresh air is pumped through pipes to the bottom of deep small dimension pits to prevent suffocation resulting from foul air, mostly caused by an individual inside the pit exhaling and reinhaling carbon dioxide. The exertion of digging makes this problem worse and one wonders how many well diggers in early times succumbed while digging such deep wells. Pliny the Elder mentions the problem of noxious gasses down deep wells, and says it can be improved by fanning with linen cloths. He also mentions that deep "well-diggers are killed when they encounter sulphurous and alum-laden fumes", (HN 31.49).

Few wells from antiquity, certainly for Roman Britain, have been excavated for information on their intrinsic water supply function. Where they have been excavated, the reason generally has been for finds found in them (Chapter 2, p.41, item 3). However, some wells have been excavated in sufficient detail to reveal their lining by steining, such as examples at London, Silchester, Scole, Southwark and Lancaster (see Table 4.3, p.108). I traced at least 30 sites with wells that were lined.
For Britain I have been able to trace 350 sites with Roman wells, but this underrepresents the likely total number. Table 4.2 shows the number of sites with wells found at the different site types. Column 2 gives the number of sites with wells for each site type, and column 4 gives the number of all sites with water-related (w/r) features for each site type.

Table 4.2: Sites with wells

<table>
<thead>
<tr>
<th>Site types</th>
<th>Sites with wells</th>
<th>Percent(^*)</th>
<th>All sites with w/r features</th>
<th>Percent(^*) of well sites in relation to total sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forts</td>
<td>43</td>
<td>31%</td>
<td>137</td>
<td>12.0%</td>
</tr>
<tr>
<td>Coloniae</td>
<td>4</td>
<td>100%</td>
<td>4</td>
<td>1.2%</td>
</tr>
<tr>
<td>Municipia</td>
<td>2</td>
<td>100%</td>
<td>2</td>
<td>0.6%</td>
</tr>
<tr>
<td>Civitas</td>
<td>11</td>
<td>78%</td>
<td>14</td>
<td>3.1%</td>
</tr>
<tr>
<td>Small towns</td>
<td>52</td>
<td>79%</td>
<td>66</td>
<td>14.8%</td>
</tr>
<tr>
<td>Settlements</td>
<td>135</td>
<td>63%</td>
<td>212</td>
<td>38.6%</td>
</tr>
<tr>
<td>Villas</td>
<td>104</td>
<td>28%</td>
<td>372</td>
<td>29.7%</td>
</tr>
</tbody>
</table>

Total Sites 350

\(^*\) Percent of sites with wells is arrived at by dividing items in column 2 by items in column 4 and multiplying by 100.

\(^*\) Percent of sites with wells in relation to total well sites is arrived at by dividing items in column 2 by the total number of sites and multiplying by 100.

The percentages in column 3 represent the proportion of sites with wells found for each site type compared with the number of sites with all water-related features for each of the seven site types. The percentages in column 5 represent the proportion of sites with wells for each of the site types compared with the total number of sites with wells for all site types. In the table the generic site name 'fort' has been used which includes fortresses, forts and fortlets.

The percentages are not statistically significant, but they do show some trend in the archaeological record. For instance, the 43 fort sites with wells is a relatively low percentage of the total number of all site types with wells, whereas 135 settlements had wells recorded, nearly three times as many as at forts. Villas with wells also show a larger percentage of sites with wells than for forts. An obvious question seems to be, did a lesser proportion of forts in reality have wells than other types of site?
It is to be noted from the data in the table of Appendix 1 that most sites have few wells; however, there are several exceptions. Table 4.2 lists the sites with 10 and more wells given in Appendix 1. At 222 sites only one well was recorded and at 128 sites more than one and less than 10 wells were found.

Table 4.3: Sites with 10 and more wells.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Site type</th>
<th>Number of wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newstead</td>
<td>fort</td>
<td>107+</td>
</tr>
<tr>
<td>Southwark</td>
<td>fort</td>
<td>38</td>
</tr>
<tr>
<td>London</td>
<td>municipium</td>
<td>51</td>
</tr>
<tr>
<td>Caerwent</td>
<td>civitas capital</td>
<td>16</td>
</tr>
<tr>
<td>Silchester</td>
<td>civitas capital</td>
<td>76</td>
</tr>
<tr>
<td>Wroxeter</td>
<td>civitas capital</td>
<td>17</td>
</tr>
<tr>
<td>Tiddington</td>
<td>small town</td>
<td>14</td>
</tr>
<tr>
<td>Stonea Grange</td>
<td>settlement</td>
<td>13</td>
</tr>
<tr>
<td>Stanwick</td>
<td>villa</td>
<td>12</td>
</tr>
<tr>
<td>Thetford</td>
<td>villa</td>
<td>10</td>
</tr>
</tbody>
</table>

It is significant that of the large towns, coloniae are not represented in this table, whereas three of the civitas capitals are represented. There is a lack of evidence for wells at these sites, to be discussed in Chapter 6.

3.2. Geology and hydrology of wells.

As mentioned above (p.45), Vitruvius gave advice on how to locate a source of water below the ground surface, but it is not known to what extent this was practical guidance to Roman water engineers charged with deciding on a site for a well. The range of geological and hydrological conditions will normally determine where wells should be dug to produce artificial sources of water, and this would in ancient times have depended on local knowledge and experience. It is also likely that accumulated experience over a long period was passed on to new generations of water engineers, who would have learnt how to recognize geological conditions where water-bearing materials existed. It would seem that some forts and towns were deliberately established in geological conditions where water from wells was easily available, such as the fort at Newstead or the town of Silchester, both of which had large numbers of wells.
Wells are dug to a depth where seepage from a perched aquifer occurs, such as at a spring line along a slope, or down into the water table zone, which would provide an adequate level of water in the bottom of the well so that water could be drawn from it continuously. Shallow aquifers usually occur in gravel and sand layers overlying clay, whereas a water table also can be shallow, for instance in marshy land or near the coast. Inland, the water table can be at depths of 10m and deeper. Fissured limestone, arenaceous rock and sandstone formations also incorporate aquifers from where water can be found. The Romans perfected the digging of wells in all kinds of geological conditions and many remains of Roman wells have been found all over the Empire including Britain.

The British government produced a series of publications from the late 19th century to the 1940s of the water supply potential of springs and wells for a number of counties. In the publication for London's water supply from underground sources (HMSO 1938) the key map (Pl.1, opp. p.1) is titled 'Map showing contours of the Chalk surface', illustrating the significance of limestone formations in underground hydrology. There are also other water-bearing formations, as mentioned above. It would be interesting to check the relationship between Roman wells and the geological stratigraphy, to discover whether these limestone and other water-bearing material aquifers were exploited by the Romano-Britons when they dug their wells. How successful the choice of sites for the wells have been, will depend on how accurately the stratigraphy of the geological formations have been described during archaeological excavations. Local modern borehole data would be useful to determine the geological formation in which such wells were made. These government reports can assist interpretation of sites where no water supply features have as yet been recorded.

An example is Brixworth (SP 747 719) (App.2), a villa in Northamptonshire, since no Roman well had been found during archaeological excavations up to 1981. However there are remains of a substantial bath-house for which water was needed. The HMSO report (1909) for this area quotes the hydrological data for four post-Roman wells, and there is also a spring nearby, indicating a water aquifer in the vicinity. The spring still provided water before 1909. Two of these wells provided almost no water and the other two produced water in the wells from 3.66m (12ft) and 3.35m (11ft) respectively. The report states: 'There are numerous wells in and around Brixworth deriving water
from the Northampton Sand’ (HMSO 1909, 80-90). This suggests that the villa probably did have a well(s), but that it has not been found yet. If the spring was functioning in Roman times it may have been the water supply for the villa.

A study of the HMSO reports could also supply information on the potential yield of wells in Roman times. Because it has been found during archaeological excavations that some of the Roman wells are now dry, it is possible, based on principles of soil mechanics and knowledge of under-ground hydrology, in some instances to estimate the drop in the water table since Roman times. This could indicate what the likely yield of wells during the Roman period would have been.

There are a number of sites where remains of baths have been found but no water supply of any kind. The reason for this may be that for many sites their complete areas were not excavated to detect wells or other forms of water supply, or the well-heads may have been covered with so much overburden that it was not possible to find them. Examples of sites where baths have been found but no water supply are Acton Scott (villa), Badbury (settlement), Bearsden (fort), Bignor (villa), Braughing (small town), Castell Collen (fort), Rivenhall (villa).

3.3. Typology of Roman wells
Wells were dug in both soils and soft rock with hand tools and the loosened material was removed by hauling it to the surface in containers such as leather bags, wicker baskets or metal buckets. The well shafts were sometimes square, particularly when dug in soils, gravels and sands, because often their walls had to be protected to prevent collapse. When dug in rock such as chalk and other types of limestone, and sandstones, they were generally round. In rock the walls of the wells were stable and did not as a rule require revetment, except in fracture zones. Wells dug in soils, gravels or sands nearly always required some form of revetment especially around the opening and near the zone where water seeped into the well.

Roman wells in Britain varied in their construction, of which there were generally three types: unlined, wood-lined and stone-lined. Many of the early wells were unlined, indicating that the materials in which they were dug were stable, such as at Colchester, although later wells with no lining have been found. There are examples of unlined wells found at forts such as at Brecon Gaer (Wheeler 1926, 41), Caerhun (Arch. Camb. 85, 1930, 77), Newstead (Curle 1911, 33-6), Richborough (Bushe-Fox,
1928, 27; 1932, 61) and Slack (YAJ.1922, 22). Whether at some wells which have been reported as being unlined, the original timber linings have perished without trace, is an issue which is unlikely to be proved. Wells in rock were generally not lined because their walls were usually stable. It has been claimed that wells dug in chalk or other rock material were steined with clay to waterproof them (Hanson 1970, 397). I cannot see the reason for this, because steining with clay can hardly improve the stability of a rock well wall, and one of the functions of a well was to allow water to seep into it. Also, if there was an aquifer higher up a slope and seepage from it flowed towards the well wall, a clay surface would be penetrated by the seepage because of seepage pressure. Wells with wood and masonry linings are discussed below.

4. STEINING OF WELLS

Revetment of well walls is referred to as steining, which consisted of lining of the well walls with wood or masonry (White 1984, 157). Steining of wells was usually carried out using three methods: timber-lined, lining the walls with stone (Archaeologia 62(I), 1911, 417) either as dressed stone or rough stone (May 1922, 35-6: Wright, 1872, 218-9; Donel, 1993, 1-2, Figs.3-5), or lined with brick (Wilmott 1982a, 2; Hodge 1992, 52). Wilmott doubts the Roman dating of a supposed stone-lined well (No.7) at Aldermary House in London, “as no other stone-lined Roman wells have been found in London” (1982a, 22). Sometimes discarded wine barrels were used to line wells, such as at London (Wilmott 1982a, 23) and Silchester (Archaeologia 61(I), 1908, 15). At Silchester it is also reported that three wells had the bottom part lined with wicker baskets below the masonry lining above (Archaeologia 61(I), 1908, 15). The opening of a well often was protected with a well-head built in either stone or brick as at the Roman well at St Paul-in-the-Bail in Lincoln (Camidge 1984, 15-21; Donel, 1993, 1-2, Figs.3-5), serving also as a means to prevent undesirable material washing into it, and a stone block as at Gloucester (TEGAS 80, 1962, 56), or as at Bar Hill (Macdonald and Park 1906, 40, 92). The well-head also could serve as the support for a water-lifting device such as a pulley and bucket arrangement, or even the more elaborate chain and bucket system. The military establishment seems to have favoured masonry or brick lining of wells (Hanson 1970, 399).
Two typical examples of Romano-British well revetment practice will be discussed: those at London (Queen Street) (Wilmott 1982a, 9-19), and Scole².

At London there is evidence that at least 13 wells were lined with disused wine barrels (Wilmott 1982a, 10, 18, 22, for example well 19 p.6 and well 37 p.5, p.12). The use of barrels to line wells must have been cost-effective, because there would have been no need to construct the lining, as was the case with the corner-post vertical timber-lining or box-frames used widely over Britain. Because of the shape of barrels they were able to withstand active earth pressures which develop as material is removed for the shaft. Sometimes box-frames and barrel linings were used in the same well. The barrels seemed always to be below the box-frames, the probable reason being, that as the construction reached the water table, the gravel layer became unstable because of seepage, so that a preformed lining had to be inserted to prevent collapse of the walls as further penetration into the water bearing stratum continued (Fig.4.1, Wilmott 1982a, 27, Fig.19, Well 31).

Corner-post construction of linings was used at many sites such as at the baths at Cheapside and at Queen Street (Wilmott 1982a, 25, Fig.18, No.24). Other examples of corner-post linings occur at Colchester, Chigwell, Skeldergate and Scole. Box-framed linings were constructed of four planks lying on their edges in a horizontal position, jointed at the ends in several ways. Sometimes the end planks were rebated so that two planks could fit into each other forming a right angle and this was done with all four planks to form a box. A number of these boxes would be fitted on top of each other for the length of the lining in a well (Fig.4.2), as shown for the upper part of well No.31.

Often for wells for which depths are not given, an Ordnance Datum level is given because it was not clear how much of their upper parts has been lost, or how thick the subsequent deposits were over the original well openings. However some observations can be made, especially regarding depths and sizes of wells and their lining. The four wells, numbers 20, 24, 35, 36, (see Table 4.4 for depths) indicate how relatively thin the gravel layer was in some areas of London and how high the water table was in the layer. Where the depths were greater than about 3m the wells were in the Warble valley where the gravel layer was about 6m thick. The gravel layer overlay the very impervious London clay, which seemed to have determined the depth to which wells were dug.

² EAA 5, 1977, 108, Fig.46, well I: 111, 112 Fig.48; 113 Fig.49; well II: 114, 115 Fig.50, 116 Fig.51, and pages 116-7 give dating of the wells.
Fig. 4.2: Box-frames and barrel lining (well 31) from Queen Street Roman wells, (after Wilmott 1982a, 27, Fig. 19). Wells 22, 31 with lap joints, and wells 19, 36 are bridled and braced.

The dimensions of some of the box-frames are quite small, probably indicating that the lining was constructed from the bottom upwards. Where instability occurred in the gravel layer, barrels were used during the digging process, which would have prevented sudden collapse.

Another method was to have four corner posts which were mortised at top and bottom and also in a face at right angles, so that it formed a framework for planks to be placed behind the posts, forming an extended box-frame, such as at Lancaster and Scole.
At Silchester 52 of the 76 wells were flint-lined, and 21 were lined with wood, and some were lined with barrels (Hanson 1970, 125). The fact that all the known wells from Silchester were lined indicates either that many people acquired the skill for revetment of wells, or that professional well-diggers were used to construct wells.

The 16 wells at Caerwent were all stone lined (Hanson 1970, 84). The need for steining of wells was no doubt learnt from hard experience of well collapse. Why at Caerwent all the wells were flint-lined (Hanson 1970, 84), is not clear, but it could have been because flint stone was readily available and that wood had become scarce because of other uses, and expensive. It would seem that the practice was to make all wells with stone-built linings round, which makes good sense, because the surrounding active earth pressure would tend to compress the stone ring, in that way making it more stable.

4.1. Well dimensions and lining.

Table 4.4 gives some examples of sites with wells and the type of steining which was used in them. Only the wells from London for which dimensional information has been given are included in the table; many more wells were excavated, but details of size were not given. The dimensions of some of the box-frames are quite small, probably indicating that the lining was pre-fabricated in sections. Where instability occurred in the gravel layer, barrels were used during the digging process acting like caissons to prevent sudden collapse.

Timber-lining of the corner-post type construction was an early type of steining, used during the 1st to early 2nd centuries, such as the two wells at Scole.
Table 4.4: Lining types and dimensions.

<table>
<thead>
<tr>
<th>Location</th>
<th>Feature</th>
<th>Lining type</th>
<th>L(m)</th>
<th>B(m)</th>
<th>D(m)</th>
<th>Depth(m)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>London, Queen St</td>
<td>2</td>
<td>barrel</td>
<td>0.63</td>
<td></td>
<td></td>
<td>1.68</td>
<td>(Wilmott 1982, 7, 8, 21, Figs. 5, 6, 14)</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>barrel</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st-2nd c.</td>
<td>35</td>
<td>barrel</td>
<td>0.93</td>
<td>0.63</td>
<td>0.35</td>
<td>1.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>box-frames</td>
<td>0.68</td>
<td>0.66</td>
<td>1.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>box-frames</td>
<td>1.30</td>
<td>0.68</td>
<td>1.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>box-frames</td>
<td>1.07</td>
<td></td>
<td>1.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>b/f + barrel</td>
<td></td>
<td>0.58</td>
<td>0.49</td>
<td>5.24</td>
<td></td>
</tr>
<tr>
<td>1st c.</td>
<td>24</td>
<td>timber, vert.</td>
<td>0.99</td>
<td>0.99</td>
<td></td>
<td>shallow?</td>
<td></td>
</tr>
<tr>
<td>3rd-4th c.</td>
<td>19</td>
<td>box-frames</td>
<td>-</td>
<td>0.99</td>
<td></td>
<td>4.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>box-frames</td>
<td>0.68</td>
<td>0.53</td>
<td></td>
<td>2.44</td>
<td></td>
</tr>
<tr>
<td>Great Dunmow</td>
<td>S11</td>
<td>box-frames</td>
<td>0.76</td>
<td>0.76</td>
<td>0.76</td>
<td>6.9</td>
<td>EAA 41, 1988, 25 Figs.4 &amp; 13.</td>
</tr>
<tr>
<td>Scole</td>
<td>Well I</td>
<td>box-frames</td>
<td>c.1.</td>
<td>c.1.</td>
<td>2</td>
<td>&gt;4</td>
<td>EAA 5, 1977, 112,113</td>
</tr>
<tr>
<td></td>
<td>Well II</td>
<td>box-frames</td>
<td>c.1.</td>
<td>c.1.</td>
<td>0</td>
<td>&gt;3.5</td>
<td>EAA 5, 1977, 115,116</td>
</tr>
<tr>
<td>Caerwent</td>
<td>16</td>
<td>stone-limed</td>
<td>2.4-</td>
<td>14</td>
<td></td>
<td></td>
<td>Hansom 1970, 84.</td>
</tr>
<tr>
<td>Lincoln, St</td>
<td>stone</td>
<td></td>
<td>2.4-</td>
<td></td>
<td></td>
<td></td>
<td>CLAU 1993, Rep.63, 1-2</td>
</tr>
<tr>
<td>Paul-in-the-</td>
<td>brick</td>
<td></td>
<td>c.16.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bail</td>
<td></td>
<td></td>
<td>1.2 (sq)</td>
<td></td>
<td></td>
<td></td>
<td>LAT 1984, 15-21.</td>
</tr>
<tr>
<td>Margidunum</td>
<td></td>
<td>stone-limed</td>
<td>c0.9</td>
<td>3.65</td>
<td></td>
<td></td>
<td>JRS 16, 1926, 37, Fig.3</td>
</tr>
<tr>
<td>Silchester</td>
<td>76</td>
<td>stone-limed (52)</td>
<td>2.4-</td>
<td>9.1</td>
<td></td>
<td></td>
<td>Archaeologia 53, 1893 to 61, 1909</td>
</tr>
<tr>
<td></td>
<td></td>
<td>timber-limed (24)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Templeboro'</td>
<td></td>
<td>stone-limed</td>
<td>3.1</td>
<td>c.9.1</td>
<td></td>
<td>May 1922, 35-6.</td>
<td></td>
</tr>
</tbody>
</table>

* L and B are the lengths and breadths of timber type linings and D is the diameter of barrel linings.

It would seem, as improved methods of working with wood were developed, steining with box-frames became the favoured style of lining wells (Fig.4.2), with further improvements during the 3rd century as illustrated by the box-frame construction from Southwark settlement, Fig.4.3 (Yule 1982, 243, Fig.1).

The Scole corner-post construction shows a crude finish to the woodwork, while those illustrated by Wilmott (Fig.4.2) and that by Yule (Fig.4.3), show a progressive improvement in quality of workmanship. Further research into steining of wells with wood is required to determine
whether the lining of wells improved over time during the Roman period, and whether it occurred only regionally or all over Britain.

Fig. 4.3: Third-century box-framed timber-lined well steining with dovetailed joints and braced, from Southwark (after Yule, 1982, 243, Fig. 1).

4.2. Steining of two wells at the villa near Scole.
Two timber-lined wells were found at the villa near Scole, identified by the excavators as the Villa Faustini, referred to in the Antonine Itinerary (Britannia 1, 1970, 47.) (TM 146 786). The villa originated in the Flavian period and was still active in the late 4th century (EAA 5, 1977, 107-17). The original excavations were carried out by the Norfolk Archaeology Unit, who identified four periods for the villa. The timber-lining of the two wells (Fig. 4.6 in the excavation report) was identified covering two phases, the earliest phase dating from the late Flavian period and the 2nd phase dating from the Trajanic to mid-Antonine period. Both wells were excavated to a depth of about 3.5m without reaching the bottom of the wells because of the high water table, even though sludge pumps were use to hold the water level below about 20m OD for Well I, and 18.4m for Well II. It is therefore not known whether the
steining went deeper. The description of the soil formations through which the wells were dug shows that the clays must have been soft unstable soils, hence the reason for steining them to the depths to which they were excavated.

Figures 4.4a to d show details of the wells and their linings from Scole (EAA 5, 1977, Figs 48-51). From the drawings of the cross-sections of the wells it can be seen that the steining probably went down deeper. Since the wells were dug through clay formations, the wells must have been deep enough below the clay to penetrate an aquifer of either a gravel or sand layer which would have been water bearing, or they may have penetrated into a porous or fractured rock formation which would have provided the necessary aquifer. The general topography of the area is low lying, being between the Fens on the west and the sea on the east, which accounts for the high water table at Scole.

Figs 4.4a and c show that the linings in the upper parts of the shafts were decomposed and were not recovered. The excavators commented that the reason for the phase 2 rebuilding was likely due to the rotting of the timbers of the drier upper part of the shaft (EAA 5, 1977, 111). For both the wells, the lower parts of the timber lining were remarkably well preserved, though the quality of the carpentry-work seems to have been of a poor standard (Figs.4.4b and d). The timbers were rough and not cut to the same size. The irregular manner in which the 2nd phase timbers rested on those of Phase 1 seems to indicate either shoddy workmanship or work done in a hurry to prevent collapse of the wells.
Fig. 4.4a: Well I at villa near Scole: section and plan (from EAA 5, 1977, Fig. 48).
Fig. 4.4b: Well I at Scole: elevations of timber lining (from EAA 5, 1977, Fig. 49).
Fig. 4.4c: Well II at Scole: section and plan (EAA 5, 1977, Fig. 50).
Fig. 4.4d: Well II at Scole: elevations of timber lining (from EAA 5, 1977, Fig. 51).
The method of steining was to insert four vertical wooden corner posts with flat planks placed between them forming roughly one metre square boxes. The planks had corner-cuts at their ends to fit round the two outside diagonal corners of the vertical posts, which also stabilized the posts in their vertical positions. The planks seemed to vary in thickness from about 5-10cm and had varying widths. The thickness of the planks shows that the contractors realized there was a need to support very unstable soils.

The plan view of Fig. 4.4a shows the 1st phase timber corner posts (hatched) which were left in place when they were replaced by the 2nd phase timber corner posts and lining. The reason for this was probably that the soil was so unstable that it would have resulted in the collapse of the wall if they had been removed before the new lining was inserted. The size of the upper portions of the excavation holes (about 3.5m across) to investigate the two wells, seems to indicate the poor quality of the surrounding soil.

4.3. Styles of steining.

The styles of steining applied to wells seems to have been both regionally based and influenced by the geological conditions in which they were constructed. However, there were also different types of steining used within the same sort of environment, probably indicating personal choice by the constructor of a particular well.

The choice of materials would have depended very much on what was locally available and cost effective. Where there was an abundance of suitable sized flint rock, it would be a natural choice. Caerwent seems to have had only flint-lined wells. At Silchester the majority of wells were stone-lined and the rest had a mixture of box frames and barrel lining. At Newstead both stone - and wood-lining were used, but the quality was of a very low standard in many of them. For London no stone-lined wells have been reported, but, as Table 4.4 shows, box-frame lining with wood was the accepted form of steining, combined in a number of cases with barrels. Sometimes barrels were used by themselves. At Southwark a very well constructed wood-lined well was found, whereas the lining at Scole the quality of the lining was of a poor quality, as shown by rough hewn timber and the construction had a shoddy appearance (pp.112-5).

There is a need for further research into these issues of regional differences, geological conditions and quality of workmanship for lining.
of wells, because it may also provide information on the development of lining techniques and could provide information on how the skills of carpentry developed from the 1st to 4th centuries.

5. STABILITY OF WELLS

Wells develop instability problems, whether dug in soils or in the softer rocks. Boon mentions that at Silchester in Insula XXIII a well had collapsed during its construction phase as the Roman workmen went below a stable upper layer into an unstable layer, leaving behind their ladder as they escaped (1982, 85). Well walls formed in clayey soils could easily have slumped as water tables rose and the soil lost its cohesive shear strength in the capillary zone, or due to swelling and shrinkage of the soil resulting in flaking of the walls of the well. Many wells must have become inoperative as a result of collapsing soils, especially in the vicinity of the water table, unless they were supported by steining.

The primary reason for steining of wells is to stabilize the walls against inward collapsing due to the earth pressure acting on an unsupported vertical wall. Positive pore pressures that could develop in the soils contribute to reducing the shear strength of the materials behind the walls of the shafts. The theory behind this is complicated but can be explained as follows. Every soil regime is subjected to earth pressure due to gravity acting vertically downwards on a soil mass and increasing with depth. Since soil can be described as a 'particulate fluid' there will also be a horizontal earth pressure component. When this horizontal earth pressure thrust exceeds the shear strength of the material a critical unstable condition is reached and a soil will fail, or become unstable. It is this horizontal earth pressure which tends to make a vertical wall unstable. All soils (and sedimentary rocks) usually have some moisture in it, which will impart to it negative pore pressures. When a soil becomes saturated the pore pressures become positive and it is these saturated pore pressures which reduce the shear strength of materials. Soil is saturated immediately above (or within) the water table and the positive pore pressure acting on the soil within this zone will reduce its shear strength to a critical low value. At a certain level above the water table the degree of saturation decreases due to evaporation from the surface and the pore pressures become negative, providing capillary suction between soil particles, which increases the friction between them and thus provide the soil with its shear strength. If there is a perched water table at a higher level than the well shaft from which water can seep downwards and sideways to its
wall surface, this seepage flow will saturate the soil and develop positive pressures in that zone. These positive pore pressures will reduce the negative capillary pore pressures, thus reducing the shear strength of the soil surrounding the well shaft. If the negative pore pressure is reduced to a very low value (of the order of about -5kPa to zero), the soil friction will be unable to resist the horizontal earth pressure due to the weight of the soil above and will collapse. The mechanics of the hydrological regime and shear strength of soils around well shafts are complicated, but have been formulated mathematically, and their physical implications are nowadays well understood. The Romans would not have had this knowledge, but they must have had experience of the collapse of soil surfaces and through trial and error learnt how to prevent it by supporting it with various forms of revetment.

The stability of the walls of wells can also be determined by the methods described by Avery (1993, III, 1-10), though there is the added complication that the well geometrical configuration is often circular, a factor not dealt with by Avery. To analyze a linear feature for instability, special empirical techniques have been developed to determine where the active earth pressure will act on a free surface and it is combined with the water pressure that acts against or on the surface of a structure or a wall face. A net resultant thrust against the wall can then be calculated using the procedures described by Avery. Included in the method will be the procedure for determining the direction and slope of the slip surface. This theory highlights the reason why steining became necessary when wells were dug in potentially unstable areas such as London, Newsteads, Silchester and other areas with unstable materials in which wells were constructed.3

The problems of well digging and their stability in difficult materials is illustrated at Newstead. Here 107 pits were found, of which 94 were outside the walls, including a number found under the later defences of

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3 Many empirical methods were developed based on classical statics and dynamics theory to determine the stresses and strains acting on a soil mass, using strength parameters and the geometric configuration of a particular structural problem. The most critical aspect of such analyses is to choose the correct strength and pore pressure parameters, usually determined by triaxial tests in an engineering soil mechanics laboratory. If the soil mass is saturated, then this water pressure can, for analysis purposes, be shown to act at a position of one third of the height of the structure from its lowest point or from its foundation. If the structure is hollow like a well and is cylindrical (this applies to some extent also to wells with rectilinear cross-sections), both the earth and the seepage pressures have the effect of compressing the surrounding soil inwards with a resulting increase in excess pore pressures. When the excess pore pressure exceeds the shear strength of the soil it collapses, particularly for sands and soft clays which have very low shear strengths. The cylindrical shape of a structure makes the mathematical formulation more complicated and cannot be expressed in a simple form such as for linear structures. Several of the references Avery quotes deal with this problem. Transcendental functions are required in the mathematical formulation to arrive at solutions, presumably the reason why Avery did not include them in his simplified presentation of stability analysis.
the fort and is reminiscent of the 99 wells found at Saalburg. The interpretation of these pits has been controversial ever since Curle reported the original excavations in 1911. He classed most as rubbish pits, but they have now been classified as wells since over 90% of the pits penetrated the water table (Clarke and Jones 1994, 115). Because of the unstable nature of the drift geology it was easier to dig new wells rather than to have cleaned out unlined or lined wells that became silted up (Clarke and Jones 1994, 117). The shafts of wells at Newstead seemed generally to have been poorly lined. Curle recorded that of 19 lined wells six were lined with river cobble stones and one with poor masonry, and others simply with stakes, so that most of the lining was ineffectual against the unstable nature of the local material (Clarke and Jones 1994, 117). The shapes of the wells at Newstead were unusual because many had a conical configuration of different kinds (Clarke and Jones 1994, 115, Fig.6), which was probably due to the difficulty of digging into the cobble and gravel drift materials. This would have contributed to the problems of stability of the wells and also would have made it difficult to line them effectively, and could well have affected the period over which it was safe to draw water from them.

5.1. Life span of wells.
How long wells functioned to supply water is difficult to say, but their life-spans must have been closely related to the nature of the local geology of a site and the hydrology of the area. At a site like Newstead it would appear that wells had a limited life span, either because they dried up, became contaminated or became unusable because of some problem with part of their structure that collapsed. In a situation such as the boulder and gravelly nature of the subsoil at Newstead and the type of latrines used by the army, it could be possible that seepage from latrines would contaminate the underground aquifer. Clarke and Jones refer to the poor cobble revetment of 6 wells and two unlined ones. One of the unlined ones lasted for about ten years before it was used as a rubbish pit (1994, 117). They suggest that if this life span was typical for the Newstead wells, then not more than 15 to 20 would have been open at the same time. Similarly, the proliferation of Roman wells in London in the Queen Street area may have been due to their limited life span.

There seems to be a lack of information on the hydrology and stability of Roman wells, both regionally and at individual sites. It is stated that the quality of the lining of wells at Newstead was generally poor,

4 'Germania Romana', Romisch-Germanischen Kommission,?, 26, Fig.xxx(2).
but whether there was a difference in the quality of the linings found within and those found outside in the surrounding vicus, is not clear. Presumably the wells inside the fort area would have been dug by soldiers, but who would have dug the large number of wells outside the fort?. It is likely that this type of problem applied to the other major sites such as London, Caerwent, Silchester and Wroxeter, where large numbers of wells have been found. The problems of stability of the wells at Newstead emphasizes the need for further research to be carried out to provide an overall picture of areas of unstable conditions, and how the problems relating to instability of wells were dealt with in Roman times.

6. WELL-HEADS AND DRAWING OF WATER FROM WELLS

Well-heads have been found at a few sites, but evidence for them is scarce. It is likely that most wells, especially those dug in soil or gravel, must have had some well-head protection to their opening. At Gloucester at one of the wells a well-head was discovered consisting of a square block of stone, about 0.3m thick and 1.3m square, with a central opening to the well of 0.75m. Surrounding the opening parallel to the four sides of the block are four shallow runnels and along the centre of one runnel to the outer edge is a sloping runnel, presumably to control water spilt from buckets. Four square holes are just outside the opening hole, appears to have been used for wooden posts which may have supported some superstructure, to which may have been attached the pulley arrangement for lifting the buckets from the well. The block is supported on the stone lining of the well. The top surface of the well-head was found 3m below street level at the Bon Marché site at Gloucester in the 1955 excavations (TBGAS 80, 1962, 56). At Wroxeter several wells were reported with well-head stone blocks. Bushe-Fox reported a well-head with two blocks forming a square with sides of 1.3m and a hole in the centre of 0.75m diameter (1912, 3-4). At another well the well-head block consisted of four separate stone blocks, but no further details are given (Wright, 1872, 218-9). It has been suggested that the number of squared oak timber posts found in the well at Bar Hill may have been remains of a wooden well-head structure (Macdonald & Park 1906, 40). The well at St Paul-in-the-Bail at Lincoln had a stone and brick arched well-head - described below (Donel, 1993, 1-2, Figs.3-6). The Templeborough fort had a large well (3.1m diameter) in the principia, which had stone blocks from the surface down to the water surface about 3.1m below ground level (May 1922, 35-6), so that water carriers could walk down to the shallow water level to fetch water.
A wide variety of methods for drawing water from wells was available, but there is not sufficient evidence to indicate whether all of them were used in Britain during the Roman period. J P Oleson (1984) discusses the remains of many forms of water lifting equipment, including those for drawing water from wells. The following are the types used in Britain:

1) a container (wood or metal bucket, skin bag), at the end of a rope that could be lowered by hand to the water level and hauled up manually. Evidence of rope marks as it scoured a trough next to the well-head opening has been recorded at Gloucester.

2) a simple single pulley attached to some framework above the well opening with a rope and bucket, operated manually. A more complicated pulley system may also have been employed.

3) a bucket and chain system where the chain would wound round a small wheel attached to a framework above the well opening, described by Vitruvius (Book 10). There appeared to have been several arrangements for this system.

The force pump (such as the one recovered from Silchester, Hope and Fox 1896, 232, Fig.1), was used to raise water from a water source, but not used down deep wells. Large wooden wheels of different designs were also used to raise water (fragments of one was recovered from Dolaucothi, Boon and Williams 1966, 126, Fig.6).

Archaeological evidence of remains for water lifting devices is scarce from the Roman period in Britain. From Bar Hill remains of a bucket, timbers and parts of a pulley have been found (Macdonald and Park 1906, 40. 92). Similar remains were found at the fort of Old Kirkpatrick (Miller, 1928, 23). From the well at Lincoln a wooden bucket with iron bands had been recovered (CLAU Archaeological Rep.63, 1984, 24, Fig.1). At the fort of Reculver remains of an unusual system for raising water in a bucket was recovered from a well, where a system of stone counter-weights were attached to a rope on a frame down the well, in such a way that the length of rope was sufficient to raise a bucket of water to the top without manual assistance from a person (Arch. Ael. 72, 1958, 160-1).

Drawing large quantities of water from wells must have been a problem especially for the larger establishments. If the bucket and rope system was used it would have been almost a full time occupation for an individual. Even at settlements and villas, water demand may have
required long periods of drawing water from a well. From illustrations of buckets that have been recovered, the quantity of water that could be raised was probably of the order of 10 to 20 litres per bucket. For the smaller establishments like villas, the domestic and bath demands were probably not more than 1,000 to 2,000 litres per day. However for public baths which were dependent on well water, drawing water with a single bucket would not have provided the quantities needed, even if water was not replaced on a daily basis. To fill a small tank of say 2m x 2m x 1m would require 4,000 litres, which could have taken a single person a whole working day. The chain and bucket system was also used for raising water from wells. This system required a well-head from which a structure to support the axle and wheel arrangement round which the chain could be operated. Various ways of turning the axle were available, generally a large wooden wheel supported on the axle for the bucket and chain system. The wheel was powered by a person 'walking' along the inside of the rim turning it about the axle. The chain would move around the axle lifting a set of containers attached to it. Even this method would not deliver a vast amount of water during a day’s work.

It can be assumed that normally one well could serve a single household with all its needs. Where the smaller establishments of non-military sites such as small towns, settlements and villas had activities such as pottery manufacturing, smithing, dyeing, fulling, etc., a single well may not have been sufficient for the needs of the community, indicating that the wells are under-represented at such sites. For the major towns and military sites this may not have been a problem if they had aqueducts and tanks to provide sources of water. Further research is required to determine how much water was needed for a particular group in a community and whether the ways of obtaining water from wells would have been adequate.

7. WELLS AT SITES IN ROMAN BRITAIN

7.1. Forts

Generally fortresses and forts had wells, but where there were also aqueducts and tanks, they would probably only have been standby water sources. Many of the forts would have been small and a well water supply would have been the obvious source if the soil or rock formations were water bearing materials. At some forts there may have been a vicus outside the defences where a water source was available, but it is unlikely that the army would have relied on external water sources for many of its forts. A possible reason could be that many forts are known
primarily from airphotos, and have not been excavated in detail, if at all, hence the lack of evidence for wells or any other features. For many sites only the outlines of the defences are known from cropmarks and very little else have survived. Wells that have been covered over with deep soil would probably not show up in airphotos.

7.2. Coloniae and municipia.
At all four coloniae, wells were found, but the number recorded at each site seems to be low for such large towns. At Colchester 9 Roman wells were found (Fig.6.17, p.198) north-west of the walls of the colonia and none were found within the town (Crummy 1984, 26-8, Fig.14). The reason for this may be that there are still large areas of the modern town covering the Roman town which have not been explored.

At Gloucester a number of wells were found in the Bon Marché area, of which two were stone-lined (Hanson 1970, 58; TBGAS 56, 1934, 73; 80, 1962, 56).

At York only 2 wells have so far been located (Yorkshire Philosophical Soc. Annual Rep. 1901, 104; RCHM Roman York, I, 1962, 53, 59, 61). This is probably because of limited excavation, because the colonia was built over gravel and sand formations, where, like at London, Newstead, and Silchester, it would have been relatively easy to sink wells.

At Lincoln two wells have been found: one near the west gate (pers. comm. from M. Jones), and the other in the east range of the forum. They must have been important sources of water, considering the uncertainties about the aqueduct.
Fig. 4.5: Well in forum at St Paul-in-the-Bail, Lincoln (CLAU 1993, 1-3).
The well at the forum (Fig. 4.5) was about 16.5m deep and had an elaborate well-head over the opening. The well-head was discovered beneath post-medieval masonry, but in a reasonable state of preservation. The shaft of the well was 2.4m in diameter in its upper section and narrowed down to 1.2m square lower down. The masonry matched that of this part of the forum, and is dated to the 2nd century, which may have been constructed after the aqueduct. However evidence seems to indicate that the original shaft may have been sunk during the legionary period, which probably at that time may have formed part of the legionary headquarters. The forum, constructed later, must have been located so as to incorporate the well, because of its importance as a source of water for the town. Above the well opening a stone-built platform was constructed with four arches resting on the platform forming a well-head. Donel describes them as follows: “There are four arches, one at each compass point. The arches are in two pairs, two smaller, to the north and south, resting on the east and west” (1993, 1). The two larger arches seemed to have been the access to the well, and the smaller arches may have held the structures for water lifting equipment. However the structure must have had many changes made to it during its long use as a source of water, so that what has been discovered may not be exactly as it was constructed in the Roman period. The well is illustrated in Fig.4.5, with an inset diagram showing the well-head.

At the municipium of Verulamium, there is evidence of a well shaft (11.6m deep) in the vicinity of Insula xiv, but it never reached the water table (TSAHAAS 1932, 18), and no other Roman wells have been found. In Chapter 3 I discussed the water supply of Verulamium, which presented problems, so that the lack of wells from the Roman period, must make it almost certain that there was an aqueduct supply to the town. Several Medieval wells have been found in the town as well as nearby St Albans with average depths of from about 15m to 23m (Hanson 1970, 70). Why so few wells have been located at Verulamium in contrast to the similar town of Silchester, is strange. It was an important town with a well developed street system like Silchester and it also had many private dwellings, and the usual public buildings and two baths, which would suggest a demand for a plentiful supply of water. An aqueduct is conjectured from piping along Watling Street within the town but with no certainty. In contrast London had at least 51 Roman wells (Wilmott 1982b, Fig.1).
7.3. Well water supply of London

For London, Wilmott comments on the 'special importance' of the underlying geology "in evaluating the nature of the ground surface on which the earliest Roman activity took place and in suggesting an explanation for the large number of wells found on these sites" (Wilmott 1982a, 3). The Thames valley in the London area has been formed by the meandering Thames river over a long period and during that time terraced gravels were deposited over the London clay derived from up-land erosion, probably during the major ice age. These gravels were covered by soil layers through which the Walbrook stream eroded the valley that bisects the site of Roman London into two low hills, Cornhill and Ludgate. London itself was built over the 1m thick brick earth layer overlying the water-bearing gravel terrace (Wilmott 1991, 14). Soil deposition continued subsequently and the Walbrook valley almost completely disappeared beneath medieval and later London. North of the Thames river the ground rises steadily and the sands and gravels formed a natural aquifer creating springs in the lower valleys. It is into this layer that the Romans dug their wells for their water supply. At the lower reaches of the valleys the overlying soils of the gravel layer were relatively thin, varying in thickness from about 2m to 5m. This made well-sinking easy, but because of the gravelly and sandy nature of the soils, they were generally soft and friable, and therefore unstable, so the wells needed internal support. In Fig.4.6, Wilmott (1982a, Fig.2) gives a reconstructed section of the geology of the area, showing how the aquifer-bearing gravel sits on top of the London clay, which is impermeable, thus providing the circumstances for springs to emerge along the lower slopes. Since the gravel layer was not deep it was relatively easy to sink wells to the water table. There were several spring lines along this area and the surrounding soil would have been saturated and had little shear strength, so that wells would invariably have had to be lined to prevent collapse.
Fig. 4.6: Reconstructed geology of Roman London (after Wilmott 1982a, Fig. 20).

Since most of London's wells required lining, their horizontal cross-sections were usually determined by the type of lining that was used. The wells were steined with wood and therefore usually square, except when discarded wine barrels were used in round shafts (Fig. 4.7). It is interesting that no stone-lined wells of Roman date have been found in London, although a number from the Medieval period onwards were stone-lined (Wilmott 1982a, 22).
John Wacher had suggested that from the evidence of Roman water pipes found in several areas in London, the town may have been supplied by an external aqueduct supply (Wacher 1995, 90, 101). Wilmott comments that the evidence for the abundance of well and spring water sources "argues strongly against an aqueduct water supply for London" (Wilmott 1982b, 241). The evidence of Roman water pipes, for instance, the pipes found at the Guildhall Extension (site 9), at the Bank of England (Site 20) and lead pipes found in a well (Site 26) (Wilmott 1982b, 241, Figs. 10 & 11), and pipes near the Mithraeum (near Site 28) and the forum (Site 36) (Wacher 1995, 101) (see Fig. 6.19), suggests that a running water distributive system was available,

Wacher comments that since the pipes at the Mithraeum were found in a north-west and south-east direction, they perhaps suggest a castellum aquae in the vicinity of Cornhill. No evidence has yet been found of any

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5 Wilmott would have used Wacher's 1974 edition of *The Towns of Roman Roman Britain*, where the same comment is made on London's water supply.
distribution tanks, or an aqueduct from outside the central town area, so that an aqueduct is neither proven nor ruled out as a possibility. Tanks may have been situated near wells from which water pipes could have led water to specific buildings, but this is also mere speculation.

Table 4.5 gives a summary of the wells at the coloniae and municipia.

**Table 4.5: Summary of wells at coloniae and municipia.**

<table>
<thead>
<tr>
<th>Site name</th>
<th>No. of wells</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colchester</td>
<td>9</td>
<td>All the wells were external; none found inside the walls.</td>
</tr>
<tr>
<td>Gloucester</td>
<td>?</td>
<td>'Many wells' reported.</td>
</tr>
<tr>
<td>Lincoln</td>
<td>2</td>
<td>Likely that there were more wells not yet found.</td>
</tr>
<tr>
<td>York</td>
<td>2+?</td>
<td>Limited excavation; gravel and sands formations suggest more wells.</td>
</tr>
<tr>
<td>London</td>
<td>51</td>
<td>Wells over most of southern part of walled town.</td>
</tr>
<tr>
<td>Verulamium</td>
<td>1 (+?)</td>
<td>Uncertainty about Roman wells as several medieval wells found.</td>
</tr>
</tbody>
</table>

7.4. *Civitas* capitals.

Of the 13 *civitas* capitals listed in the database 10 had wells. It is likely that the remaining *civitas* capitals also had wells even if they also had running water supplies such as at Caistor-by-Norwich, or even Aldborough for which an aqueduct is only suggested. Neither Carlisle or Carmarthen has wells recorded, but they had aqueducts and baths. It seems strange that all the other listed *civitas* capitals should have wells but not these four, and again it would seem there could be some reason why they had not been found. All the wells reported at the *civitas* capitals were intermural.

At *Caerwent* 16 wells have been recorded (Hanson 1970, 84) and it also had a running water supply as implied by a sophisticated distribution system (*Archaeologia* 61(2), 1909, 157). Four of the wells were situated in houses in the south-west of the town, and the rest in the middle north, mostly in the premises of private houses. There may be more
undiscovered wells because the plan by Brewer (Wacher 1995, 380, Fig.170) shows that the areas of the north-west and south-east and east parts of the town had not been excavated by the 1980s.

Both Chichester and Cirencester had four wells, but the other six civitas capitals had only one or two recorded at each site. Four wells at each of these two relatively large towns seem low, which suggests that excavation have not revealed the true number, for whatever reason.

At Dorchester 3 wells have been recorded and a further 3 at Colliton Park Villa (RCHM(E) 1970, 556). At Leicester 3 wells have been recorded, though apparently some more have been found, but are not yet published.

Silchester is exceptional with 76 wells recorded over a long period of excavation during the late 1800s and early 1900s. Although there was this large number of wells in the town, neither the public baths, nor the mansio with its substantial bath, obtained water from wells, and the indications are that they were not supplied from an external water supply (Hanson 1970, 126). However, abundant springs in the vicinity of both baths were their likely sources of water, but it is not clear how water was transferred from the springs to the baths. The wells at Silchester were evenly distributed throughout the 37 insulae of the town as shown on the large map produced by Hanson.

At Winchester one well has been recorded and it has been suggested that there may have been more, but because of the present high water table excavations have not been carried out in areas where there were likely more wells (Britannia 3, 1972, 271-6, 348-9).

At Wroxeter Bushe-Fox (1912-4) reported 11 wells and Atkinson (1942) reported an additional 6. Ten of the wells found by Bushe-Fox were found closely grouped south of the forum area near a large house. The 6 found by Atkinson were all in the Forum and first bath area. Much of Wroxeter has not been excavated yet, so further wells may still be found during future investigations.

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6 A problem with the archaeological record is that often a report on a site will refer to it having a number of wells without giving the actual number found. In such cases I have usually recorded them in my database as W1+, and where it is stated that a site had a large number of wells I recorded them as W1++.

7 Hanson (1970, 126, Plan) produced a large scale plan, showing all 37 insulae, on which all the wells were plotted with their depths in feet. Excavations of Silchester were reported in a series of reports in Archaeologia from 1893 to 1911, reporting on the systematic excavation of the whole Roman town.
The evidence suggests that there must have been more wells at the civitas towns. Wells are generally underrepresented at all the major towns.

Table 4.4: Summary of wells at civitas capitals.

<table>
<thead>
<tr>
<th>Site name</th>
<th>No. of wells</th>
<th>Site name</th>
<th>No. of wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldborough</td>
<td>nil</td>
<td>Cirencester</td>
<td>4+</td>
</tr>
<tr>
<td>Caerwent</td>
<td>16</td>
<td>Dorchester</td>
<td>2 + 4</td>
</tr>
<tr>
<td>Caistor by</td>
<td>nil</td>
<td>Leicester</td>
<td>3+</td>
</tr>
<tr>
<td>Norwich</td>
<td></td>
<td>Silchester</td>
<td>76</td>
</tr>
<tr>
<td>Canterbury</td>
<td>1+</td>
<td>Winchester</td>
<td>1+</td>
</tr>
<tr>
<td>Carmarthen</td>
<td>nil</td>
<td>Wroxeter</td>
<td>17</td>
</tr>
<tr>
<td>Carlisle</td>
<td>nil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chichester</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.5. Small towns.

Wells at the small towns, settlements and villas are poorly described in the records. Out of a total of 66 small towns listed by me, 52 sites had wells; however, they still represent only 53% of the total number of small towns (97) listed by Burnham (1986, 187). The distribution of the small towns where wells have been found is concentrated in the south and midlands regions of Britain. The number of wells found at small towns varies considerably, from one well to as many as 14 at Tiddington (Burnham and Wacher 1990, 312, Fig.107). At six sites I recorded W1+, indicating that there were more than one well at each site, since I found some records not clear on how many were found at those sites. Tripontium and Scole both had 7 wells, Ewell 6 and Ancaster 5, the rest with more than one well all having two or three wells. Whether the sites with one well reflect the true situation for an urban community is problematic, because it would imply that it could have been a public well. This does not seem to be a correct interpretation, because of the uncertainty of how closely a small town community cooperated as a unified group. Since there is evidence that some small towns had a number of wells, the situation could well be that for most of those sites with only one well, the remains of others have not been found.


Wells were found at 135 settlement sites out of a total of 212 recorded in the database. However, the number of total sites recorded in the
The database is small compared with the total number of sites in the archaeological record, hence the number of sites with wells is a poor representation of the true number of settlement sites having had wells. The densest distribution of sites at settlements with wells is broadly within the Midlands region north of the Thames valley, in the same area where the majority of sites with wells was found for small towns and villas.

Most of the settlements had only one or two wells, whereas six sites had 3 and 4 wells, the site at Cow Roast had 8 wells, Long Wittenham had 7, Lower Slaughter had 11 and Stonea Grange had 13. These last four sites were probably much more spread out settlements than the others, each with larger communities not living close enough to each other to be able to share wells, hence the larger number of wells, or they may have had special functions such as Stonea Grange which had some form of an administrative function (Britannia 13, 1982, 366). Also, wells may have become disused for some reason and new ones dug. At some of the other sites all the wells may of course not have been found. The number of sites with wells indicates that it was the principal form of water supply and the likelihood is that sites with wells were far more widespread than the archaeological record suggests.

Pitt-Rivers (1887, 193 & 198) excavated two wells in Dorset at Woodcut Common near Rushmore, within a small settlement, one was 41m (136ft) deep and the other 50.6m (188ft) deep. These were major structures cut into chalk, hard enough to have required considerable effort to sink them, both monetarily and in terms of labour. Comparing the sections given of the shafts by Pitt-Rivers with more modern drill holes made by him, seems to indicate that they may have reached the water table when originally dug.

7.7. Villas.

Villas also used wells as their main supply of water, but the record again underrepresents the likely number that had wells. The evidence of remains at many sites is often limited to a few finds and no information is available about their water supply, as clearly shown in Scott's gazetteer on villas (1993). The three sites of Oakley with 7 wells, Stanwick with 12, and Thetford with 10, probably indicate villa complexes with several households and where certain commercial activities needed plenty of water. A possibility could have been that all the wells may not have been serviceable at the same time. The majority of the other sites had records of only one or two wells, and
only four with 3 wells as at Ashill, Barnsley Park, North Leigh and Rockbourne, and two with 4 wells at Colliton Park and Greetwell Fields. Six sites have been recorded as having had more than one well, but how many wells I did not discover. At Scole 2 wells were found with their wood-lined steining still in a good state of preservation (see pp. 111-4). Since the excavations reported in 1977 further excavations reported in Britannia (25, 1994, 278) states that "an area of the 'small town' was excavated...other possible structures were found and seven wells". It is not clear to me how far the villa is from Scole, and whether these new discoveries belong to it, or to the small town.

8. WELLS AND RELIGION

8.1. Religious aspects of wells.
This is a controversial specialized subject and I do not wish to get deeply embroiled in the debate relating to the nature of religious wells. The principal criterion for identifying 'ritual' wells/shafts is the structured way in which supposed votive articles have been deposited within well or shaft fills (Webster 1997, 136). An example is the 12m shaft at Ashill, Norfolk, where from about 5.8m down "urns were found placed in layers in a symmetrical manner, and continued to be so placed down to the bottom" (Ross 1968, 258). At Jordan Hill there was also evidence of votive objects placed in a deliberate manner, suggesting that the purpose of the shaft had a ritual function only (Ross 1968, 266-7). Votive offerings were placed in wells and springs by the Celts and, as is suggested in recent literature on Celtic religion, these offerings in pits and shafts/wells were regarded by them as entrances to the underworld. Jane Webster states that "Almost without exception, it is the nature and characteristics not of the cut but of the subsequent filling of wells and shafts which has been the basis for their archaeological identification as 'ritual' features" (1997, 136). She also comments that "despite the fact that wells and shafts are firmly entrenched in the 'Celtic ritual' corpus, numerous uncertainties surround the fundamental issues of both date and function" (1997, 135). Clearly one needs to judge carefully early evidence and the original interpretation in reaching conclusions from the reported literature on archaeological finds in well shafts. Some wells/shafts seem to have been focal points for religious practice, but whether wells used as water supplies also had ritual functions seems doubtful.

8.2. The evidence for religious wells.
Ann Ross (1968, 255-85) gives details of 59 sites where she considers that 'shafts, pits and wells' had a religious significance. She emphas-
izes the great importance religious ritual had for the soldiers of the Roman armed forces and that many Roman army artifacts are found in wells of the Romano-British period. Few of these structures are dated, but the implication for her is that many of them are in origin of pre-Roman date. As a result of analysis of their fills, wells that were previously classified as Iron Age, “cannot in fact be shown to predate the conquest” (Webster 1997, 136). Webster mentions “some spectacular Romano-British examples” and quotes Jordan Hill as an exemplar of such ritual wells (136). A number of the structures of all three designated kinds are very deep, in excess of 10m and some as deep as 30m and more. For only a few of the structures is there any indication that water was found in them. This may have been due to it not having been recorded by the original excavators, many of the excavations dating from the 18th and 19th centuries, or the water table may have dropped. Also, the topography and geology through which wells were cut have rarely been discussed. However, the deep structures were often cut through an upper layer of soil cover to the underlying flint and chalk rock formations. It would be unusual for shafts deeper than 10m not to have had seepage water from the fractured chalk and flint formations, particularly if they were not situated on the top of hills. Many of the sites are generally lower down the slopes of hills or even in valleys, which would provide conditions for seepage from the aquifers in the upper slopes where perched water tables could be present.

Ross makes it clear that some structures were specifically sunk as ritual shafts, such as the shaft at Minnis Bay (Birchington) and Bekesbourne (Fig. 66, 276). She observes that during the Viking period at the fortress of Trelleborg “two of the ritual wells appear to have been cleaned out and used as water wells”. She then suggests that might have happened in “certain instances in Roman Britain, especially in towns such as Caerwent, Silchester and Wroxeter” (278). Ross prefaces her entries for each one of the three sites with the comments that they were “extremely difficult to classify”, or “selection is sometimes difficult”, or the “difficulty to differentiate between those having cult importance and those having none” in that order. In none of the Caerwent wells she quotes were the small finds specifically placed or found in an ordered fashion (Ross 1968, 262). For Silchester, she is much more general in the description of finds in the wells. She mentions as evidence the ritual use of a well in Insula I, in which a sword blade

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8 Ann Ross does not specifically define her interpretation between shafts, pits and wells. However, she comments “A shaft of over 120 feet in depth, for example, may also be a well; and pits seem to have begun their existence as wells which had subsequently dried up or where digging had been abandoned before water was reached” 1968, 284.
broken in two and two iron bars were found, with below them a collection of almost 60 iron objects. In another well not identified except by depth, a collection of over 100 iron objects was found (Ross 1968, 273). At Wroxeter, the three wells she gives as examples of possible ritual use, the type of finds are no different to what have been reported in other wells (Ross 1968, 274). At Bar Hill she refers to the 13m deep well in the praetorium as having several capitals and bases of columns, a fragment of an inscribed tablet and pieces of oak, and some iron objects and other finds, and interprets this as possible ritual use of the well. An alternative explanation would be that the Caledonians were using the well as a convenient hole down which to throw anything suggestive of Roman origin. None of the cases given here suggests the type of shaft such as found at Bekesbourne, Kent, (about 7m deep), where urns seem to have been found placed in an ordered fashion on a platform with other ritual items round them, probably indicating a ritual site (Ross 1968, 260). Wait is critical of Ross' interpretation of some of the religious implications of the finds in shaft/wells, but agrees that some finds represent ritual deposits in the shafts (1985, 51). It seems to me that Ross was reading into the finds from the wells more than is justified. Many of the examples she gives are typical of wells filled with rubbish or the deliberate discarding of material such as happened when the army vacated a fort, or when civil sites were abandoned, or perhaps when Christian religious groups disposed of all pagan evidence.

Webster considers 17 sites where previous scholars have intimated that wells or shafts were classed as ritual-type structures, but on close analysis she casts doubt on some of the interpretations, particularly their pre-Roman dating. Many of these sites were excavated by amateur archaeologists in the last century or earlier in the present one. She draws attention, very significantly, that wells and shafts which have been excavated within the last 3 or 4 decades in similar areas to the older excavated sites, have produced only post-conquest fills, in contrast to what was reported for excavations from the earlier excavated sites (135). This, in fact, seems to be a problem with the interpretation of other types of finds also, and that of their dating. She makes it clear that “many wells and shafts had principally functional origins (being cut for water and chalk)” (136) She very firmly states that “Wells and shafts are not part of an Iron Age ‘Celtic’ tradition, but attest to the development of Romano-British traditions of practice and belief” (141). I agree with that view, as I consider that the data I have collected on water-related features and other structures, were partly instrumental in the development of
cultural and religious interaction between the British and Romans after
the conquest. Many of the remains that are described in the
archaeological record during the Romano-British period clearly are the
type of structures that exhibit a Roman influence such as the buildings,
roads, and water-related structures. The Britons adopted many of the
Roman innovations and evolved a new material culture which blended with
their own British traditions.

Springs converted into wells were often the centres of religious
practice. Probably one of the more publicised of these religious
wells is that of the well-spring of Coventina, at Brocolitia (Carrawburgh), first reported in 1732 by John Horsley in his
Britannia Romana. Many votive offerings were recovered including
pins, more than 14,000 coins, votive heads in bronze, a bronze dog
and horse, etc. Large intact altars dedicated to the goddess of the
well were also found there (Ross 1967, 30; Allason-Jones & McKay
1985). The most famous Roman associated native votive spring is that
at Aquae Sulis, Bath, where the cult of the local nymph-goddess was
important, derived from the native deity or Sulis. This local god and
the ritual associated with it became equated with the cult of
classical Minerva (Ross 1967, 30). Other springs or wells, where
Celtic and local goddesses were important, in Roman times, and seem to
have been adapted as Romano-British religious figures, are: at Buxton,
Derbyshire (spring, for Aquae Arnemetiae); at Well, Yorkshire (spring,
local cult); High Rochester, Kent (relief depicting nymphs); and at
Chester, a dedication of local nymphs and springs, where wells were
worshipped. In Scotland offerings made in wells have been found at
Carlingwark, Eckford, Blackburn Mill and at Torrs in Kirkcudbright (Ross
1967, 30). However Webster points out that this could all represent
"the growth of new, idiosyncratic rites which should properly be
considered as Romano-British rather than as Roman or Celtic" (1997,
141). Earlier interpretations were inclined to view votive finds as
either Roman or Celtic rather than as a combination of local forms of
Romano-British religious practice. Clarke (1996, 76) suggests that
the original interpretation by Curle of many artefacts as ritual
objects from the wells/pits from the Newstead fort is unlikely. The
more recent view of wells and shafts in the Romano-British period is
that the vast majority, when they were situated in forts, towns or
other settlements, were used primarily as sources of water supply.

A few special wells or shafts have been excavated because they are
isolated from other archaeological sites and it is not clear whether
they were used as wells for the supply of water or were used only as ritual wells or shafts. In other instances wells normally used as a water supply also seem to have had religious associations. The Wilsford shaft in Wiltshire (SU 1086 4148) excavated in 1961-62 is considered by some scholars to be a ritual shaft while others believe its initial function was as a source of water (Ashbee, et al, 1989). Ashbee (1963, 118-9) suggests, based on radiocarbon dating of organic matter found in the shaft, that it could date from the Bronze Age period, and also on the evidence of a bronze broad-bladed axe that was found at the bottom of the shaft. It was found to have a large surface opening of about 6m (20ft) in diameter, with sloping sides down to about 6m, after which the shaft diameter became constant at about 1.8m (6ft) to a depth of about 30.6m (101.6ft). Urns with Celtic religious motifs were found in the shaft at a level of about 18m which seemed to indicate to some of the excavators that the shaft may have had some religious significance, but what the connection was has not been established. Other artifacts found in the shaft are also interpreted by Ashbee as being of a votive nature (Ashbee, et al, 1989, 133-8). Whether the water in the last 10m of the shaft was ever utilized is not clear. The original excavator Edwina Field (Proudfoot) believed it was primarily a well used for its water only, and Paul Ashbee favoured both a religious purpose in addition to its use as a source of water. For whatever reason such a deep shaft was dug, it must have been a costly and labour demanding enterprise.

Other such shaft/wells have been found at Maiden Bower and Biddenham, also in Bedfordshire. The latter was 11m deep and contained a variety of small finds that are reported to have been deposited for ritual cult reasons. Another shaft/well is from Wolfhamcote at Sawbridge, Warwickshire (Haverfield 1904, 249), which had a stone slab at 6m depth on which stood 24 urns of gray ware (Ross 1967, 28), but it remains undated (Webster 1997, 143). The shaft at Ashill, mentioned above, with its many objects including urns placed in layers embedded between leaves of hazel and hazel nut, fibulae, some iron utensils, bones, and flints, seems to reflect some Celtic custom (Ross 1967, 28). What is puzzling about some of these comments are that certain artifacts were apparently found in an ordered state and in a horizontal position. This would indicate that they were placed in the shaft rather than thrown down as

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9 In the HBMC(E) English Heritage Publication, 1989. Wilford Shaft : Excavations 1960-62, the excavators who were in charge at different times during the excavations, give separate reports, each one with their own interpretations of the shaft’s function and what parts they played in the excavations itself. Each one has definite opinions about the original function of the shaft.
is found in many other wells. The question here seems to be not their dating or whether they originated from a particular ethnic group, but how they came to be in those specially placed positions and why? For such instances where the finds down a well or shaft seems to have been deliberately placed at a certain level, the probability must be high that these shafts were in fact used for a ritual purpose, whatever their original function may have been. I think that in the confined space of a well from which water was drawn, it could hardly also have been used for ritual purposes with objects placed at specific levels, because the movement of buckets or other containers would have destroyed them. Votive objects may have been thrown down a well, but that would not be the same as using the well as a ritual shaft.

8.3. Interpretation of views on religious features.

What is important in view of Webster's comments regarding the finds at certain sites is that different scholars interpret the same data quite differently. Curle (1911, 113) and Frere (1987, 136) advocated a theory "that Newstead had suffered a disastrous military encounter with a native force, which had overrun the site or forced a hasty withdrawal" (Clarke 1996, 73). Ann Ross, in contrast, suggests that most of the pits were ritual shafts (Clarke 1996, 73). Finally, he observes that Manning takes a view opposite to both Curle and Ross, arguing that 'by and large the deposits were quite normal for Roman period sites, representing the simple disposal of rubbish' (Clarke 1996, 73). These comments raise two main issues: 1) that very competent scholars using the same raw data can reach totally opposing interpretations based on archaeological information, and 2) even if one agrees with the interpretation of the ritual significance of a site, it seems to depend on what one's background approach is to the subject that colour one's interpretation. Ann Ross seems to have seen most ritual sites in Roman Britain as having had a Celtic dominant aspect, and as Jane Webster says, so do most of the 'Celtists' archaeologists. Clarke suggests that there is a considerable amount of data indicating that up to about 25% of the pits/wells excavated showed some form of votive content, deposited over several centuries, but that the Celtic content was not dominant. The soldiers who occupied the fort were from many different ethnic groups from both local origin and elsewhere in the empire and the diverse ritual small finds of a ritual nature reflect that diversity (Clarke 1996, Table 2 68). Clarke says that from their recent analysis of their own excavations and that done by Curle, that of the more than one hundred pits and wells found, only a limited number appears to have been in use at any one time.
The association of religious contexts with a functional structure such as a well, which was primarily used as a source of water supply, was complex. There seems to be evidence that under some circumstances votive objects may have been cast into wells for some ritual purpose by individuals or groups, but this would not necessarily mean the well was a religious well. Merely the association of deep down in the unknown and the presence of water would have provided the motivation to cast votive objects into it, which would not have detracted from the use of the well as a water supply. Evidence that some shafts were used primarily as religious features have been suggested, but I am not sure that it can be categorically accepted as having been positively proven. It would seem that much past evidence needs to be reexamined in order to provide more rational answers to this complex problem.

9. CONCLUSION

Wells and springs were important sources of water supply to many sites. Although many of the wells were lined, the useful life of wells was often limited. In areas such as London, Newstead and Silchester, wells were relatively shallow because of the high water table in the gravel beds on which the towns were built. In all the three towns many springs ensured plentiful supplies of water, but little evidence has been found about how their water was effectively supplied to baths and other consumers. Because of the nature of the geological conditions in many areas, wells invariably had to be lined to prevent their collapse. Archaeological evidence seems to indicate that wells silted up, in part due to infiltration of soil as a result of seepage, and often resulting in their having to be abandoned, and new wells dug nearby. It would be useful to investigate the extent of this problem and whether there was evidence for maintenance of wells.

The record about availability of tanks for catchment of rainwater is not well documented. How water was transferred from them to baths is poorly understood and needs to be investigated.

In towns like Caerwent, London, Silchester and Wroxeter, and for instance the settlement of Goadby Marwood (see App.2), there is evidence that a number of private residences had well water supplies. There may have been regional differences that need to be investigated. I have not specifically studied this aspect of well water supplies, but there is a need for research on how ‘normal’ it was for private residences to have had wells during the Romano-British period. Many forts, towns, villas
and settlements had wells, but it is considered that there were likely to be many more sites with wells, and more wells within sites than shown by the archaeological record.

This raises the issue whether there were professional well diggers who tendered their services to owners of homes to dig their wells, because although the operations are simple, there is a certain amount of general knowledge required to be efficient at well digging and to be aware of the dangers involved. The same question may be asked about well digging for public use, and the contractual implications that would have been involved. Was this part of the duties of the local builders? Where geological conditions were not difficult for digging of wells, private owners of homes may have dug their own. Most men would probably have had the skills to build their own homes and may also have been able to construct their own wells and their linings. The constructional aspects of well digging for the Romano-British period are poorly understood and needs to be investigated.

Very little evidence is available on how much water was needed by a community, and how much water could be drawn from wells to provide their needs. The supply of water to baths from wells and from rainwater catchment could have been adequate for only the smaller baths. In the next section I shall be discussing baths over a large range of sizes and the question of how effectively they were supplied with water, which at present is not well understood.
CHAPTER 5.
OTHER WATER-RELATED FEATURES: BATHS, DRAINS AND SEWERS

1. GENERAL
In this chapter I shall discuss various aspects of Roman baths in Britain, as well as drainage and sewer systems at military sites, towns and villas. Drainage was an essential feature of most sites to remove used water from baths and waste material from latrines, and to control surface runoff. Some military sites and towns had elaborate sewer systems for the removal of waste materials. In order that such systems could function efficiently many sites had a running water supply to flush waste materials into the sewers, and to facilitate cleaning of drains and streets.

Excavation reports regularly present the notion of continuous dynamic change throughout the Roman period, not only political and social, but also at sites and to the many structures within their boundaries. The reasons for the changes at sites are varied, of which the most important ones were wear and tear of structures, destruction by fire - especially of earlier wooden constructions, abandonment of a site for a period, new occupation or ownership, the need for improved facilities, and to provide defences to towns. These problems are illustrated by the phases of reconstruction referred to in excavation reports for baths and other structures at forts, towns and villas. In a few instances there is epigraphic evidence (all from forts) for repairs to baths (Welsby, 1980, 89-94). An inscription from Bowes (RIB 730) records that c.AD 197-8, Virius Lupus "restored the bath-house, burnt through violence of fire" (Welsby 1980, 89). Inscription RIB 791, probably from the fort of Brougham (Cliburn), records that "...this bath-house...which after the old work had been burnt had fallen into ruins,...by renewing the pillars in all the rooms and by...the channels and pipes...". At Birdoswald an inscription (RIB 1912, AD 296-305) records that both the praetorium and the baths were restored, which may indicate that the fort was attacked, or abandoned for a period (Welsby 1980, 91). The bath-house and basilica at Lancaster were restored about AD 262-66, because they were "ruined by age and fallen into ruin" (RIB 605) (Welsby 1980, 92). There appears to be no epigraphic evidence for such repairs to baths at other types of sites. However excavation reports regularly report on the various phases of repairs and reconstruction of all type of structures, water pipes and drains, which also allows one to consider developments in bath construction and style.
I have traced evidence for the remains of 488 Roman baths in Britain at all site types. Baths were introduced to Britain by the army as they advanced west and northwards. Fortresses and some forts had internal baths, but at a number of forts baths were built extramurally in the vici that developed nearby. As towns were established baths became an important acquisition to its amenities. There appears to be no evidence for Roman Britain concerning the commercial basis on which public baths were operated. At villas or private houses baths would most likely only have been used by the household members, their labourers, families and visitors.

Classification of baths is discussed in detail by Nielsen (1990) and Yegül (1993), both accounts being based on the principles laid down by Krencker, et al., (1929). I shall not discuss the elaborate bath arrangements found outside Britain, but will look at the local bath configurations used at both military and other site types, with particular reference to their relative areas. The superstructures of baths in Britain are poorly known and most of the reconstructions that have been suggested usually are based on counterparts from elsewhere in the Empire.

I have found dating of structures a problem because it is often not known when during the life of a site the various structures were built. Although baths can be easily identified because of their distinctive layouts (heating, drainage and decorations), in the absence of detailed excavation, it is not generally possible to provide reliable dates for their construction, useful life and abandonment. Inscriptions usually indicate when a structure was dedicated, not necessarily constructed, but the information is nevertheless useful. Dates are often referred to as being during the early, mid or late parts of a century. For some sites circumstantial evidence may be known, such as when events took place during a governor's period of office, for which dates are known. The sites related to the Antonine Wall can generally be dated to within narrow limits because of the two short periods of occupation of Scotland. Some lead and ceramic pipes or tiles can be dated because of stamps found on them.

Millett lists the loss of public buildings, including baths at four Roman towns, only by the century during which they went out of use, were destroyed or demolished (Millett 1990, 130, Table 6.1). For these reasons the chronology of water-related features can generally only be
referred to in broad periods. For instance, it is known that the
civilian bath-house at Wroxeter was built after Hadrian’s visit to
Britain and destroyed in the 4th century. It is not known when the
aqueduct to the town was constructed or when it went out of use. In a
few instances I have mentioned dates given by excavators based on
findings of pottery and coins, or other datable material, but often
these only give an end date for the structures. Reference to dating of
structures has therefore been limited to those that are fairly certain.

2. ROMAN BATHS

The subject of Roman baths is vast. It has been documented in detail
during the 1980s by Manderscheid in a number of publications1, sup­
plemented by Inge Nielsen’s seminal books on Thermae et Balnea2,
covering baths from all over the Empire, and Fikret Yegül’s Baths and
Bathing in Classical Antiquity. Roman Britain has its fair share of
baths, initially introduced by the army and subsequently adopted by
sections of the civilian community. The bath institution became a
feature of the Romano-British landscape, both private and public, from
the mid first century AD to the early 5th century AD. Whether baths were
used in Roman Britain on the same commercial basis as were their
counterparts in the rest of the empire is difficult to say because there
is no literary evidence and virtually no epigraphic evidence about baths
for Britain. Both Nielsen and Yegül discuss the many literary references
relating to baths, particularly about those in Rome and Italy, and to
the numerous inscriptions about various aspects relating to them.

Roman baths were the places where the Romans washed and bathed, sought
their communal pleasures and companionship, and where they could
socialize, drink, eat, have massages. The ritual of daily bathing was
generally popular among the élite and wealthy members of communities
throughout the Empire, but the poorer classes also used them. The
entrance fee was low enough for all people to have access to bathing
(Nielsen 1990, I.132). It would seem that baths were lucrative business
enterprises which attracted many other forms of business activities
within their precincts (Nielsen 1990, 144-6). The Britons and many of
the other nations conquered by the Romans adopted the bath as a part of
their own culture under Roman rule, hence the large number of baths
traced by me from the literature for Britain.

2 Nielsen 1990, Vols.I & II. In Vol.II 13 baths from Roman Britain are listed.
Natascha Zajac, has posed the question, "Did the Romans go to the baths to get clean or be dirty?" (Omnibus 32, 1996, 16-20), which is a refreshing and interesting commentary on the social aspect of the Roman baths institution. She says, "The trouble with Roman baths is that they are common as muck: they are the most common archaeological remains in the Roman Empire, and they are common in the sense that they are seen as part of low culture and associated with dirt, bodies, and sweat, rather than the high culture of religion, politics and art. However, far from being simply public conveniences, they were an integral part of daily life and a defining element of Roman culture" (my italics, p.16). She also notes that the baths were nicknamed "the palaces of water" (p.19). Zajac is discussing mainly the activities in the large thermae, the public baths, where all sorts of traders, pimps and the like, came to attract business from the bathers. New research into the customs of the Roman world is providing a panoramic view of the ordinary daily social behaviour of Romans as exemplified in their use of the public baths and other amenities. Katherine Dunbabin has commented on the large amount of epigraphic evidence relating to baths, which extols both the pleasures and dangers of bathing, and also its curative value (1989, 7-12). There seems to be a confirmation of the unsocial behaviour that Juvenal complained about (Sat. 6.419-21), of women attending the baths only in the evening seeking pleasure, and what the moralist Seneca "perceived to be the increasing perversions of bathing habits" (Omnibus, 1996, 19). Seneca (Let. 56, 86) complains about the 'deafening noises', the panting and grunting of men swinging weights, and the smacking noise of body massage, the shouting of traders advertising their wares, and other complaints. Such contemporary comments give an insight into the behaviour of people at public baths. Whether it can be concluded from those perceptions that such behaviour was normal in other public baths around the empire is difficult to say. We have no comparable information for behaviour at baths in Roman Britain. Most of the public baths in Roman Britain were much smaller (Table 5.3) than those in Italy and lacked the grandiose atmosphere that was so typical of those of Rome and possibly also those of Pompeii and Ostia. On the other hand, many of the vici at forts in Britain had Roman baths and, since their inhabitants provided some of the commercial and service needs for the army, it is likely that similar activities took place also at public baths in Britain during the Roman period.

2.1. Types of baths.
Classification of baths is difficult, particularly if they are to be characterized by their layouts. I shall use ideas from other scholars,
but simplify them to fit in with the layout patterns found for Roman baths in Britain. Krencker (1929) classified and defined eleven areas within a bath complex as being typical and he designated a code of letters related to each one of the areas to indicate them on plans, and most scholars who have written about baths have adopted his conventions (Yegül 1992, 130-2). The typical Roman bath had a caldarium, tepidarium, frigidarium, the usual sequence in which it is believed they were used. Additional facilities were a laconicum or sudatorium (dry sweating room), apodyterium (changing room), latrines, a praefurnium (furnace) and a vestibulum (entrance area). Some baths also had a palaestra (sports area), a natatio (swimming pool), and usually a service yard. The last three items generally identified the difference between thermae and balneae types, although thermae were usually very large complexes. Within the first three type of rooms would have been plunge baths with hot, tepid and cold water respectively. The size of the plunge baths would depend on the size of the three main bathing rooms. The earlier hot water plunge baths were heated by hot convection currents coming from heated air generated by the furnace. Later plunge baths received their hot water from heated tanks through a pipe system controlled with stopcocks. All the elements described above have been identified in Britain. Heated water introduced special problems and the large baths would require greater volumes of water which would have had to be replaced fairly frequently because the heating was at a temperature that was conducive to algae growth.

Roman baths developed from the γυμνασιον (gymnasia) and βαλνατον of the Greeks. Vitruvius gives a basic theoretical approach to Greek baths and gymnasia for the Hellenistic period (Vit. 5.10 on baths and 5.11 on gymnasia), but his model was superseded by the development of the Roman bath during the later 1st century BC and the 1st century AD. What specifically characterize Roman baths is the addition of hypocausts during the early first century, which brought a whole new social dimension to the comfort and pleasures of bathing (Nielsen 1990, 14-22; Yegül 1992, 356-95). Nielsen and Yegül both seem to agree that Roman baths were broadly divided into two types: large public baths (thermae), which usually had palaestrae attached to them and smaller...
bath-suites (balneae), many of which were run as business enterprises. However Nielsen defined thermae to be baths with a palaestrae and often included an external swimming pool, whereas balneae are defined as baths without these additional facilities (Nielsen 1990, 3). According to these definitions the eleven large monumental baths in Rome were thermae, as were many other baths with palaestrae found elsewhere in the Empire. Baths without palaestrae were classed as balneae, as used in this thesis.

Inscriptions generally attest the construction of baths by private citizens and that they had a commercial purpose (Yegül 1992, 43 no.97), but none has been found for Britain. During the Republican period all Roman baths used by the public were described as balneae, and were usually privately-owned businesses. It was during the reign of Augustus that Agrippa built the first thermae (approx. 1ha) in 25 BC, which included sports and other facilities not specifically connected with bathing. After his death they became public buildings, as were all the other thermae in Rome (Yegül 1992, 135).

The layout and size of Roman baths varied widely over the Empire, and although Britain did not have the monumentally large public baths found in Rome, the legionary baths and some of the civitas capital baths were of the thermae type because they had (palaestrae), of which examples are Caerleon, Chester, Exeter (fortresses), and at the civitas capitals of Leicester and Wroxeter. The term thermae was generally used to describe large bath suites, which included palaestrae and the term balneae was applied to smaller bath structures.

There are, however, other ways of classifying Roman baths, most notably through their layout.

The following simplified layout classification of baths will be used in what follows for discussion:

1. the linear or row type (Reihentyp),
2. the block type, and
3. a complex linear or block type layout of the basic bathing rooms with various additional rooms.

The block type bath layout varies in pattern because the three types of bathing rooms can be linearly orientated with additional rooms to form a block pattern, or the basic bathing rooms can with an additional room form a square. For the larger bath complexes all three types of layout
may have had *palaestrae*. There were many variations of each type and the intention is not to discuss details of classification, but merely to have a basis for discussing layouts of baths at some typical sites.

2.2. Roman baths in Britain.

Both *thermae* and *balneae* were built in Roman Britain. The type of bath built at a particular site depended on the need of the type of site and on the economic circumstances that prevailed at the time, particularly for non-military sites. The large numbers of soldiers concentrated in legionary fortresses and larger forts often required substantial baths of the *thermae* type as at Caerleon, Chester and Exeter (fortresses), Red House and Gelligaer (forts) (Nielsen 1990, II, 19). The large towns also had *thermae* type baths such as at Leicester, London, Silchester and Wroxeter. The reasons for these towns also having *thermae* type baths are probably because of their large populations, the healthy economic climate during the 2nd and 3rd centuries and that the inhabitants of the towns had become used to their daily bathing ritual. I have not been able to ascertain whether any other sites had *thermae*, but it is likely that some of the other main towns and legionary fortresses had them.

The large Roman baths were notable for the richness of their architectural attributes and provided communities with a special type of spatial layout. Many baths had beautiful and well executed mosaics and often painted walls to create a pleasing ambiance for the users. Both paintings and mosaics often used water images from mythology to create an atmosphere of pleasure associated with the act of bathing. The mosaics at Bignor villa are illustrations of such images. There has sprung up a whole literature amongst archaeologists, anthropologists and sociologists about the concept of ‘social space’, and for the social functions of the daily Roman bath ritual this architectural space was explored to its fullest.

The legionary bath at Caerleon (Fig.5.1) is a prime example of the standard of architectural refinement achieved by the Roman army ‘architectus’, the remains of which David Zienkiewicz (1986) describes in detail. He makes comparisons between the four similar baths at Caerleon and Exeter in Britain and Avenches and Vindonissa in Germania Superior, (115-29), all of the same vintage, with very similar architectural features.
Fig. 5.1: Caerleon fortress thermae showing bath with palaestra and swimming bath (after Zienkiewicz 1986).
The reconstructed exterior of the thermae and the palaestra with its swimming pool and sports area are illustrated in Fig.5.1. Legionary fortress baths were large structures that had to serve a garrison of at least five thousand soldiers, and perhaps also their dependents. The structures were of a monumental type which required large halls that were unobstructed by internal supports. For practical reasons the arched roofing were constructed of masonry, so that very large vaulted spans were attempted (Zienkiewicz 1986, 22). The heights were as much as 15m with spans of 12m.

The baths usually were the most massive structures in the fortresses and at Caerleon covered an area of nearly one hectare (Zienkiewicz 1986, 27). None of the baths found in Britain compares with the eleven large imperial baths of Rome whose construction seems to have been motivated to show the power of the Emperor and to win the confidence of the people.

2.2.2. Size of Roman baths in Britain.
Table 5.1 gives comparative sizes of some baths in Britain extracted from information given by Nielsen (1990, II, 19-20). I have added fourteen additional sites with their estimated areas for comparison6.

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6 The areas calculated are only estimates, since they are based on plans given in various texts and it depends on how the dimensions were used. Different texts will seldom give the same areas for the same sites, as for instance the total areas for Wroxeter are variously given as 0.81ha, 0.53ha and 0.45ha, depending on the areas that are included as part of the baths, such as the marcellum and the piscina, both within the bath precinct.
Table 5.1: Areas of some Roman baths in Britain (after Nielsen 1990, II, 19-20, and an additional selection).

<table>
<thead>
<tr>
<th>Location</th>
<th>Category</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viroconium Cornoviorum (Wroxeter)</td>
<td>civitas</td>
<td>0.533ha (thermae, palaee.0.150ha)</td>
</tr>
<tr>
<td>Ratae Corieltauvorum (Leicester)</td>
<td>civitas</td>
<td>0.420ha (thermae)</td>
</tr>
<tr>
<td>Castell Collen</td>
<td>fort</td>
<td>0.103ha</td>
</tr>
<tr>
<td>Corioscopium (Corbridge)</td>
<td>fort</td>
<td>0.230ha (palaestra.0.140ha)</td>
</tr>
<tr>
<td>Gelligaer</td>
<td>fort</td>
<td>0.210ha (palaestra 0.130ha)</td>
</tr>
<tr>
<td>Calleva Atrebatum (Silchester)</td>
<td>civitas</td>
<td>0.069ha (thermae)</td>
</tr>
<tr>
<td>Hurnnum (Halton)</td>
<td>fort</td>
<td>0.065ha</td>
</tr>
<tr>
<td>Aesica (Great Chesters)</td>
<td>fort</td>
<td>0.054ha</td>
</tr>
<tr>
<td>Cilurnnum (Chesters)</td>
<td>fort, vicus</td>
<td>0.049ha</td>
</tr>
<tr>
<td>Brocolitia (Carrawburgh)</td>
<td>fort</td>
<td>0.044ha</td>
</tr>
<tr>
<td>Conisercum (Benwell)</td>
<td>fort</td>
<td>0.044ha</td>
</tr>
<tr>
<td>Vindolanda (Chesterholm)</td>
<td>fort, vicus</td>
<td>0.031ha</td>
</tr>
</tbody>
</table>

Sizes for other sites:

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isca (Caerleon)</td>
<td>fortress</td>
<td>0.80ha (thermae, 0.576ha palaee.)</td>
</tr>
<tr>
<td>Deva (Chester)</td>
<td>fortress</td>
<td>0.64ha (thermae)</td>
</tr>
<tr>
<td>Isca Dumnoniorum (Exeter)</td>
<td>fortress</td>
<td>c.0.40ha (thermae, Bidwell)</td>
</tr>
<tr>
<td>Bath</td>
<td>small town</td>
<td>c.0.22ha</td>
</tr>
<tr>
<td>Londinium (London)(Huggin Hill)</td>
<td>municipium</td>
<td>0.131ha (thermae)</td>
</tr>
<tr>
<td>Durnovaria (Dorchester)</td>
<td>civitas</td>
<td>0.126ha (palaestra ?)</td>
</tr>
<tr>
<td>Red House</td>
<td>fort</td>
<td>0.109ha (0.046ha, palaees.)</td>
</tr>
<tr>
<td>Chedworth (north bath)</td>
<td>villa</td>
<td>0.032ha</td>
</tr>
<tr>
<td>Caerhun</td>
<td>fort</td>
<td>0.030ha</td>
</tr>
<tr>
<td>Rockbourne (West range)</td>
<td>villa</td>
<td>0.028ha</td>
</tr>
<tr>
<td>Great Witcombe (S-E bath)</td>
<td>villa</td>
<td>0.029ha</td>
</tr>
<tr>
<td>Bewcastle</td>
<td>fort</td>
<td>0.024ha</td>
</tr>
<tr>
<td>Brecon Gaer (internal)</td>
<td>fort</td>
<td>0.021ha</td>
</tr>
<tr>
<td>Bearsden</td>
<td>fort</td>
<td>0.016ha</td>
</tr>
<tr>
<td>Bothwellhaugh</td>
<td>fort</td>
<td>0.014ha</td>
</tr>
</tbody>
</table>

The listed baths from Britain are a whole order smaller than the baths of Rome or some of those from North Africa. In contrast the areas of the large British baths were relatively small in comparison with the bath complex of Caracalla in Rome which occupied a total area of c. 11.05ha, of which the area without the palaestra was 2.508ha, and about 1200m² of this area would have been used to hold water (Nielsen 1990, vol II, 3, item C.8). The large thermae at Carthage covered a total area of 3.99ha of which the bath-suite had an area of 2.625ha (item C.208). Most of the large public baths in Rome and elsewhere were imperial baths sponsored and funded by emperors, whereas the public baths at urban centres in
Britain were probably funded locally by the towns and financial contributions from benefactors.\(^7\)

One of the problems of comparing sizes of different baths is that generally published information includes the area of the *palaestra* where it existed. This masks the true area of the bathing section. I suggest that, when such comparisons are made the area of the *palaestra* should not be taken into consideration, except when comparisons are made of *thermae* with their *palaestrae*.

For instance, the total area of the Caerleon fortress bath is calculated to be from c. 1ha to 0.80ha depending on which areas are included, whereas the area of the three rooms of the bathing area is only about 0.1ha (12.9% or 14.8%).

At Red House fort the area of the bathing block was c. 0.0634ha and the area of the *palaestra* was 0.0458ha, which occupied 42% of the total area of the complex (0.1092ha).\(^8\) The bathing area at Wroxeter is about 0.133ha, while its total area including the basilica (*palaestra*) attached to the bath is 0.533ha. The bath at Silchester is about 11 times smaller than the bath at Wroxeter, and the last five forts in Nielsen's list are of the order of 16 times smaller than that at Wroxeter and the legionary bath at Caerleon. The baths at villas are also very much smaller than those at fortresses, forts and towns. The area of the S-E bath at Great Witcombe villa is only about 4% of the total area of the baths at Caerleon and only about 6% of that at Wroxeter. If the Great Witcombe bath area is compared with only the bathing-suite area of Caerleon, then its area is nearly 30% of the area at Caerleon and about 22% of the area at Wroxeter. To illustrate comparisons of total areas and areas without the *palaestrae*, I compare firstly the area of the bath at Great Witcombe villa with the total areas at those of Wroxeter, Caerleon, Carthage and the Baths of Caracalla - 1:28:34:137:381, and secondly, with the estimated areas of the bathing areas only, at the same sites - 1:4.6:3.4:90:86. These areas are all estimates based on the data and plans found in the literature. Nevertheless these percentages and ratios provide relative orders of magnitude. Arising out of these comparisons an important statistic is

\(^7\) Wroxeter's second public baths may have been sponsored and paid for by the Emperor Hadrian (Barker 1990, 2).

\(^8\) Another problem is that plans given in the literature are often copies of either original plans or even copies of copies, so that measurements made from these and using the scales provided can introduce errors. Therefore areas calculated from these plans can only be approximations of what the remains actually represent on the ground.
that the bath at Great Witcombe villa is quite substantial in terms of provision of bathing facilities when compared with the larger baths in Britain, and the areas of the bath-suites at Chedworth and Rockbourne villas given in the table above, indicate similar trends.

An important aspect of the size of baths would have been the cost of running them, of which the cost of fuel would have been a major factor. Fuel requirements of the smaller more compact baths would have been much less than for the larger baths because the volumes of rooms to be heated would have been smaller. The larger baths would have been more difficult to heat efficiently because of the large size and height of the rooms. The ratios between the larger baths of Britain compared to the large baths of the Mediterranean indicate that their heating costs would possibly have been much lower, a probable reason for the more modest size of baths in Britain. To what extent the colder climate of Britain would have influenced heating costs of large sized baths compared to those of the Mediterranean countries would require special study, but certainly during the winter months more heat energy would have been required per unit area in Britain than in the southern Mediterranean warmer areas.

2.3. Layout of baths in Britain.
Both Nielsen and Yegül discuss a variety of configurations of baths across the Empire with often complicated classifications. From an examination of the bath complexes illustrated by Nielsen and Yegül it would seem to me that baths built before the Trajanic period can be divided into two basic groups: firstly, bathing areas consisting of the usual hot, tepid and cold rooms, each room type with their respective plunge baths and changing rooms, and secondly, the thermae type baths that had the additional areas for palaestrae. After the Flavian period many baths in the other provinces took on exotic plans with the distribution of the basic bathing areas configured in many different patterns, even for private villa baths. These are not found in Roman Britain. In order to examine the bathing area layout of bath facilities it is necessary to concentrate on the bathing area alone, ignoring the palaestra area and other buildings associated with the baths, as is so clearly shown for the baths at Wroxeter.

2.3.1. Military sites.
Legionary fortresses usually had internal bath-houses, and they were necessarily large to be able to cope with the large number of users. Auxiliary fortresses normally had their bath-houses outside the fort.
However there were exceptions, such as the later small internal baths at Brecon Gaer and Caernarfon for reduced garrisons when the areas of the forts were reduced (Johnson 1983, 193-4). Excluding the bath-suites of commanding officers, which were always within the defences, the bath-houses for other ranks were usually outside forts. Sixteen bath-houses are known in the zone of Hadrian’s Wall, of which four were inside the forts, Bewcastle, Carvoran, Halton Chesters and Risingham (Gillam, et al, 1993, xv), the others all being extramural in the nearby vici.

Some of the smaller forts had the linear type (1) layout with all the rooms along a single linear axis, with apses sometimes projecting from the sides, or some small rectangular rooms appended to it, and often an apodyterium was added at either end. Examples are the forts of Halton Chesters, Bearsdon and Bothwellhaugh (Fig.5.2); block type (2) baths are found at the forts of Benwell, Carrawburgh, Red House and Vindolanda (Fig.5.3); and of the large baths with a palaestra such as at Caerleon the bathing rooms had a linear type (1) layout (Fig.5.4). The very large room at Red House is shown as an apodyterium by Anne Johnson (1983, 221), but this seems to be unusual. There is a large room to the right of the frigidarium which is unmarked on her plan and also on Roger Wilson’s plan (1980, 62, Fig.75A), with its entrance on the right leading from the large enclosure (see Fig.5.3). This unmarked room may be the apodyterium, and the large room is the palaestra, or an enclosure with some other function, perhaps of a religious nature, since it has the portico in its centre. Daniels, the excavator, called this a courtyard (1959, 176, plan). (Scale for small bath layouts is 1:380, and for large baths is 1:900).

The size of these changing rooms vary considerably. At the four block type sites, Benwell, Carrawburgh, Red House and Vindolanda (Fig.5.3) they were the largest rooms in the bath-suites. The four bathing rooms (hot, tepid, cold and dry hot rooms) at Vindolanda forms a symmetric square block, as shown in Fig.5.3. Next to the cold room is a rectangular cold plunge bath, and the rectangular apodyterium with its entrance to the bath-house, lies at its east end next to the cold bathroom and the hot dry room.

Military sites seem to have used only the linear and block type layouts, whereas civilian baths used both of these, and also complex linear and block type layouts. It would seem that it was the fashion at military sites to have this block type layout during the later 2nd century.
Fig. 5.2: Linear type layouts:
(a) Halton Chesters (from Nielsen, II, 1990, Fig. 136);
(b) Bearsden and (c) Bothwellhaugh, (from Wilson, 1980, Fig. 74(a), (b)).
(Scale 1:380).
Fig. 5.3: Block type layouts: (a) Red House, (b) Carrawburgh, (c) Vindolanda, (d) Benwell, (from Wilson, 1980, Figs.75(a), (b), (c), (d)). (Scale 1:380)
Fig. 5.4: Caerleon fortress baths, (from Yegüı 1992, 78, Fig.87), (1:900)
The forts along Hadrian's Wall such as Benwell, Bewcastle, Chesters, Great Chesters and Vindolanda were in the active military zone, and for those sites probably the important need was to provide a basic service, rather than additional facilities such as palaestrae. Also, space within many fort enclosures did not allow for large sports areas. At Strageath the bath-house was of the simple row type with only a caldarium and a frigidarium, because it had to fit into a narrow space between the ramparts and the barracks (Frere & Wilkes 1973, 1989, Fig. 53).

Chesters is an example of a fort which went through several phases of changes during its occupation. George Macdonald produced a study of the site (1931, 219-304) in which he gives details of the construction of the baths and its changes, but makes clear it is not an excavation report.

At several places Macdonald refers to the changes that were made to the structure over time, as at the entrance to the apodyterium. He comments on the drain which starts in the frigidarium and flows out towards the apodyterium and into the drain of the latrine adjacent to the east wall of this room. There seems to have been a change in the direction of flow since the original drain flowed in the direction of the north-west corner. It would seem that new floors were laid in the hot rooms at this time, most probably because the original floors had deteriorated due to the heat from their hypocausts. There appears to have been evidence that at a later stage the drain area in the frigidarium settled and that repairs were made so that flow could be maintained to flush the latrine drain.

Evidence shows that the lintels of the doors between the caldarium and the plunge bath to its north were altered at some time. The floor of the tepidarium was also replaced and so was the roof of the hypocaust of that room. The floor of the sudatorium west of the apodyterium also was replaced. Little can be said about repairs or changes to the superstructure, other than about the lower parts of surviving walls. Although no dates are given by Macdonald, it is clear that many alterations and repairs were made over the useful life of the baths. Such repairs must have been standard operations at most military sites, and especially after there was a period of non-occupation.
2.3.2. Civilian sites.

Civilian baths had all three type layouts, but the larger baths seem to follow a linear complex layout. Some villa baths were of the complex block type layout, such as Great Witcombe, Darenth and Eccles.

The civitas capitals of Wroxeter (0.533ha), Leicester (0.42ha) and Silchester (0.069ha) had large thermae type baths. The baths at towns such as at Caerwent, Chichester, Dorchester and Winchester would have been classed as balneae, probably dictated by economic limitations preventing them from having palaestrae.

Large towns.

At Wroxeter the original three bathing rooms of the Hadrianic baths was of the row type (1) (Fig. 5.5), with a pair of lobbies (6 and 7) separating the frigidarium from the tepidarium. During the later 2nd century, perhaps after the fire of c. AD 165-85 (Wacher 1995, 367), extensive alterations were made to the baths, with the addition of another caldarium (17), converting the baths into the complex type (3) layout. The second laconicum (11) was enlarged (shown as a tepidarium by Wacher, 1995, 47, Fig. 11), and changes to the heating system was made to accommodate the additions. The bathing rooms all had rectangular plunge baths at both ends, and the new caldarium had both an apsed and a rectangular plunge bath. Why the second set of smaller baths were added is uncertain, but they may have been used to also accommodate bathing by women. How long the baths survived is uncertain but by the late 4th century the basilica had been dismantled, as was part of the baths. It is difficult to say whether the dismantling process was a deliberate act to destroy the structure, or whether the building had deteriorated to the extent that it became unsafe and had to be pulled down. The bath dating from the fortress period also had a linear type layout (Atkinson 1942).
The baths at Leicester were unusual for Britain (Fig.5.6), because even though the caldaria, tepidaria and frigidarium were in linear sequence, there was also a symmetrical lateral spread of three caldaria and tepidaria next to each other, giving them a type (3) layout. The excavators did not speculate on the reason for this triplcation of the warm baths. They may have served different sections of the community, but there is nothing to suggest it. The two outside caldaria, each with an area of about 140m², had apsed plunge baths along their outside walls and at their west ends. The centre hot bathroom had a rectangular plunge bath at its west end. Each caldarium had its own furnace, which must have used an enormous quantity of wood fuel to heat them. Then follows a tepidarium and what appear to be two plunge baths at its north and south ends, and two laconicae next to them.
The frigidarium was a large room (c.220m²) whose entrance to the baths was from the west wall of the adjoining palaestra, of which the existing remains is known as the Jewry Wall. The baths seemed to have had an extensive drainage network with a major drain running along three sides of the complex. There is controversy over the water supply for this large bath complex, discussed in Chapter 3.

The Silchester public baths (Fig.5.7) were much smaller in total area (0.069ha) including its palaestra than the baths at Wroxeter and Leicester. Its baths also had a sequence of hot, tepid and cold rooms, but they were not in the true row type alignment as can be seen from the plan. The layout suggests that the original bath may have had the row type (1) layout, but subsequent additions and alterations converted the baths into a complex type (3) structure. The small caldarium may have been the original hot room with its furnace at the rectangular plunge bath end, but a later larger caldarium seems to have been added with a larger furnace. The room also had two plunge baths, but their positions have been reversed.
The plan shows the tepidarium with a small plunge bath, while the frigidarium had a plunge bath larger than the cold room itself.

Fig. 5.7: Silchester baths layout (from Wacher 1995, 45, Fig.10(2)).

Next to the frigidarium is a room referred to by Wacher as a service room, which may at one time have been part of the frigidarium. The entrance to the baths was through the apodyterium, which was adjacent to the largest room, the palaestra.

The size of the individual bath rooms at Silchester was smaller than those of Wroxeter and Leicester, probably indicating that the number of people using the baths were not as numerous as they were at the other two towns, and/or that the town could not afford to have a larger public bath.

The evidence indicates that known civilian public baths were of the complex type layout, even though they may originally have had a linear layout. Some of the other larger towns have not been excavated sufficiently to indicate the layout of their baths, or not sufficient of their remains have survived. There is a need for more investigations of these sites to provide a better understanding of these complex structures.
Small centres.

The needs of small towns, settlements and villas would have been quite different to that at forts and large towns, and the smaller size of bathing areas indicates that at these sites much lower numbers of people used the baths at any one time. The baths were usually part of a single unit of buildings, seldom freestanding, especially at villas, and their size had to conform to the size of the rest of the buildings.

The small town of Godmanchester\(^9\) had a bath-building occupying an area of about 365m\(^2\) and the bath-building at the small town of Well\(^10\) was even smaller (c. 190m\(^2\)), although it had an aqueduct water supply. Neither of the baths at these two sites had anything more than the basic requirements for bathing. It is not clear whether baths in small towns were available to the inhabitants of the towns or whether they were the property of private owners.

An exception seems to have been the early bath at Gadebridge Park villa, which initially was separated from the main house, and later was linked with secondary rooms.

The baths at the small town of Bath were a special case. They developed as spa type baths and were probably run on a commercial basis. The baths were adjacent to the temple of Minerva, which was associated with hot springs with ritual connotations, which may have affected the status of the baths. The baths had a long history of development, there being four periods of major alterations. The bath started as a small spa at the west end near the spring end as a bath-suite with the complex block type (3) layout (Cunliffe 1984, 140, Fig.85) (Fig. 5.8a). Eventually the Great Bath was constructed with an area of c.300m\(^2\) inside a hall with an area of about 875m\(^2\). The hall was magnificently decorated with portico pillars holding up a high roof. A smaller bath was added east of the main bath, referred to as the Lucas bath. During the 3rd period a caldarium and tepidarium and other rooms were added at the extreme east end, which was of the linear type (1) layout. The total area of the bath complex during the 3rd period was about 0.22ha. The bath complex had elaborate water supply and drainage systems (Cunliffe 1984, 145), (Fig.5.8b). A lead pipe was still in place when found, which shows the soldered joint.

\(^9\) JRS 49, 1959, 116, Fig 13.
Figs 5.8a, b: The baths at Bath, and their water supply and drainage systems, (after Cunliffe 1984, 140, 145).

Villas.

Villas developed from the early 1st century simple cottage type houses to the variations in sophisticated layout of the 2nd to 4th centuries, which would have depended on the wealth of their owners. The small villas of the early period would have had simple bath arrangements of one or two rooms. With the passage of time many villas would have developed into the elaborate layouts found all over Britain south of Durham, whose occupation extended into the 4th century, indicating the considerable wealth of their later owners. They, like other site types, went through continual change and this was reflected in the different phases of bath construction at many sites. Several villas of the later period had more than one bath-suite, for example, North Leigh had two (Wilson 1988, 128), and Rockbourne (Fig.5.9) had three, either because
more than one household lived on the site, or to separate the family bath-suite from that used by the workforce, or simply because the owner wanted an improved bath layout. In the case of Rockbourne, over its long period of occupation, the first two sets of baths went out of service. The more sophisticated layout and fancy construction of the east bath of the 4th century indicates a wealthy owner. Villas varied in their layout, but must have evolved over a long period at some sites such as Northleigh, where it started as an L-shaped site and eventually, in the 4th century, became a courtyard type villa enclosed on all four sides. It was probably during periods of alterations and additions that some villas acquired more than one bath and had mosaics laid out on the floors.

Rockbourne villa had a complicated history of changes and development extending over three and a half centuries. The RCHM(E) report (1983, 129-50) states that the original excavation did not reach everywhere through to the lower levels, that is to the earlier phases of construction of the villa, before much of the site was covered up. Pottery finds indicate the site was continuously occupied from the late Iron Age for about 350 years. The villa site (Fig.5.9 for partial layout) was occupied during its 1st phase before AD 43, the first building being a round hut from the late Iron Age period. It was replaced during the 2nd phase by a simple three-roomed Roman house at the same position, possibly in the late 1st century. Towards the north-east of this house there was evidence of an early bath, subsequently replaced by a later east range bath-suite (A). During the 3rd phase, c.AD 150 the west range house was constructed, and some time during the second half of the 2nd century a bath-suite (B) was added at the back of the new house. This bath-suite was a simple row type with small rooms of the order of about 12-14m², while the area of most of the house-rooms were at least of the order of 27-30m². Over a period the bath was modified (phase 4) with additional rooms added to the house and baths, and new arrangements for the furnace room. Later the old furnace room was recommissioned (5th phase) to provide heating for rooms to a modified house. During the late 2nd century or early 3rd (phase 6) development took place on the north range, and additions were made to the west bath.
Extensive changes were made to the villa with additions to the south wing. New east baths (B) were constructed during the 7th phase (3rd century), and the west baths seem to have been abandoned by this time. During the 8th phase, probably during the 4th century, the east baths were extended with the addition of a plunge bath and drainage and an extension towards the east. This brief statement is intended to indicate the evolution of this villa site over time, for which there were a number of reasons, the most important being that the structures would have needed continuous repairs and replacement because of deterioration over the 300 years of Roman period occupation. Also, the villa came...
under new ownership at different periods who may have added or replaced structures at the villa.

The Great Witcombe villa's original bathrooms were linearly aligned with the west wing of the house, constructed c. AD 250-270. Later alterations were made over the period c. AD 270-400, during which time a more elaborate block type bath-suite was added in the south-west of the villa, of which two of the rooms of the west wing were modified to accommodate this enlarged bath (Fig.5.10).

Fig. 5.10: Great Witcombe villa baths, (Britannia 1, 1970, 294, Fig. 9).
The layout seems to be poorly planned and not squarely aligned with the rest of the house. The new caldarium (Room 5), within Room 4 of the original house, was constructed with a new entrance and the old one was blocked. It had no hot plunge bath. The original Room 6 now became the frigidarium with an apsed plunge bath (7) on its east side and a rectangular plunge bath (7a) along the south wall of this room, which was damaged by subsidence. The impression seems to be that the rectangular one was built first and when it was damaged the new apsed plunge bath was built. On the west side is a large sudatorium (10) with a hot plunge bath (11b). A large tepidarium (8) with a plunge bath (8a) is sandwiched between the sudatorium and the frigidarium. The space between the north-west wall of Room 4 and the caldarium was a latrine. The bath-suite had an overall area of about 290 m². At least four drains were associated with it. There is a change from the west baths linear type layout to a more complex one for the east baths. This was a major change to a private estate. Over a period of time other major alterations were made to the villa, including the addition of mosaics laid in four of the rooms, probably indicating the increasing wealth of successive new owners.

Gadebridge Park Roman villa was also a large villa estate developing through six phases from a simple homestead of only a few rooms. The original freestanding baths (Fig.5.11) of the linear type (1) were built during the 1st phase, and improved during the 2nd and 3rd phases. They were considerably enlarged during the 4th period in the late 2nd or early 3rd century and it was during this time that the house and bath were connected by other rooms. During the 6th period, c. AD 325 a large bathing pool was built approached from the baths.

They were in use for nearly 150 years; the excavator suggests that they may also have been used by the public. This would have been an unusual use of baths at a private estate, if the suggested interpretation is correct. The villa was served by a well water supply until the enlargement during the 4th phase, when the leat water supply from the 1st century was improved (Neal, 1970, 69-71).

11 Neal D S (ed.), 1974, 68-9, 73-75. At p.75 Neal says that "In the light of present evidence the pool can be assumed to have been for public use, but whether it had religious associations is far from clear".
Gadebridge Park is another example of the evolutionary development of villas over an extended period, reflected in the changes to their baths. These developments are indicative of the changing life styles of a section of the Romano-British community. In this context, the Britons had their round houses and within a short period they adopted the linear form of Roman type housing, which finally culminated in the elaborate villas of the 3rd and 4th centuries, coincidently from the no-bath situation during the PRIA to the elaborately complex Gadebridge Park villa (layout type (3)) of the 4th century. The major structure in each of the villas discussed, which were changed significantly, was invariably the baths, which reflects a progressive change in the social status of the inhabitants of the houses. Table 5.2 shows examples of
villas which started off as simple homes and developed into prestigious villas.

Table 5.2: Prestigious villas.

<table>
<thead>
<tr>
<th>Site name</th>
<th>County</th>
<th>Dating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chedworth</td>
<td>Gloucestershire</td>
<td>2nd to late 4th c.</td>
</tr>
<tr>
<td>Great Witcombe</td>
<td>Gloucestershire</td>
<td>late 1st c. - 5th c.</td>
</tr>
<tr>
<td>Woodchester</td>
<td>Gloucestershire</td>
<td>1st half 2nd c. - 4th c.</td>
</tr>
<tr>
<td>Cosgrove</td>
<td>Northamptonshire</td>
<td>c. mid 2nd c. - progressive disuse during 3rd and 4th c.</td>
</tr>
<tr>
<td>Fishbourne</td>
<td>West Sussex</td>
<td>AD 75 - c. AD 280</td>
</tr>
<tr>
<td>Gadebridge Park</td>
<td>Hertfordshire</td>
<td>c. AD 120 - early 5th c.</td>
</tr>
<tr>
<td>Lullingstone</td>
<td>Kent</td>
<td>late 1st c. - 5th c.</td>
</tr>
<tr>
<td>Northleigh</td>
<td>Oxfordshire</td>
<td>late 1st c. - 5th c.</td>
</tr>
<tr>
<td>Rockbourne</td>
<td>Hampshire</td>
<td>mid-1st c - 4th c.</td>
</tr>
</tbody>
</table>

Of this group of villas Fishbourne is unusual as it started off as a palace and eventually developed the characteristics of a villa. These are examples of villas spread over southern Britain occupied for periods of about 2 to 4 centuries. They all show characteristics of increasing wealth generated on the estate. This is particularly noticeable in the development of their baths and the decorations of the floors with mosaics, and their wall paintings. To this extent the development of baths at villas can be taken as a measure of the "expressions of habitus" (Rippengal 1993, 100) in the social and economic development of rural communities and most likely also for other type sites. This seems to indicate a romanization process developed by the Britons themselves.

2.4. Comparison of baths in Britain.

To compare bath structures based on plans, often showing minimal remains of only foundations, is problematic, because what characterizes buildings are usually their outward appearance. However, from the floor plans of the remains of Roman baths some characteristics are apparent. All site types with baths showed the three basic room types of hot, tepid and cold rooms. The earlier baths for both civilian and military baths seemed to have had the row type layout, with or without plunge baths.

Military baths seemed to be built in rigid layout patterns of the row and block types with not much variation other than the size of rooms.
This suggests that military architects have arrived at sound working layouts of baths for military use, for which there was no need to change the layout and bring in the complications of recalculation of quantities and setting out procedures. The legionary fortress baths were generally large and the individual rooms were spacious.

A number of forts had internal baths of both the row and block types. Most bath-suites had changing rooms, although occasionally quite major baths did not have one, as for instance the legionary bath at Caerleon. Several fortresses and forts had facilities for exercise and sport within their bath complexes. Because of limited archaeological details of baths at the coloniae, not enough information is available to discuss their layouts.

The baths at the major towns generally had quite different layouts compared to the military baths. Their plans appear to be more bulky, and more ornamental than the plans of the military baths, partly because of their enlarged apsed plunge baths. They also often duplicated bathing rooms such as at Leicester, Silchester and Wroxeter. The military baths seem to have a rigid style of layout, while the civilian public baths seem to indicate an entrepreneurial freedom. The initial layout of the civilian Hadrianic baths at Wroxeter seem to be not very different from the earlier military baths described by Busche-Fox, both of the linear type. This may imply similar origins in the earliest plans of civilian and military baths. The duplication of bathing rooms may have been due to the continual changes that were made to the layout of civilian baths because of a demand for more bathing facilities, and also to create separate facilities for men and women. Except for the large legionary baths at Caerleon and Exeter, the bathing rooms of the civilian baths are somewhat larger than their military counterparts. When town public baths were modified they were often extensively altered, which do not seem to have been the case with military baths. Repairs seem to have been the main additional work carried out on military baths.

Baths at villas were generally small compared to those at military and town sites. The early villas started with simple bath layouts and they were often of the row type, but later they seem to expand into the complex type (3) layout as new owners reconstructed and made additions to them. A feature that characterized many villa baths were the beautiful mosaics on the floors. What is surprising is that so many have survived considering that they were often laid on floors that were heated. The changing style of bath layouts at villas suggests a parallel
change in the social structure of their successive owners. Many of the early owners of the 1st century adopted the Roman type housing, which, by the 2nd and 3rd centuries, developed a new élite who acquired a taste for the luxury of expensive baths, exemplified by the many luxurious villas. Bath style development could be a fruitful avenue of study for the development of society in Britain during the Romano-British period, because it particularly reflects a high style of living and changing economic circumstances of later owners. Many Roman baths have been excavated in Britain and their morphology needs to be analyzed. There is also a need to study their local context of interrelationships and setting within the Romano-British landscape, both regionally and for all of occupied Britain.

3. SEWERS AND DRAINS

3.1 Terminology.

Sewers and drains have specific functions in modern municipal technology. Usually two types of sewers are provided in municipalities: sewers for human and animal waste materials, and stormwater sewers; both types are usually in the form of under-ground conduits. The former are directed to sewerage treatment works where the waste materials are treated for health reasons and possible subsequent use. Stormwater sewers remove rainwater run-off or water flowing in urban areas which is not controlled and usually discharges into rivers, the sea or lakes, or specially controlled areas. By separating the two systems stormwater does not go through the costly process of sewerage treatment. This distinction was not made during Roman times.

Drains were local surface conduits, and were usually stone- or timber-lined in Roman times, to regulate rainwater run-off and surplus surface water flow in urban areas. In Roman times, drains were a common feature in fortresses, forts, towns, settlements and villas.

3.2 Roman sewers.

Sewers were standard structures at Roman military sites and towns for dealing with human and animal sewage. Twenty sites with sewers have been identified for Roman Britain.

Roman sewers normally had a basic rectangular channel shape, either built in stone or brick, generally lined with a sealing mortar, and usually had a vaulted roof; occasionally the channel was covered with
stone slabs, such as at York\textsuperscript{12}. The roof vault would usually be an arched design and the whole structure would be large enough to allow access for labourers to clean or repair them. Regular manholes were provided for entry into them and also for the escape of gasses that can develop in closed sewers, and to provide air and light for workmen.

\textbf{Fig. 5.12: York (Church Street) sewer system (after Whitwell 1976, 4, Fig. 2).}

\textsuperscript{12} I have not seen the sewers at York, but have been in a section of the sewer at Colchester. This sewer was very well constructed and similar in shape to the aqueduct of Köln which was an arched structure.
Some military sites and towns of Roman Britain had major sewerage systems for the control of their sewage. The major sites where sewers have been found are at Bath, Caerleon, Canterbury, Chester, Chichester, Colchester, Dover, Lincoln, London, Wroxeter and York. At York an elaborate sewer system, referred to as the Church Street sewer, has been reported (Whitwell 1976) (Fig. 5.12). The primary function of the sewer seems "was to drain the various services within a legionary bath building", (Buckland, 1976, 1). There were difficulties with dating material, but the excavator reports that it was probably constructed during the 2nd century while York was still a legionary fortress. Because the rescue excavation was limited, it was not possible to relate the sewer with other buildings, except to show that the branch sewers pointing to the west was in the direction of the baths. The floor of the sewer was built with Jurassic sandstone slabs laid closely together with joints sealed with mortar and set in clay. The channel was covered with Millstone Grit slabs, presumably for their strength. The walls of the sewer generally consisted of limestone ashlars also set in clay, to render the system water proof.

A large vaulted 'drain' at the fortress of Caerleon is shown in Fig. 5.13. Zienkiewicz calls the frigidarium drainage structure a 'drain', which was in fact the Roman vaulted sewer. Both the Caerleon and York sewers were constructed with massive stone blocks, but the Caerleon sewer was arched in the standard military fashion, whereas the sewer at York had a roof of flat slabs.

14 AT 3/1, 1976, 5-13, Figs. 2 & 3.
According to John Wacher, Lincoln "is known to have possessed one of the
best developed sewerage systems in any town in (Roman) Britain", (1995,
138). Figure 5.14 shows the sewer lines and drains of Lincoln (Wacher
1992, Fig. 10).

The discovery of the sewers in Lincoln below the Bailgate was reported
during the the 1850s16, but they have since been covered as a result of
development in the area. The sewers varied in width from 0.71m to 1.22m

16 Arch. J. 19, 1862, 169; 40, 1883, 319; 103, 1946, 67; Archaeologia 56, 317; Hanson
1978, 54-5.
and were from 1.37m to 1.52m high. A series of cross sewers and small house drains discharged into them.

Bellairs reported on one of the "main sewers" of Roman Leicester, which ran from the Jewry Wall baths towards the north-west where it discharged into the river Soar. The sewer was first reported by Throsby in 1793, when sections of the sewer was still in place. Stukeley mentions that the ancient subterranean canals of vaults and arches of Chester were still perfect in his time (Hanson 1970, 190).

A number of sewers were reported for London by Richard Kelsey, who installed a new sewer system during the mid 19th century, when the Roman structures were discovered (Kelsey 1840; Hanson 1970, 29, 32). At Knightrider Street the remains of an arched brick sewer was found in good condition (Merrifield 1965, 146, Plate 56). However it has not been established whether an inter-linking network of sewers existed in Roman London or if sewers were constructed where a problem arose at any given time.

Fig. 5.14: Lincoln colonia sewer system (Wacher 1990, 24, Fig. 10).
3.3. Drains.

One of the prime purposes of specially constructed drains in forts, towns, villas and private homes was to remove water from baths and latrines and to control stormwater run-off. The drains were usually stone channels or timber lined gullies running along streets and buildings in forts, urban areas and in villas. Forts had elaborate drainage systems to dispose of rainwater run-off, and also to remove waste materials from latrines and from the stables where cavalry regiments were housed inside the forts, such as at Baginton.

Drains were used to control the flow of rainwater, and excess surface water from aqueduct supplies and waste materials of outflows from baths and houses, and were sometimes discharged into conduit-constructed sewers, or often into ditches. They were constructed as both open and covered channels, particularly along the outside of buildings and along streets. Inside buildings they were invariably covered with stone cover slabs. Some drains discharged directly into the sewers into openings provided for that purpose, while others terminated outside built up areas to discharge onto down-sloping ground, or were led directly into rivers or streams.

The 179 listed sites in the database where drains have been recorded seems to be too low for such an important feature. The drainage systems on military sites were particularly well developed and the army seems to have been aware of the importance of well-planned and well-constructed drains, such as reported for Inchtuthil. The via principalis on both sides had stone channel drains 0.81m wide and 0.81m deep. It would seem that water was collected from roofs and discharged into these drains which were then channelled into tanks. Along both sides of the officers' temporary compound were drains, and a stone-lined drain is shown leading from the latrine. From the bath-building an internal drain leads into an outfall timber drain towards the River Tay. Drains around the hospital also converge into a main drain (Pitts and St Joseph 1985, 191-4). The drainage at Housesteads was also designed to collect water from buildings in small drains which discharged into main covered stone-lined drains along the principal streets (Arch. Ael.' 25, 1904, 211). A number of the forts on the Antonine wall from both the Antonine periods (c.AD 142-55, c.AD 158-63), had standard type drainage facilities, similar to those at the slightly earlier fort of Housesteads (AD 124-6), probably indicating that by the mid 2nd century most military masonry construction technical methods had become standardized. Figure 5.15 shows an open stone channel drain at Caerleon, typical of the drains.
from military sites. A length of lead piping is also shown in the picture.

Fig. 5.15: Open channel drain and lead pipe from Caerleon fortress (after Zienkiewicz, 1986)

Complex drainage systems are also found in some towns, although several towns seem to have had poorly developed surface drainage, as for instance at Caistor-by-Norwich and Silchester, where the drainage consisted mostly of central street drains with no provision for drainage from private houses (Hanson 1970, 92, 132). Atkinson has reported on the extensive central town drainage at Wroxeter, but not much seems to be known about the drainage from private houses (Atkinson 1942, 56-58, 91).
Verulamium had a well-developed drainage system, where there seemed to be a preference for wood-lined drains. There seemed to have been a problem with drainage related to the flat topography of the site, which appears not to have functioned properly during the later 2nd century (Frere 1964, 104-5). It may also have been related to the deterioration of the wood, which seems not to have been replaced.

London is reported to have had a network of drains, with particular emphasis on removal of water because of an apparent rise in the water table during the Roman period (Merrifield 1965, 82). Open plank drains, brick and tile drains and some disused wooden distribution pipes used as drains have been found, (Merrifield 1965, 148; RCHM III, 1928, 111, 49). A brick drain was found on a chalk platform supported on wooden piles (Merrifield 1965, 149, Fig.29). This indicates the instability problems of the area that arose from strong seepage flow. The rising water level could have been due to land movements, but an important contributing factor must have been the continual construction and levelling of old sites, and rebuilding over them, which raised the level of the spring line. In one instance a low lying sewer had to be replaced by one exiting the town wall at a higher elevation (Merrifield 1965, 82). London obviously had as much of a problem of disposing of excess underground water as Silchester had.

Villas also had extensive drainage systems for removal of water from kitchens, baths, latrines, and for control of surface run-off of rainwater. Sixty-seven villa sites are listed in the database where drains have been found. Architectural variations in villa types would have dictated the sophistication of its drainage facilities. Some of the early villa structures, consisting of no more than a few rooms, referred to as ‘cottage houses’ by Hingley (1989, 36-9, Fig.15), probably only used cesspits for disposal of waste materials, whereas during the later phases of villa development they generally incorporated drains for the removal of waste products. An example of Hingley’s second phase of development is Great Witcombe winged corridor villa, with a plan of its 3rd to 4th century bath and the remains of many drains (Fig.5.10). They may not all have been in use at the same time over the 150 years during the active life of the villa. The majority of drains on the site seem to run in a south easterly direction away from the villa, which would indicate the direction of fall of the land. If this is the case then the feature shown at the top of the page may well not be a drain, but could have been the water supply line towards the older bath-suite, collecting water from springs above the site. Lysons reported that the room (number
on the plan) adjacent to the baths was at a lower level than the rest and had a tank in its centre, which was fed by a pipe, indicating that the villa probably had a running water supply (Antiq. J. 19, 1939, 194). However, a detailed study of the contours and the juxtaposition between the villa site and the springs will have to be done to confirm this suggestion. A drain is shown to come from the latrine above the caldarium of the later baths, and also one from the latrine in the north-east range, both of which may have been small sewers. This may suggest that the two wings were originally independent and used by two families, hence the duplication of drains. All the drains were stone-lined. Another example is the villa at Rockbourne (Fig.5.9), for which the plan shows evidence of extensive drainage round the site, both for draining the three bath-suites and for controlling run-off from the buildings.

The evidence of such developed drainage systems at towns and villas seems to indicate an awareness of health considerations, which was a new concept to the indigenous people of Britain, particularly during the 2nd and 3rd centuries when considerable building development took place in the province. However, archaeological evidence seems to indicate that after a while, either because of lack of funds for maintenance, or indifference from inhabitants, at many of the sites drainage deteriorated. This is commented on by Frere (1972) for Silchester and Hanson (1970) for Caistor-by-Norwich. A serious consequence of poor drainage was that where wells were important water sources and at shallow levels, seepage into the permeable gravel and sand layers could easily contaminate well-water, such as at Caerwent (p.133), Caistor-by-Norwich (p.133), the vicus outside Newstead fort (p.123), and London (pp.130ff). In the absence of organized drainage at these places and other sites, it would be useful to study the contamination of well-water supplies for an understanding of water-related diseases during the Roman period.

Information about drainage is scarce for smaller centres such as vicī, small towns and settlements. Lancaster is a good example of a site where the vicus settlements developed around all four sides of the fort in a haphazard manner and it is likely to have created a serious health problem because there appeared to have been no planned street network, and presumably therefore no planned drainage (Shotter & White 1990, 32). At Housesteads a vicus developed south and west of the fort, but there is no indication of whether it had an effective drainage system. The vicus outside Vindolanda had some street plan to it, and it is likely
that it had a system of street drainage. No mention is made of any drainage system related to the irregular street system on both sides of Ermine Street of the walled small town of Water Newton, even though it developed over a long period (Burnham & Wacher 1990, 81-91). The excavation report for Corbridge (Bishop & Dore 1988), a former fort and later a small town, says nothing about the extensive drainage system of the various phases of the forts and later town. However Fig.3 of the report shows a number of features which indicate drains, including those on both sides of the Stanegate and in West Dere Street. It is difficult to understand why there is this lack of information on the drainage of the smaller urban areas.

Military sites and early coloniae seem to have had the best constructed drains, mainly because they were constructed to fixed standards. They were generally incorporated during the planning stage and were constructed at the same time as the fortress or the fort was constructed. London and Silchester both had excess spring water to remove and the most suitable drain type that could serve the purpose was used. At sites where there were poor drainage systems there was the danger of pollution of wells from cesspits such as at Caerwent where there were no drains for private householders (Chapter 4, 128), Newstead (Chapter 4, 138), and London where pollution seemed to have been a major problem. It seems there was no systematic approach to construction of drains at non-military sites, probably because they were simple structures and their distribution on a site was often dictated by reconstruction as drains became necessary for new or the altered structures.

5. CONCLUSION
The importance of Roman baths as an institution in Roman Britain is demonstrated by the speed with which they spread as urban and rural development took place soon after the conquest. Every site type had baths, classified into linear, block and complex layouts. The military baths were mostly of the first two types, but civilian baths varied in style, particularly those constructed after the mid 2nd century. However not enough is known about these aspects of baths and whether there were any regional differences. It would seem that baths are very much underrepresented in the archaeological record. The number of sites with baths represented in the database seems to be too low compared to the total number of sites listed in the database, and much too low compared to the known number of sites where baths could be expected.
The army built baths at many military sites and made provision for efficient drainage, and disposal of sewage and stormwater. This was not always the case at non-military sites. The Britons were quick to adopt the style of housing and institutions, including baths. Large public baths were built in almost all the towns and many of the houses at villas had baths, even at the smaller cottage type houses, indicating that bathing became a voluntarily accepted cultural characteristic, not common before the Romans introduced them to Britain. How public baths were managed in Britain is not known, nor how frequently they were used by the public. However the number of public baths found seems to indicate that they were popular with the public. Drainage was an important form of control on all site types, although standards varied. However, by the late 4th century there was a distinct decline in the condition of bath facilities and drainage of towns, due to the lack of maintenance to these facilities.

Baths have been described in some detail for a few sites, but generally there is need for a synthesis of the context of baths and their setting in the Romano-British landscape. A particularly useful investigation would be the layouts and status of baths at all site types for Roman Britain.
CHAPTER 6.
THE DISTRIBUTION OF WATER-RELATED FEATURES IN ROMAN BRITAIN

1. GENERAL
I have traced 815 sites in the literature, but eight sites\(^1\) on closer examination of the available information indicated that no water-related features have been proven at those sites. The final number of sites in the database with water-related features is therefore 807. Table 6.1\(^2\) gives a breakdown of the number of sites with different types of structures. The percentages given are calculated on the total sample of sites listed in the database. They are not intrinsically important, but they do give a feel for the frequency of occurrence of the number of sites with the various types of water-related structures. The data is statistically biased and incomplete because of many factors (incomplete excavation, poor preservation, inadequate records, position, etc.).

Table 6.1: Distribution of number of sites with water-related features

<table>
<thead>
<tr>
<th>Aqueducts</th>
<th>Baths</th>
<th>Wells</th>
<th>Drains</th>
<th>Pipes</th>
<th>Springs</th>
<th>Tanks</th>
<th>Sewers</th>
<th>Total sites listed</th>
</tr>
</thead>
<tbody>
<tr>
<td>134</td>
<td>488</td>
<td>350</td>
<td>179</td>
<td>84</td>
<td>47</td>
<td>102</td>
<td>20</td>
<td>807</td>
</tr>
<tr>
<td>16.7%</td>
<td>60.5%</td>
<td>43.5%</td>
<td>22.2%</td>
<td>10.4%</td>
<td>5.8%</td>
<td>12.6%</td>
<td>2.5%</td>
<td></td>
</tr>
</tbody>
</table>

In comparison with the total number of sites in the database with water-related features, the number of sites for each type of feature is relatively small for each category of site. Aqueducts were recorded at 134 sites but seem to be under-represented in the archaeological record. Wells were the most common form of water supply (350 sites) for the Roman period but are also underrepresented, indicating that many remains of water supplies are still undetected. Even though springs have been included in the database as one of the sources for water supplies, only 47 sites associated with springs have been traced. One possible reason for this dearth of spring data compared to aqueducts is that only a few

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\(^1\) The eight sites are: Ardoch, Limestone Corner, Neach and Whickham (forts); Coldharbour (settlement); Brantingham, Frampton and Kingscote (villas).

\(^2\) The information for Table 6.2 has been extracted from Table 6.1 and the other special tables.
aqueducts have been traced along their complete routes to their spring sources. Also, springs were usually outside the areas of excavation and may not have been recorded, particularly at villas and settlements, where they may have been the primary source of water supply. Springs were also used as sources of water supply within several sites, such as at Bath (Ch.5, p.162), London (Ch.4, Sect.6.2.1) and Silchester (Ch.4, Sect.6.3), and perhaps Colchester. Remains of baths were found at more sites than any other feature (487), although the total fell far short of the number that I would have expected. The total of 179 sites where drains are recorded is also low, perhaps because they are not always mentioned in reports, though in some cases I may have missed them in plans of the sites. The number of pipes is particularly low (84), but this probably can be ascribed to the fact that wooden pipes have long since rotted and the usual iron rings may have been robbed or have been completely corroded away; many lead pipes would also have been robbed, and ceramic pipes could have been reused or destroyed by later activities on the sites.

The information contrasts with Hanson's 65 sites3 (Table 2.1a) with water-related structures. For example, the number of aqueducts located by me in the literature is more than double the number known to Hanson. She reported aqueducts at 42 forts (29 certain, 13 conjectured), while the number of forts that had aqueducts recorded in my database shows an increase of 24 sites. She reported five forts that had internal water pipes which may have indicated running water supplies. She also referred to 18 other sites (17 towns and 1 villa) that had aqueducts. Her primary purpose was to look at the known aqueduct water supplies for military and town sites and thus there are some omissions in her work regarding rural sites.

Table 6.2 gives a summary of all the sites for the eight water-related structure types. The different fort categories have collectively been referred to as forts, though in the text fortresses, auxiliary/cavalry forts and fortlets will be referred to separately as it becomes necessary. From this table are derived other tables in the text which amplify specific issues of the analysis.

Major and minor towns, settlements and villas were invariably situated south of Hadrian's Wall, but features such as aqueducts,
baths and wells were also found at forts north of Hadrian’s Wall. This is shown for the distribution of sites with baths in Figs. 6.6 to 5.10. (Note: All distribution Figs. 6.1-6.15 are given at pp.239-253).

Table 6.2: Distribution of site types with water-related structures at listed sites

<table>
<thead>
<tr>
<th>Data type</th>
<th>Forts</th>
<th>Coloniae</th>
<th>Municipia</th>
<th>Civitates</th>
<th>S-towns</th>
<th>Settlements</th>
<th>Villae</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueducts</td>
<td>66</td>
<td>4</td>
<td>1</td>
<td>11</td>
<td>8</td>
<td>19</td>
<td>24</td>
<td>134</td>
</tr>
<tr>
<td>Baths</td>
<td>85</td>
<td>3</td>
<td>2</td>
<td>13</td>
<td>30</td>
<td>49</td>
<td>305</td>
<td>487</td>
</tr>
<tr>
<td>Wells</td>
<td>43</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>52</td>
<td>135</td>
<td>104</td>
<td>350</td>
</tr>
<tr>
<td>Drains</td>
<td>52</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>17</td>
<td>30</td>
<td>67</td>
<td>179</td>
</tr>
<tr>
<td>Pipes</td>
<td>28</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>34</td>
<td>84</td>
</tr>
<tr>
<td>Springs</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>23</td>
<td>47</td>
</tr>
<tr>
<td>Tanks</td>
<td>32</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>8</td>
<td>16</td>
<td>38</td>
<td>102</td>
</tr>
<tr>
<td>Sewers</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Number Sites</td>
<td>137</td>
<td>4</td>
<td>2</td>
<td>14</td>
<td>66</td>
<td>212</td>
<td>372</td>
<td>807</td>
</tr>
<tr>
<td>AQ * BA</td>
<td>45</td>
<td>3</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>4</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>AQ + W</td>
<td>16</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>AQ * TA</td>
<td>23</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>* AQ - WP</td>
<td>27</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>AQ * DR</td>
<td>22</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>BA - W</td>
<td>26</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>18</td>
<td>10</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>BA * TA</td>
<td>24</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>BA * DR</td>
<td>11</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>11</td>
<td>7</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>W * TA</td>
<td>19</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>AQ * BA - W</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>AQ * WP - W</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AQ * SP</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>BA * SP</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

*Note: The numbers indicate sites where a particular feature or combinations have been found. The symbols are as defined in Chapter 2, for Table 2.1a.

No water supply source has been recorded for 258 sites with baths (53% of all sites with baths). Similarly, no baths have been recorded at 231 of the sites (67%) where wells have been noted, while 50 sites with aqueducts have yielded no trace of baths (37% of all sites with aqueducts). These figures show up a complex problem in the archaeological record, emphasizing the incompleteness of the records due to factors relating to coverage of a site by excavation or disappearance of remains of particular features over time.

Table 6.3 gives the numbers and percentages of sites that had the different categories of water-related features for each type of site. Care has to be taken in the interpretation of these percentages for two reasons: firstly, where there are only a small number of a
particular site type and the same feature has been found at all the sites, the proportion is given as 100%. The data is not from a statistically normal population, because there is a bias in the sample of data represented by the listed sites in the database compared to all known sites. This is due to the lack of information about features found at sites for a variety of reasons, hence the data cannot be used for standard statistical analysis.

Table 6.3: Comparison of known water structures and listed sites

<table>
<thead>
<tr>
<th>Feature</th>
<th>Forts</th>
<th>Coloniae</th>
<th>Municipia</th>
<th>Civitas capitals</th>
<th>Small towns</th>
<th>Settlements</th>
<th>Villas</th>
<th>All* sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueducts</td>
<td>66</td>
<td>4</td>
<td>1</td>
<td>11</td>
<td>8</td>
<td>20</td>
<td>24</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>48%</td>
<td>100%</td>
<td>50%</td>
<td>78%</td>
<td>13%</td>
<td>9%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Baths</td>
<td>85</td>
<td>4</td>
<td>2</td>
<td>13</td>
<td>30</td>
<td>49</td>
<td>305</td>
<td>488</td>
</tr>
<tr>
<td></td>
<td>62%</td>
<td>100%</td>
<td>100%</td>
<td>93%</td>
<td>45%</td>
<td>23%</td>
<td>82%</td>
<td></td>
</tr>
<tr>
<td>Wells</td>
<td>43</td>
<td>4</td>
<td>2</td>
<td>11</td>
<td>52</td>
<td>135</td>
<td>104</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>31%</td>
<td>100%</td>
<td>100%</td>
<td>78%</td>
<td>79%</td>
<td>63%</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>Drains</td>
<td>52</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>17</td>
<td>30</td>
<td>67</td>
<td>179</td>
</tr>
<tr>
<td></td>
<td>38%</td>
<td>75%</td>
<td>100%</td>
<td>57%</td>
<td>24%</td>
<td>14%</td>
<td>18%</td>
<td></td>
</tr>
<tr>
<td>Pipes</td>
<td>28</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>34</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>75%</td>
<td>50%</td>
<td>50%</td>
<td>4%</td>
<td>4%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Springs</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>23</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>7%</td>
<td>50%</td>
<td>100%</td>
<td>7%</td>
<td>4%</td>
<td>-</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Tanks</td>
<td>32</td>
<td>2</td>
<td>-</td>
<td>6</td>
<td>8</td>
<td>16</td>
<td>38</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>23%</td>
<td>50%</td>
<td>-</td>
<td>43%</td>
<td>12%</td>
<td>8%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Sewers</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>7%</td>
<td>75%</td>
<td>50%</td>
<td>75%</td>
<td>1%</td>
<td>-</td>
<td>&lt;1%</td>
<td></td>
</tr>
</tbody>
</table>

*Total sites 137 4 2 14 66 212 372 807

*Note: The column for forts include fortresses. The ‘all sites’ in the last column represents all types of sites where each category of feature have been found. The ‘total sites’ in the last row represents the total number of each type of site in the database.

However, inspection of these percentages provides some insight into the likely relationships between the types of features and the total number of sites on which the database sample is based. They also indicate that there is a bias in how the information was obtained and what archaeological information was available to be recorded. Also, the sample of sites recorded in the database bears no relation to the actual total number of archaeological sites that have been found to
an analysis of the distribution of the different water features follows. Each type of site will be treated separately, but there may be some overlap in comment because of the geographical relationships between certain types of sites. Forts are a special category of site, because as military sites, the water-related features were intimately bound up with their administration and would have been financed at provincial level, or their funding may have come from the military accounts for a particular fort. This was not so for towns, perhaps other than coloniae which may also have been financed by Rome.

2. DISTRIBUTION OF WATER-RELATED STRUCTURES AT FORTRESSES AND FORTS.

The Ordnance Survey map of Roman Britain, 1991, lists 235 Roman forts and 75 fortlets. Jones and Mattingly (1990, 91, Map 4.24) show 9 legionary fortresses (for a total of 10 if Inchtuthil is included), and 16 vexillation fortresses and 6 possibles. With allowance for new discoveries, this gives a total of c.350 military establishments known in Roman Britain, though they were not all active at the same time. Only c. 40% of these forts (137) have yielded specific evidence of water-related features, the remaining 60% of known sites are unaccounted for in my database. The 85 baths found at military sites represent only 25% of the total known military sites, which seems low.

Table 6.4 gives a summary of the information of all the features at forts. Of the 137 sites where forts are listed in the database, 66 sites (48%) are recorded as having had aqueducts out of the total 134 sites with aqueducts. At 28 forts, water pipes of some kind have been found, in every case at sites also having aqueducts.

<table>
<thead>
<tr>
<th>Aqueducts</th>
<th>Baths</th>
<th>Wells</th>
<th>Drains</th>
<th>Pipes</th>
<th>Springs</th>
<th>Tanks</th>
<th>Sewers</th>
<th>Total sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>66</td>
<td>85</td>
<td>43</td>
<td>52</td>
<td>28</td>
<td>10</td>
<td>32</td>
<td>10</td>
<td>137</td>
</tr>
<tr>
<td>48%</td>
<td>61%</td>
<td>31%</td>
<td>38%</td>
<td>19%</td>
<td>7%</td>
<td>23%</td>
<td>7%</td>
<td></td>
</tr>
</tbody>
</table>

4 A special problem arises when fortresses and coloniae are discussed, because the four coloniae developed on the same sites as the fortresses or adjacent to them. However I shall make it clear when it is a fortress or colonia that is being discussed. The same problem occurs with some civitas centres, such as Exeter, which I have entered as a fortress, but it eventually became the capital of the Dumnonii as Isca Dumnoniorum.
It is not always clear whether these pipes formed part of the aqueduct, or whether they were part of a distribution system within the fort. The reported records do not always indicate what type the aqueduct was. Where possible I have indicated in the table Appendix 1 what the aqueduct type was. At some forts it is mentioned that evidence of a water pipe was found at one of the gates, implying that the pipe was the aqueduct. Both Hanson (1970) and Stephens (1985b) mention instances where the aqueducts consisted of water pipes, e.g. Balmuildy (clay water pipes), Brough-on-Humber auxiliary fort (water pipeline entering west gate), Caernarvon (3rd c.) (wooden pipelines), Chester (clay pipe along line of aqueduct), Fendoch (aqueduct channel carrying a pipeline), Pen Llynystyn (wooden pipeline), and so on. Some military sites had stone channel aqueducts such as the fortress at Exeter and the fort at Lanchester.

I traced 8 forts which were reported to have had leat aqueducts: Bowes, Burrow-in-Lonsdale, Dalginross, Dalswinton, Great Chesters, Tomen-Y-Mur, Trawscoed and Wetwang, and there may have been more. The aqueducts serving Chesters most likely were leats but they may have been stone channels or even pipelines. Because of its high elevation, Housesteads was not served directly with an aqueduct (Arch. Ael. 12, 1935, 243-4), but it has been suggested that a leat brought water from the north to near the site of the external bath, from where it was raised by unknown means to the fort (Birley 1961, 181). Leat aqueducts are normally major earth moving construction projects for which the military engineers would have been responsible at forts and they would probably have assisted in the planning of leats at towns. The stone channel aqueduct at Halton Chesters was reported by Bruce (1867, 134) and is shown on the OS map of Hadrian's Wall (1989) as being about 1.5km long. Stone channel aqueducts, such as the three channels at Lanchester, would also have been major construction projects. For these large quantities of dressed stone would have been necessary, generally obtained from Roman stone quarries. Leat type aqueducts may have been resorted to during the 2nd century for water supplies because of the high cost of quarried stone and particularly that of transport. Even so, the comparatively high number of forts with aqueducts indicates significant military investment in a running water supply.

Figure 6.1 shows the distribution of the 66 forts with aqueducts as listed in the database. These sites seem to cluster in three regions.
There are 12 widely spaced sites south of the central Wales-
Birmingham axis. The remainder all lie from north Wales to as far as the Antonine wall with a concentration of sites round Hadrian's Wall.

The chronological distribution of forts and fortresses changed considerably from the pre-Flavian (AD 43-68) through the Flavian (AD 70-96) period to the third century (Jones and Mattingly 1990, 89, 98, 100, 132), but the distribution given in Fig.6.1 shows all the sites with recorded remains of aqueducts for the whole of the occupation period. They appear to be evenly spread over Roman Britain with the largest concentration of sites in the middle north, the military zone.

The distribution of forts with baths (Fig.6.6) divides between three regions: a northern region concentrated in the area of the Agricolan conquest (c.AD 79-85) and later Antonine frontier (c. AD 138-61), a region around Hadrian's Wall (c.AD 117-38), and a southern region south of Hadrian's Wall. For this latter region baths would have been constructed over the period from the later 1st century to the early 4th century, depending very much on when forts and fortresses were first commissioned. Some sites received additional baths at later periods, as for instance a bath was built in the early 4th century in a barrack at Housesteads.

I have recorded wells at only 9 of the possible 32 fortresses⁵ which were active at various times (of which 4 became coloniae later). Although most of the fortresses eventually had running water supplies, it would be expected that every fortress would have had a well in the praetorium or at least one well within the walls of a fortress. The missing ones may be due to them not having been found yet, or they may have been destroyed, or I may have missed them in the reported literature. Wells were traced at 35 of the auxiliary forts (10%), which also seems low, considering the c.350 known forts.⁶ Fig 6.11 shows the distribution of sites where wells have been found at military sites.

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⁵ There were 10 legionary fortresses and 22 (16 plus 6 possibles) vexillation fortresses (Jones and Mattingly, 1990, 91, Map 4.24; OS Map, Roman Britain, 1991, lists only 12 vexillation fortresses). Not all the fortresses operated at the same time, however when they were established well water or some other source would have been necessary before a running water supply was provided.

⁶ The OS Map Roman Britain, 1991, records 235 forts and 75 fortlets. This gives a density of about 13 forts per 100km square grid, based on an estimate that Roman Britain covered roughly 18 grid squares of 100km². All the forts would not have been operative at the same time, and some may have been abandoned for a period and then reestablished at a later date. Others may have been abandoned permanently well before the Romans left Britain in the early 5th c.
listed in the database including the 4 coloniae. Five are in the north, 6 are associated with forts along Hadrian’s Wall and 2 along the west Cumbrian coast. Seven were in Wales and the remaining 15 are in England south of Hadrian’s wall. I only traced 2 fortlets with wells. Why so few wells are recorded in the literature for military sites is difficult to understand, because we are considering wells within the fort walls.

2.1. Dating of water-related features at military sites.
This raises the issue of when did forts acquire their aqueducts? An aqueduct at a fortress/fort suggests that they may have originally been planned as permanent bases, as would well-built defences and buildings with stone foundations. Some of the larger forts of greater strategic importance and were expected to be held for a considerable period, may have had their aqueducts constructed soon after the fort itself came into operation. Forts of comparatively short occupation which were served by aqueducts must have had them built during that time. Thus we can date a number of Flavian aqueducts; similarly the three forts of Balmuildy, Mumrills and Inveresk from the Antonine wall (c. AD 142-55) would have had their aqueducts constructed during this phase of occupation. With long occupied forts precise dating is much more difficult and a further complication is that some forts went through several phases of occupation and abandonment, and the date of first provision and the possible maintenance of running water supplies is unclear.

It is not generally known when the aqueducts and baths at forts were constructed. From the evidence at Inchtuthil where construction started c. AD 83, a bath, praetorium and an aqueduct were planned. Although sites appeared to have been reserved for them (Pitts and St Joseph 1985, 189), the building of the first two structures had not yet been started and it is suggested that “work on the contour course of the channel had already begun” after most of the rest of the fortress was completed (Pitts and St Joseph 1985, 31, 191). Precedents for this delayed approach to the building of such stone structures at fortresses were at Caerleon, where the baths and praetorium were erected on ‘reserved plots’ (Boon 1972, 30), and the same may have applied to the praetorium at Chester (Pitts and St Joseph 1985, 189). The planned bath at Inchtuthil would have been built in stone and would have had to be large in order to provide bathing facilities for a whole legion. However, before these three structures could be built the order was given to demolish the fortress in c. AD 85.
If a fort or fortress had a substantial bath-building, such as at Chesters, then an aqueduct may have been built at a time closely related to that of the building of the bath. It would appear, for instance, that the construction of the baths at Exeter and Caerleon fortresses commenced soon after the forts were established. At Exeter the legionary fortress was established in c. AD 55, and its bath appears to have been built contemporaneously (Bidwell 1979, 1980). It would seem that there was an earlier aqueduct servicing this bath, but there is some uncertainty about it. The legion stationed at Exeter moved to Caerleon c. AD 75. The first buildings at Caerleon were built of timber during about AD 74 or 75 and were gradually replaced by stone structures during the AD 80s and 90s. The fortress baths were probably also started at this time (Arch. in Wales 1978, 51-2; Zienkiewicz 1986). The first running water supply seems to have been a lead water-main, which was later replaced with a stone channel (Zienkiewicz 1986, Fig 10). The same conclusion can probably be drawn for the leat aqueduct at the Great Chesters fort on Hadrian's Wall, which was constructed soon after AD 128. The fort had baths which were supplied from a water tank into which the aqueduct discharged. These three water supplies can be reasonably dated, but this is not the case with many of the other running water supplies. The date of construction of wells at forts is not known. Often only a terminus post quern can be established based on the small finds found in them, which indicates the start of their infilling and their likely abandonment.

Many forts from the more southern region would have been established early as the occupation progressed northwards and provision for either well or aqueduct water supplies would have been made at or soon after their establishment. Black reports 24 military sites that had mansiones, and they always had baths, implying that they had some form of a water supply (1995, 118). Most of these sites seem to be dated from the second to fourth centuries, probably indicating that some forts also would have acquired their running water supplies at a late stage (Black 1995, 13-16).

The inscription RIB 1049 (see Chapter 3 p.79) found at Chester-le-Street fort, mentions the building of a bath-building for the troopers of the cavalry regiment including a water supply, and RIB 605 found at Lancaster refers to the rebuilding of a bath-house for cavalry troopers, both under the governorship of Sabinus, dated between AD 263 and 268.
This provides positive dating for when these two baths were built or restored.

2.2. Problems with records for water-related structures at military sites.

Although I have listed only 137 forts in my database, they represent only sites at which I traced water-related features. Of the total number of military sites (341) 66 (19.3%) have yielded evidence of aqueducts, 43 (12.6%) sites had wells (of which 16 were associated with aqueducts) leaving 27 with wells only. Thus a total of 93 forts has a proven water supply, while at 248 sites this is unaccounted for. In other words, for 72.7% of the number of known military sites no water supply has been recorded. Clearly this shows that for water-related features there is a distinct bias in the record, which could be due to any of the following reasons.

1. The historical background of excavation at sites would be an important element. It could be that only the fort defences have been excavated in some instances.
2. During excavation water-supply features may not have been found.
3. In many instances the external and internal remains of water-related features have been irretrievably lost.
4. Some forts did not have an aqueduct water supply, though in many cases also no evidence for any other form of supply has been identified.
5. The excavation within a site was constrained to limited areas so that remains still extant have not yet been found.
6. Many of the sites have not been excavated at all, and are known by means other than excavation (such as air-photography) and water-related features have not been observed or reported.

Based on the little available information for forts where a water supply has been found, there is an expectation that the others would have had either a running water supply or at least a well because water is such an important commodity. In the database 34 forts had baths without a running water supply. Forts could of course easily have functioned without a running water supply, but it would have produced problems with the various facilities normally requiring water. The fort at Housesteads is an example.

At Housesteads, a large fort (2.1ha, occupied 2nd to 4th c.), no running water supply nor any internal wells have been found, though two external wells have been recorded. Five large tanks have been
found (one each near the North and South Gates, one at the north-east angle and a large one at the south-east angle, and one in the commanders quarters), but how they were filled is not known (Arch. Ael. 3 25, 1904, 248-9). Inside the commander's house was a small bath for his personal use, and a bath was built during the 4th century in one of the barracks. An external bath-house existed near the Knag Burn west of the fort, which must have been used by both the 1,000 soldiers and the inhabitants of the vicus. In addition to the two wells it had been suggested that a spring, which appears to have been converted into a well (Fig. 6.16: OS Pathfinder 546 map at easting 379,180m, northing 568,940m), near the external baths north-east of the fort, was the water source for the baths, since a workman had seen a pipeline from the spring towards the bath (Arch. Ael. 3 25, 1904, 253-4).

Fig. 6.16: Map of Housesteads-Broomlee Lough area: suggested route of R Selkirk's aqueduct (Anglia Archaeology No.5, 1995, 2-3, with figure). (OS Pathfinder Map 546).
Bousanquet suggested that the Romans chose the site because of the ready availability of water (Arch. Ael. 3 25, 1904, 207) and Eric Birley suggested that water was pumped up from the Knag Burn (1961, 181). Manning suggested from finds of iron-pipe collars and the fact that the fort had a range of water related structures (a fountain, an internal bath for a period and an external bath-building) that the fort must have been served by an aqueduct (1976, 40.151, Fig. 24.151). However, no evidence of an aqueduct has been found. The piping may have been water distribution pipes from one or more of the 5 tanks found in the fort.

Raymond Selkirk (an Air Survey Pilot) has now claimed that he has found the aqueduct for Housesteads with its source being Broomlee Lough (A, Fig.6.16), about 7.5km due north of the fort (Selkirk 1995, 2-3). (In about 1980 the water level of the lake was at about OS level 255m above mean sea level). Selkirk told me that he had found air photographic evidence of the route of the aqueduct running in a south-west direction from the Broomlee Lough until it reaches the ridge north of the Knag Burn, then turned south-east towards the gap where the Burn passes below the wall east of the fort (OS level about 245m). Based on this evidence he and his associates “calculated the spot which would entail the shortest possible bore” When they arrived at this position they found the “huge cutting through the hill...Its purpose was obvious - the Romans had tapped Broomlee Lough for their water supply to the Knag Burn” (p.2).

He does not give the depth or the length of the cutting. From the OS map the contours seem to indicate that the maximum depth of the cutting would have been of the order of 5 to 8m (Fig.6.16). From the Ordnance Survey map (1:25,000) it is not possible to estimate the length of the suggested cutting for the aqueduct that would have had to be made through the high ground between the lake and the Knag Burn.

He also describes an intricate water-wheel and pump system, which he suggests could have been used to raise water from the level of the Knag Burn to the fort c.15-20m above. According to Selkirk the water-wheel would have been rotated by water flowing in the Knag Burn, activating a “Ctesibian double action Roman pump”. The pump drew water from a sump, which he suggests was the supposed Roman well and it pumped water some 20m up to the fort. As discussed in Chapter 3
for the pump solution on the Lincoln aqueduct, it is highly unlikely that a Roman type pump could push water up a pipe for a distance of 20m. He does not mention water being diverted for the external bath-building which was located near this well. The route of the aqueduct he proposes would need to be investigated more thoroughly, to substantiate his claims. It certainly is true that the building of such an aqueduct would have been within the capabilities of the Romans. It is surprising with the depth of study and archaeological investigations of the Housesteads fort that such a feature has not been detected. However, the conception is quite novel and it would be of interest to have the opinion of an archaeologist, after inspection, of Selkirk's suggested aqueduct route. I have not therefore included it in the database as an aqueduct site.

Distribution of water-related features within forts has been difficult to assess, because the subject of water supply is seldom dealt with in reports. At the fort of the Lunt there was no external source of water supply. Six wells have been reported, and water may also have been drawn from the river. In the 2nd Interim Report 15 tanks are mentioned and a plan shows that 7 were located within barracks, 4 were inside a building south of the gyrus, and external tanks were distributed round the site (Hobley 1973, 35-8, Plan). The tanks outside the buildings were either filled by water carriers, or from rooftops, evidence for which was found of a gutter-fed tank from the north-west granary roof with an overflow into another tank. Possibly some of the tanks within the barracks could also have had catchment arrangements, but this is not mentioned in the report. One of the wells was situated between the gyrus and the rampart, and another well was located near the north-west angle of the fort. The fort was active from c. AD 60 to AD 74, and was demolished in AD 75 (Hobley 1973, 15), a short time for such an elaborate establishment, indicates the pragmatic approach of the Roman army to its military needs.

The military camp of Lyne is reported to have had an aqueduct, probably a pipeline from springs about 1.5km north of the camp, which

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7 If these pumps were indeed used to remove water from Roman ships, the height that water would have had to be lifted would not have been more than a couple of metres. J P Oleson (1984), in his book on remains of 'Greek and Roman Mechanical Water-Lifting Devices', does not give a single example of the type of 'Roman pump' Selkirk refers to and shows in his article. It seems that Roman pumps had to stand in the water source to draw water into the cylinders by the action of the pistons. There has been no record of a Roman pump with a suction pipe attached to it to draw up water into a cylinder from a source as shown by Selkirk.
fed 4 ground level tanks (Richmond 1941, 42). The main tank outside the headquarters building had a capacity of about 65,000 litres and together with the other three tanks would have supplied the camp with about 100,000 litres of water. The early excavators interpreted the stained remains of the pipeline as a drain, but later excavation showed them to be parts of a wooden pipeline. There is no indication of a bath at the site.

The case studies mentioned above indicate some of the problems of sites where features have been lost or have not been found. Whatever the present understanding of the water related problems of Housesteads are, the fort functioned for a long time, so that a water supply system existed that worked, however awkward it may have been at times for the 1,000 soldiers. The remains at the fort of the Lunt indicates that it functioned with a water supply system of 14 tanks and 6 wells. In the case of the fort at Lyne there seems to have been an over-supply of water and no bath has been found. These are contradictions in demand versus supply of water, indicating the problems facing archaeological investigations relating to water-related features.

3. TOWNS - COLONIAE, MUNICIPIA AND CIVITAS CAPITALS

Remains of baths have been found at most of the chartered towns and civitas capitals. At the colonia of Colchester a single bath has been found, and at Lincoln and York remains of two baths were found. At Gloucester there is evidence of hypocausts and lead piping suggesting the possible presence of a bath, but there is still some uncertainty (McWhirr 1981, 23-4). Here, as is so often the case, modern development has prevented excavation of large parts of the ancient site. Both the municipia had baths, London with at least 4 baths, and 2 have been found at Verulamium. The large thermae bath at Huggin Hill (site 14, Fig.6.19), built during the Flavian period (AD 69-96), was demolished in the 3rd century because it became flooded, and the bath at Cheapside (12), probably dating from the late 1st century, went out of use during the 3rd century, which may have been related to its water supply. The bath at Billingsgate (39) was constructed before the 3rd century and was still in use in the late 4th century, while the bath at Pudding Lane (38) constructed in the 2nd century was still in use after AD 370 (Rowsome 1995, 418, 420). All 13 listed civitas capitals had public baths. At Exeter remains of two baths have been found, one was the

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8 Exeter is listed as a fortress in the database, but later it became the civitas capital of the Dumnonii.
fortress baths, and the other one was probably public baths built after
the town obtained civitas status. Wroxeter had a large second bath built
(A, Fig.6.17) during the Hadrianic period and expanded during the late
2nd or early 3rd century (Webster 1965). Atkinson reported an earlier
bath (B) which was built soon after AD 60, but was abandoned during the
AD 90s, and was demolished during c. AD 120 to make room for the Forum
(1942, 25-54).

Fig. 6.17: Roman Wroxeter showing baths (A, Hadrianic, and B, from AD
60) and wells (circles), and aqueduct C. (Barker 1990, Fig. 3).

At Canterbury and Dorchester remains of two baths were found at each
site. The large baths at Wollaston House, Dorchester, either Flavian-
Trajanic or Hadrianic in date, were extensively altered c. AD 300 and
seem to have gone out of use during the mid 4th century (Wacher 1995,
325-6). Silchester also had two baths, the public baths in the south-east of the town (insula xxxiii), and the mansio with its baths, located in the south near the south gate (Archaeologia 59(2), 1905, 133-4).

3.1. Coloniae.
A major problem with archaeological evidence of remains is that it often only covers relatively small areas of ancient sites, because frequently modern development overlies the sites, and this particularly applies to the four coloniae. The water supply for each of the four coloniae also presents special problems because for three of the towns (Colchester, Gloucester and York) their aqueducts are only inferred from evidence of piping near the entrance gates to the towns or from distribution systems within them. For Lincoln (Chapter 3, section 11.2) there is the problem about the source of the earthenware aqueduct from the north. Little is known about the second aqueduct, of which minor remains have been found east of the lower town. A discussion of the water supply of the coloniae follows.

Colchester colonia and its surroundings with contour levels is shown in the plan Fig.6.18. There is speculation about Colchester's water supply, particularly because of the water pipes found at the Balkerne Gate. Geographically the Roman site was located at too high a level relative to the surrounding country-side to have had a gravity flow type aqueduct.

Figure 6.18 (Crummy 1984, Fig.14) shows that the colonia of Colchester lies between the 8m contour along its northern wall and rises above the 30m contour to the highest point at the Balkerne Gate. A large part of the town lies above the 23m contour (hatched on the plan), with the highest point at about 30-32m near the Balkerne Gate. For the Romans to have been able to provide a running water supply to the town, water must have been brought to at least a higher elevation than the 30m level. Remains of six separate water mains consisting of wooden pipes, held together with iron bands, have been found at the Balkerne Gate (1984, Figs.14, 107, 108), but from which direction outside the town they came is not clear. If the pipes originated north of the Balkerne Gate, their grade would have been uphill, and this would imply some system that could force water up the pipes, of which no evidence has been found. In the excavation Reports 3 and 6 (Crummy 1984 and 1992), reference is made to water mains at several places within the colonia (1984, Figs.84, 90, 91;
1992, Fig.13, 109). This seems to suggest that when the fortress was replaced by a *colonia* (c.AD 50-55), the *colonia* developed an internal water distribution system, implying that there must have existed an effective running water supply. How water would have reached the Balkerne Gate site has not been resolved, however some possibilities are discussed below.

About 450m to the west outside the Balkerne Gate are the strong springs at Chiswell meadow, which were the source of water for later Colchester.

**Fig. 6.18: Colchester *colonia* showing site and Roman wells (after Crummy 1984, 27, Fig. 14)**

Crummy suggests it could also have been used by the Romans to bring water by means of an aqueduct to the west wall at about the 15m contour level. From there it could have been raised into a tank placed on top of a tower near the Balkerne Gate, the highest point in the town, from which water would have been distributed to the lower parts. However, here there seems to have been the same problem that existed at Lincoln, how water was raised to a tank about 15m above the delivery point of the aqueduct. This tank would have had to be
higher than the tank at the Balkerne Gate. No evidence has been found of either the means of raising the water or of raised tanks.

Crummy discusses the water supply of Colchester in some detail, suggesting two alternatives (1984, 26-8). Firstly, he suggests that an aqueduct may have brought in water from the upper part of the Roman River about 11km to the west, but this certainly would have required an inverted siphon to traverse lower ground near the town. No evidence has been found of either. In his recent book 'The City of Victory' (1997), he gives an illustration of the town as it was likely to have appeared in the 2nd century. Below the Balkerne Gate is shown a conjectured elevated aqueduct delivering water to a distribution tank inside the town east of the west wall. This is based on his discussion of the water supply for the town in Report 3 (1984, 27-7). A second suggestion is, that the water supply may have been from wells. Nine Roman wells are shown on his plan located from north of Sheepen to the three wells at Middleborough north of the north-west corner of the colonia wall. No Roman wells have been found within the walls, though a number of Medieval ones are shown on the map. This suggestion does not take account of the evidence for a water distribution system within the town, because it is unlikely that a central distribution tank would have been filled by carrying water from the wells outside the walls.

An aqueduct is recorded at the outlying suburbs of Sheepen, where there were pottery works, and another has recently been noted at Gosbecks. A short length of the “Claudian leat” at Sheepen is shown to run from the north-west along the 12m contour in a curve from the Sheepen springs towards the colonia. The contour (40ft) is shown to continue to the north-west corner of the colonia, and at this point on the plan it refers to “Roman remains and pipes” and “leat and later lead pipe” (Crummy 1984, 27, Fig.14). This seems to indicate that the Romans brought water to the north-west corner of the early fortress (c.AD 43-60/1). The plan shows there are 5 springs within the town walls (possibly more), three along a spring line at about the 15m contour, one about 4m higher near the north wall, and another at the mithraeum at about the 21m level. How much water would have been available from these springs is questionable, because the catchment area is relatively small - smaller than the colonia area. Considering springs as a major water supply during the town’s period of prosperity in the 2nd and 3rd centuries is doubtful.
In summary the evidence for the water supply at Colchester colonia is:
1) 6 water mains found at the Balkerne Gate at about the 30-32m level,
2) water mains found at several places within the colonia,
3) a leat from the Sheepen springs seems to run towards the fortress,
4) an aqueduct from the Chiswell springs to the west wall at 15m level,
5) 9 Roman wells outside the colonia,
6) at least 5 springs within the colonia.

If item 1 was part of an aqueduct system, there are two possibilities: firstly, an elevated aqueduct of substantial height (of order 15m+) brought water from some distance away in the west (the Roman River has been suggested as a possible source). However, no evidence for such a major structure has been found, either as a wood trestle support for a conduit, or as stone or earth constructions. Secondly, an inverted siphon, also from the west, may have brought water to the Balkerne Gate. The 6 wooden pipes found at the Balkerne Gate, could have been part of an inverted siphon, but again there is no evidence for pipes found further west outside the town. The area is extensively cultivated, so that any evidence of a wooden pipeline would have been destroyed. Also, wooden pipes used in an inverted siphon would have presented problems of bursting under pressure, unless they were encased in concrete, or well protected in the ground.

The evidence of water mains elsewhere in the colonia is very suggestive that a running water supply did exist, but from where it was distributed is unclear. Items 3 to 6 have been discussed above with their limitations in view of the evidence of distribution water mains in several parts of the town. It seems to me there is sufficient evidence to accept the theory that the colonia did have an aqueduct water supply, even if it was not brought to the highest point, for distribution to some of the lower parts of the town. However, much more study is required to resolve the uncertainties surrounding its source of water, route and type of conduit, where it entered the town and how it was operated.

At Gloucester, as at Colchester, an aqueduct is also presumed because of the evidence of remains of collars of wooden pipes near the east-gate, and several wooden pipes which formed the distribution system.
within the colonia. There is also a record of two wells, which hardly seems to represent the number that should have been available for a large town. Hanson suggests that the source of an aqueduct could possibly have been the springs near Matson on Robinswood Hill about 3km south of the town (1970, 367). Wacher adds the suggestion that an aqueduct supply could also have come from north of the city (Wacher 1995, 159). It has been reported that a large "9m-wide tank has been located in the fortress" and he suggests that this may have been the terminal reservoir for an aqueduct (Stephens 1985b, 223; JRS 1967, 195). Other tanks have also been found. A bath-house is implied from remains of an apsidal hypocaust at Westgate Street, but the limits of excavation on the site prevented more of the structure being revealed (Wacher 1995, 158). The colonia had a sewer, but it is not clear how extensive it was, and this would probably also point towards a running water supply. It would seem that not sufficient archaeological evidence is available from outside the colonia to confirm a running water supply, but, as for Colchester, internal evidence seems to indicate the town did have an aqueduct.

The problems of the aqueduct water supply at Lincoln have been discussed in detail in Chapter 3 section 11.2). A summary of the evidence for the water supply of Lincoln follows:

1. Sections of an earthenware pipe encased in concrete was found as indicated on Fig.3.7a (p. 76) between points B to X (about 96m); point X is the most southerly position where piping was found, about 0.5km from the north-east corner of the town wall.

2. The aqueduct was a rising-main of about 2km length from the Roaring Meg stream towards the colonia, with a difference in elevation of about 21m to 24m, depending on at what point water was delivered at the town.

3. Immediately south of the Roaring Meg, 11 foundation bases were found.

4. Early antiquarians of the 18th and 19th centuries reported having seen a tower with a tank near the Roaring Meg stream.

5. In 1786, a Swiss artist, Grimm, drew two sketches (now in British Museum) of a bridge structure that coincides with the position of the foundation bases; they show the line of the aqueduct pipe on the structure (Thompson 1954, Pl.VII A, B).

6. At base VIII nearest the Roaring Meg (E, Fig.3.7a), Thompson reports finding in the filling of the construction trench 'a rustic ware cooking-pot of late 1st or early 2nd century' (1954, 117) (possible dating evidence for construction of the aqueduct).
7. A short length of earthenware pipe (E) encased in concrete found east of the lower part of colonia above the spring line (P) (Fig.6.19; Lewis 1984, 71).

8. Two water tanks - one next to the north wall near the Newport Arch (B, Fig.6.19), and the other next to the east wall near the East Gate.

9. Two wells - one within the Forum east range (H) (Chapter 4, p.122, Fig.4.5), and the other near the West Gate (I) (not yet reported).

10. Two baths - one south of the north tank (A), and the other in the lower part of the colonia (K).

11. A fountain (J) with inlet and outlet pipes found near the lower bath.

12. An extensive underground sewer system (G) was found during the 19th century in the upper part of the town, the main sewer running along the Bailgate.

The evidence of items 2 to 5 seems to indicate that a) the source may have been at the Roaring Meg; b) that there was some evidence of a substructure carrying the concrete encased pipe to near the Roaring Meg stream, and c) that there was evidence of a raised tank that supplied water to the rising main, forming a pressure system in the form of an inverted siphon (the probable reason for a concrete encased pipe). Two main problems, as yet unsolved, are firstly, was the Roaring Meg stream the water source for the postulated inverted siphon, and if so, how was the system supplied with water? Thompson (1954) discussed these issues proposing possible solutions on the basis that the Roaring Meg was the water source. Suggestions have been made that the water source was further north (Chapter 3, section 11.2, Fig.3.8).

Limited further investigation was carried out during the early 1980s in the vicinity of the masonry piers, but nothing new was discovered (personal communication from Mick Jones, May 1997). The public bath (A) (Fig.6.19) in the colonia near the presumed castellum aquae (B) about 100m east of the Newport Arch (C), seems to confirm that the aqueduct (D) was aimed in the direction of this tank. It has been suggested by Lewis that water may not have flowed in the aqueduct (D), based on the fact that no encrustation shows in the ceramic pipe (Chapter 3, p.86), which would have been expected from the lime-rich water coming from this limestone region (Lewis 1984, 68-9). It is uncertain whether the second earthenware pipe (n.7 above) was in fact an aqueduct supplying water to the lower part of the colonia.
Fig. 6.19: Lincoln colonia (after Wächer 1995, 134, Fig. 57). Features discussed in the text are marked A to K.
From its position it seems unlikely that it could have supplied water to the northern part of the lower town, which may have obtained its water from the upper colonia aqueduct and that in turn would require an effectively functioning upper aqueduct.

There are other indicators which demanded a plentiful running water supply such as evidence of an elaborate sewer system (G) in the upper town and possibly a water distribution system. However, as discussed in Chapter 3 (pp.82-6), calculations, based on delivering water from the Roaring Meg stream (OD level 39.5m) to a tank near Newport Arch (OD level 65.5m), show that only about 72,000 litres of water per day was likely to have been supplied by this aqueduct. The distribution of this quantity of water between two baths, a fountain, sewers, other public buildings and to a domestic distribution system, seems unrealistically low. Whitwell has suggested that “The system of water supply to the town would have been based on fixed hours during which the water was pumped up to storage tanks, and similarly regulated periods when the water was available to the various consumers, public and private” (1970, 33). There is no evidence for such a control system, but it is likely that the Romans had developed water regulating systems.

If the observations by the early antiquarians and Grimm’s drawings are acceptable as evidence for a tower structure near the Roaring Meg and that the aqueduct’s intake was in the vicinity of this tower, as suggested by Thompson (1954), then it implies that the Romans created an elaborate water raising facility in the vicinity of foundation VIII. These early sources do not describe the tower or the material of its construction. In my calculations (Chapter 3, pp.82-6), I considered a single chain and bucket arrangement to lift water to a tank on a tower high enough to allow water to flow along the pipe to the delivery point in the colonia. If there existed a battery of 3 or 4 bucket and chain systems to deliver water to the tank, the water supply to the town could possibly have been sufficient for the basic needs of the colonia if supplemented by wells. However, wells would have had to be of the order of 16m deep, cut through the Jurassic ridge limestone to reach the water table; this complication may have been the reason for building an aqueduct.

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9 Even 4 systems would have delivered only a little more than one quarter of a million litres per day, which is still many times less than what the aqueduct at Dorchester delivered per day.
Notwithstanding much of the negative aspects related to the source of water and the operation of the aqueduct, the Lincoln colonia must have had a working running water supply, because the town was still economically active up to the mid-fourth century (Wacher 1995, 149). Further investigation is necessary to resolve uncertainties about the water supply of Roman Lincoln, and in particular to re-examine the early evidence.

York is built on a gravel and sand layer which overlies clay formations, similar to the formations at London and Silchester, and is reported to have had several wells and springs (RCHM(E) 1962, 59). Well-water could therefore have been a significant source of water for the Roman town. Only two wells have been reported.

An aqueduct for York is only inferred from evidence of other remains such as a fountain, a bath (of which only a small part has been found because of the limited area of excavation) and lead pipes leading to it, and a massive lead pipe crossing the River Ouse (RCHM(E) 1962, 49-51; Wacher 1995, 176, Fig.79). The fountain was in the shape of a 1m square tank fed with water from a pipe in a vertical slab at its back, with an outlet pipe (75mm diameter) in the right wall. This implies a constant supply of water, and therefore it is accepted that the colonia at York must have had an aqueduct water supply, but no other evidence for it has been found, other than that the town had a public bath, said to have had the largest caldarium in Britain (Richmond 1946, 76-7).

3.2. Municipia.

Roman London, built on the gravel terraces above the Thames River, developed around the Walbrook valley where springs and wells were the principal sources of water supply (Fig.6.20)(Wilmott 1984). Wacher, however, has advocated an aqueduct as an additional water supply, to have come from Highgate or Heampstead (1978, 104-8), because he considered that the bath-houses of London would have required large volumes of water (Chapter 4, section 6.2.1). As evidence he cites the wooden water-pipes found at the Bank of England site (20) and those found in the Walbrook valley (26, 28), and also near the forum (36), implying some form of a water distributive system (Wacher 1995, 90, 101) and hence an aqueduct system. He does not refer to the pipes in relation to either springs or wells. Wilmott states that "these pipes make it unlikely that they were used for anything other than the water supply of fresh water, but there is no need to assume that they
were aqueduct fed" (1984, 241). This would imply that the pipes could have collected water from either springs or wells, in what Wilmott refers to as "intermural aqueducts" (1984, 242). Grimes (1968, 97) believed the wooden pipes to have been used for drainage, which seems to have been a costly way of providing drainage (Wacher 1995, 101).

Because of a rising water table, a major problem was the disposal of excess water, not collection. Both Wilmott (1984, 241) and Merrifield (1965, 146) argue that the evidence for the well and spring water supply for all London’s needs outweighs the evidence for an aqueduct system. Wilmott (1984, 239) convincingly argues that all four of the bath-houses (Cheapside 12, Huggin Hill 14, Pudding Lane 38, Billingsgate 39) were close to a spring-line, which would have facilitated the provision of their water requirements by "intramural aqueducts" collectors. This leaves the question of an external aqueduct unresolved with the balance of present opinion that it would have been a superfluous addition to the water supply of London. The control of excess water due to the high water table seems to have been closely related to the development of the area around the Walbrook valley.

Wilmott reports 51 wells found within the walled area of Roman London (1982a, 1982b, 1984, 1991), shown on Fig.6.20 (Wilmott 1982b, 235, Fig.1). Except for three reported wells to the east of the forum, all the wells were found along a central band mostly west of the Walbrook stream, with concentrations in the Queen Street area (sites 25 and 26) (1982a, 20 wells) (Fig.6.21a and b, and Table 4.4), and Middle Walbrook area (10 wells). In the latter area at Bucklersbury and Compton Court (28), 5 barrel-lined and 5 box-lined wells were found (Wilmott 1991, 20-52, Fig.7 & 22)\(^\text{10}\). Later another 5 wells were reported, bringing the total in this general area to 35 (Wilmott 1984, 7). The remaining 16 single-well sites suggests that they may have belonged to private homes or business enterprises.

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\(^{10}\) Wilmott's 1991 paper is to some extent a summary of the three CBA Research Reports Nos.69, 70 and 88 on the Archaeology of Roman London in the Walbrook valley area.
Fig. 6.20: The wells and other water-related features of Roman London (after Wilmott 1982, 235, Fig. 1).
Fig. 6.21a and b: Localities of Roman wells in the Queen Street area, London, (after Wilmott 1982a, Figs 5, 6).

Thirteen of the wells dated from the 1st-2nd centuries and 9 to 3rd-4th centuries (Wilmott 1982b, 240), and the remainder of this group with less secure dating. Whether the later wells were new because of additional requirements, or whether they replaced some of the earlier ones that may have become disused or polluted needs further study. A well is shown within the supposed Governor’s palace area (Wilmott 1982b, 235, Fig. 1 Site 33), the only building shown to be associated with a well. Near the Cheapside bath a well is shown, but it is not clear
whether it was directly associated with the bath, because the bath seems to have its own watertank supply (Fig.4.8). In addition there were other wells/pits which have not been dated and with uncertain origin, so they are not included here. The information about most of the wells was published in a gazetteer compiled by Merrifield (1965), and others reported by Grimes (1968).

Wilmott suggests that some of the Queen Street wells may have been used as public wells for the inhabitants in the area (1982a, 16). The large number of wells over such small areas seem to indicate that Roman London must have had clusters of wells concentrated in certain areas, which may have been related to the changing topography of the Walbrook valley during the 1st to 5th centuries.

This change in topography was mainly brought about by demolishing of old structures and building new ones over the changed levels (Chapter 4, sect.6.2.1). It is possible that many of the wells became inoperative because of silting up, or because of contamination due to domestic and latrine waste seeping into them through the open graded gravel and sand deposits.

Verulamium seems to be even more of a problem regarding the source of its water supply. Frere (1983, Vol.2), makes many comments on aspects of the considerable evidence for internal distribution of water, which implies a running water supply for the Roman town, but he says that an aqueduct has not yet been identified (p.19). The municipium was the third largest town of Britain during the Roman period, but little seems to be known about its water supply, other than that there must have been a sophisticated water distribution system from the inception of the town. Frere suggests that the army may even have been involved in aspects of construction within the town during the early phases (Frere 1964, 104-5). The geological conditions did not favour wells as an easy way of obtaining water, as at London or Silchester. Frere mentions that "Verulamium contained a number of wells, e.g. Insulae IV, XIV, XXVIII (p.20), but only describes a well in Building 3 in Insula XXVIII (1983(II), 242-3), and one well was abandoned before it reached the water table (Hanson 1970, 70).

Wheeler identified a wooden pipeline by a number of iron collars along Watling Street at Chester Gate in the north-west of the town (Wheeler, 1936, 70), and later Frere found two tile-lined conduits at the Monumental Arch on Watling Street, one a sewer and the other
presumed to have been a water main (Frere 1962, 154). Further along in Insula XVII a stone conduit was discovered by Richardson (1938, 85-6), who suggested it may have been the water supply that came from higher up the River Ver that flows along the north-east boundary of the town (Hanson 1970, 70). Whether there is a connection between the conduit found by Frere and this latter one is difficult to say, because not sufficient excavation has been done in between to confirm it. Near the centre of the town evidence of a number of wooden pipelines have been found, which implies a running water supply for the town. Regarding the discovery of the iron collars of a wooden pipeline in Insula XXVII (Frere 1983, 236, Fig.89) dated to the 5th century, Frere comments, that even at such a late period “we find that the technical skill necessary to maintain the city’s aqueduct and to install a piped supply from the castellum divisorum was available” (Frere 1960, 20-1). This probably represents a new internal distribution pipeline, indicating a continuation of the urban water supply at a very late date. The water source for any aqueduct that may have brought water to the town has not been identified during the periods of major excavations in the 1950s and 1960s.

3.3. Civitas capitals.

Eleven of the major towns of civitates, are recorded as having had aqueducts and 10 sites had both aqueducts and baths. No evidence of aqueducts has yet been found at Chichester and Silchester although both towns were important, well-laid out urban centres with baths (Wacher 1993, 264, Fig. 117, 274, Fig. 123), while at most of the other listed civitas capitals they have been found. The supply of water to Leicester is also a problem because of the uncertainty about the Raw Dykes being an aqueduct and to the baths. It is perhaps significant that at Chichester and Cirencester only 4 wells had been found at each town, which may be due to the level of excavation of the towns. In contrast where excavation covered almost all of a town site, as at Silchester, 76 wells were found (Hanson 1970, 124) and at Caerwent 16 wells were found (Hanson 1970, 84). Most of the wells at both towns seem to have been associated with private houses. Caerwent has evidence of an aqueduct and also had an elaborate water distribution system in the mid-north part of the town. Some of the town sites may have had aqueducts during their certain or suspected military phases and therefore did not have to rely only on wells during the town phases, such as at Aldborough and Carmarthen, and at the capital of the Iceni, Caistor-by-Norwich. On the other hand,
remains of wells have not yet have been found because of insufficient detailed excavation. No wells have been recorded for Carlisle. At Canterbury, Dorchester, Leicester and Winchester\textsuperscript{11} wells have been recorded but the archaeological indications do not show that they had many wells, suggesting that wells were not their principal form of water supply. For Wroxeter, Atkinson reported on the distribution of pipelines in the town dating from the later 2nd century, but the evidence is not sufficient to associate them with distribution for domestic water supply (Atkinson 1942, 122; Hanson 1970, 140). Bushe-Fox discovered 11 Roman wells during the 1912-1914 excavations at Wroxeter, and Atkinson reports a further 6 wells during the excavations of 1923-7 (1942, 114-22). This suggests that even though the town had an aqueduct water supply, for a number of private residences wells may have been the main water source. There seems therefore to be evidence that some towns had combined aqueduct and well water supplies, though the data is not clear as regards the balance between the two.

Caerwent (Venta Silurum) and Silchester (Calleva) are two contrasting civitas centres as revealed by their water supply and drainage systems. Silchester (40ha) is more than double the size of Caerwent (18ha). The larger town had a well-established drainage system even though it did not have a running water supply, whereas Caerwent seem to have had poorer public drainage facilities, with many houses having to dispose of their own waste water and sewage into cesspits. Silchester had a large public bath, whereas the public bath at Caerwent was more modest (Wacher 1995, 45, Fig.10.2 and 47, Fig.11.4), though it appears not to have been completely excavated. At Caerwent a second bath-house is shown in the south-east, but it is not clear to me whether it was also a public bath. Three houses in the south-west where wells have been found also had baths, which seems to imply that some other private houses may have had baths, but have not been identified as such from their remains. Caerwent was close to the fortress at Caerleon and several scholars have commented that the facilities at Caerwent, in particular its water supply and public and domestic distribution system may have been influenced by the availability of army engineering personnel\textsuperscript{12}. The town streets seem to have developed over a period well into the late second

\textsuperscript{11} At Winchester the water table is so high that it has hampered excavation of the Roman remains below the Medieval period remains.

\textsuperscript{12} Millett is critical about the suggestion that military engineers were involved in the construction of civitas capitals (1984; 1990, 69-75; Blagg 1980, 1984).
century (Brewer 1990, 75), so that it must be assumed that the distribution system also expanded with the street development (Britannia 16, 1985, 201-2). Whether the aqueduct supply was modified as the town developed is not recorded.

4. SMALL TOWNS

The 66 small towns listed in the database with water-related features represent 68% of the total number of 97 suggested by Burnham (1986, 187). Of the 9 which had aqueducts, only two are recorded as also having had wells. The aqueducts at Dolaucothi, Kelvedon and Nettleton are leats, and that at Bath is a lead pipe, and that at Chelmsford a wooden pipe. The aqueducts at Godmanchester, Wall and Wilderspool are undefined and the aqueducts of Corbridge are also not known though it is suggested that they were either channels or leats. Fifty-two sites had wells and 30 had baths, five of the small towns had aqueducts and baths and 18 had baths and wells. Most of the small towns show only one well, but Tiddington had 14 wells, Scole and Tripontium each had 7, and Ewell 6, Ancaster and Heybridge 5 each. Wells were the preferred water sources at many small towns, but it cannot be ruled out that some residents drew water from nearby springs or streams. Thirty sites are recorded as having had baths, of which some were associated with mansiones (Black 1995, 118), but given the dearth of excavation information of small towns in Britain it is quite possible that this figure is too low.

5. SETTLEMENTS

Settlements are defined in this thesis as sites which do not fall within the other six types of sites. However, when I started with the analysis of site types in relation to the water related features found at them, it became clear that some sites which I have listed as settlements may need to be examined in greater detail for possible reclassification. Hingley states that few settlements have been excavated extensively and "in enough detail to provide comprehensive and reliable evidence for the form and chronology of a settlement" (1989, 75). Below I give some reasons why I consider some sites should be considered for reclassification.

Of the 212 sites listed in the database, 135 (63.7%) had wells. As minor sites, I did not expect them to have had aqueducts, though 20
were recorded, of which 8 were leats. In most cases these were presumably simple channels bringing water from springs or streams at not too far a distance from the settlement. Only 4 sites with aqueducts also had baths, whereas 10 sites had baths and wells. The implications of these combinations are discussed below.

An important problem is when we consider the recording of a bath and/or an aqueduct at a settlement, which is associated with a villa. It may not be clear whether the bath and/or aqueduct belonged to the settlement or to the villa (Hingley 1989, 102-3, Fig. 55). There are however settlements where certain water-related structures have been found, which were unlikely to have been built without some urban type infrastructure having been responsible for their planning and construction. This is exactly what a small town is considered to have had and rural settlements supposed to have lacked. For the types of urban or rural communities we are looking at, wells would not necessarily be an indicator of a special organization during the Romano-British period. But the presence of a bath-building of some size (the standard three-roomed bath-suite) and/or an aqueduct immediately suggests that there must have been some organization responsible for their planning and construction or that the owners were wealthy enough to be able to afford such luxuries. It certainly is unlikely that a loosely nucleated group of rural small households would have invested in such expensive structures. Of the 212 settlement sites initially listed in my database, there were 69 sites with major structures (Table 6.5) (20 with aqueducts, and 49 with baths). Four of these, had both - Grafton Estate, Ivy Chimneys, Prestatyn and Southwark Street. Some of the baths are described as being small baths in private homes, but it is not always clear whether the larger baths were public baths or private ones. Table 6.5 gives a summary of the aqueducts and baths at settlements.

<table>
<thead>
<tr>
<th>Table 6.5: Settlements with aqueducts and baths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Settlements with aqueducts</td>
</tr>
<tr>
<td>Settlements with baths</td>
</tr>
<tr>
<td>Settlements with both aqueducts and baths</td>
</tr>
<tr>
<td>Settlements with either aqueducts and/or baths</td>
</tr>
<tr>
<td>Settlements with aqueduct only (20 - 4)</td>
</tr>
<tr>
<td>Settlements with bath only (49 - 4)</td>
</tr>
<tr>
<td><strong>Total settlement sites</strong></td>
</tr>
</tbody>
</table>
What needs to be established is where these settlements were situated in relation to forts, because if the settlements were vici outside the forts then it is likely that the baths would have been used by both the soldiers and some of the vici residents. The status of baths at settlements seems not to have been studied, so that it is not clear whether any settlements had public baths.

The question arises whether these so-called settlement sites with aqueducts and/or baths should still be classed as settlements, since the inhabitants apparently did not have an outward structured political or economic organization, or should consideration be given for at least those which may indicate group action to be reclassified as small towns? The evidence seems to suggest that the four sites with both an aqueduct and a bath were planned by group action and should be given the status of small towns. I suggest that if a settlement had an aqueduct, usually a reasonably expensive structure, it would indicate some political organization which could make communal decisions for the construction and management of an aqueduct, and therefore such sites should be accorded small town status. The problem settlement sites are those with baths only, which need to be examined whether the indirect evidence could indicate whether the baths were public or private.

Of the 64 settlement sites at which either aqueducts or baths were found, at least 20 should be classified as small towns, on the basis that 16 had aqueducts and four sites had both an aqueduct and baths. It is possible that some of these aqueducts were rather minor structures, in which case they need not have involved group action. For the remaining 41 the evidence of the baths need to be examined in detail to determine whether any of them should be reclassified.

Burnham discusses the morphology of 'settlements' (item 3(a)) where they are classed as major or minor towns. At items 3(c)-(h) and 4(a)-(d) he lists the requirements that were necessary to classify a settlement as a small town. An important component would at least be a "restricted range of building types", but no mention is made of either baths or aqueducts as parameters in his classification. I consider that these two structural types should be included as parameters defining a small town.

In Appendix 1, the 41 sites classified as settlements with baths (marked with a + sign) are given in Table 6.6, but in Chapter 2 it
was indicated that because of problems with their descriptions in the
literature, they need to be examined more closely where they have
baths. If a site is a simple farmstead consisting of only a few rooms
and a bath is listed in the literature, this bath may not be the
three-roomed type referred to in Chapter 5. However, if the baths at
a settlement site were of the sophisticated three-roomed type, the
site type may also be more than a simple settlement, and could fall
in the category of a villa. Several of the sites are listed in
Eleanor Scott’s ‘Gazetteer’ (1993) on villas, though with no
definitive statement that they were villas. However it would be
sensible to assume that some of these were indeed villas, for
instance High Ham, Rowlands Castle, Sandringham and Stonesfield.
Because of the element of uncertainty I entered them as settlements.
Sites at Lyminge, Orton Longueville and Scawby, based on Scott’s
descriptions, could be either settlements or villas, but insufficient
information is given to be certain about their classification, so I
have listed them as settlements. A number of sites started off as
settlements during the early Roman period and later developed into
villa estates, as at Boreham, Durham, Haddon(?), Somerford Keynes and
Yarwell, but I have listed them as settlements, because of the
uncertainty. Others were vicus sites associated with forts where the
baths were outside the forts, and it is most likely that the baths
here were public. Whether these vicus later developed into settlements
or towns in their own right, as is known happened to some vicus,
especially when the associated fort moved or ceased to function,
needs to be investigated. Two examples are the vicus of Leintwardine
and Romford. Some of the other settlement sites, particularly those
with mansiones may also have started off as vicus, for example
Chigwell, Cold Knapp Point, Romford and Tilston. Many settlement
sites are associated with villas and it is clear that the villa had a
bath. However some of the settlements near villas had their own
baths, usually small baths with only one or two small rooms, such as
at Aldbourne, Asthall, Castor(2), Pulborough and Salford Priors. The
remaining sites were settlements as listed in the literature and had
baths, but with no clear indications of the sizes of the baths or
whether they were used only by the household members of the houses
located in those settlements. Those sites which are listed in the
literature as villas, should be given that classification unless it
is proved otherwise. The sites which started off as settlements and
later developed into villas (or may be even towns) are probably
likely to have had their baths built during the later Roman period.
Vici often had mansiones and hence would have had public baths which were used by the cursus publicus officials (Black 1995, 14, 118, 120). The vici baths were most probably built by the army if they were built soon after the associated forts were built. Both Leintwardine and Romford vici are likely to have had official mansiones with baths, also constructed by the army. Chigwell, Cold Knapp and Tilston also fall in this category. Settlements near villas probably had private baths in individual houses. The remainder are settlements which seemed to have developed from very simple nucleated communities to more elaborate urbanized settlements and consideration should be given to raise their status to a higher category such as small towns or villas rather than simple settlements. Both Chigwell and the site of Castor(2) (my database number), a suburb of Durobrivae, situated at Normangate Field, were classified by Rodwell & Rowley (1975, 3) as small towns, while all the other sites are not listed as small towns by either Rodwell & Rowley, or by Burnham. Although the literature refers to them as settlements, some reports pre-date the debate about how to define 'small towns'.

In Table 6.6 I propose that the sites listed should be classified as shown in the first column.

For the database record these settlements should therefore probably be entered as villas, though because of the uncertainty I have recorded them as settlements until more rigorous study can positively determine their status.

14 Todd 1970, 114-30; Rodwell & Rowley (eds.), 1975, several authors; Rivet 1975, 111-14; Brown (ed.), 1995, several authors, in particular Burnham, 1995a, 7-17.
A perplexing question is, how one would determine whether the communities at these proposed reclassified settlement sites, in fact, had the organizational and political structures to make decisions on spending money for public facilities? It is possible that at least at some of them there would be additional indicators, such as other building structures of a public nature, or evidence of a common approach to agriculture, which could also imply a more sophisticated community than mere loose farmsteads close to each other. This would require detailed study of the evidence for each site, which I have not done. Condron has made a detailed study of both small towns and settlements in the East Midlands (1996) and in her Figure 2.1 (p.28) she shows the distribution of as many as 1850 sites in this region. There is little reason to suppose that settlement distribution over other regions of Roman Britain was significantly less densely populated. Rodwell refers to Richmond’s comment on "the enormous
number of settlement sites" in the Essex region. Many of these numerous settlements were probably simple farmsteads with little pretension (Hingley 1989, 75), which produced only sufficient for their own needs. Many British settlements would have produced surplus crops which would have been available for distribution to markets, or may have been associated with villas to whom they supplied their excess products.

It seems clear to me that in order to determine the status of the minor settlements, not only must their social and economic circumstances be studied but also the sophistication of the buildings which comprises a settlement, and baths would be an important element in such a study.

6. VILLAS
Of the 372 villas recorded in the database 305 had baths (82%), but even this seems to be low considering that there were probably about 2000 known villas. The remains of villas with baths are spread over the whole area of Roman Britain, the most northern one being at Holme House in County Durham. The large number of villas recorded to have had baths seem to indicate that many more must have had them.

Table 6.7 shows that 104 villas listed in the database had wells and 24 had aqueducts. This represents 34.4% of the sites for which some information is available on water-supply structures. Comparing my Fig.6.15 of the distribution of villas with baths with a general villa distribution map (Jones and Mattingly 1990, 241, Map 7:6), it is apparent that the sites with wells are fairly evenly spread over the area of Roman Britain where villas have been found. From descriptions of villas in excavation reports the differences between villas where wells have been found and those without wells are similar, so their water needs could have been the same. It would seem reasonable therefore to conclude that since the 104 sites with wells were randomly scattered amongst the population of known villas, the likelihood is that most of the other villas also had wells. The 305 baths (82%) at villas (Fig.6.10) represents the most prolific feature at all the sites recorded in the database and the same conclusion is likely to be true about their distribution as was suggested for wells.

### Table 6.7: Distribution of water-related structures at villas

<table>
<thead>
<tr>
<th>Structure</th>
<th>Number</th>
<th>Percentage</th>
<th>AQ + BA</th>
<th>AQ + W</th>
<th>AQ + TA</th>
<th>AQ + WP</th>
<th>BA + W</th>
<th>BA + TA</th>
<th>BA + SP</th>
<th>W + TA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueducts</td>
<td>24</td>
<td>6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baths</td>
<td>305</td>
<td>82%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells</td>
<td>104</td>
<td>28%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drains</td>
<td>67</td>
<td>18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipes</td>
<td>34</td>
<td>9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Springs</td>
<td>23</td>
<td>6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanks</td>
<td>38</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewers</td>
<td>1</td>
<td>&lt;1%</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Total number of villas:** 372

The recorded number of springs associated with villas is very low considering the abundance of springs in Britain. The main reason may be that excavation did not generally extend outside the villa building areas, and probably also because the excavators were not particularly concerned with the water supply problem of villa sites. The number of tanks are also low. The sewer that is indicated at Great Witcombe is queried and I wonder if it was not an elaborate drain referred to as a sewer.

The relatively low number of villa sites (about 5%) where remains of wells have been found compared to the postulated order of 2000 (Scott 1993, 5) seems unrealistic. If the number of villas with wells are compared with nucleated settlements with wells, the difference also seems unrealistic. To what extent there were real differences in many of the farmstead settlements and the minor villas would require special study. One of the reasons why the figure for wells at villas is low relates to the past history of villa excavation, which has concentrated on the main building and its mosaics, and other features. Rarely has extensive excavation been carried out around villas, investigating subsidiary structures, yards and associated features such as wells and aqueducts (Hingley 1989, 55).

Some villas had relatively large bath complexes such as at West Park villa near Rockbourne with 2 baths and 2 wells\(^{16}\), and Northleigh had 2 baths and 3 wells. At Fishbourne villa (palace) an aqueduct was found (Britannia 25, 1994, 289). It is likely that at a number of sites where at present there is no evidence of water supplies, future excavations may discover such features.

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Figures 5.9 (Rockbourne) and 5.10 (Great Witcombe) show villas with their baths and it is clear that they are much less complex than the larger baths, but they still have some of the main elements of the larger baths such as the caldarium, tepidarium and the frigidarium, and the usual hypocaust. Great Witcombe is a large villa with an original bath complex in the west range dating from c. AD 250-270, and a second more complex bath-suite was added c. AD 270, which lasted till c. AD 400. This bath had a hot water tank which supplied heated water to the hot plunge bath next to it. There are existing springs above the site, which may have been the source of a water supply to the villa during the Roman period. Excavations at Bignor villa, with two bath-suites (Frere 1982) and two fountains have so far revealed no water supply. There appear to be no springs nearby which could have been a source, though any springs that may have existed could have disappeared because of intensive cultivation in the area. At this site there are large areas which have not yet been excavated, so that its water supply may yet be found during the ongoing excavations.

7. SITES WITH COMBINATIONS OF BATHS, AQUEDUCTS AND WELLS.
The relationship between baths and their water supply was an important aspect, but about which there is uncertainty in many cases for all types of sites. Below the implications of associated features at sites are discussed.

7.1.1 Combinations of water-related features at military sites.
The table of Appendix 1 shows that at many sites several different categories of water-related features were found at the same site. Table 6.8 gives a summary of water-related features at forts and shows various combinations of features. There are other groupings, but I have chosen the ones listed below which had a special interrelationship with each other.

More than half the fort sites with baths also had aqueducts, whereas only about one quarter of the forts had both baths and wells. This may suggest that the army preferred to have a running water supply rather than relying on wells. Nearly half the listed forts had aqueducts of one or other kind, which contrast with only 31% with wells and 61% with baths. These figures seem to indicate several anomalies, which are discussed below.
Table 6.8: Combination of water-related features at military sites

<table>
<thead>
<tr>
<th>Feature (Abbreviation)</th>
<th>Count</th>
<th>Percentage</th>
<th>Feature (Abbreviation)</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueducts (AQ)</td>
<td>66</td>
<td>48%</td>
<td>AQ + BA:</td>
<td>45</td>
<td>33%</td>
</tr>
<tr>
<td>Baths (BA):</td>
<td>85</td>
<td>61%</td>
<td>AQ + W:</td>
<td>16</td>
<td>12%</td>
</tr>
<tr>
<td>Wells (W):</td>
<td>43</td>
<td>31%</td>
<td>BA + W:</td>
<td>26</td>
<td>19%</td>
</tr>
<tr>
<td>Wells only:</td>
<td>26</td>
<td>20%</td>
<td>AQ + BA + W:</td>
<td>14</td>
<td>10%</td>
</tr>
<tr>
<td>Pipes (WP):</td>
<td>28</td>
<td>20%</td>
<td>AQ + WP:</td>
<td>27</td>
<td>20%</td>
</tr>
<tr>
<td>Tanks (T):</td>
<td>32</td>
<td>23%</td>
<td>AQ + W + WP:</td>
<td>9</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TA + W:</td>
<td>19</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AQ + TA:</td>
<td>23</td>
<td>17%</td>
</tr>
</tbody>
</table>

Total number of forts with water-related features: 137

Total number of sites with aqueducts: 134

The probability must be high that most auxiliary forts with baths had running water supplies. Along Hadrian's Wall, the forts at South Shields, Benwell, Halton Chesters (with an elaborate bath), Corbridge, Chesters, Vindolanda, Great Chesters and Birdoswald, all had aqueducts. It would therefore be unusual for the forts at Wallsend, Rudchester, Carrawburgh, Carvoran, Old Carlisle and Bowness-on-Solway also not to have had running water supplies. Housesteads was an exception because of its high elevation. There are indications that the forts on the west coast at Beckfoot and Maryport had aqueducts, but positive evidence is lacking. On the Antonine Wall there are also forts with aqueducts at Inveresk, Mumrills and Balmuildy, but at the forts of Crammond, Falkirk, Rough Castle, Castlecary, Cadder, Bearsden and Duntocher (there is a suggestion of an aqueduct here) only baths have been recorded. Again, why not aqueducts at these sites? The same situation probably prevails at many of the other forts. The lack of consistent distribution of water-related features seems to indicate that fort excavation has generally concentrated on the defences and internal buildings. Structures such as aqueducts in the surrounding areas may therefore in many instances not have been investigated even if their remains are still extant.

Of the 43 listed forts that had wells, 16 (12%) of them were also associated with aqueducts, so that 27 (20%) listed forts had only wells as a means of water supply. The data indicate that about one third of the forts had wells, but, again, since few sites have been extensively excavated, it is likely that many more wells may originally have existed at fort sites. Only 9 forts are recorded in the database with wells not associated with either baths or aqueducts. Nine forts (7%) were associated with aqueducts, wells and
water pipes. The pipes could well have been part of the aqueduct systems. Thirty two (23%) forts had tanks of which 22 (16%) sites were associated with aqueducts and 16 (12%) with wells. Five forts and a fortlet had tanks which were not associated with any other form of listed water supply. This indicates to me that these forts would have had either wells or aqueducts, if not both. Three of these tank sites were associated with baths and therefore strengthens the impression that they should have had water supplies.

Remains of 85 baths were found at forts (61%), but only 45 (33%) sites had both aqueducts and baths. This indicates that 39 of the listed forts had baths without running water. Twenty-two forts had both baths and wells, and only 13 had baths associated with both aqueducts and wells. If the actual bath tubs (labra) were not too large then well water supplies would have been adequate. However, forts would usually have had bath complexes that were large enough so that they could provide bathing facilities for anything from about 80 to 500 soldiers, suggesting that baths would have had to be more than mere tubs. At a number of forts, baths were located in the associated vici, though no doubt these were used primarily by the soldiers, but perhaps also by the inhabitants of the vici. Some praetoria would have had bath arrangements for the commander, but these do not seem to have been listed separately as baths at forts. Some of the smaller forts did have internal baths for the soldiers, but they do not seem to have been large and could have had their water supply from wells. However army policy would seem to have favoured running water supplies, especially at fortresses and larger forts with baths.

The 45 sites that had both baths and aqueducts at military sites seem to confirm that aqueducts were the preferred form of water supply, though there are still a large number of sites listed in the database where evidence for both baths and aqueducts is lacking. Wells are poorly represented and this is surprising, because I believe that many more forts would have had them and especially if a site also had a bath.

7.1.2. Combinations of features at villas.

Table 6.7 also shows combinations of different water-related structures for villas. Two-thirds of the villas that are recorded to have had aqueducts also had baths, and this may indicate that the baths were quite substantial or the owners of these villas were wealthy. The relatively low figure of 55 sites (18%) with both baths and wells, considering that both features by themselves represented
high numbers for villas, probably indicates the selective excavation of remains.

In the database 24 villas had aqueducts of which 16 had baths associated with them. Nineteen settlements are listed as having had aqueducts, but only 4 are associated with baths. By contrast, I have found only 8 listed small towns with aqueducts and 5 associated with baths. I discuss the implication of this anomalous situation for the settlements and small towns below.

7.3. Analysis of combinations of water-related features.

For the seven site types Table 6.2 shows the number of sites with the eight typographical features recorded in the database and also combinations of these. Some of the combinations do not have particular interest, however the combinations of aqueducts and baths, wells with baths and aqueducts with wells or the combination of three structural types are significant, because they suggest some anomalies in the archaeological record. What also is of interest are the numbers of sites which do not have any of the above mentioned combinations by calculating the difference between the total number of sites of a particular feature and a combination of two feature types. The difference will give the number of sites with the chosen feature.

Table 6.9 shows a summary of some of these combinations and also other associations.

<table>
<thead>
<tr>
<th></th>
<th>Forts</th>
<th>Coloniae</th>
<th>Municipia</th>
<th>Civitas</th>
<th>Small</th>
<th>Settlements</th>
<th>Villas</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ + BA</td>
<td>45</td>
<td>3</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>AQ + W</td>
<td>16</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>AQ + TA</td>
<td>23</td>
<td>2</td>
<td>-</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>AQ + WP</td>
<td>27</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>-</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>BA + W</td>
<td>26</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>18</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>BA + TA</td>
<td>24</td>
<td>2</td>
<td>-</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>W + TA</td>
<td>19</td>
<td>2</td>
<td>-</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>AQ+BA+W</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>AQ+WP+W</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>

The combinations of features are particularly clear for forts and villas, but is applicable for all the data. For instance, using the data from Tables 6.2 and 6.9 for forts, and calculating differences
by taking associations of two features at a time from amongst aqueducts, baths and wells, and subtracting the number of sites with that combination from the total number sites of each type, will give the number of sites with each feature. There are 6 permutations for the three features:

\[(1)\quad AQ_{\text{total}} - (AQ+BA) = AQ_{\text{only}}, \text{ i.e. } 66 - 45 = 21, \text{ and}\]
\[BA_{\text{total}} - (BA+AQ) = BA_{\text{only}}, \text{ i.e. } 85 - 45 = 40;\]
\[(2)\quad BA_{\text{total}} - (BA+W) = BA_{\text{only}}, \text{ i.e. } 85 - 26 = 59, \text{ and}\]
\[W_{\text{total}} - (W+BA) = W_{\text{only}}, \text{ i.e. } 43 - 26 = 17;\]
\[(3)\quad AQ_{\text{total}} - (AQ+W) = AQ_{\text{only}}, \text{ i.e. } 66 - 16 = 50, \text{ and}\]
\[W_{\text{total}} - (W+AQ) = W_{\text{only}}, \text{ i.e. } 43 - 16 = 27.\]

The same calculations can be made for the villa data, for example, for features of aqueducts and baths, the following information is given:

\[24AQ_{\text{total}} - 16AQ+BA = 8AQ_{\text{only}}, \text{ and } 305BA_{\text{total}} - 16AQ+BA = 289BA_{\text{only}}.\]

In summary, Table 6.10 for forts and villas shows the differences between the associations and the totals for aqueducts, baths and wells. The last column shows the totals of each type of structure. The associations for the other sites are not as significant as for forts and villas.

There are other associations, such as combinations of all three features, that is AQ+BA+W = 14 in the case of forts. The calculations will be similar to those for only three associations, so that the number of forts with AQ_{\text{only}}, BA_{\text{only}} and W_{\text{only}} will be 52, 74 and 29 respectively.

**Table 6.10: Number of fort and villa sites with aqueducts, baths and wells only.**

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forts:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AQ_{\text{only}}</td>
<td>21</td>
<td>BA_{\text{only}}</td>
<td>59</td>
<td>AQ_{\text{only}}</td>
</tr>
<tr>
<td>BA_{\text{only}}</td>
<td>40</td>
<td>W_{\text{only}}</td>
<td>17</td>
<td>W_{\text{only}}</td>
</tr>
</tbody>
</table>

| **Villas:** |        |        |        |        |
| AQ_{\text{only}} | 8      | BA_{\text{only}} | 250   | AQ_{\text{only}} | 19    | AQ_{\text{total}} | 24    |
| BA_{\text{only}} | 289    | W_{\text{only}} | 49    | W_{\text{only}} | 300   | BA_{\text{total}} | 305   |

W_{\text{total}} | 104    |

Tables 6.9 and 6.10 show that there are anomalies in the excavated data for forts and villas, and would also apply to the other site.
types, but not sufficient data is available for them to make this type of analysis meaningful. For forts the figures indicate to me that there is information missing in the record I traced, because it is unusual that in group (1) 45 sites should have had both aqueducts and baths, but 21 sites had only aqueducts out of the total of 66. Similarly, 40 sites had baths only while there were 66 aqueducts and 85 baths recorded. The same questions are applicable to group (2): 26 sites were recorded as having had both baths and wells, yet out of the 85 baths and 43 wells recorded, 59 had baths only, and 17 had wells only. For group (3): 16 sites had both aqueducts and wells, but only 50 sites had aqueducts and 27 had only wells. Although this analysis is based only on the sites I traced, it shows the biased nature of the data. Of the 137 military sites recorded in the database, at 71 no aqueducts were found and at 94 no wells were found, indicating that at more than half the military sites no water supply had been found. There is clearly data missing, even if it is argued that for some of the sites water could be obtained from a spring or stream. At only 10 forts were springs recorded. It would have been out of character for military sites not to have had provision for some specific water supply. These 137 military sites represent only about half the known number of sites, which would imply that only about a quarter of the known sites had aqueducts and about one third had baths. This seems doubtful, but difficult to prove in the absence of archaeological evidence.

The information for villas in Table 6.10 also shows that there is a lack of data in the archaeological record which can be due to some of the reasons given in section 2.2. Of the 305 villas sites where baths were recorded 289 sites were not associated with aqueducts and 250 were not associated with wells. Also, 182 (305 -(104+19)) were not associated with both aqueducts and wells, which shows that more than half the villas listed in the database had no water supply, unless they all were supplied by springs, which are then also grossly underrepresented in the database.

This type of analysis can be done for all the other types of sites, but they will not be as obviously significant because of the small numbers involved. Clearly the record, based on the available information, indicates that there are many anomalous gaps in the record, which needs to be investigated further.
A discussion of the geographical distribution of water-related features follows.

8. AQUEDUCTS

The data indicate that aqueduct water supplies to military sites in Britain were common (48% of my sample), indicating a rational military planning approach to water supply for forts. Forty-five of the listed 66 forts with aqueducts were located in the northern half of Roman Britain (Fig.6.1), where much of the army was deployed especially from the early second century AD onwards. The highest concentration was associated with Hadrian's Wall. The remaining military sites with aqueducts were all located south of Hadrian's Wall. The other types of sites with aqueducts were geographically mainly concentrated south of the military zone. A possible conclusion is that aqueducts were rare in the initial phases of the conquest, and much more common in the long-term military deployment, and at civil settlements during the century after the conquest.

Where aqueducts formed part of the water supply system of fortresses and forts, they would have been constructed soon after the sites became fully operational. A number of these would date from the Agricolan period during the later first century, but those along Hadrian’s Wall would have been constructed between c.AD 122-38, such as the aqueducts at Chesters, Great Chesters and Halton Chesters. The chronology of the fort at Vindolanda is fairly well attested because of the numerous writing tablets that have been recovered in the last two decades. The first timber fort at Vindolanda appears to have been constructed c. AD 85, and rebuilt twice in timber from about AD 95 to 102. When Hadrian's Wall was started the fort was again rebuilt (c.AD 122-30) and was capable of housing 1,000 men. It may have been during this period that the stone channel aqueduct to the fort was constructed (Birley 1931, 188; Hodgson 1840, 195), but there is no firm evidence to confirm this date. During the early AD 140s the first stone fort was constructed on the same site, but it was smaller than its predecessors. A probable reason why the forts were reconstructed so often was that the wood did not last for more than about 10 to 20 years. Around AD 220 the fort was rebuilt for the last time, which is the remains that are now visible. It seems that at this time a civilian population also grew up outside the western wall and a mansio with a bath was also constructed, which obtained water from a tank at the terminal end of the aqueduct and from a well near the tank.
Aqueducts were found at 16 (of the major town sites out of the 20 listed (4 coloniae, 2 municipia and 14 civitas capitals), which with the 66 at forts, accounts for 61% of the total number of sites where they were found. The proportion of sites with aqueducts at all the known forts (341) and major towns (20) amounts to 22.7%. As mentioned above (p.225), it is considered that many more forts would probably have had running water supplies, so that the 22.7% proportion at both forts and major towns underestimates the likely real situation.

In contrast to forts and major towns, comparatively few small towns, settlements and villas have been listed as having had running water supplies, representing only 8% for all those site types (650) in the database.

The small number of only 8 small towns with aqueduct remains (Fig.6.3) is low considering that 30 sites had baths. Of the 97 listed small towns (Burnham 1986, 187), 8 had aqueducts and 52 had wells, of which only two were recorded as having had both. A number of small towns had mansiones for which well water supplies would have been adequate, as is suggested by the 18 sites at which both wells and baths are recorded whereas only 5 sites had both aqueducts and baths.

Settlements also had a low number of aqueducts (20), but that is to be expected. I have not included aqueducts for agricultural purposes.

The 24 villas (6.5%) that had aqueducts also indicate a low proportion and that aqueducts were not the normal form of water supply to villas, since only 6.5% of the 372 listed villas had them. It is likely that only the more prosperous owners would have gone to that expense. However, whether the low figure represent the real number of villas that would have had running water supplies is uncertain. Many villas may have been sited to exploit localized spring sources, requiring only minor constructions to canalise them and thus leaving little or no trace archaeologically.

To what extent private home owners in Romano-British times had access to running water supply is not well established. The most common water supply to private establishments is wells as is found at Caerwent, London and Silchester. Even at towns which had aqueduct water supplies as at Dorchester and Wroxeter, wells have been found at private homes.
As elsewhere in the Empire, running water supplies appear to have been limited to only a small number of the richest houses.\textsuperscript{17} I have found only 22 sites with running water supply to private establishments for Roman Britain, for example such as at the villas of Woodchester (Clarke 1982, 216-7) and Fishbourne. In the detailed excavation report on the houses in Roman Cirencester there is no comment on water supply for the houses investigated (McWhirr 1986). The house or villa at Colliton Park in Dorchester probably had a running water supply, presumably coming from the distribution conduit branching from the Dorchester aqueduct, and it also had a well.\textsuperscript{18} Many rural sites in Britain were probably privately owned, like the villas and farming settlements along the Lower Nene valley river system (Jones & Mattingly 1990, 248, Map 7.13), which would not generally have had aqueduct water supplies.

9. BATHS.

Baths were the most common single type of water-related structure in Roman Britain (and also one of the most archaeologically visible), representing 60.3\% of the total number of recorded sites in the database. Not unexpectedly 62\% of military sites had baths, and a quite staggering 82\% of villas had them.

The distribution of the 85 fort sites with baths is grouped in three regions: the Scottish region north of the Tyne-Solway isthmus, a band in the frontier zone concentrated around Hadrian’s Wall, and the remaining sites spread widely south of this zone.

Thirty of the 66 small towns listed in the database had baths, and it is likely that most of the others had baths too. Only 5 of the sites with baths are associated with aqueducts, whereas 18 sites had both baths and wells, which seems to confirm that wells were the more commonly utilized water supply. Except for Corbridge, all the small towns with baths, wells or aqueducts were situated below the Humber-North Wales axis.

Eighteen villa sites in the database indicate two baths and three sites, Grimstead, Littlecote Park and Northleigh, had three baths.

\textsuperscript{17} For example at Rome and Pompeii, and Ptolemais in Libya (Ward-Perkins 1986, 109-53) and Volubilis in West North Africa (Wilson 1995, 52-6). Wilson comments on the importance of social status that provision of running water supply brings to owners of houses.

each, though at none of these have any form of running water supply been found. At Grimstead the only water-related structures recorded are the three baths, whereas both Littlecote Park and Northleigh had in addition three wells each.

10. WELLS

Some aspects of the problem of wells at forts have already been referred to in relation to associations with aqueducts and baths. Many forts had at least one well in the *praetorium*, but it hardly seems possible that it would have supplied all the water required for the establishments of 500 and 1000 soldiers. At 18 of the 43 forts where wells have been found more than one well has been recorded: 4 had 2 wells, 3 had 3 wells, and 5 records merely show more than one well. The fort at Templeborough had 5 wells, and Derby and the Lunt each had 6 wells, while Newstead had a record 107 wells/pits already discussed. The *coloniae* had wells which may have been dug when they were still fortresses. The 43 fort sites where wells have been found underestimate the number of forts which would have had wells.

Wells were found at all four *coloniae* and the two *municipia*, and at 10 of the *civitas* capitals, and the implications associated with their water supplies have been discussed above. For the *civitas* capitals 7 out of the 14 sites had aqueducts associated with wells and 9 sites with wells were associated with baths. At some of the *civitas* capitals very few wells were found in contrast to those at Caerwent (16), Silchester (76) and Wroxeter (17). There are several reasons why wells may not have been found, such as unsuitable geology and therefore the hydrology of the site, hence a greater reliance on aqueducts, springs, river water and rainwater. Usually wells were of a sufficient depth that they would have been difficult to destroy completely by human activity other than quarrying, so that remains of many wells still remain to be discovered.

Table 6.2 shows that wells were the most important form of water source at small towns (52), settlements (135) and villas (104), and this trend would likely be even more pronounced if more data at sites on wells were available. Aqueducts clearly were not the preferred water supply for villas, indicated by only 24 sites that had them whereas 104 (28%) wells were found, but even this is unrepresentative for the large number of known villa sites. Many villas with wells seem to lie in a broad band along the Jurassic Ridge from the East Midlands to the Gloucester/Cirencester area (Fig.6.15). Whether there
is any specific significance in this distribution is not clear, other than that limestone deposits are often water-bearing because of their fissured nature. But the spread of other villas indicates that there are other environments, and other factors which must have determined their localities. Comparing the distribution of the 305 baths listed (Fig.6.10) with that of wells, the spread of sites is more even and more dense south-east of the Severn River/East Midlands axis. The distribution of all villas would be much more densely spread if the assumption is made that many more sites would have had wells and baths, which seems to be confirmed by the data of Table 6.10 for the limited sample of sites in the database. There were 182 villas with baths which were not associated with either wells or aqueducts. It seems to me that there were many sites that had both baths and wells but they have not been found for any one of the reasons given in section 2.2. Springs may have been an important source of water for many villas, but they have also not been recorded, and the conduits linking them have disappeared.

The distributions of sites with wells for forts, small towns and settlements (Figs.6.11, 6.13, 6.14) also indicate that they were topographically uniformly distributed over Britain when compared with the distribution of all sites for Roman Britain. Comparing Fig.6.11 with Fig.12 (Millett, 1990, 47) for forts and Fig.6.13 with Fig.61 (Millett, 1990, 143) for small towns, indicate that these sites with wells were also uniformly spread over the landscape, so that it would be reasonable to assume that many of the other sites were also likely to have had wells. This also applies to the civitas capitals. The distribution of Romano-British settlements is uniformly spread over the whole of Britain and Fig.6.14 showing settlements with wells match this uniform spread. So it is reasonable to say that many of the sites where no water supply has been found are very likely to have had wells but they remain undiscovered.

11. WATER PIPES

Considering the total number of sites listed in the database, the 84 sites listed with water pipes is very low. Water pipes were associated with aqueducts and distribution systems within forts and towns, and are also found at settlements and villas. The materials for pipes (see Chapter 2.5.5 and 1c-f p.30) were wood, lead, ceramics and stone. Stone pipes were not used in Britain, presumably because of cost and the skill required to manufacture them. Ceramic pipes were used as aqueducts at Chester, Lincoln and Netherby, and were
also found at Bath, Chichester, Inchtuthill, and Newstead. Evidence of lead pipes were found at 7 sites and lead would appear to have been used to repair other forms of pipes. Lead pipes were most commonly used in inverted siphons (but apparently not in Britain) and often encased in concrete, probably because they could be hermetically sealed (difficult to accomplish with other forms of piping), which was important for pipes forming a pressure system. It was also an expensive material to use and costly to manufacture pipes. Lead pipelines are reported for Beaufort Red House, Carpow, Chester, Hardknot Castle and Winchester, and for internal distribution at Caerleon, Chester and York (Stephens 1985b, 223-9).

Wood was the most common form of pipe, partly because it was readily available and relatively cheap. To bore out lengths of wood 1m to 3m long must have been quite an art, because the drill bits are inclined to wander off-line during the process. At several sites in the record it is mentioned that a stone channel carried a wooden pipe aqueduct. Stephens lists 20 sites where wooden pipes were used either as aqueducts or in the internal distribution systems (1985a, 198-202; 1985b, 222-30). He listed only pipes at towns and forts, whereas pipes have also been found at 3 small towns, 8 settlements and 34 villas.

Distribution water pipes must have been one of the most vulnerable features on all types of ancient sites because of the continuous phases of reconstruction of structures along street fronts where piping existed. Wooden pipes would generally have had a limited service life before they needed replacement and evidence has been found of repairs to wooden pipes, as at Caerwent (Chapter 2, p.26). Lead piping would have been robbed for its material value. Later development would also have removed traces of piping, hence the comparative lack of evidence of internal distribution pipes. Where they do occur they suggest that a running water supply existed, but it has been difficult to associate some of these distribution systems at sites that also had aqueducts. At Wroxeter where distribution pipes have been found and it is known that the town had an aqueduct, it has not so far been possible to directly link the two systems.

12. TANKS AND CISTERNS
The terms cistern and tank do not seem to be used consistently in the literature. Hodge defines a cistern as a masonry tank used to store rainwater either from roofs or from surface run-off. However tanks
were also constructed of wood (Beauport Park and West Wickham), and wooden-lined (Chichester and Littlecote Park), and in lead (Ashton and Icklingham), and at Gatcombe a metal-lined tank was found. Tanks for rooftop catchment (and wells) may have been used predominantly to store drinking water. They were built above ground level or immediately below and were usually either round or oblong, fed from the top (1992, 58). In Roman Britain tanks were as a rule above ground level both at forts and elsewhere, however some sunken tanks have been reported, such as at Lyne.

At Colchester five tanks have been found, two clay-lined tanks were at private dwellings outside the Balkerne Gate (Report 3, 1984, 141-2), and three are reported at building sites inside the colonia in Report 6 (1989): a timber-lined tank (89-90, Fig.3.48), a tile-lined tank (89, Fig.347, 255), and a lead-lined tank (355-6). This variety of tanks at one site is unusual. Figure 4.8 shows a timber-lined water tank from London.

Tanks cannot really be regarded as primary water supply sources, except perhaps those in some of the minor forts and milecastles on Hadrian’s Wall and poorer class housing, where the volume of water demand was comparatively small. However some tanks have been found that were at the terminal end of a running water supply, such as the very large tank at the North Wall Gate of the Lincoln upper colonia. At Housesteads fort, five tanks were found of which one was a well preserved large tank associated with the latrine at the south-east angle. Roof-top runoff was probably a major means of filling the tanks. The fort at the Lunt had 15 tanks of which some were probably filled from rooftops for drinking water supply.

The more simply constructed tanks in Britain where they were at the terminal end of an aqueduct, served the same function as the castellae of towns in Gaul, Italy, Spain and North Africa. However their relatively small capacities did not allow for back-up storage if an aqueduct was damaged or out of service.

Tanks used as catchment for rainwater were probably more common than the archaeological record indicates because excavators cannot always be sure whether a tank near a building received its water from a rooftop. Although 102 sites with tanks have been listed in the database, 70 of them were at forts (32) and villas (38), the remaining 32 were divided amongst all the other site types, they are under-
represented in the record. Daily availability of water must have been an absolute necessity at forts, certainly for drinking and cooking purposes, so that the lack of evidence of more fort sites with tanks indicates a problem of tank survival. Similarly, of 212 settlement sites recorded in the database only 16 had tanks, with no obvious indication from the evidence that the less Romanized sites such as farmsteads and minor villas had tanks. This may be due to insufficient site exploration or poor preservation of tanks at these sites. However it cannot be ruled out that stored water in tanks may have been a normal source for the smaller settlements and villas. Before the construction of structures in stone became the accepted construction material in Roman Britain it is likely that water was stored in clay-lined pits or in some form of ceramic container. Wooden barrels could also have been used extensively as water butts, but would normally leave no traces in the archaeological record.

13. DRAINS AND SEWERS

Drains in towns can be broadly classed as street drains and drains which removed water and waste products from domestic properties. However at some sites drains are shown to cut across a plan of a site, which is interpreted as belonging to an earlier phase of the site. Remains of drains have been found at most site types. They were used for the control of run-off from buildings, squares and roads, and excess overflow from fountains, waste water from baths and often from latrines, especially where no sewers existed for that purpose, and from domestic waste water outlets. Whether they were called drains or sewers depends largely on how the excavator defined drains. Generally a drain would be used to remove surface water at ground level. Drains from homes, baths and latrines often were channels covered with stone slabs, and they often discharged directly into street drains19. This is an indication of a lack of understanding of basic hygiene principles as we understand them, which is surprising considering the desire to bath regularly and to have clean water from spring sources.

Drains were recorded at 179 sites. Remains of drains are usually found in association with baths and latrines, and between barracks in forts. In towns, drains sometimes were in the centre or along the sides of streets. Forts would have had a network of drains, especially at Chesters which also housed a cavalry unit.

19 Etienne 1960, pl.II; Adam 1984, 262, pls.612, 613).
Sometimes drains were stone-lined and covered with slabs, especially along town streets and in forts; plank-lined drains have been found at London, Melandra, Strageath and Verulamium. At Corbridge the remains of elaborate stone channel drains were found along both sides of Dere Street, and the Stanegate running through the town. When drains were along the centre of streets they were sometimes provided with a kind of stone grating with openings cut into a paving slab so that water can flow directly into the drain below. A number of such gratings have been found, examples of which are shown by Hodge, including a grating slab from Housesteads (Hodge 1992, 342, Fig.238). It is likely that most of the sites where drains have not been recorded, had some form of drains but they have not been found or shown on plans, most probably because they are no longer visible.

Roman sewers were generally major structures and have been traced at 20 sites. They are recorded as having been found at most of the site types, but sometimes it is not clear whether the excavator actually referred to the major sewer type of arched structures, such as found at Caerleon, Chester, Lincoln, Verulamium or York, or to large open drains. For instance at Great Witcombe villa a sewer is mentioned, but it is probably a large drain. Hanson (1970, 254) refers to the “stone-built latrine trench or sewer, 3 feet (0.9m) wide by 2.5 feet (0.75m) deep” at Housesteads. This is an open drain and not a conventional sewer. Sewers were usually closed structures, but this is not always clear from reports.

Dating construction of sewers in towns is a problem, because they were often cleaned out, so that datable finds of pottery or coins may not necessarily reflect the earliest deposits in the sewers closer to the time when they were constructed. The sewers at Caerleon, Chester, Colchester, Lincoln and York were major underground arched stone structures large enough for them to be inspected and cleaned out by maintenance workers. At York, the remains of an elaborate main sewer system with minor sewers along side streets received run-off water and sewage from side drains, presumed to be house drains, which in turn discharged into a main sewer as shown in Fig.5.12 (Whitwell 1976, 4-5, Figs. 2 & 3). The plan (Whitwell, 1976, Fig.3) shows the main sewer (which was high enough for a person to walk through) and its branch lines. The sewer system, probably constructed during the early part of the 2nd century, was modified by AD 170, because of problems associated with flooding of the River Foss, into which it is suggested the outfall of the sewer is likely to have discharged.
Branches 2 and 6 of the sewer may have formed part of the draining system of the baths about 40m south of the main sewer.

The remains of the main sewer at Lincoln now lie buried below the present Bailgate, (Wright 1852, 235-6). Plans of the sewer system usually show two branch sewers running into the main sewer (see Fig. 6.19) and one sewer parallel to the main sewer along a street to the east of Ermine Street. Figure 6.22 shows a sketch T. Wright made of the sewer and the linking sewers from cross-streets (Whitwell, 1970, 33, Fig. 2). Lincoln became a colonia during Domitian's reign (AD 81-96), so it is likely that the sewers may have been constructed during this period or early during the 2nd century. The distribution of these sewers in the town implies that the running water supply at Lincoln was able to provide sufficient water to flush the sewers. Atkinson (1942) refers to the 'main sewer' at Wroxeter, and so do reports in Britannia (8, 1977, 323-4, 394-6; 10, 1979, 297-8). I have not been able to establish whether it was similar to the ones at Lincoln and York, or whether the reference is to the large open drain along Watling Street through the town between the forum and baths insulae.

Fig. 6.22: Sketch of Lincoln main sewer (after Whitwell 1970, 33, Fig. 2, from original by T. Wright 1852).
A probable reason could be that some sites were occupied initially for short periods before a start could be made on such large construction works, or that when the later forts were built the inclination to build such costly structures seemed less necessary. Why so few civitas capitals had sewers is also puzzling. The four sites listed all had military origins, which probably accounts for them having had sewers. Cost may also have been a factor for not building them as their funding would have had to come from the inhabitants of the towns, and sewers did not really contribute to the status of the community or town.

It is not clear to me whether the drainage channel from the spring reservoir at Bath was a sewer or an elaborate drain. Cunliffe does not refer to a sewer, but refers to a "permanent main drain from the spring" which was arched (1985, 39), and drained into the main outfall drain (p.53). Its main function seems to have been to dispose of large volumes of water from the springs. Similarly, the reported sewer at the Great Witcombe villa was most likely a major drain rather than a conventional sewer.

Table 6.11 gives a summary of the listed sewer sites.

**Table 6.11: List of sewer sites**

**Fortresses:** Caerleon, Chester, Exeter, Malton, York.

**Forts:** Chester-le-Street, Dover, Housesteads, Piercebridge, Vindolanda, Lyne.

**Coloniae:** Colchester, Lincoln.

**Municipium:** Verulamium.

**Civitas capitals:** Canterbury, Chichester, Leicester, Wroxeter.

**Small town:** Bath.

**Villa:** Great Witcombe.

The sewers were always large stone-built arched structures at some of the military sites and coloniae, but there seem to be some uncertainty about the so-called sewers at other sites, which needs to be investigated (Chapter 5, sect. 3.2).
14. CONCLUSION

The distribution of water-related features implies that many more sites with aqueducts, wells, baths and the other features are still to be found. The record also indicates that many sites have been found with some features but that associated features are missing, such as baths without a water supply. It is also shown from the limited sample of sites listed in the database that the favoured means of water supply for forts and coloniae were aqueducts. Wells were the preferred water supply at small towns, settlements and villas, although they were also found at many military sites and major towns. In some towns such as London and Silchester wells appear to have been the only form of water supply. Springs may have been more widely used as water sources at all types of sites than indicated by the record. Baths were found at sites of all types, though they appear to be underrepresented at forts, small towns and settlements, and even at villas where many sites have been found with baths, they are few compared to the known number of villas. Evidence seems to indicate that water catchment from rooftops may have been common, implying that roofs must have had gutters. Tanks were a simple and effective way of storing water, so that the low number of sites recorded with tanks seems to be unrepresentative. Water pipes at many sites indicate their wide use, but they are underrepresented in the record. Drains are also poorly represented at all sites considering the importance attached to the control of rain water and effluent. Sewers were specialized structures, mainly constructed at military sites and the larger towns.

Dating of structures has been difficult because of lack of information. Some structures, especially at military sites can be dated related to military deployment and a few inscriptions.

The main conclusion is that there are serious gaps in the knowledge relating to water-related structures.
Distribution of Aqueducts: Figs. 6.1-6.5, 239-243.

Distribution of Baths: Figs. 6.6-6.10, 244-248.

Distribution of Wells: Figs. 6.11-6.15, 249-253.
Fig. 6.1: Fortresses and forts with aqueducts
Fig. 6.2: Civitas capitals with aqueducts
Fig. 6.3: Small towns with aqueducts
Fig. 6.4: Settlements with aqueducts
Fig. 6.5: Villas with aqueducts
Fig. 6.6: Fortresses and forts with baths
Fig. 6.7: Civitas capitals with baths
Fig. 6.8: Small towns with baths
Fig. 6.9: Settlements with baths
Fig. 6.10: Villas with baths.
Fig. 6.11: Fortresses and forts with wells
Fig. 6.12: Civitas capitals with wells
Fig. 6.13: Small towns with wells
Fig. 6.14: Settlements with wells
Fig. 6.15: Villas with wells
CHAPTER 7.
SOME SOCIAL, ECONOMIC, ORGANIZATIONAL AND CONSTRUCTION ASPECTS OF WATER-RELATED FEATURES

1. INTRODUCTION
This chapter will briefly deal with some aspects of romanization and the social impact that the provision of water and water-related structures had on the Britons. The coming of the Romans to Britain introduced a new social perspective for the local people, and new systems of organizing the towns that were created specifically to urbanize the local population. In particular the organization and administration of water supplies and the public baths became integrated with the management of towns, villas and even settlements. A case study of the planning and construction of an aqueduct is discussed. Provision of water supplies did not directly affect the economy of Roman Britain but it did have financial implications. The Roman public baths were costly structures both to build, to manage and maintain, which will be considered for the British situation.

2. ROMANIZATION DEBATE
It would appear that the romanization debate for Roman Britain has taken two directions: a socio-religious approach and a pragmatic one. The first can be explained as an interaction of cultural processes and change between that of the conquered societies of the Empire and the established social order of Rome. The second deals with the material culture introduced to those societies in the form of urbanization and Roman buildings, housing, baths, water supplies and imported wares. The Romans had a long history of romanization of their widespread empire and Britain was one of the last areas to be exposed to their influence. Recent research indicates that the British, particularly in the south, were exposed to Roman goods and imports even before the conquest and their response to the material culture introduced by Rome followed a natural development of their own culture as they encountered the newly imported romanized cultural influences. After the conquest romanization became a subtle form of acculturation brought about by the exposure of communities that had come under the commercial or political influence of Rome, and the importation of many material culture products that directly or indirectly were of Roman origin (Haselgrove 1984, 20). Baths and running water supplies were introduced to Britain as new forms of

1 Brendel 1979.
material culture, unfamiliar to Britons. As Britons became exposed to these aspects of Roman material culture, they gradually adopted it to improve their standards of living and adapted their own traditions and cultural values in order to benefit from the material changes brought to Britain by the Romans, as illustrated by the many small towns and villas found south of the northern military zone.

Burnham poses three key questions relating to this process of romanization: "(i) how did the process of interaction and romanization work? (ii) how did things actually change under Roman rule? and (iii) how deep did the veneer of romanization percolate?" (Burnham 1995, 121). The Romans actively "promoted town growth as the focus of self-government" and they expressed this through the provision of public buildings and amenities, including baths, water supplies and sewerage systems (Burnham 1995, 122). Rome exploited the political divisions within the indigenous British tribal communities, but was careful not to break up the existing social structures unless security demanded it (Haselgrove 1984, 6). It in fact started in the early 1st century BC, and received impetus under Julius Caesar's invasions of Britain and by Augustus' policy of diplomacy during the period of indirect contact, which was "'romanization' at a remove" (Haselgrove 1989, 22). When direct contact was eventually established by Claudius' conquest, more substantial acculturation in the form of Roman building programmes manifested themselves on the British landscape. The public buildings of civitas capitals, for instance, were a manifestation of what Rome saw as the romanized cultural expression of how they intended the Britons to perceive their newly established civitas centres. I do not intend to enter into a profound discussion of the romanization process, but Burnham's second question is relevant to the provision of water-related structures and is recognized as part of the material changes the Romans offered to the Britons in order that they would accept more readily the occupation of the country. The Britons, especially the élite, did absorb some of the material aspects that the Romans introduced, such as stone buildings for their homes, baths, aqueducts and wells.

Keith Branigan (1994, 9-16) comes out strongly in support of the theory that the amenities which the Romans introduced during their

3 Haselgrove, 1989, 17-30, and nos.16-22, provides an analysis of the so-called 'romanization' process before and immediately after the conquest period. The whole process of romanization is very complex, but it is evident that the acculturation of the British (and the Gauls) was a deliberate process, without it being enforced by coercion, as an expression of Roman values for their hopeful adoption. In large measure the romanization was achieved at certain levels and may have changed the lifestyles of Britons in many respects, but did not change them into Roman Britons.
establishment of forts, towns and civitas capitals created a new outlook for the British people, which they seem to have adopted readily. This was particularly evident from the many elaborate homesteads and villas that spread over southern Britain amongst the élite, a kind of self-romanization. The poorer Britons may not have responded to the romanization process with equal enthusiasm, since they could not escape entirely from having contact with the Romans, mainly because of their obligations for the taxes demanded by the occupation power. Even so the construction of Roman forts, stone housing, temples, baths, aqueducts and fountains must have had a profound effect on all the local people in spite of them adhering to much of their own cultural traditions.

Clarke, commenting on the analysis of the data from the fort at Newstead, comes to the conclusion that "On Britain's northern frontier the gulf between material cultures of these (Roman and native) is so great as to make the distinction between military and civilian, seem petty. In reality it can now be seen that there is no such thing as Roman society, or Roman culture, but rather many sub-cultures each with its own aspirations and values" (1995, 81). There was no policy of separation between Romans and Britons, but there may have been selective differences between their cultural practices. Gildas writing at the end of the 5th century made it clear that Britons and Romans remained separate groups throughout the period of Roman occupation (Jones 1996, 9), which is confirmed by Zosimus' writing in the 6th century. Nevertheless, however separate the two groups may have remained culturally in some respects, the material culture aspect at a pragmatic level contributed to the romanization process as the British adapted to stone housing, Roman baths and running water supplies. Villas were probably the clearest expression of this romanization process during the 3rd and 4th centuries, when villas were transformed into large houses. The new owners built elaborate baths richly decorated with paintings and mosaics at great cost, indicating a considerable increase in wealth and social status.

When the Romans departed early in the 5th century the Britons discarded the Roman influences as the Anglo-Saxon invaders imposed new cultural values on a decentralized nation without a unifying leadership.
3. ORGANIZATION AND ADMINISTRATION OF WATER SUPPLY PROJECTS

In the absence of literary or epigraphic information on the organization and administration of towns in Roman Britain, evidence from other parts of the Empire must be used. Epigraphic evidence of a law, the *Lex Coloniae Genetivae Juliae*, setting out the charter for the *colonia* of Urso in Spain and the details of how the town had to be administered, is given in a set of tables in which various procedures were explained, such as how the *decuriones* were to make decrees regarding carrying out of public work and for the building of an aqueduct (Hardy 1912, 44, XCVIII & XCIX). *Coloniae*, *municipia* and *civitas* capitals developed from the 2nd century BC into the Empire period, their administrative structures being based on that of Republican Rome and of the Empire period, but their municipal status was ranked at a lower level than that of Rome (Abbott & Johnson 1926, 3-20). The models for those towns seem also to have applied to the towns in Britain.

Chartered towns were able to raise revenue through the *incolae* (residents) who would be liable to the *munera* (a liturgical obligation) for the town (Duncan-Jones 1960, 160, 164, 174-8), but this did not apply to *civitas* capitals. The four *coloniae* were preceded by a military presence on their sites, so it is likely that the army would have had a considerable influence on their initial construction and layout. Once a *colonia* was established it would create its own ordo and elect its own municipal officers to administer the town, though initially the army must have been involved in their planning and layout. Whether the army was ever involved in the construction of the aqueduct for the *colonia* at Lincoln is uncertain, but the quality of the workmanship of the concrete encased pipe seems to indicate considerable skill, which was readily available from the army. The indications are that Verulamium was a *municipium* and the army surveyors may have been involved with setting out its street grid, and possibly also were involved in the construction of its sewers and original street drainage (Frere 1964, 104-5). London was an unusual

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4 Hardy 1912, gives translations of several laws relating to municipalities of which the *Lex Julia Municipalis* and the *Lex Coloniae Genetivae Julia* give information on municipal administration. A set of tables was found at Osuna in Spain giving remains of the *Lex Coloniae* for the people of Urso containing the charter granted to the *colonia Genetiva Julia*, and clause XCIX deals specifically with aqueducts.

5 Abbott and Johnson gives the original surviving texts of 206 inscriptions and documents relating to the provinces on various edicts and laws issued during both the Republican and Empire periods. Many of these relate to municipalities and their administration, defining the powers of officials and how the affairs of towns had to be conducted. These were generally called *leges datae*, such as the *tabula Heracleensis* of 45 BC (no. 24) and the *lex coloniae Genetivae Juliae* of 44 BC (no. 26).
town having had a walled fort of uncertain date, but founded about AD 100 (Frere 1974 125) and incorporated into the city walls probably constructed during the 3rd century (Morris 1982, 171). There is no suggestion that the army was involved in the planning of the town, though the construction of some structures such as the basilica and the Huggin Hill baths may indicate that there was imperial involvement and hence probably the army (Selkirk 1995, 329). The fact that London had a fort within its walls complicated the question of its administration, but Selkirk suggests that it might have been a municipium and would therefore have had an ordo like the coloniae.

Ways of raising revenue by civitas capitals could have been from minor local taxes of different kinds (Duncan-Jones 1960, 160 n.8), or by benefactions from the wealthy (178-81), for the construction of public buildings and baths, including funding for a costly aqueduct. Competition between families and individuals to gain personal status in a community seems to have been important, so that elected magistrates would spend large amounts of money as benefactors to towns (Duncan-Jones 1960, 170(5.2). A town council (ordo decurionum) consisted of decuriones, who elected duoviri responsible for the organization and administration of a town (Abbott and Johnson 1968, 65). According to the Lex Coloniae Genetivae Juliae the duoviri would put a proposal for an aqueduct to at least two-thirds of the decuriones who would decide on “the lands through which an aqueduct may lawfully be brought” (Hardy 1912, 44-5, (sect. XCIX)). The duoviri appointed magistrates, the equivalent of aediles, who were responsible for running the affairs of the town, including public buildings, public baths, streets, the water supply and drainage. It would seem reasonable to assume that this model for town councils also applied to the public towns of Roman Britain and that decisions to build an aqueduct would have followed a similar procedure as that at Urso. All the civitas capitals would have been administered based on the same model as that of the chartered towns without the benefit of raising taxes for its development projects, and this would have applied to Durnovaria (Dorchester).

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6 Duncan-Jones 1990, 174-8 and 1982, 84. ‘Pliny mentions that the summae honorariae of new councilors at one town, Claudipolis, were immediately put to use in building new town baths’: 1761. Summae honorariae applied to chartered towns like coloniae and municipia. There are inscriptions from Lepcis Magna and Subratta implying very large individual contributions towards the cost of aqueducts and fountains. The town of Durnovaria must have relied heavily on private donations from inhabitants and local taxes.
3.1. Social aspects and dating of the Dorchester aqueduct water supply.

The settlement at Durnovaria became the tribal civitas perigrina of the Durotriges, c. AD 70 (RCHM(E) 1970, 534), but later, because of prosperity in the region of Ilchester, it may be likely that during the 3rd or 4th centuries there was also a civitas centre created at this town (Wacher 1995, 324). Why and when the decuriones of Durnovaria decided to build an aqueduct is uncertain. There was certainly prosperity amongst the native British during the 2nd to 4th centuries (Salway 1981, 235-8). Based on the remains of the public buildings - such as a forum, basilica, public baths and amphitheatre - the economic situation at Durnovaria was prosperous during the later 2nd and 3rd centuries (Putnam 1984, 36-8). However, the construction of a costly aqueduct (Fig. 7.1), is suggested to have taken place earlier than the 2nd century period of prosperity, even though the town already had wells to supply drinking water.

Fig. 7.1 Photo of Dorchester aqueduct near Poundbury (AB, 1994).

Dating evidence from pottery and coin finds seems to suggest that the first period leat aqueduct was constructed about two decades after Durnovaria became the civitas capital. Green (1987, 49-51) suggests 3 periods of construction of the aqueduct, based on excavations during 1968 and 1980, at least in the vicinity of Poundbury (A, Fig. 7.2a).

7 According to Bill Putnam (1984, 32-3), the Durotriges were originally not all that interested in the building of a new civitas town at Dorchester during the Flavian period, but by the 3rd century their wealth had considerably improved, as for instance, can be seen by the extensive villa of Colliton Park.
Fig. 7.2a: Poundbury Camp and aqueduct (after Green 1987, 16, Fig. 1);
Fig. 7.2b: The aqueduct channel showing the three levels of construction: 1st, 2nd and 3rd phases, (after Green 1987, 50, Fig. 23).
Dating is difficult, but is based on samian ware of the late 1st or early 2nd century found in the channel silt, and a slightly worn silver coin of Vespasian (AD 69-79) found in the diversion conduit on Colliton Park (RCHM(E) 1970, 588-9; Green 1969, 172). Samian ware was also found at one of the places sectioned along the east side of Fordington Bottom (B, Fig. 7.4). Based on this evidence, the narrow channel of the aqueduct (Fig. 7.2b) of the first phase was cut during the late 1st century. Green suggests that due to flow problems encountered soon afterwards, the aqueduct was reconstructed 0.5m higher along this section, to a different cross-section with a wider channel and steep sides, perhaps also in the late first century or early 2nd century. At a much later date the channel was again reshaped at a higher level about 0.3m above the phase 2 level. A grooved bowl dating to the 3rd century was found in layer 6 of the in-fill of the Colliton Park conduit, below the final 7th layer which was ‘certainly not complete before the 4th century’ (RCHM(E) 1970, Vol.2, 589). There seems to be evidence also for such changes at Bradford Peverell (see C, Fig. 7.4) (Green 1987, 51). This last phase may have coincided with the building of the Roman baths.

The tenuous nature of the dating evidence for the first two phases of construction of the aqueduct, raises the issue of whether a newly created civitas capital would at such an early date have embarked on a costly aqueduct. There seems to be a need to investigate this aspect because aqueducts at civilian towns seem to have generally dated from the Hadrianic period, unless perhaps there were veteran army personnel who could have provided the expertise to plan and construct a leat. Green indicates that the earthwork structures were started ‘within decades of the dereliction of the Camp’ (1987, 49), which seems to exclude military involvement. The final phase 3 aqueduct seems to date from the mid 2nd century or later.

The Romans initially created the large Durotriges civitas capital (by mid 2nd century 28 to 32ha)8 with little regard for the political division between the northern and southern groups9 and this must have created intense rivalry between families from the north and south. The northern group centred round Lindinis (Ilchester, 8.9ha) may well have been the wealthier as indicated by the number of villas surrounding it

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8 RCHM(E) 970, n.3, 533.
9 Ilchester seems to have become a separate civitas centre at a later date (Wacker 1995, 21), but see Rivet and Smith, giving the alternative views of Stevens and Bogaers (1979, 392-3). Stevens suggested, based on inscriptions, that the Civitas Durotrigum was subdivided with Ilchester as the capitol in the north and Durnovaria that of the south. Bogaers disagreed, suggesting that civitas Durotrigum simply meant “town in the territory of the Durotriges”.

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(Wacher 1995, 324). Since the initial civitas capital was at Durnovaria (32ha) it is possible that there was competition between the two groups to hold office within the ordo, as rival factions vied with each other to provide benefactions for expensive building projects to gain civic status. The material remains indicate clearly that the inhabitants of the civitas did indulge in considerable expenditure at Durnovaria to improve their social standing, material culture, and civic status, but this aspect has received minimal attention.

This would have applied to other public structures constructed during the same period. If the calculation of water delivery suggested for the aqueduct is valid (RCHM(E) 1970, 587), then much of the water gained at great expense was allowed to be wasted back into the river.

A number of questions arises when a civitas capital embarks on major building programmes such as the construction of an aqueduct. Firstly, the town did not have the power to raise funds by imposing taxes, so funding for public buildings and facilities had to be raised from amongst the community themselves. Durnovaria was one of the smaller civitas centres, so why did they indulge in excessive spending on public facilities? Secondly, did this contribute to overstretching of resources? The answer to the first question was complex, because the Durotriges community as a civitas stipendiarius also had tax commitments to the province, but as suggested above, rivalry between the northern and southern groups could have been a motivation. The Durotriges tribal area had several important LPRIA hillforts with rival élite families who had accepted the romanized building styles, but retained their former wealth and power. An important element could well have been the competition between the two groups for civic status. However, having overspent large sums of money on public buildings, baths and an aqueduct, it is possible that further sources of revenue for maintenance of these structures had become unavailable, and they slowly deteriorated until they no longer functioned effectively.

Although we have no direct evidence for Durnovaria, evidence for other towns such as London, Silchester and Wroxeter, shows neglect of many public buildings by the fourth century (Millett 1990, 130, Table 6.1). Inflation and increased tax also became significant factors during the 4th century and the decuriones became less inclined to contribute to development of cities during the 3rd century (Millet, 1990, 128, 204). Either the wealth of even the rich declined during the later 3rd century, or the northern people transferred their funding to Ilchester,
thus depriving Durnovaria of further munificence from that quarter. It may in part also have been connected with the internal political and military situation of the late third century resulting from the insurrections of Carausius and Alectus (Frere 1974, 337-40), and the troubles on the northern and eastern frontiers in the 4th century (346-8), which could have adversely influenced the markets that provided the wealth of the previous century. New demands were made on the wealth of inhabitants to provide defences, as at Durnovaria and other towns in the civitas, so that many public facilities must have suffered because of lack of maintenance. The expenditure of the earlier period in many areas of Roman Britain could not be sustained later as available resources became overstretched by channeling it into defences. The rich also spent more on providing themselves with more luxurious homes, further removing financial resources from towns and inevitably the towns declined as their buildings, water supplies and drainage deteriorated, in spite of having become walled towns. Durnovaria seems to have declined in this way during the 4th century when its public baths went out of use, probably because the aqueduct was also no longer in use.

4. DORCHESTER AQUEDUCT CASE-STUDY

4.1. Discovery of Dorchester aqueduct.

J.N. Coates first recognized the remains of the linear features of an aqueduct at Dorchester in 1902 (Fig. 7.3).

![Diagram of Coates' route of Dorchester aqueduct]

Fig.7.3: Coates' route of Dorchester aqueduct, (PDNHAFC 22, 1901, 80).
His plan shows the source for the aqueduct to be in the Church Bottom stream in the vicinity of the masonry dam at Foxlease Witkybid(?). He shows a profile for a section of what he interpreted as part of the aqueduct (marked (1) on his plan).

The leat aqueduct to Durnovaria has been investigated on three occasions, but the actual source has never been reliably located notwithstanding Foster's survey of 1922 and the re-survey of 1925 (RCHM 1970, 585). P. Foster (like Coates a major in the Royal Artillery) subsequently suggested in 1922 that the source of the aqueduct was at Notton Mill (G, Fig. 7.4), its length being about 18km (11 miles) from the West Gate of the Roman town.

Fig. 7.4: Plan of Dorchester aqueduct route (from RCHM(E) 1970, 586). Places along aqueduct are marked A: Poundbury; B: Fordington Bottom; C: Bradford Peverell; D: Penms Plantation; E: Muckleford; F: Putnam’s suggested dam wall; G: Notton Mill.

For linear features such as aqueducts and roads, it is not practical to carry out excavations in detail for their whole lengths. This has been the situation with the Dorchester aqueduct, and is one of the reasons
why the source of its supply has not been located. Bill Putnam has been doubtful that the source was at Notton Mill and has been excavating along the aqueduct since 1992, looking at some of the problems associated with the structure and trying to locate its source. Four reports have been published so far in the *Dorset Proceedings* and there is an interim 5th report relating to the 1996 excavations. Previous to Putnam’s work the aqueduct's route had been firmly established as far as Penns Plantation (D, Fig. 7.4). Putnam has now extended and confirmed the route as far as Littlewood (F), that is about 2.5km further than was previously known (Putnam 1995, 128-31). In the interim report he suggests that a dam was constructed across the Steps Bottom stream just south of the Littlewood farm buildings (F), which he suspects was the source of the aqueduct, and will be investigated during 1997. This would reduce the length of the aqueduct by about 4km, to a length of about 14km instead of the length given in the RCHM(E) article (1970, 585) of about 18km. However, in my analysis below I use the latter length.

There are a number of factors which determine the type of construction of an aqueduct, such as cost, available revenue, labour resources, suitable water source, and topography. The topography along the chosen route of the aqueduct was such that for the Dorchester aqueduct it was decided to have an open leat aqueduct, cut into soil and in places into flint rock to maintain the flow rate.

The straight line distance from the town to Notton Mill (G) is only about 9.1km (5.7 miles) (as compared to the length of 18km), indicating the tortuous route needed to provide an acceptable gradient. The fall over the total length is 7.6m (25ft) giving a slope of about 1:2400, approximately the same as suggested by Vitruvius. Level readings have been taken at selected points and the RCHM(E) article states that where the depth of the channel below present ground level is known, it shows considerable variation. It is not known whether the variation is due to "imprecise cutting rather than to cleaning or natural scouring of the channel".

It is not known who was responsible for the construction of the Dorchester aqueduct. Usually the necessary expertise was supplied by the architects and engineers in the Roman army. If the army was involved, what would have been the relationship between it and the civitas? A pos-

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sibility is that some retired army veterans with the required knowledge might have settled in the town and helped with the technical aspects related to the aqueduct. Alternatively, the town ordo might have hired qualified engineers and contractors retired from the army, or could have called in the army to assist. It is also quite possible that private individuals had also acquired the technical skills necessary for construction, and especially in surveying (Campbell 1996, 77-80). It would seem that the provincial authorities allowed the army to assist with technical help for towns if they were not occupied on military campaigns, as for instance Tacitus\(^1\) suggests that "Agricola gave private encouragement and official assistance to the building of temples, public squares and private mansions" and presumably other types of construction such as aqueducts.

4.2. Sequence of construction procedures.
We have limited knowledge of how the Romans actually set about the building of such construction projects. We can observe the remains of their finished structures and how the labourers manipulated the materials for building the structures can conjectured. Adam (1994) discusses the problem and from visible features on extant structures makes some suggestions about construction methods\(^1\) such as the erection of formwork and scaffolding. For instance, bridge structures like the Pont du Gard give indications of support points for them.

The sequence of operations during the construction phase of an aqueduct after a route has been decided is not known. For the construction of Hadrian's Wall some possible sequences of construction have been suggested, but the details are still partly obscure. We can conjecture about them by applying modern technological knowledge (itself very varied) but the reconstruction of actual Roman practice will always be highly conjectural.

There might have been other aspects of detail which would come to light only as the work progressed. For instance, if a bridge spanned a river, the operations for constructing the caissons, or for the installation of wooden piles, would have necessitated special sequences. Cutting into


\(^{13}\) Adam J-P, 1994 (English Ed.), 20-215. Adam gives many illustrations of how it is considered the Romans might have built certain structures. Many of these are based on methods drawn from the renaissance period and from modern practice with a Roman flavouring to them. In spite of this the book gives an excellent approach to how it could have been done with the simple aids at the disposal of the Romans.
rock, as had to be done on the Dorchester aqueduct, would have involved additional sequences.

Nevertheless it can be assumed that a typical sequence could have been as follows:

Table 7.1: Sequence of construction procedures.

1. decision by the decuriones to construct a structure, e.g. an aqueduct;
2. agrimensores instructed to survey a route;
3. planning of the feasibility of the project depending on the results of the survey;
4. raising funds for work;
5. preparation of drawings, if any;
6. organization of a workforce and equipment for use on construction;
7. provision and mustering of materials and tools for the project;
8. provision of food and accommodation where necessary for workforce;
9. facilities for payment of the workforce;
10. arrangements for the control of the workforce and allocation of work to various sections of the project;
11. arrangements for the inspection of the work;
12. execution of the work;
13. approval by senior authorities of the progress of the work;
14. final acceptance of the completed work.

4.3. Hypothetical construction of the Dorchester aqueduct

As an engineer who was involved in the design and construction of similar projects some 1800 years later I am aware of some of the complexities of planning such enterprises. I am going to consider the likely implications of the planning, construction and cost of an aqueduct such as the one at Dorchester. I shall base these on a set of hypothetical assumptions in order to establish some order of costing and also to assess the workloads that would have been necessary to provide Dorchester with a running water supply. The town already had wells as the main water supply, but the town decuriones must have decreed to build a gravity-fed aqueduct. The appropriate duovir would then have been instructed to make all the necessary arrangements to plan and have the aqueduct constructed. The next step would have been to identify an appropriate water source, either based on the knowledge of an army engineer or on that of the local inhabitants. A geometrical, or as we now call it, a tacheometer survey, would then have been necessary for identification of a route along contours to ensure a sufficiently low
fall of elevation, yet allowing for a reasonable rate of gravity flow to bring water to a position in the town where it could be distributed to public amenities and private individuals. It is at this stage that the highly trained army agrimensores\textsuperscript{14} would have most likely been used, primarily to look at the terrain and to assess the practical feasibility of the scheme, and hence to establish an adequate route\textsuperscript{15}.

Today, if we want to determine the feasibility of such a scheme it would be a simple matter to look at airphotos or contour maps for the planning of a possible route. Geological and hydrological maps could assist in location of spring or river sources which would be at a high enough elevation above the delivery point. It is customary for modern engineers to do a feasibility study from contour and geological maps before they go into the field to survey a projected site or route. A preliminary survey would then be carried out, most probably from the source end (but not necessarily so), with a crudely calculated rate of drop in elevation over a fixed distance. If this preliminary survey showed that the rate of fall could be maintained over the projected length of the route, a more detailed survey would be done providing levels of the invert of the channel. This latter measure indicated the depth of cut to form the channel.

Many aspects of Roman surveying remain uncertain. However, we know the type of very simple instruments they used such as the groma, chorobate and dioptra (Dilke 1980). Various possible methods of surveying technique have been suggested that could have been applied. Whatever methods they actually used, their skill at high quality surveying of difficult routes is attested all over the Roman Empire\textsuperscript{16}. The surveying of the routes of the Nîmes aqueduct in France and the Köln aqueduct must be among the more outstanding surveys done by the Romans. The fall in elevation for the Nîmes aqueduct, in quite broken and hilly countryside,

\textsuperscript{14} Agrimensores, 'measurers of land', 'were the land surveyors of ancient Rome', from AOW Dilke's The Roman Land Surveyors, 15-8.

\textsuperscript{15} Surveyors in the Roman empire were generally trained in the army, but there were skilled surveyors in the private sector. Hyginus, writing in the late first/early second century indicated he was a surveyor and he offers advice to other surveyors (JRS 86, 1996, 77). There may have been survey personnel available after retirement from the army who would have contracted to do surveying for civitates, but there is no certainty that such freelance surveyors had been employed on the aqueduct at Dorchester. There is likely to have been some working system by which towns other than the chartered towns had survey facilities as indicated by the plans of their regular street grids. Civilian sites with aqueducts must have had surveying facilities.

\textsuperscript{16} The Corpus Agrimensorum is a collection of surveyor's manuals that has come down, often in corrupt and fragmentary texts. Frontinus is one of the earliest contributors to this corpus, and many of the authors give details of how to solve certain specific problems. However, none of the manuals actually describe the procedure used for using the surveying instruments. AOW Dilke, 1971, passim.
of one third of a metre in a kilometer over a distance of 51km is an outstanding achievement. The surveying on some of the least routes in Britain was also of high quality, as for instance those of the Dorchester, Great Chesters and Winchester aqueducts.

A series of 14 cross-sections was taken along the Dorchester aqueduct by several surveyors between 1855 and 1956, including the profiles produced from the survey work done by the Royal Engineers in 1925 (RCHM(E) 1970, 586)17. Some of the data from these surveys are used in the following analysis. Figure 7.5 shows two assumed cross-section profiles, one for sloping ground and the other for level ground. Calculated areas are shown for these cross-sections, and volumes calculated for an aqueduct length of 18.23km. From these, estimated volumes of materials removed can be made for the likely original construction of the channel, and then some estimated costs can be calculated. These figures will all be highly speculative, but the intention is to give some idea of how planning and budget costs are arrived at in practice today (very much simplified). It is not intended to imply that this was the procedure followed by the Romans.

It is to be noted that for the fairly low degree of sloping ground of ratio 1:3, about 20 degrees to the horizontal, the area is nearly double that for level ground. However, since it was necessary to follow the contours to maintain a steady fall for a reasonable rate of gravity flow, in this case about 1:2400, it is not possible always to avoid sidecuts such as shown in the profile. Sometimes the situation arises where on level ground a fairly deep cut has to be made, which brings its own special construction problems. In practice, from a tachy survey and levels, a detailed cut-and-fill projection can be made to provide a reasonably accurate estimate of the quantities of material to be removed to form the invert base-line and profile of the aqueduct channel. It is not known whether the Romans went to such sophistication in their planning or during the construction phase.

I calculated the in situ volumes of earth that would have had to be moved for the two profiles (Fig. 7.4), assuming the entire length of the aqueduct consisted of a single type of cut. These were respectively 51,790m³ and 30,900m³. The actual quantities would likely have been somewhere in between these two values depending on the slopes of the countryside traversed.

17 The details of the field work of these cross-sectional surveys and the surveys by the Royal Engineers are in the archives of the Dorset County Museum, Dorchester.
These are large volumes of earth and rock to move, considering that the tools used were principally pickaxes and spades, hammers and chisels to loosen the rock and soil. I have chosen for convenience of calculation a value near the mean of those volumes, that is 41,400m³.

In the RCHM(E) article (1970, 587) it was suggested that the slopes of the walls of the actual cut were at the ratio 1:0.5. This is very steep, giving a vertical to horizontal slope of about 63 degrees. For soils in general, at steep slopes like this, as swelling and shrinking takes place over a period of time during wetting and drying cycles, one can expect slumping of the sides to the natural angle that would be stable for such soils. Each soil type has its own characteristic behaviour depending on its plasticity properties, grain size and state of in situ consolidation. I have used the suggested slope, but would have thought

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18 The RCHM article actually refers to a “flat-bottomed ditch with steep sides in ratio 2:1”. The conventional approach would be to express the ratio as 1:2, in terms of the trigonometric function used to calculate the angle of the slope. But a ratio of 1:2 gives a flat slope to the sides of 26º, whereas a ratio of 1:0.5 would give the angle of the “steep sides” sides of 63º.
that a maximum slope would have been at most 45 degrees (ratio of 1:1). This would have increased the chosen volume by about 9,000m$^3$ (22.2%).

When we try to estimate the labour force required to excavate such quantities of soil one can apply the modern experience of labour-intensive construction in, for instance, some of the African or Indian communities. For certain publicly-financed projects in these countries the decision was taken not to use modern excavation equipment in order to give maximum employment to people. However, it should be noted that the spades and picks in use today are made of steel and are much more durable, and somewhat larger, than those used by the Romans. Similarly, the size and shape of these tools are better adapted for work-efficiency than the typical examples of spades and pickaxes which have been recovered from antiquity.

4.4. Previous estimation of quantities and cost for the Dorchester aqueduct.

There has been only one previous estimate of the work and cost of the Dorchester aqueduct. Stephens (1985a, 204) gives estimates of the earth that had to be removed for the construction of the Dorchester aqueduct, giving a volume of 30,750m$^3$ 'of spoil removed'. He used the cross-sectional dimensions given in the RCHM(E) article for level ground. Stephens then used "modern tables of building estimates" and arrived at a figure of 92,300 man-hours for the Dorchester aqueduct, which he adjusted upwards by 50% to allow for the difference in time-scale and the inefficiency of Roman "shovels and spades", which were smaller than those that his tables would have been based on. This gives him an estimated "total number of labouring-hours" of 138,400. It is not clear what he means here by the term "man-hours", but I interpret it as the total number of hours worked on the project based on the efforts of a single person. He then divided this figure by 8 to get to an 8-hour 'working-day', giving 17,300 working-days. He assumes the wage of a labourer to be HS2.5 per day, and calculated the cost of the aqueduct multiplying the single labourer wage with his 17,300 working-days to obtain a total cost figure of HS43,000. For a number of reasons, this seems absurdly low (see below). He does not give details of his calculations. It would appear that he took into consideration only the operation of digging loose the soil, which in practice is only part of the operation. If removing the soil is taken into account Stephens’

19 Based on the 138,400 labouring hours and the volume of material of 30,750m$^3$ it would have taken 4.5 hours to dig a cubic metre of compacted material or 1.78m$^3$ per day. If a present wage of £4/hour is taken, it would cost £18 to dig one cubic metre of material, which seems low.
estimate could at least be doubled. He did not take into consideration cutting into the flint rock. I suspect the original number of "man-hours" to be too low for the reason mentioned, and that he did not allow for side-cut into sloping ground, of which there was a fair amount.

4.5. Calculation of aqueduct quantities.
Initially it will be assumed that all the excavation is only in soil. Allowance can be made for rock chipping and removal afterwards.

At the Leiden Museum in the Netherlands, I measured the size of a Roman spade recovered from the Roman fort at Valkenburg. The blade dimensions were approximately 0.273m wide by 0.219m high. Assuming that a typical spadeful of earth would form a roughly triangular prism, I estimate that it would have required about 10 spadefuls of loose soil to fill a cubic foot\(^2\) \((0.0283m^3)\) container, or about 353 spadefuls to fill a cubic metre container. Comacted soil \textit{in situ} will, when loosened, occupy between 1.65 to 1.75 times its compacted volume; I have used a factor of 1.71. Hence the uncompacted volume calculated from the cross-sections shown in Fig. 7.5 should be 41,400m\(^3\) multiplied by 1.71 giving 70,700m\(^3\) to be dumped as uncompacted spoil. For calculation purposes I used the slightly higher volume of 70,800m\(^3\) (c. 2.5 million ft\(^3\)) to make the calculations clearer. At 353 spadefuls per m\(^3\) (10 spadefuls per ft\(^3\)), this would have required about 25 million spade movements\(^2\).

Based on personal experience of unskilled labour-intensive road- and dam-building projects, I shall consider two time lengths that it would have most likely taken to complete a spade movement: a half-minute and a one-minute time span. These time spans vary considerably in practice, but it provides an order of work activity for estimation purposes. These also take account of waiting time between different activities, breaks and changeover time.

To start with, let us consider the basic spade movement of half a minute to set out the calculation procedure for the time spent on shoveling the loosened earth into containers. The figures thus produced can then be adjusted as multiples of the half-minute base value. On this basis it would have taken of the order of 12.5 million minutes or roughly about 8,680 man-days for a 24 hour day (23.8 man-years), to fill the

\(^{20}\) Initially I calculated everything in the feet/pound system and then converted the values to metric values. The original figures were all rounded figures but on conversion to metric equivalents tens and units enter into the values which is not really justified as one cannot usually estimate large bulk volumes so closely.

\(^{21}\) See previous note.
containers with the total of 70,800 m$^3$ (2.5 million ft$^3$) of loosened soil. For an 8 hour working day the above will come to 26,040 man-days (71.3 man-years). If the period was one minute for completion of a spade movement the time taken would be doubled. The above applies only to the filling of the containers. The diggers loosening the soil would have taken a comparable time and so would the carriers of the spoil. So effectively the three operations would have involved three concurrent periods of 26,040 man-days.

Next, I consider the number of labourers required to do the digging, the filling of containers and the removal of soil. I have used the calculation of time taken by the labourers who fill the containers as the basic unit for calculating the overall time of construction, as their work regulates also the carriers' work load and the rate at which the project progresses. I have considered four units of labour forces used to fill the containers with soil: 200, 100, 50 and 25. I present the estimate of the time taken for 200 men to complete all the excavation, and for the other labour force units the calculation is summarized in Table 7.3 (p.276). If we assume that the large force unit of 200 'labourers' was available to fill the containers each day, that would give a figure of 43.4 labour-force-days for a 24 hour work-day. If a day's work was based on 8 hours and the efficiency 75% ($43.4 \times 3 + 0.75$), then the time taken would have been 174 days (about half a year) to complete the excavation if all the work was only in soil. With a labour force of 100, the work would require 348 days, or about 1 year. If the labour force was only 50, the work would take 696 days or nearly two years, and with only 25, the work would have taken 1,392 days or nearly 4 years. If the time period is one minute per spade movement on average, then the above figures would all be doubled. Therefore, for the labour force of 50 the project could easily have taken about 4 years, and with half that number the project could have taken about 8 years.

The logistics of the movement of the containers, based on practical experience, would have required a proportion of carriers directly related to the distance they had to walk to dump the spoil. This ratio multiplied by the 200 labourers who filled the containers would give the number of carriers for each distance. Table 7.2 (no.23) gives the

22 For modern construction projects, apart from the preliminary planning period, the actual construction period on earthworks projects is usually governed by the time excavation and moving of earth takes to complete. The same would apply to a building project where the controlling operation is usually chosen to estimate the length to complete a project.
relevant information from which to determine the number of carriers required23.

Table 7.2: Ratios of filling times relative to times taken to dump spoil.

<table>
<thead>
<tr>
<th>Distance walked from pickup position (m)</th>
<th>Time taken and dumping (mins)</th>
<th>Pickup time to dump soil (mins)</th>
<th>Total time to fill container (mins)</th>
<th>Filling ratio: 1:0.5min per spadefull (mins)</th>
<th>Ratio: 1:1.0min per spadefull (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>6.4</td>
<td>0.4</td>
<td>6.8</td>
<td>2.72&quot;</td>
<td>5.0</td>
</tr>
<tr>
<td>143.75</td>
<td>4.6</td>
<td>0.4</td>
<td>5.0</td>
<td>2.0</td>
<td>5.0</td>
</tr>
<tr>
<td>100</td>
<td>3.2</td>
<td>0.4</td>
<td>3.6</td>
<td>1.44</td>
<td>5.0</td>
</tr>
<tr>
<td>65.625</td>
<td>2.1</td>
<td>0.4</td>
<td>2.5</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>50</td>
<td>1.6</td>
<td>0.4</td>
<td>2.0</td>
<td>0.80</td>
<td>5.0</td>
</tr>
<tr>
<td>25</td>
<td>0.8</td>
<td>0.4</td>
<td>1.2</td>
<td>0.48</td>
<td>5.0</td>
</tr>
<tr>
<td>10</td>
<td>0.16</td>
<td>0.4</td>
<td>0.56</td>
<td>0.29</td>
<td>5.0</td>
</tr>
</tbody>
</table>

* This situation will pertain when the soil is dumped onto the embankment directly by spade. For only this situation will no carriers be needed.

" The ratios show that the time taken to walk the distances can be either more than, equal, or less than the time taken to fill a container. When the ratio is equal to 1, then the number of carriers required match the number labourers filling containers. If the ratio is greater, more carriers are required by the proportion indicated by the ratio. If the ratio is less than 1, then the number of carriers needed will be less by the proportions shown by the ratios. If the ratio is zero then no carriers are involved and the spoil is dumped in its final place by spade. The critical distances shown for the ratios to be 1 is shown in bold numerals. On a labour intensive project tables of this kind (usually more elaborate) are used to regulate labour distribution for this type of work. Equations of the linear relationships are given by 1) $y_{2.5} = 0.4x$, and 2) $y_5 = 0.2x$. Equations relating the distances walked to the relative ratios are given by 3) $y_{2.5} = 0.0144d$, and 4) $y_5 = 0.0072d$. From these any other values of the ratios can be calculated based on the time taken and distances to walk to dump the spoil, from which estimates can be made to balance number of labourers filling containers against number of carriers.

23 The mass per unit volume of in situ soil is about 1800kg/m$^3$, i.e about 112 lb/ft$^3$. Therefore, in its loosened state it will be about 112/1.65 pounds or nearly 70 lb/ft$^3$. It is estimated that a carrier will on average carry about 35 pounds of earth at a time. For a rate of 0.5min per spade movement and 10 spades per cubic foot of soil, it will take 2.5 minutes to fill a carrier's container of about one-half a cubic foot. If the spade movement is 1 min/spade it will take 5 minutes. The distance the soil will have to be carried will vary. Table 7.2 shows distances from 200m to zero and assuming that the carrier walks at a pace of 16 min/km. The times taken to walk to the dumping position and back are shown in second column, to which must be added the times shown for items 1 and 2 below, which remains constant. The sequence of his movements will be as follows:

1 - pick up container and adjust to carry 0.2 min.
2 - dump soil a get ready to return 0.2 min.
3 - filling of container by shoveller: 1/2min/spadefull; 2.5 mins (constant). 1 min/spadefull 5.0 mins (constant).

Therefore, proportion of filling time: collecting, walking and dumping time, expressed as a ratio of $y:x$, where $x$ are the times given in the 4th column, and $y_{2.5}$ and $y_5$, the ratio values given in column 6 as 1:$y_{2.5}$, and in column 8 as 1:$y_5$. 274
There would have been a labour contingent who loosened the soil with pickaxes. It would probably have consisted of at least as many labourers as those who filled the containers, that is another 200 labourers. As there would have been any number of miscellaneous duties to perform I also add another 100 men of more professional status. There were likely to have been other functionaries such as accountants, paymasters, blacksmiths, carpenters, and others such as ordnance staff. This gives a labour force of roughly 700 men based on the initial 200 unit. This means for the 50 men basic unit, the total labour force would probably have been of the order of 175-200 men. Pure speculation, but if one has to produce a budget for a project these are the kind of estimates and assumptions that are made in practice, always with some past experience to help in projecting an acceptable initial budget for planning purposes. It generally always seems to be too low when compared with actual construction costs.

The question of economics would have been an important consideration in determining the size of a team, particularly with regards to the raising of revenue for the project. Local town administrations were responsible for their own cults, public buildings and social services, and for their own finances and provincial tax. So it may have been reasonable for the city’s administration to have wanted to spread the work out over a longer period in order to extend the period for raising funding from whatever sources. Hence, they may well have preferred to use a smaller work force and spread the cost of constructing the leat over a number of years, rather than a large force capable of completing the project in less than 1 year (see Table 7.3). The work force might therefore have been at the lower end of the scale shown in the table. And, of course, the number could have varied from time to time during the work period.

Who the labourers were that worked on the aqueduct at Durnovaria is not known. Pliny the Younger refers to criminals condemned to work as forced labourers on public works (*damnatio ad opus publicum*)\(^4\). Citizens in some Spanish and Egyptian cities could be conscripted to give a small number of days service on public works (Duncan-Jones 1990, 176-7). The same could also have applied to the province of Britannia. However, this can only be surmised, as we have no way at present of determining what actually happened.

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Table 7.3: Estimated period of aqueduct construction *

<table>
<thead>
<tr>
<th>1/2 minute spade movement</th>
<th>1 minute spade movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 12.5 million minutes</td>
<td>= 25 million minutes</td>
</tr>
<tr>
<td>= 8,680 man-days</td>
<td>= 17,360 man-days</td>
</tr>
<tr>
<td>(24 hour-day)</td>
<td>(24 hour-day)</td>
</tr>
<tr>
<td>= 23.8 man-years</td>
<td>= 71.3 man-years</td>
</tr>
<tr>
<td>= 26,040 8-hour man-days</td>
<td>= 52,080 8-hour man-days</td>
</tr>
</tbody>
</table>

Number of labourers used for shovelling earth into containers.

For 8-hour workday:

<table>
<thead>
<tr>
<th>Labourers</th>
<th>¼ min/spade</th>
<th>Days</th>
<th>Years +-</th>
<th>1 min/spade</th>
<th>Days</th>
<th>Years +-</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td></td>
<td>174</td>
<td>0.5</td>
<td>348</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>348</td>
<td>1</td>
<td>696</td>
<td>1.9</td>
<td>3.8</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>696</td>
<td>1.9</td>
<td>1,392</td>
<td>3.8</td>
<td>7.6</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>1,392</td>
<td>3.8</td>
<td>2,784</td>
<td>7.6</td>
<td>14.28</td>
</tr>
</tbody>
</table>

* The estimated figures shown are based on the assumptions used in the text. The periods given for construction imply continuous working without any breaks. If there are breaks in filling containers the periods of construction will be lengthened by the amount of time during which work is not carried out.

4.6. Calculation of cost of aqueduct.

If the labourers were paid, which I assume, I will initially use the rate of pay suggested by Stephens (1985a, 204), which he considers as generous of HS2.5 per day for labourers doing the digging, shoveling and carrying on the project. Hélène Cuvigny (JRS 86, 1996, 139-45) discusses the rates of pay of quarry-workers at Mons Claudianus in Egypt, based on the Ostraca Claudiana (inv.4751, AD 136-146), using 22 selected cases, and arrived at a pay rate of 47 and 48 drachmae per month (1 drachmae = HS1). This works out to a daily rate (30 days per month) of c. HS1.6 per day. I have used both rates of HS2.5 and HS1.6/day for an estimate of cost of digging the leat.

25 Rates of pay for labour is not easy to sort out from the literary evidence. Duncan-Jones (1990, 105-17) discusses the 'pay and numbers in Diocletianus army', and Speidel (192, 106) gives a table of 'The pay of the Roman army' from Augustus' time to AD 235. In the first decade of the 1st century a miles legionis received HS900, in AD84 HS1200, in AD197 HS2400, in AD 212 HS3600 and in AD 235 HS7200. During the last quarter of the 2nd century the inflation rate was 2.67 times that in Augustus' time. The rate of pay of HS2.5 per day is the pay used in my calculations, but it probably should be at least two and a half times that rate or about HS6 per day.

26 For comparison the pay of a Roman foot soldier in AD 1 was HS900/year (legionary) and HS750/year (auxilia). In AD 84 it was HS1,200/year and HS1,000/year or HS3.3/day and HS2.75/day respectively. In AD 197 these rates increased to HS6.6 and HS5.8/day.
Duncan-Jones’ quotes the wage scale for farm labourers as determined by the Diocletian Price Edict of AD 301 (1982, 11, n.6) as being 25 denarii per day and food, which seems to reflect an inflation rate of 17-19 times of the wheat-price compared with the 2nd century prices (Duncan-Jones 1982, 366). If these rates of inflation are applied to the 25 denarii/day, the uninflated rate in the 2nd century wage would have been about 1.4 denarii/day or HS5.6. This is 3.5 times the Mons Claudianus rate of HS1.6/day and 2.25 times the rate of HS2.5/day. The construction of the Dorchester aqueduct is suggested as having been built in the late 1st or early 2nd century, or about 200 years before the DPE had effect. Therefore the rates of pay provided for in the DPE cannot be used as a common labourer’s wage for the 1st and 2nd centuries. The rates of pay of ordinary soldiers were HS2.75 and HS3.3/day in AD 84 and had doubled by AD 197 (see n.26), which may suggest that the labour pay rate of HS2.5/day is not excessive and that the rate for the Egyptian quarry workers may not necessarily have applied in Britain.

Based on the two rates of HS2.5 and HS1.6 for the assumed 600 common labourers and a higher rate of HS5/day for the 100 specialized workers, (assuming that skilled workers and professionals would have earned at least double that of the unskilled labourer), the cost estimates for the project for all workers, are:

a): (HS2.5 /day x 600) + (HS5 x 100)) men x 174 days/men = HS348,000

and

b): (HS1.6 /day x 600) + (HS5 x 100)) men x 174 days/men = HS254,040.

If the aqueduct was actually 4km shorter, as suggested by recent excavations, the costs would have reduced by a factor of about 22%, that is, to HS278,400 and HS203,200.

It is difficult to compare these figures with costs for aqueducts in other parts of the Empire where costly stone channels and bridge structures carrying the aqueduct conduits were involved.

By AD 212 the rates of pay had increased by 4 times and by AD 235 the rates had increased by 8 times to HS9,200 and HS6,000/per year, or HS19.7 and HS16.4/day. (M A Speidel in JRS 82, 1992, 106). The author states that the bold figures are based on direct documentary or literary evidence.

27 Duncan-Jones 1990, 176-7: Wacher 1978, Roman Britain, 215, says that the basic agricultural wage for a day labourer was 25 denarii, but he also received fringe benefits of food. I have not included food costs, assuming that the labourer provided his own food.
Pliny writing to Trajan mentions the cost of HS3,318,000 for an incom­
pleted aqueduct.\textsuperscript{28} Coulton (1987, 84, n.43) gives costs of several
aqueducts varying in cost from about HS8 million (Aspendos) to HS30
million (Alexandria Troas) for aqueducts in the Eastern Empire (Coulton
1987, 84). Duncan-Jones (1982) gives extensive tables of estimated costs
of buildings and other structures, but not costs of aqueducts, except at
p.318 n.4, where he states that the cost of ‘the Aqua Marcia (built in
the second century BC) was HS180 million, and the Aqua Claudia and Annio
Novus HS350 million’. (Macmullen does not seem to give costs for
aqueducts). These structures involve stone bridge work, which generally
would be more expensive.

What has not so far been considered is the excavation in the flint chalk
rock, of which there has been evidence in the recent excavations. The
photograph shows the rock cut at the lower part of the channel on both
sides. Because the flint rock would have been pervious, it was lined
with a clay layer shown in the picture (Fig. 7.6).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{rock_cut.jpg}
\caption{Photograph of rock cut of the Dorchester leat, near Bradford
Peverell (AB).}
\end{figure}

This activity would have included another sequence in the construction
operation, not allowed for in the cost estimate of the aqueduct. I have
no figures for the length of channel that was in rock-cut, but if one
takes a stab at 5\% (I suspect it was higher), and at a rate of four

\textsuperscript{28} Pliny, \textit{EP.} 10.37.
times the cost of excavating the soil, then we need to add another fifth
to the above cost amount giving an excavation labour cost of a) about
HS365,400, and b) about HS266,700. To this should be added the equipment
and material costs, such as pickaxes, shovels, hammers, chisels, sack
and bucket containers, rope, pegs, levelling staffs, surveying
equipment, and other peripheral costs. This is usually taken for estima­
tion purposes at 40%. So an overall rough estimate for the Dorchester
leat aqueduct for the two rates of pay is a) about HS511,500, and b)
about HS373,400.

However, if one considers the inflation that has taken place indicated
by Duncan-Jones' figure of 25 denarii/day for farm-workers during the
later 3rd to early 4th century, the rate of pay for labourers could have
increased by a factor of 2, which would have doubled the cost of the
aqueduct. This aqueduct was a simple earthworks type structure only, but
the cost of digging and moving of one cubic metre of soil/rock would
have been about HS15, which is low considering that a fair amount of
rock was present in the excavations. The cost calculated applies only to
direct labour costs for digging and dumping the material. There usually
are hidden costs such as surveying and problems with the peculiarity of
the site, which would have added to the total cost. The assumption is
that the town hired the labour for the project. If the town had a
private contractor who tendered for the work, the costs would probably
have been considerably higher, because a contractor has to allow in his
tender for some profit and for hidden costs, and the constraints placed
on him.

The above cost estimate is based on a number of assumptions which might
not have applied at all during antiquity, but it gives an order of cost
for such a major project in the 2nd century AD. This would have
represented a large sum of money for a town like Durnovaria,
notwithstanding the much higher costs suggested in the sources for
aqueducts elsewhere. My calculation could easily be out by 30 to 50%, or
even more either way, but the implication is that constructing an
aqueduct like the Dorchester one was a major undertaking. The appointed
aedile would initiate, plan, budget, organize the labour force, provide
technical expertise, food, equipment, and finally supervise the
construction of the aqueduct. The maintenance of the aqueduct once
constructed, would have been his responsibility, but even so must have
been a constant concern for the town administrators. There however seems
to be no evidence of maintenance activities on the Dorchester aqueduct,
which, of course, for an earthwork type structure could have been obliterated during the later periods.

4.7. Flow in the Dorchester aqueduct.
The RCHM(E) article (1970, 587) quotes the discharge volume calculated according to Lewis and Jones (1960, 78-9), arriving at a maximum discharge rate of 58,908,000 litres/day (12,958,000 galls/day), for a depth of 0.61m (2ft) of flow in the leat. This is an enormous quantity of water. Figure 7.7 illustrates the ratios of water flow for different depths in the leat. For a depth of flow of only 0.305m (1ft) the water quantity would be less than half the previously suggested discharge rate, that is only 27,040,000 litres/day. If the flow depth was 0.24m (1/2ft) the quantity of water delivered would be only about 1/5th the suggested figure at 11,781,000 litres/day. The storage capacity at the source end would have had to be considerable to provide even this low quantity of flow. This low flow rate is still a large amount of water for a town, of say, about 10,000 inhabitants, providing about 1,200 litres/head/day. Conceivably during heavy rains and a flood period the high figure for the Dorchester aqueduct could have been possible and even greater, but it is likely that the town authorities intended the flow to have been at the lower end of the scale.

\[
\frac{A_2}{A_1} : \frac{A_1}{A_0} = 1 : 0.46 : 0.22
\]

Approximately 1 : 1/2 :

Fig.7.7: Relative flow in channel (AB).

Hodge (1993, 347) gives a table of estimated deliveries of water for a number of the aqueducts of the Empire. In contrast to the Dorchester aqueduct, the Anio Novus, Marcia and Claudia aqueducts each delivered to Rome in excess of 184 million litres of water per day. Many other aqueducts are reported to have delivered water in excess of 100 million
litres/day. One of the reasons why aqueducts provided such large quantities of water, is that the engineers had to ensure that a source would be able to deliver a sufficient quantity of water to justify the expenditure on an aqueduct. A second factor in antiquity was that they had no real practical means of controlling the flow from the source to the delivery end. In modern times very sophisticated gate-valves are provided, which are controlled electronically, to supply an urban community on a demand basis. It also means that it is a simple operation today to stop flow in an aqueduct for maintenance purposes. This was not such an easy matter in ancient times, though there is evidence of sluice gates (cut-off wooden planks which could be slipped into grooved slots) (Hodge 1983, 319).

There is also archaeological evidence of accumulated sinter or calcium carbonate deposits which had to be removed from the channels of aqueducts. The phenomenon is caused by a chemical reaction between calcium in the water and carbon dioxide in the atmosphere to form calcium carbonate. Once the initial surface reaction has started the calcium carbonate continues to deposit on the layers of sinter already deposited. There does not appear to be any evidence for this along the aqueducts in Roman Britain, mainly because in leat systems the calcium carbonate that does deposit is probably eroded. However, there are pipes in Roman Britain which have evidence of sinter deposit.

The Romans always allowed for overflow facilities and apart from the public function of fountains as water supply points, excess water was used to clean the drains along streets and public latrines, and thereafter discharged into the sewer system or directly into a river. At Dorchester near the west gate, Bill Putnam (1984, 40) comments that the aqueduct must have delivered its water to the fons aquarum, or public fountain, and the “surplus water overflowed from the fountain, and was used to flush the lavatories before returning to the river below the town” (40). It has been suggested that the deep conduit which was found in Colliton Park served both as a spillway for excess water from the aqueduct and as a distribution channel to private homes. This wastage of water is an indication that water was not generally considered as a material from which income could be derived.

The construction of aqueducts, however simple, entailed major works for any community. We know very little about how the Romans set about construction of their major projects, although a few sculptures and paintings do give some indication of men at work and what tools they
used. Frontinus and Vitruvius mention some aspects of construction, but generally they only give rules about of how to find things like water and how it was distributed in Rome.

5. DIGGING OF WELLS
A number of sites referred to in Chapter 4 had wells which drew special attention, either because of their considerable depths or because they required steining. Wells that required steining is usually an indication that they were made in soils which showed stability problems. Only a few wells from the Roman period have been described in detail, such as the well at Wilford in Wiltshire (p.137) and the well at the forum in Lincoln (pp.123-4). Pitt-Rivers refers to the two deep wells he excavated near Rushmore (p.132), and a 30.5m well is reported at Brading on the Isle of Wight. However, not much has been said about how the wells were likely to have been dug, and about the remains of the steining timbers or masonry used in them. Detailed drawings have been made for the well-head at Lincoln and the stratigraphy of the materials through which the well was dug. Digging of wells was a well developed procedure and they are found at every type of site, and often in large numbers as at Silchester, London and Newstead. I shall briefly look at some problems associated with digging of wells.

Construction of wells was a special type of project because usually few people are involved. It is not known who were used for digging wells, but there is the possibility that there were professional well diggers, who were used at civilian sites. At military sites soldiers may have been used, but because of the nature of the work it is likely that cheap local labour or slaves may have been employed working under supervision of a military officer. Hand dug wells had to be of such a diameter that at least one person could dig and place the loosened material in containers for hauling to the surface. For that reason wells are seldom recorded as having a diameter less than one metre. A number of wells have been found with diameters of 2m, and larger. In large diameter wells more than one person could work down a shaft at the same time. Wells with a square cross-section may not necessarily have been dug square, but their steining timbers give the impression that they were square. There were advantages to digging a round well to insert square steining timbers, because if the diameter was slightly larger than the diagonal of a square steining structure it would assist in supporting

[29] In areas where shafts were sunk for recovery of lime in the chalk formations of southern England the shafts were usually larger than 2m in diameter so that more than one person could work below at the same time.
the corner posts and would have provided the space to place the lateral planks in position. Working in the confined space of wells creates special problems, particularly from the health point of view (see p.101). To what extent that would have been a consideration if slaves were used, is not known. Another problem would have been the supply of sharpened tools for working in rock.

It is difficult to estimate the cost of deep wells for the Roman period because extrapolation of costs based on modern practice would be invalid. Modern costs for drilling shafts with the large diameters mentioned in the literature (i.e. from 1m to 2.75m) would be of the order of £3000 to £6000 per metre drilling in soft rock, with at least another 25% additional costs to establish the equipment and personnel on a site to do the work. A shaft of 30m depth could cost from £100,000 to £250,000. Drilling in hard rock formations could increase those costs by several orders. In antiquity digging a shaft in soil or gravel conditions would almost always have required support of the walls by steining, which would have taken a long time considering that everything was done with hand tools and using rope, ladders or steps cut into the walls of the shafts. If the soil or gravel layers were unstable from the start steining would have had to be carried out at regular depth intervals before it would have been safe to proceed further down. Major problems in digging a shaft by hand are dust and lack of fresh air from about 6m down. It is customary for amateurs who dig wells by hand to have air cylinders blow fresh air into the hole with a pipe lowered to the bottom. The ancients did not have this advantage.

The rate of digging a well is difficult to assess because it depended on the material to be penetrated and the quality of the chissels used to loosen the rock. Soils and gravels would be relatively easy to dig, but as the depth increases removing the loosened material would change the rate of effective penetration of the shaft. Table 7.4 gives the volumes of materials that have to be removed for wells of different diameters and depths.

When a layer has been loosened it would have to be placed in a container to be hauled to the surface, which would take a longer time as the depth increased. If a container of 0.5ft³ (0.015m³) is used to haul the material to the surface it would require well over 2000 movements of the container for a 1m diameter well 10m deep.
Table 7.4: Volume of material in round well shafts (m³).

<table>
<thead>
<tr>
<th>Diameter (m)</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0.78</td>
</tr>
<tr>
<td>2</td>
<td>3.14</td>
</tr>
<tr>
<td>3</td>
<td>7.07</td>
</tr>
</tbody>
</table>

Effectively the rate of digging the shaft could decrease from 1m for the first metre of digging per day to 1/5th and less per day for deep wells. At an average rate of 0.2m/day for a 1m diameter shaft it would take a minimum of at least 50 working days to dig 10m and for a 2m diameter shaft it would take a minimum of at least 200 working days. To this would have to be added the time taken to install the steinning, which could easily double the length of time taken, since this operation would become increasingly more difficult with depth. Digging in soft rock would be several times slower and here the rate of progress would depend more on the rate to penetrate the rock and usually steining was not necessary. The above estimates are based on working an 8 hour day without stopping, which would hardly happen in practice, so that the rate of progress of sinking a well would have taken even longer than shown above.

This brief discussion is intended to show only some aspects of well digging, as there are other problems that would have faced the ancient well digger. An important issue always was where to dig and be certain of getting to water-bearing layers. Although Vitruvius (Vit. 8.1) gave his views on finding water, in practice it seems that digging was carried out on a site where water was required, hoping that water will be found. In areas like London and Silchester the materials were water-bearing gravels so that water was easily found. The two deep wells at the settlement at Rushmore and the one at Lincoln were in rock.

6. WATER IN THE ECONOMY OF ROMAN BRITAIN

There seems to be no evidence that water from public water supplies had to be paid for in Roman Britain, as for instance, it was paid for in Rome by private owners of baths. This would imply that water was not used as a source of revenue by towns which provided running water to communities, but this cannot be proved. However, indirectly water was necessary for many industrial enterprises such as agriculture, mining, quarrying, building, lime production, tile manufacturing, metal working, tanning, pottery and the mosaic industries. Agriculture would have depended on rainwater, so that special
provision of water supplies to irrigate crops and market gardens would not have been necessary.

Many industries would have been located near rivers for easy access to water, while for some others, well supplies would have been adequate. Roman pottery manufacturing was a major industry in Britain, illustrated by the wide distribution of kilns south of the military zone (Jones and Mattingly 1990, 206, Map 6:24). Several excavation reports describe the kilns and type of pottery produced. Swan mentions a number of pottery sites where wells and springs were the main water supply sources (Swan 1984, 6). Usually wells, tanks or other provisions for water storage were situated within about 400m of the workshops or kilns, (1984, 6). She refers to the pottery industry at Sheepen, Colchester, where there was a well near the kiln sites (1984, 44). At Colchester there is indication of an aqueduct at Sheepen, which possibly could have served the extensive pottery works at Warren Fields (Swan 1984, 92-5, Fig. XXIII), where more than 30 kilns have been found. The pottery production centre at Alice Holt Forest, also with more than 30 kilns as indicated by waster dumps, was another sizable operation. Two short leats have been found taking water from small streams to two clay pits near the kilns (Lyne & Jeffries 1979, 3-4, Figs. 1 & 2). In the Cantley/Rossington area, Doncaster, one of the "largest excavated regional kiln concentrations in Britain" with more than 40 kilns (Swan 1984, 105), seems to have produced the remains of only a single well near kiln 14 (Gilmour 1955, 536-45; YAJ 39, 1956, 33, Fig. 1). If this was the only well it must have been a public well, which introduces the question of ownership. The plan shows concentrations of kilns about 3/4km and 1 km from the well, which is a long way to carry water daily. It is likely that alternative water supplies must have been available. If, for the production of pottery at each kiln, a minimum of 100 litres of water per day was required, then a minimum of 4,000 litres/day would have had to be drawn from the well each day. A 2m diameter well with a constant water depth of about 2m would have been adequate to provide that quantity of water each day. The constant preparation of the potting clay would have required water storage closer to the workshops where the pottery were made than the distances from the well seem to indicate. Swan has indicated that water storage facilities were usually nearby kiln groups. The extensive pottery

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30 AJ 38, 1955, 403-6, 407-12, 536-45, Pls.I-IV; 39, 1958, 32-47, 364-88. Continued excavation of the sites seem to have been terminated because of lack of further funding at that time.
industry along the Nene valley most likely obtained its water directly from the river.

The Dolaucothi gold mine in Wales is an important example of a site where aqueducts were specifically constructed for industrial use. Since the mines would have become imperial property once the people of west Wales were subdued, it is likely that the aqueducts were constructed by the army with the help of slaves. The main aqueduct was 11km long and tapped the Cothi river near the Pwll Uffern waterfalls north of the site. Several sections were rock cut, and Haverfield commented that some sections may have had a flat ledge on which wooden troughs or pipes were laid, which have long since disappeared (Jones, et al, 1962, 72). It filled a large masonry tank of about 11 million litres capacity, from which water could be quickly released in great volumes to remove soil in the hushing technique to expose gold-bearing quartz veins. Excess water was directed into a reservoir above the main workings, which was used for ore-washing (Jones, et al, 1962, 72-5). Two shorter aqueducts along the Annell and Gwenlais valleys provided water for other parts of the mine workings (Burnham 1994, 42-3). At one point the Cothi aqueduct crossed a low point and it has been suggested by the excavators that a conduit of some kind may have been carried on wooden trestles to maintain a flow gradient, but there is no visible evidence of remains to confirm the suggestion. It has also been claimed that an aqueduct near Linley (Shropshire) also supplied water for sluicing purposes to expose lead and silver ore bodies. There may have been other sites where this hydraulic technique was used (Jones and Mattingly, 1990, Table 6.1).

Tanning and metal working industries would also have needed water, for which wells and other simple water storage facilities would have been adequate. Evidence for tanning operations have been found at Wroxeter (Brit. 9, 1978, 437), at Brithdir (Brit. 7, 1976, 296) and at Alcester (Hingley 1989, 93). At the latter site wells were most probably the water supply, but no water supply has been recorded for the fortlet at Brithdir, for which the water supply was probably the River Wnion. Metal-working industries during the Roman period were widely spread over Britain, and at many of the sites water supplies have been recorded, but the water requirements for the industries have not received much attention.
The need for water in the building industry would primarily have been used for mixing of mortars to lay bricks and bond masonry in structures, plastering of walls, and for mortar sealant for tanks and channel type aqueducts. The water could have been obtained from any source such as local springs, streams, wells or from running water supplies if they were available. Mining, quarries, tileries and lime production required substantial quantities of water and would have needed dedicated water supplies, which could easily have been channeled from springs or streams. Industrial enterprises would generally have been close to water sources such as rivers, streams or springs, unless water was brought in by aqueduct or wells were dug nearby. I have not studied the problem of water requirements for these special industries other than the aqueducts supplying water to the gold mine at Dolaucothi.

7. COSTS AND ADMINISTRATION OF BATHS

How public baths were administered in Roman Britain is not known. From the literature and inscriptions of baths elsewhere in the Empire there is evidence for quite a complex bath management staff. Nielsen says "The Roman system of bathing was so complex that a whole team of persons of different rank was necessary for the baths to function satisfactorily" (1993, 125).

The large thermae complexes could have been publicly owned, either by the state in the name of an emperor, as for instance the large thermae of Caracalla, or the bath of Agrippa. In many places like Rome and Ostia, baths used by the public could be privately owned (Nielsen 1990, 119). Towns were the owners of public baths through the elected body administering the town. Depending on the size of these baths there would have been employees who would have been specialized to run such an enterprise. Nielsen suggests they were often freedmen or slaves (1993, 125). If there were traders, tavern-keepers and prostitutes at baths, they no doubt paid some form of rent to the owner. In Rome many baths were constructed by private persons and run as commercial enterprises (Nielsen 1990, 120). In Britain it is not certain whether there were any privately owned baths that could be used by the public. Privately owned baths in Britain usually were associated with villas or houses in towns. However there were large public baths in towns such as the baths at Wroxeter, Leicester and Bath. It is not known how these British baths were administered and whether they were run on the same basis as their counterparts elsewhere.
It would seem that the supervision of public baths came in the early
days under the aediles, one of the town magistrates, and during imperial
times were supervised by an appointed curator, and still later became
the responsibility of the city prefect.31 There was an official called
the balneator who seemed to be the person who was in daily charge of the
baths (Nielsen 1993, 127), with many responsibilities, and it was he who
had to oversee that the bath temperatures were correct, and that there
was enough fuel of the right kind. He was the person against whom
complaints were made to the owner if there were some aspect bathers
objected to in the running of the baths. However, we do not know whether
the same sort of control existed at public baths in Britain. Conceivably
one of the aediles or an assistant would have exercised that duty at
baths in British towns. Who would have been the employees at baths in
Britain is difficult to ascertain, because the type of person in Britain
who would have worked at a bath would not likely have been freedman or
slaves as suggested for Italy or other parts of the Empire. Whether
baths were run by the town itself or whether they were leased out as a
commercial enterprise we will probably never know. Small private baths
probably had one attendant, mainly to ensure that the furnace was
regularly stoked and that there was always water in the three different
kinds of baths. Baths at forts or fortresses would no doubt have been
under the direct control of the army, but even for those baths it is not
sure who would have carried out the more menial type jobs.

Wood fuel would have been a most costly item to provide, especially as
costs would have involved the original purchase of the wood, cutting and
transporting to a destination. In a papyrus from Egypt (Plondon 1166,
lines 72ff (AD 42)) it is required 'that a gymnasiarch 13 months before
taking office should furnish, for the baths belonging to the gymnasion,
fuel amounting to 12,000dr. = HS12,000 per annum' (Nielsen 1993, 123).
This is about 13 times the amount paid annually for water, also for Egypt
(see below). The cost of water to baths is a difficult issue, because
public baths run by a town may have owned the aqueduct and therefore the
supply of water would normally have been supplied free to the bath. But
there are several references indicating that water supplied to some
public baths was paid for, for which the evidence is cited by Nielsen
(1993, 124, ns.26-29). For instance water for the Severan baths in Egypt
cost 18 obols per day, the equivalent of HS924 per year (Nielsen 1993,
124, n.30).32 It was not uncommon for a benefactor to invest an amount

31 Nielsen S, 1993, 125, n.7, refers to O Robinson who published an article 'Baths, an
1065-82. I have not been able to refer to this reference.
32 Plondon 1177, lines 30ff, (AD 113).
of money that would cover the cost of water supply and fuel for public baths. If baths were leased out, the lessee would have had to bear the cost of supplying water to the bath and have had to obtain a license to draw water from an aqueduct (Nielsen 1993, 123-4). Baths would have required regular maintenance because of the high temperatures to which many parts were exposed. It is clear then that a public bath, even of modest sizes would have represented considerable expenditure for a town. Towards the later 3rd and 4th centuries the operation of baths became so expensive that additional demands were imposed on many different groups of the community and in some instances the state may have taken them over to ensure their continued operation (Nielsen 1993, 125).

Nielsen (1993, 131-5) gives a detailed discussion of admission charges for bathing. The source material reveals that it was common to charge for bathing from early antiquity, and later the term used for this admission charge was referred to as the balneaticum, in Greek βαλνατικόν. Public baths were paid for by a tax, documented in many accounts and receipts from the Ptolemaic period (Nielsen 1993, 131, n.3), but there seems to be little evidence for this tax in the Roman context. However the costs of running town public baths seem to have been paid as a liturgy or munus by elected officers of the town council (Nielsen 1993, 123 n.4), or by donations. Evidence from Egypt, recorded on Greek papyri and ostraca, show the two methods of payment by tax and admission (Nielsen 1993, 132). An entry fee was charged to Greek gymnasia and the king of Egypt received a large income from public baths. If the baths were leased out, the king received a third part (trith) of their income (Rostovtseff 1941, I, 312). As commercial enterprises no doubt the rents charged for the various facilities offered within the baths would have been based on some profit making basis, because the admission charge would be insufficient to cover all the costs of running the baths.

There are many references to the payment of admission charges, first referred to by Cicero (Cic. Cael. 62), who stated that the cost to use baths in Italy was a quadrans, (= 1/4 as). From Diocletian’s time bathing was affected by inflation, who in his Edict of Prices dictated that the charge to public baths would be 2 denarii (Nielsen 1993, 129, 133). It seems there was, during the later Empire period, an additional charge of 2 denarii for cloakroom facilities both at public and private baths, collected by a capsarius (Nielsen 129, 133). From the admission charge the leaseholder of a privately owned public bath was expected to pay his annual tax. Admission charges would therefore have covered only
a small portion of the running costs of a bath. The leaseholder met his financial obligations by sub-licensing certain functions, such as cloakroom facilities, shops and other facilities, and the supply of oil. However, little information is available on how these privately leased baths functioned (Nielsen 1993, 124). For Roman Britain we also have no information on the financial implications of running bath institutions.

Yeğül refers to the text of the management of a small bath belonging to the state mines and the mining community of Vipasca (modern Aljustrel?) in Portugal. The bath was leased out under contract to a lessee, giving the details of his obligations (1995, 47, and CIL II, no. 5181, lines 22f). The contract stipulated that the lessee were '... required to heat the baths and keep them open for use entirely at his own expense every day from day break to the seventh hour for women [until c. 12.00-1.00pm] and from the eighth hour of the evening to sunset for men [from c. 1.00-2.30pm to c. 6.30-8.30pm; the first set of figures being winter hours], at the discretion of the procurator in charge of the mines'. The lessee was responsible for 'a proper supply of running water for the heated rooms, to the bath-tub at the highest level and the basin, for women as well as men. He shall charge men 1/2 as and women 1 as each [1/4 of a sestertius]. Imperial freedmen and slaves in the service of the procurator of the mines are admitted free; likewise minors and soldiers...'. It seems to have been the common practice for men and women to have different bathing hours, and in some of the larger establishments even separate bathing facilities. However gradually mixed bathing became common, at least in Rome, as referred to by Martial and Juvenal33, and probably as a result of increasing scandals, Hadrian placed a prohibition against mixed bathing ("lavacra pro sexibus separavit")34. The hours of bathing reserved for men during the afternoon session coincides with the social practice of having dinner in the late afternoon, so women had to use the baths during the morning. There may have been other reasons why the sexes were separated, particularly moral reasons, as commented on by both Pliny the Elder and Seneca35. Another possible reason may have been that women used the baths differently. The enforced separation time when they could bathe would have increased the cost of the bathing facilities, a probable reason for the increased entrance charge to them in this instance. The

33 Martial, 3, 51; 3, 72; 7, 67; 11, 47; Juvenal, Satires, 6, 412ff.
34 SHA, Hadrian 18,10. The ban was revoked under Marcus Aurelius, but raised under Elagabalus. See Yeğül, 1995, 429, n.24.
lessee was also required to keep the bronze equipment of the baths and its fixtures clean by washing, drying and coating them with fresh grease every 30 days. He had at all times to keep a supply of wood sufficient for 30 days, and was not allowed to sell wood. If the baths were not kept open and properly furnished he could be fined by the procurator up to HS200 (Yegil 1993, 47). There clearly were very strict regulations to control the running of baths and to ensure the safety and health of the public.

It is not known whether there were any baths used by the public in Britain and leased out to private lessees, and whether similar type contracts were in force.

7.1. Construction costs of baths.

The economics of baths is a complex subject which I cannot deal with adequately here. There is very little information on the actual construction costs of baths in the Roman Empire; however, because of their complex structural features, they must have been very costly structures to build compared to other major public buildings. Duncan-Jones (1974) gives some useful statistics on the cost of baths or the donations made by benefactors. The Forum Baths at Ostia cost about 2 million sestertii, whereas the baths at Teanum Sidicinum in Campania cost as little as HS60,000 (30-31, 124-30). Fronto expected to pay HS300,000-350,000 for his baths, excluding the cost of the land (Nielsen 1990, 121). Pliny gave a donation of HS300,000 for the decoration of the baths at Comum, his home town and a further HS200,000 for the tutela or maintenance of the baths. He probably also paid for the construction of the baths.36 We have no similar cost figures for baths in Roman Britain, but when baths of comparable sizes are compared from Britain to those in other parts of the Empire, the public baths at Leicester would be considered medium sized (0.42ha). It is suggested by Nielsen that medium sized baths could have cost from HS300,000 to HS600,000, (Nielsen 1990, 122). If a modest bath cost say HS250,000 (=1 million asses), at a charge rate of 1/2 an as per person, it would have required 2 million persons to be admitted to cover the initial cost of the baths. At 100 persons per day it would have taken about 60 years to have accumulated this cost.

36 CIL V 5262 COMUM, c. 111-113 AD. It is not clear whether the tutela generally included cost of staff and running costs, such as provision of fuel and water (Nielsen 1993, 122-3).
8. CONCLUSION

Romanization was a two-way process: Rome who initiated a course of action to persuade her provincial subjects to adopt the Roman way of life and in the case of Britain, the Britons who adopted aspects of the process. There was, however, a large section of Britons, generally the wealthy and powerful families, who seemed to impose on themselves a kind of self-romanization as they voluntarily adapted to Roman housing, baths and water supplies, particularly reflected in the development of Romano-British style villas without imposition from above. To provide these romanized buildings with the mosaics and wall paintings, professionals from Rome and Italy must have been deliberately hired. On the other hand, culturally and religiously Britons seem to have remained British. This was a tenuous influence, which became evident when the Romans departed and Britons adapted to the new influences of the Anglo-Saxons and Normans.

The source of the Dorchester leat, like all the other known leat aqueducts in Britain, is still not known. The costs of aqueducts in Britain are unknown. A hypothetical analysis of the construction of the Dorchester leat indicates some practical aspects of its construction and provides an order of costs. Additional issues relating to dating, maintenance and length of time the aqueduct remained in service is unknown. The implications for a civitas capital when a utility like an aqueduct went out of service must have been serious, because of the dependence of other utilities on its supply of water. In any study relating to the towns of Roman Britain, the loss of their running water supplies must be an important consideration.

Nothing is known about the costs of baths, the single most popular building type that was introduced to Britain by the Romans. How the public baths were run and how they were used, compared to what is known about them elsewhere needs to be studied. There is no ancient literature on the subject, so that interpretation would have to be based on archaeological finds and remains of bath buildings.

There is a real need for a study to determine what level of importance water-related structures had in the economics of urban communities, and what part Roman public baths played in the social life of Britons.
CHAPTER 8.
CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

Roman water supplies and baths were dominant structural features at many sites in Roman Britain, but their relevance to the social and economic development of urban and rural centres has rarely been included in academic discussion. The economic implications of providing running water supplies and baths would have been important for the communities involved, yet discussions on them do not enter debate on the development of towns or rural settlement (Todd, 1970, 1978; Burnham 1986, 1987; Hingley 1989; Burnham and Wacher 1990). To understand fully the development of urban and rural centres it is important to evaluate the contribution of water supply structures and baths to the development of the economy of Roman Britain and what their social and material impacts were on towns, settlements and villas. The most recent research on water supplies was by Hanson (1970), confined to military sites and major towns, and a review of civil and military water supplies by Stephens (1985a, b)

Aqueduct water supplies brought a new dimension to urban and rural British communities who were quite unfamiliar with artificial methods of providing water where it was required. Their construction involved considerable expenditure for towns and villas, and was related to their economic wealth. Failure of a running water supply had serious consequences for the inhabitants, who became dependant on public facilities such as baths and fountains. The failure of the Dorchester leat aqueduct during the 4th century was possibly responsible for the baths going out of use (Green 1984, 51), which could have accounted for the progressive deterioration in the viability of the town. This may also have been the problem at Wroxeter (White 1990, 5) More research is necessary in order to determine the extent of the effect that failure of water supplies had on the communities they served.

The high rainfall in Britain has tended to reduce the importance attached by scholars for the need of water supplies, but even in the wet countries they were priorities for both the Roman rulers and the public. Even though water was such a basic need, it seldom enters analyses of the ancient economies and development of urban and rural settlements. It was necessary for drinking and cooking, and it was used for washing of the person, washing of clothing, and was needed for bathing facilities, for specialist production in textiles,
potting, tanneries, etc. Yet many scholars who comment on development of urban or rural communities in Roman Britain, hardly ever use the word 'water'. Any synthesis of urban and rural society should take note of the importance of the water needs within that society.

Several issues relating to water requirements are uncertain, such as the amount of water a household would have needed or what quantity was used by industry. It may be possible to arrive at some order of requirements of water usage based on contemporary pre-industrial societies, which will need special study. It is also not known whether towns supplied water only to public facilities and households, or also for specialist production, which needs to be investigated.

Aqueduct water supplies usually came from rural areas, but it is not known what effect the taking of water from a particular area to a town would have had on settlements based near the water source, which needs to be investigated.

Aqueducts found in Roman Britain were mainly of the leat, pipe and simple channel types (Chapter 3, p.57), but no systematic study has been made of their typology in Roman Britain. They were used at all site types, but mostly by military establishments and towns. Where they were used at rural sites like villas, they were usually of pipe construction and relatively short in length, tapping nearby springs. Some leat type aqueducts have been reported for villas (as at Gadebridge Park). Although there are many leats from the Roman period, little has been published about their physical and hydrological characteristics. Along the Dorchester aqueduct, probably the most thoroughly investigated leat, a number of cross-sections have been made in places where the structure has been positively identified, and on Fig.7.4 (pp.264 & 269) 3 cross-sections are shown. Along sections where it was cut into flint rock the shape is likely to be that of the original cut. Over a period silt deposits would have accumulated at the bottom of the leat to find a flow level for a specific grade along a section, which may have given the impression that the leat was lined with clay. However, the quantity of water that flowed in leats, or for how long the leats supplied water, is not known. The hydrological aspects of aqueducts is poorly understood and needs to be researched to understand how effectively they functioned as water supplies.
Aqueducts have been described at individual sites where they have been found, but at many sites insufficient information is available to determine exactly what type of structures they were, such as the probable aqueducts for Colchester, Gloucester or York. It has been established that leats, wooden, lead and ceramic pipes have been used, but there is a need for correlating the information so that a distribution pattern can be obtained for the whole of Britain. In my database I have listed some of the types of aqueducts found at sites, but the record is not complete. A detailed study of all the sites where aqueducts have been recorded would be necessary to provide a complete distribution by type of conduit.

Provision of aqueducts to urban communities in Roman Britain must have influenced the development of towns and indirectly had some impact on their economy, but no comment has been made on this aspect of water supply in the literature. Determining the life spans of aqueducts may be useful in analysing the prosperity or decline of towns. The life span of wooden aqueducts must have been very limited, implying it was not a long-term means of providing water. Leats could silt up or their banks could have collapsed, so that unless effective maintenance was carried out regularly, an aqueduct could after a while be ineffective as a supply of water. Archaeological evidence seems to indicate that the disuse of the baths at Dorchester was related to the end of the effective supply of water from the aqueduct (Green 1984, 51). This may also have been the problem at Wroxeter (White 1990, 5). How widespread this problem was needs to be studied, because it is likely that failure of aqueducts would have impinged on the economy of a number of towns.

Wells were a standard form of water supply at most inhabited sites, notwithstanding the number of sites where they have not been found. At several sites (for example at Lincoln, London, Silchester and Wroxeter) provision of public wells must have had special significance for those people who did not have wells (Chapter 1, 7 and n.9). Wells were not only sources of water but often they were also used for ritual purposes and as depositories for religious artifacts (Clarke 1996, 79; Ross 1968, 255-85). Although wells have been found at Silchester where they were the main source of water supply, their internal distribution and use have not been specifically studied since they were first reported during the 1890s and early this century. It would be a particularly useful study to determine how many wells were in operation at the same time, and who
used them. At London a large number of wells have been found, but large areas have not yet been examined, with the likelihood that more wells will be found. At Newstead, recent further excavations have revealed more wells/pits than the original 107 found by Curle (Clarke and Jones 1994, 110, Fig.1). At Wroxeter wells were found grouped in two localised areas (Chapter 6, 196, Fig. 6.17), with large areas of the Roman town still unexplored. No Roman wells have been found at Colchester within the *colonia* walls. At the other major Roman towns there is also a lack of evidence for wells. Further archaeological work will be needed to provide a more balanced distribution of wells.

Wells are not easily categorized, basically being a hole in the surface soil and the substrata down to water-bearing materials. Their shapes were generally dictated by the materials in which they were sunk and the type of linings if steined, square for boxframed and round for barrel linings. Depths range from about 2m to well over 30m. When dug into gravel, sands and clays their walls may have been unstable and needed steining for support. Many wells with linings have been found but the distribution of sites with different types of linings and inter-site differences need to be correlated. Box-framed linings changed in construction over time and also need correlation. This is particularly well illustrated by the difference in workmanship between the wells at Scole (Fig.4.4a-d, pp.112-5) from the 1st century to that illustrated for London (Fig.4.2, 107). This could have been due to improvements in carpentry skills and tools, a topic well worth investigation.

Archaeological evidence indicates that at a number of sites the life spans of wells were often of short duration. The density of well distribution shown for Newstead (Clarke and Jones 1994, Fig.1), both in the fort and the *vicus* to the south, suggests that many wells were in use for short periods and only about 10 to 15 were in use at any one time (Clarke and Jones 1994, 117). This may also have been the case in London where there were concentrations of wells in the Queen Street area. Whether wells had a similar short life span at Silchester is uncertain because most of the wells were associated with separate buildings. A study of the life span of wells may provide information on changes that may have taken place within sites and could be significant for villas.

Who dug wells is not known, but with the difficulties of well digging it seems possible that itinerant professional well diggers may have
performed that task. There is no direct evidence to prove this assertion. Builders may have contracted to do the work when they were hired to build public buildings or homes for private owners. A study of well digging and their steining could bring to light other aspects of specialist skills in the building trade during the Roman period, especially the progress in carpentry. For instance, it may be possible that the skills in construction of steining of wells followed local building styles.

Baths were closely linked with water supplies because they were often the largest consumers of water. They were the most common single type of water related structure, the main reason having been their importance as social centres, both publicly and in private homes. More baths have been recorded at villas in Britain than at all the other site types grouped together, indicating their social importance to the private sector during the Roman period. Although public baths had the practical function of bathing, perhaps their major function was as centres where people could meet socially and obtain services which were not otherwise available. However, for Roman Britain nothing is known about these functions of public baths. Much of the literary and epigraphic information about behaviour at baths outside Britain is supplemented by finds found at baths or associated structures. Perhaps it may be possible to gain some knowledge about the people who used baths in Britain from a study of such finds in the context of their clothing, jewellery and other artefacts, and with some imaginative interpretation. This can be judiciously supplemented from what is known of behaviour at the continental baths. To understand fully how Britons lived in Roman Britain it is necessary to supplement that knowledge with a study of the influence the introduction of baths may have had on their life styles.

The social importance of baths in the Roman world is well documented, but their significance for Roman Britain has not been evaluated. Baths were often constructed at military sites where occupation was for short periods, indicating a specific social need. At many military sites aqueducts were the main water supply, especially at sites where baths were important structures, such as at Caerleon, Chester, Chesters, Halton Chesters, Great Chesters, Benwell, and Vindolanda. The issue of the social importance of baths in Britain requires detailed research, and will require imaginative interpretation based on archaeological evidence in the absence of any contemporary literary comment.
The remains of only two Roman baths in Britain have been described in detail, the two at the fortresses of Exeter and Caerleon, but the discussions do not refer to the management of the baths, who would have carried out the duties of attending to the baths, and the provision of the large amount of fuel that was needed for heating. Baths at military sites may not have had the typical image of public baths, but there was a social aspect to them as well, which needs to be explored. Public baths were costly institutions to maintain, but no information is available on entrance fees or whether any revenue was derived from various activities that were permitted within their precincts. At Wroxeter public baths, White (Barker 1990, 4) suggests that as many as 1,000 people may have used the baths daily, implying a large staff was available to run the institution and that considerable social activities were available. Archaeological evidence shows that the baths required regular maintenance and repairs, and were extensively altered over a period of at least 150 years. The reasons for this may be obvious, but it is not known how it affected the use of the baths. There is a similar lack of information at the other public baths of the towns of Roman Britain. Roman baths had a variety of shapes, layouts and sizes, but no systematic study has been published of their characteristics in Britain. They are spread throughout Britain and there is a need to classify them on a regional basis.

An overall impression from the data presented is that the distribution of all water-related structures for Roman Britain is under-represented.

Summary of conclusions relating to Roman Britain:
1. There is a lack of modern commentary on water-related structures.
2. Little detailed information is available about aqueduct types, and their physical and hydrological characteristics.
3. The distribution of aqueduct types is not adequately correlated.
4. Their construction and functions are poorly understood.
5. Wells were a standard form of water supply to all communities and their distribution needs to be correlated on a regional basis.
6. The lining types of well steining varies considerably.
7. Baths are the most common water-related structure recorded in Britain.
8. Their classification, particularly their layouts needs to be systematized for Roman Britain.

9. The management and running costs of public baths in Britain during the Roman period is completely unknown.

2. RECOMMENDATIONS

The following set of recommendations are made with a view to providing a basis for a better understanding of the relevance of water-related structures in Roman Britain.

a). Research on water supply and aqueducts in particular, has been extensive outside Britain over the last three decades, whereas in Britain the lack of scholarly attention to them has obscured their importance. The reason for this may be due to the absence of the topic of water supply in both undergraduate and masters courses. In order to have a more balanced view of the development of urban and rural communities it is important that the topics of water supply and baths be integrated into studies of urban and rural development. To create motivation for future research, it is therefore recommended that the topics be included in both archaeology and cultural courses so that students become aware of the part water supply and baths had on settlement development.

b). There is no existing detailed analysis of the type of aqueducts that served all the different types of sites. For a better understanding of water supplies in Roman Britain specific research is necessary on the typology of aqueducts and their distribution. As a first phase in the study of the typology of water supplies, it is recommended that studies be undertaken to make a detailed analysis of the existing archaeological record of the remains of aqueducts at all site types. This may have to be followed with further field studies. As a second phase, research is necessary on what part water supplies had on both the economy and social aspects in Roman Britain.

c). A number of leat aqueducts have been found in Roman Britain, but they have all been investigated individually. A comparative study of these leats can provide information on whether there was a common approach to leat construction. There is also no information on the costs of leats, except Stephens' (1985a, 204) estimation of costs of the so-called Leicester aqueduct and those at Dorchester and Wroxeter. I have made an attempt to arrive at a cost of the
Dorchester leat aqueduct based on how it would be approached in the modern context. Research, however, is necessary to determine how leats would have been planned, costed and constructed in Britain, based on knowledge of Roman construction techniques. A comparative study of the details of construction aspects of leat aqueducts needs to be undertaken, and in particular whether there were any stability problems and whether maintenance was carried out during the Roman period.

d). Wells have been reported at many sites in Roman Britain, though the number of sites are considerably under-represented. At a number of sites such as Colchester, Caerwent, Gloucester, London, Wroxeter and York, and others, large areas are unexplored, and further research is necessary to provide a more balanced distribution of wells. Their distribution on a regional basis, and by site type, needs to be correlated using existing archaeological information. Internal distribution of wells at specific sites, and especially what function they served at particular structures, also needs to be studied. Wells are found in various type of geological environments, but at present it is not known how different geological formations influenced their distribution during Roman times, or which formations provided the most successful wells. Of the techniques of digging of Roman wells little is known. How sites for wells were located and who dug them needs to be investigated. Steining of wells with a variety of lining types have been reported at many sites, but for a better understanding of linings it is necessary to correlate the available information. Further research on lining of wells at minor sites is also required. It is recommended that selected topics from the above can be used as dissertation presentations at either undergraduate or masters level.

e). Roman baths were such an important social amenity in the Roman world, but in Roman Britain they have not been studied systematically in detail. There is a need to correlate the existing archaeological evidence on baths found at all the site types in Roman Britain. Currently the International Association for the Study of Ancient Baths is making a register of baths, and in due course there will appear one for Britain. Although baths have been studied extensively for the Empire, detailed work on the typology of baths in Britain has not been done except for a few sites. Classification of bath types based on the simple three layouts used in this thesis, of row, block and complex types (Chapter 5. p.145), oversimplifies their
configurations. There is need for research into this topic to systematize the way baths are described in the literature. Other aspects of baths in Roman Britain that need to be studied are the distribution of bath types, how the public baths were managed, their costs, and their place in Romano-British society. This research would be a major study and it is recommended that it be allocated as a thesis study.

f). A number of major unresolved problems relating to specific sites needs to be investigated, such as the aqueduct water supplies of Colchester, Caerwent, Gloucester, Verulamium, Dorchester, Lincoln, York and others. Specific research is required to solve these issues. The uncertainty of the Lincoln aqueduct is especially significant, since it is the major earthenware pipe aqueduct in Roman Britain. A solution to the location of its water source and how it functioned, will only be resolved by further archaeological research. The solution to this important aqueduct will be a triumph for archaeology and it is considered vital that the funds be found for further investigation of this difficult site. The same applies to the other sites, where details of their water supplies are still unknown.

g). The lack of scholarly debate on water-related structures in Britain has resulted in an important element being left out of the debate on urban and rural development, and I consider that it perhaps distorts the true evaluation of the economies of those centres and their social importance. The most important recommendation I can make is that water supplies and other water-related structures are made topics for study both at undergraduate and research level, on an equal basis with many other archaeological studies.
THE WATER SUPPLIES AND RELATED STRUCTURES
OF ROMAN BRITAIN

Volume 2: Appendices

Thesis submitted for the degree of
Doctor of Philosophy
at the University of Leicester

by

Alfonso Burgers BA (Cape Town), MS (Purdue)

School of Archaeological Studies
University of Leicester

October 1997
### APPENDIX 1: DATA FROM DATABASE

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<td>Well</td>
<td>Drain</td>
<td>Pipe</td>
<td>Spring</td>
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<td>DA1+</td>
<td>M1+</td>
<td>D92+</td>
<td>WPl+</td>
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APPENDIX 2: DATABASE REFERENCES.

Abbots Langley, Hertfordshire

Abergavenny Gwent, Wales.

Abingdon, Barton Court and Ashville Trading Centre, Oxfordshire
Britannia 4, 1973, 320; 5, 1974, 456-7 villa and Iron Age settlement; 6, 1975, 279 Iron Age settlement and 4th c., well; 8, 1977, 419-20 Fig 28 showing well, SU 483 974, water-hole, well and well-house examined; 9, 1978, 466; 11, 1980, 396; 12, 1981, 343, Iron Age and Roman period; 19, 1988, 454; 20, 1989, 296; 21, 1990, 333-5, Fig.17, p.335, the excavated well is square, stone-lined, 2.8m deep, and with timber framework at the bottom. Originally an Iron Age site, Roman occupation pre-mid 2nd c., when major changes took place on site. Pottery finds suggestive of prosperity.

Abinger Hammer, Surrey

Abridge, Essex.

Ackworth Low, West Yorkshire

Acton Scott, Shropshire
Adel, Leeds, West Yorkshire.
Simpson 1879. West Yorkshire Archaeological Survey 1, 1981, 143-5. YAJ 32, 1934-6, 229, 459; 34, 1938-9, 231. TIRBS 1987, 1, major settlement, possible Roman fort on York-Ikley road; coins dating from 1st to 4th c.; altars dedicated to the goddess Brigantia; possible aqueduct. RIB 629-633. (Brigantes).

Ailsworth(1), Sutton Field, Lower Nene Valley, Cambridgeshire.

Ailsworth(2), Cambridgeshire.
Artis 1828 415, located a square stone-lined well at Normangate. Condron 1996, 415-6, Peterborough Museum record nos. 799, 816, 820, 823, 824, 829, 934, 1844, 1848. Swan 1984, fiche 368, `...several wells were also found...', dated to AD 140-160, fiche 366-7, a well, c. AD 140.

Alcester, Warwickshire

Alcester, Oxfordshire.

**Aldborough, Boroughbridge, North Yorkshire**

*Britannia* 1, 1970, 40, 42, 47 Ant. Itin. 465.3 (Isurium), 468.3 (Isuriam), 476.1 (Isubrigantium); 5, 1974, 416 cobble foundation; 6, 1975, 237, 'the Helican pavement mosaic'; 17, 1986, 76, 'Roman administration centre of the tribal area' of the Brigantes, pre-Roman occupation; 18, 1987, 373, lead sealing; 21, 1990, 322 ribbon development; 25, 1994, 265 street. CSIR: Great Britain I.3, 1983, Nos. 15-17. JRS 52, 1962, 169. PNRB 1979, 379-80. There is a large and deep Roman quarry below the *civitas* capital, also worked during the Medieval period. This quarry must have been a major source of stone since Roman times and supplied other centres with stone during the Romano-British period. It must have been a major undertaking to win the stone, as it was low down in the valley, and to transport the stone to other sites. Smith 1852, pls.xviii & xxviii. Wacher 1995 (2nd ed.), 401-7 (1974, 398-404), refers to baths near west gate, probably for a mansio (403). A possible aqueduct that fed water into the stonelined water tank, 2.7m by 1.8m, but not sure about the aqueduct (405). There is slight evidence that there may have been similar tanks at the east and west gates. YAS Bulletin No.7, 1990, 15-20. YAJ 40, 1959, 1-77. TIRBS 1987, 2, RIB 708-10. Defensive earth bank built late 2nd c. (22ha); stone wall added in 3rd c., bastions in 4th c. Decline late 4th c. There was a civilian settlement towards end of 1st c., and the *civitas* capital was probably founded under Hadrian. (Brigantes).

**Aldbourne, Upper Upham, Wiltshire**


**Aldenham, Netherwylde Farm, Colney Street, Hertfordshire**


Aldermaston, Berkshire.
Arch. Ex., 1976, HMSO. Britannia 8, 1977, 419, bath, well 4m diameter. Current Arch. 54, vol 5, Jan. 1976, 220f. 'In the late 3rd c. or early 4th c. an extensive field system was laid out. One of its ditches underlay a small bath-house: c. 12m x 4m....Beyond was a latrine pit and a well 4m in diameter, which yielded a sherd of c. AD 350.

Alfoldan, Slinfold, West Sussex.

Alresford, Essex.

Alwinton, Northumberland.
Arch. Ael.(2) 8 1877-80, 75-6, 'ritual well at St Ninian's at Alwinton'. Hope 1893, 111-2.

Ancaster, Lincolnshire.
Angmering(1), West Sussex.

Angmering(2), Highdown Hill, West Sussex.
Black 1987, 152. Scott 1993, 181, SMR 2237, WS 3, NAR TQ 00 SE 3; see also WS 4 at TQ 06 04, NAR TQ 00 SE28, uncertain Roman bath. SxAC 80, 1939, 63-87.

Apethorpe, Northamptonshire.

Appleshaw, Redenham, Hampshire.

Arbury Road, Cambridge, Cambridgeshire.
Ardoch, Porthshire, Scotland.

Armoth, Trelissney, Dyfed, Wales.

Arreton, Robin Hill Villa, Isle of Wight.
Britannia 5, 1974, 456 'excavations unearthed 2 mosaics, one of them with a dolphin motif, in or near a bath-suite, together with evidence of flooding of the hypocausts'. Isle of Wight County Press, 4 Aug., 1973.

Ash, near Sandwich, Kent.
Scott 1993, 102, KE 4, baths, TR 32 59. VCH Kent 3, 1932, 34. (Cantiaci).

Ash-Cum-Ridley, near Aynsford, Kent.
Britannia 1, 1970, 303, villa re-explored. Haverfield 1915, 25, 103, Fig 21, 'sunken bath, 7ft square,...A deep pond close by is said to be fed by springs'. KAR 20, 1970, 13-20, Fig 1 shows a small bath building within the complex. A pond (pit 2) next to the bath; a drain discharges from the bath into the pond. Scott 1993, 102-3, KE 5. VCH, Kent 3, 1932, 103-4. TIRCGLL 1983, 21; corridor villa; bath-house. (Cantiaci).

Ashdon, Essex.

Ashill, Robin Hood's Garden, Norfolk.
two deep timber-lined wells' - contained lots of pottery; EAA Fig 5, p.12 illustrates a shaft or well No.3 to a depth of 12.14m (40ft), oak-lined, 1.52m (5ft) square from 1.82m (6ft) below surface. Norwich Mercury 24 Oct. 1874. Scott 1993, 129, SMR 8712, NF 4, two 1st c. wells. VCH Norfolk 1, 1901, 295-6. TIRBS 1987, 3, at TF 908 057. (Iceni).

Ashtead, Ashtead Common, Surrey.

Ashton, Northamptonshire.

Asthall, Oxfordshire.

Atworth, Wiltshire.

Auckley, West Riding, Yorkshire.

Axminster, Woodbury, Devon.
Note: There seems to be some confusion about this site in the literature. Scott suggests that this site is that of the Moridunum in Devon, but Rivet and Smith, in PNRB identify two Roman Moridunum forts, one at Carmarthen (SN 41 20) (p.422) and the other at Sidford in Devon at SY 13 89 (p.180, Fig.24, & p.421). Other literature cited also gives contradictory positions for this fort. Archaeologia 93, 1993, 41, (1-50 + pls.I-X), 'The British Section of the Ravenna Cosmography'. Britannia 19, 1988, 471-3; 22, 1991, 281-2, Fig 26, plan showing Woodbury Fort and how Fosse Way Roman road was diverted towards it. Ephemeras Epigraphica (Eph. Ep.) 9, 1913, 645: 'Statio Moridunum (Ant. Itin. 482, 483, 486; Ravenna Cosmography 425.8; Tab. Peut.) modo viae huius tractus flexibus vallium implicatas recte indagavimus, probe Seaton quaerenda est'. Exeter Museum Arch. Field Unit Rept. 87.06; 91.14; 91.18: at p.281 it is suggested that Axminster is the lost site of Moridunum. JRS 11, 1921, 211; 51, 1961, 188: 'Moridunum, site near Axe estuary identified as'. For a discussion on the location of Moridunum, see Rivet and Smith, PNRB 1979, 180, 421-2. PDAS 42, 1984, 33-57; 51, 1993, 33-133, comments, 'The status of the settlement, a mansio at Woodbury, i.e. within the fort, rather than a villa. Therefore a bath quite likely (p.79), and the site at Moridunum....' (p.78). Scott 1993, 49, DE 1, cites this site as possibly the Roman fort Moridunum. TDAS 17, 1885, 280; 54, 1922, 66-8.

Badbury, Wiltshire.
Arch. Review 1971, summary report. Britannia 2, 1971, 282; 3, 1972, 346 (uses SU 195 810), bath-house found during excavations for M4 motorway on east side of Ermin Street, 1.5 km N-E of Chiseldon, and it is 'attached to the front corridor'. WANHAM 57, 1958, 24-29. TIHGGL 1983, 22, baths; occupation 1st to 4th c. (Belgae).

Badgeworth, Dryhill, Gloucestershire.
RCHM 1976, 5-6, small brook, c. 139m (450 ft) north of villa, and a spring c. 139m (450 ft) S-W of villa, probably near the 182m (600 ft) contour. Scott 1993, 68, SMR 450, GS 7, ?bath.

Baldock, Hertfordshire.

Balmuildy, Strathclyde Region, Lanarkshire, Scotland.

Bancroft, (formerly Bradwell), Wolverton, Buckinghamshire.

Banwell, Chapel Leases, Winthill, Banwell Hill, Avon.

Bar Hill, Strathclyde.

Britannia 10, 1979, 276, 'the bath-house and latrine block', and referring to the frigidarium and caldarium, 'a culvert along N side of the baths collected water from furnace and bath-rooms; this and a 2nd culvert from the intervalum road, flushed the latrines...'. 11, 1980, 48, fort; 14, 1983, 288; 15, 1984, 276; 16, 1985, 267; 18, 1987, 21, 25, 29. Hanson 1970, 358, 'The terminal tank of an aqueduct was found inside the fort and this in turn supplied the internal bath-house. Neither source nor means of supply are certain but the discovery of channelled stones in the vicinity of the water tank suggest that these had either formed the water channel or, as at Balmuildy, had carried a pipeline'. Macdonald 1934, (2nd ed.), 271-85. Macdonald & Park 1906. Robertson, et al, 1975, BAR 16. Roy 1793, Plate XV. TIRBS 1987, 5, small fort (1.6ha) at NS 708 759, and a small marching camp at NS 707 757. RIB 2165-73.

Barkby Thorpe, Hamilton, Leicestershire.


Barming Heath, Kent.

Scott 1993, 103, TQ 72 53, KE 9, and TQ 72 54, KE 8, numerous small rooms and hypocausts; possibly there was a bath. VCH Kent, 3, 1932, 104, item 6, near the building 'was a curious and ragstone pit, 4ft (1.2m) deep, 9.5ft (2.89m) long and 4.5ft (1.37m) wide....Its walls were of Kentish rag and tuffa, cemented with pink mortar and bonded with tiles; its floor was paved with tiles measuring 12 x 16 inches (0.3m x 0.4m)'. Possibly a water tank.

Barnack, near Peterborough, Cambridgeshire.

Antiquity 47, 1973, 145-6, pl. XV A. Britannia 2, 1971, 180, quarries; 5, 1974, 257, '...A square stone-lined well lies on the west side close to the presumed position of the front door, of a small house presumed to be near the front door, 2.5km W of the villa. JRS, 55, 1965, 74-89. Simpson 1966, 23. Whitwell 1982, 112. TIRBS 1987,
5, (i) Villa (Basilican type) at TF 080 066; (ii) small house 2.5km W of villa with a well at TF 056 065. (Catuvelauni).

**Barnsley Park, Gloucestershire.**

Arch Review 1973, 26. Britannia 1, 1970, 293; 2, 1971, 274; 3, 1972, 338; 4, 1973, 307, 331; 5, 1974, 446; 6, 1975, 271; 7, 1976, 352; 9, 1978, 455; 10, 1979, 318; 19, 1988, 465, settlement. Current Arch. 72, 1980, 11. JRS 41, 1951, 135; 53, 1963, 143, 164; 54, 1964, 171; 55, 1965, 216; 56, 1966, 212. McWhirr 1981, 89-90. RCHM 1976, 9-11, Figs, at pp.9b, 10, 11. It is noted that in the RCHM article figure, 3 wells are shown, while in the Britannia Fig.16 only two wells are shown and two stone-lined pits, of which the previously mentioned well 3 is one. TEGAS 86, 1967, 74-87, Webster comments that the villa 'is sited on almost flat ground with ample water supplies near by. It consists of a building...nearly 100ft long ..., with a bath-house in the corner,...Occupation of site originated in the 2nd c. ...the main building and bath-house, associated with domestic occupation, were erected c. AD 350-60. Wells 1 & 2, were both dug to a depth of about 7.6m (25ft)'. The site may have changed from Roman use after c. AD 380. 2nd c. Main building and bath-house associated with domestic occupation were erected c. AD 350-60; continued in use after c. AD 380 and evidence that site was occupied into 5th c.; 99, 1982, 121-78. Scott 1993, 68, SMR 1, GS8. TIRглаll 1983, 24; built 2nd c., flourished especially between AD 330 and 375. Bath-house and two wells, depths c. 7.6m (25ft), plus a 3rd well. (Dobonni).

**Barnwell(1), North Lodge Farm, Northamptonshire.**


**Barnwell(2), North Lodge, Northamptonshire.**


**Barochan, Strathclyde.**

Barrington, Gloucestershire.

Bartlow(1), Cambridgeshire.

Bartlow(2), Essex.
Arch. J. 10, 1853, 17-21, bath, plan of building opp. p.18: `...we were opening an old well,... and at a depth of 31ft (9.43m) reached the water'. Well structure not described. The well was 0.91m from the edge of the building on its N side. A 0.15m long piece of lead-pipe still in place in the excavated wall (p.17). Dunnett 1975, 101-2. Frere & St Joseph 1983, 224-6. VCH Essex 3, 1963, 40. TIRBS 1987, 5, TL 586 449, a small villa 100m NE of a set of two rows of 4 barrows. (Catuvelauni or Trinovantes).

Barton Court Farm, Radley, Abingdon, Oxfordshire.
AEx. 1974, 61-2; 1975, 74; 1976, 95. Britannia 5, 1974, 456, Fig 22; 6, 1975, 279; 7, 1976, 372, well: `To the east was found a well 50 cm square built of large Corallian Ragstone placed within a clay-lined construction-shaft, each course of stone being bedded on moss. It was 7m deep, and the base of the stoning rested on two superimposed square frames of oak(?). A well-hook and bucket-binding was recovered'; 8, 1977, 419-20, Fig.28 shows a well discovered in an earlier quarry. Current Arch. 30, 1972, 332. Miles 1986. Scott 1993, 161, SMR 8376, OX 45.

Bath, Avon.

**Bathford, Waverleigh Lodge Farm & Horselands Farm, Avon.**


**Beadlam, Yorkshire.**


**Bearsden, Strathclyde, Dumbarton.**


**Red House, near Corbridge, Northumberland.**

Beauport Park, Sussex.


Beckfoot, Cumberland.

*Arch. J.* 132, 1975, 28. Birley 1961, 214-6. Bruce 1978, (13th ed.); idem. 1867, 365, plan at 536; idem. "The Roman Stations in the West", *Arch. Ael.* (2) 5, 1861, 137-41. Frere & St Joseph, 1983, 71-3. Hanson 1970, 262, 359, discusses some of the problems (262) associated with this aqueduct, with its unique construction of flag-stones sloping outwards over a hewn channel which carried the water in a wall, which is raised towards the terminal end as it enters the fort. At p.359: "The terminal end of a raised aqueduct channel, made of channelled stones, was found entering the fort near its S-E angle. The water was delivered into two stone tanks only fragments of which remained". Robinson 1880, 138-9. *TCWAAS* (1) 5, 1880, 136-48; 36, (2nd ser.), 1936, 76-84, Collingwood, (Fig 1 shows a plan by J B Haney, 1879-80), who comments, "...The other structure was a raised water-channel at the S-E corner associated with stone troughs. From his description of it, I suppose it to have been the end of an aqueduct leading water to the fort at that corner" (p.79). *JRS* 41, 1951, 56, with pl.IV.2. *TIRBS* 1987, 6-7. (Brigantes).

Beddingham, Preston Court Villa, Sussex.


Beddington, Park Farm Sewage Plant, Greater London.

Adkins & Adkins 1986. *Britannia* 13, 1982, 375-6, 'excavation...relocated the bath-house first discovered in 1871 (no.221), and showed it to have undergone at least one phase of rebuilding (Fig 19). ...Immediately to the west of the bath-house was a large ditch dated to the late 2nd c., and a recut at least 4 times....Pottery suggests a mainly unbroken occupation from the late 1st c., to well into the 4th c.'; 14, 1983, 312-3; 16, 1985, 298; 17,

Beenham, Berkshire.


Benwell, Hadrian's Wall, Tyne and Wear, Northumberland.


Bere Regis, Bere Down, Bagwood, Dorset.

Archaeologia, 39, 1853, 85-92. RCHM County of Dorset, 3(3), 1970, 594, 'A well, supposed to lie some 36m (120ft) N of the Roman Road, was excavated in 1860, ... to a depth of 18m (60ft) to 21m (70ft) without reaching bottom. It was 2.4m (8ft) in diameter and cut in chalk with the upper 3m to 3.6m (10 to 12ft) revetted with regularly laid blocks of chalk and 'green sandstone' about 0.3m (1ft) square....'. Note 1: 'Another well and remains, possibly of a religious nature, were found by J C Mansell-Pleydell in 1888 in a "neighbouring field" in Winterbourne Kingston Parish'. There appears to have been Roman buildings in the area of Bere Down at SY 8401 9723. PDNHAS. 85, 1962, 103-5; 86, 1963, 100; 87, 1964, 111; 88, 1966, 116. Warne 1853, 85-92.

Berinsfield, Oxfordshire.

Britannia 10, 1979, 302-3, well, wattlewood-lined and a number of water holes. Original site dates from Neolithic through Bronze Age, Iron Age to Roman period.

Bewcastle, Cumbria.

Bibury, Gloucestershire.


Biddenham, Bedfordshire.


Biglis, Glamorgan, Wales.


Bignor, Sussex.


**Billerica, Essex.**


**Binchester, County Durham, North Yorkshire.**


**Binstead, Wyck, Hampshire.**


**Birdoswald, Cumbria.**

item 31 he comments, 'The fort was supplied by a triangularly-shaped stone channel from the west. This fed a distribution tank near the centre of the fort, where water was filtered through charcoal (Bruce 1867, 261). Percolation was mentioned by Vitruvius (de architectura, 8.6.15), but is not otherwise attested in Roman Britain; the medieval supply to West Minster Abbey seems to have been filtered through sand (Micklethwait 1892-93, 166). The shape of the channel suggests the aqueduct was almost certainly a wooden pipeline held in a stone duct. It is undated'. Water was filtered through charcoal in the tank (Bruce). TIRBS 1987, 8, RIB 1872-1929. (Brigantes).

**Birrens, Dumfries & Galloway.**

Arch. J. 142, 1985, 216-36, Stephens comments, 'The fort was supplied by a line of channelled stone running through the north gate. This probably fed a distribution tank behind the gate, from which water was distributed in pipes - probably wooden - held in stone casings (Richmond 1937-38). Another channel, a "large drain" of triangular section, pierces the north-east angle rampart (Christison et al, 1895-6, 99). Crop marks in this area have been tentatively interpreted as those of the mansio (St Joseph, 1951, 57). The triangular channel should be re-interpreted as a casing of a wooden pipeline that supplied this building. The system is Antonine' p.225. Britannia 1, 1970, 42, 67 n.96, 201; 3, 1972, 38, 41, 47, 49, 153, 274, 314, well in fort; 4, 1973, 317; 5, 1974, 154, 159; 11, 1980, 19; 16, 1985, 326; 23, 1992, 317-8. Bruce 1978, (13th ed.), 315-20. Hanson 1970, 359, 'An aqueduct of channelled stones was discovered entering the fort by the north gateway and its construction can be dated to early in the 4th c. The source of water is unknown'. PSAS 72, 1938, 275-347. Bath is within the fort in the commander's quarters. The aqueduct is stone-lined, Fig.13 p.298. The two pipe-lines are of wood, Fig.19 p.304. Macdonald & Barbour, 1897. Miller (ed.), 1952, 85-7. Robertson 1975. Roy 1793. RCAHMS Dumfriesshire 1920, 100-6. St Joseph 1951, 57. TIRBS 1987, 8, RIB 2091-2116.

**Bitterne, Hampshire.**

established whether Clausentum was at Bitterne (SU 474 132), or at Wickham (SU 57 11). TIRCGLL 1983, 27, RIB 97, 2222-8; small town and port near mouth of river Itchen; dates from Claudian period to 4th c. (Belgae).

**Bittesby, High Cross, Venoeae, Leicestershire.**

**Bitton, Avon.**

**Bledlow-Cum-Saunderton, Buckinghamshire.**

**Bletchingley, Surrey.**

**Blisworth, Northamptonshire.**
BNFAS 4, 1970, 38. George 1904, 10. RCHM County of Northants, South-West 4, 1982, 17-19, items 3 (some wells SP 735 530) & 7, Fig.32. VCH Northamptonshire, 1, 1902, 216. Whitwell 1982, 195.

**Blyborough, Lincolnshire.**

**Boreham, Great Holts Farm, Essex.**
Britannia 25, 1994, 279-80; 26, 1995, 359, 'a late Roman farmstead immediately to the N of the site excavated in 1992-93, of 2nd to 4th
century date, was examined, when structural remains (4th c.) of aisled building 12m by 4.5m were found associated with field boundaries and trackways, and a boxed cremation of the 2nd c. The trackway leading to a large enclosure c. 140m square and to a field..., its 4th c. timber successor 15m by 28m, a bath-house,... Two Roman wells, a pond, and a cremation burial'.

Borough Hill, Northamptonshire.

Bothwellhaugh, Bothwell, near Glasgow, Lanarkshire, Strathclyde.
Britannia 6, 1975, 20-35; 7, 1976, 304-5, Fig.8, showing bath with 'decorating cover in the middle of the cold room, feeding a drain outside the east wall....The cold plunge bath drained by a lead pipe', (pl.XXVI A); 8, 1977, 370, bath-house, c. 100m west of the fort. Two phases of construction, both dated within the Antonine period; both ended in destruction. Glasgow Arch. J. 8, 1981, 46-94. Miller 1942, 172-87. TIRBS 1987, 9, at NS 731 578.

Bottesford, Lincolnshire.

Boughton, Northamptonshire.
ENFAS 4, 1970, 16; 5, 1971, 22. RCHM Northants, N-W, 3, 1981, 14-6, item 5 no.6, Fig.24. Well, located south of Boughton Grange, on Northampton Sand at 105m above OD.

Boughton Monchelsea, Kent.
Archaeologia 29, 1842, 414-20, pl.xliiv opp. p.414. Britannia 7, 1976, 96, coin of Adminius. Scott 1993, 103, KE 12. VCH Kent 3, 1932, 105-6, Fig.22 bath-house, sited in a large sloping field 'The Slade'.

Bourne, Lincolnshire.

Bourne/Morton, Lincolnshire.

**Bourton-on-the-Water, Salmonsbury, Gloucestershire.**


**Bowes, Durham County, Yorkshire.**


**Box, Wiltshire.**


**Boxted Farm, Upchurch Marshes, Kent.**

Bozeat, Northamptonshire.


Bradford Down, Bradford Abbas, Pamphill, Dorset.


Bradford-on-Avon, Wiltshire.

_Scott_ 1993, 198, SMR SW 309, WZ32, bath.

Brading, Morton, Isle of Wight.


Bradley Hill, Somerton, Somerset.

BRAINTREE, ESSEX.


BRAISHFIELD, HAMPSHIRE.


BRAMPTON, NORFOLK.


BRANDON, HEREFORD AND WORCESTER.


BRAUGHING, MENTLEY FARM AND WICKHAM HILL, HERTFORDSHIRE.

*Archaeologia* 93, 1949, 32. *Britannia* 1, 1970, 118, 120, 123, 127, 313; 2, 1971, 180, 188, 192; 4, 1973, 299; 5, 1974, 437, pl. xxxviii B, 3-roomed bath-building 22m x 4.5m and was abandoned during the 3rd
Braughing is a complicated site; occupation from the Iron Age through to 4th century, and probably later. There was a villa at Mentley Farm, north of the small town at the Wickham Hill site, where there is evidence of a street system. A bath-house, dating from the Flavian period (c.AD 70-90), went out of use in early to mid 2nd c., situated in the bend of the River Rib, presumably its water supply. TIRCGLL 1983, 30, major settlement on the road between London and Durovrigutum, Godmanchester; occupied 1st to 4th c. (Catuvellauni).

Brecon Gaer, Y Gaer, Fenni Fach, Powys, Wales.


Brewood, Engleton, Staffordshire.


Brislington, Bristol, Avon.


Bristol(1), Avon.


Bristol(2), King's Weston Park, Avon.


Brithdir, Gwynedd, Wales.

Brixworth, Northamptonshire.

Broadfields, West Sussex.
Britannia 4, 1973, 320; 5, 1974, 457; 6, 1975, 282. This site was occupied from 1st c. to 4th c., and had 36 iron smelting furnaces, a large industrial enterprise, including agricultural activities on the settlement. TIRCGLL 1983, 31, Iron workings. Well. (Regni).

Bromham(1), Wiltshire.
Scott 1993, 198, SMR NE 303, WZ 35. VCH Wiltshire 1, 1957, 51. WAM 6, 1859, 260; 35, 1907-8, 441; 45, 1930-2, 178-9, bath; 72-3, 1977-8, 180 well(?); 74-5, 1979-80, 205. At ST 96 66 WZ 37 (Scott) and ST 97 66 WZ 39 there appear to have been evidence of villas. (Belgae).

Bromham(2), Bedfordshire

Brough-by-Bainbridge, North Yorkshire.
pipeline' (Wade, 1952, 13). This must date from the Severan period, since it cuts through the foundations of an Antonine granary and is overlain by an apparently Severan road. The pipeline will have formed part of a distribution system, whose existence shows that the fort was supplied by an aqueduct. The pipeline - although not necessarily the aqueduct - no doubt formed part of the rebuilding programme attested c. 205-08 (RIB 722, 723). Wade 1952, 1-19 Figs.3 & 11; Proc. Leeds Phil. Soc. 1, 1928, 261-84; 8, 1955, 153-6. Notitia Dignitatum xl, 56, (Trib. Coh, Sextae Nerviorum Virisido), occupation 3rd to late 4th c. CSIR 1.3, 1983, Nos. 106-7. TIRBS 1987, 4 & 12, RIB 722-724, attested c. AD 205-208; Flavian fort or fortlet; 2nd c., fort burnt at end of 2nd c., rebuilt c. AD 205; annexe. (Brigantes).

**Brough-on-Humber(1), Humberside.**

Hanson 1970, 360, item 9: 'Excavations revealed the gulley probably formed by a wooden water pipeline entering the fort by the West Gate. Its source may well have been the upper reaches of one of the streams that run down into the Humber to the west of the fort' (Wacher 1969, 16); item 10: 'The civitas capital: Another possible pipeline was discovered at the North Gateway of Petvaria and could be dated to the end of the 3rd c. Its source, if pipeline it was, could very well have been the springs on Elloughton Hill about 2km (1.25 miles) to the north of the town', (Wacher 1969) 41-42. JBAA (3rd ser.) 7, 1942, 1-30. PNRB 1979, 437-8, 443. Stephens 1985b, 227, item 46, comments 'Gullies found in both the Vespasianic fort and the later naval base may have been pipe trenches'. Wacher 1969, 41-2. TIRBS 1987, 12, RIB 707 (aediles vici Petuariensis); Not. Dig. xl, 31, (Pf. numeri supervenientium Petuariensis); ?Itin. Ant. 466.4 (Praetorio)’. Flavian fort c. AD 70-80; stores depot, c. AD 80-125. Late 2nd-c. earthwork defences walled c. AD 270; external towers added in 4th c. Presumed civitas capital. Theatre and vicus epigraphically attested. (Parisi).

**Brough-on-Humber(2), Humberside.**

Britannia 24, 1993, 287; 26, 1995, 347 ‘(a) immediately east of the defences at SE 9410 2675 considerable evidence for activity was present. Four phases of ditch-systems, wells, and a timber building, etc...., suggest agricultural activity through much of the Roman period’.

**Brough-on-Noe, Derbyshire.**
The site lies on a low spur of land 170m (545ft) OD, in a bend of the river Noe, near the confluence with the Bradwell Brook. 1st phase Flavian c. AD 68-98; 2nd phase c. AD 158-300; 3rd phase after AD 300, i.e. 4th c.

Hanson 1970, 360, 'A covered stone water channel feeding an underground water tank at the fort could represent the point of entry of an aqueduct'. Hart 1981, 83-7.

The fort was supplied by a stone channel passing through the s-w gate. This fed a distribution tank constructed below ground level, from which water was distributed in another stone channel (Taylor & Collingwood 1940, 108, pl. XII.2). The tank's west rim has a round inlet hole, showing that it was supplied by a pipeline - probably wooden in view of the size of the hole - although water may have been distributed either in stone channels, or in pipelines supported by such channels. The aqueduct dates from Phase II, c. AD 158 (RIB 283)'.

Bryncross, Gwynedd, Wales.

Britannia 24, 1993, 269, two round houses, with external drainage gully, and the 2nd house had a stone-lined drain internal to a number of concentric wall slots.

Buchley, Strathclyde, Dunbartonshire.

Britannia 12, 1981, 320; 18, 1987, 28. Robertson 1979, (2nd ed.), 32. Camp on the Antonine Wall. 2 drains, stone-lined culverts c. 12.5m apart, one to east of the enclosure and the other, roughly at its centre, which apparently was deliberately blocked when the wall of a structure was repaired.

Bucknowle Farm, Corfe Castle, Dorset.


**Buckton, Hertfordshire.**


**Bunny, Nottinghamshire.**

EMAB 9, 1966, 38, pottery found dating from c. AD 250-300; remains in very poor state; no buildings found. Well 12.2m (40ft) deep, 0.76m (2.5ft) to 1.41m (3.67ft) diameter. Nottinghamshire SMR 13, 14, 5195.  *TTSN* 71, 1967, Alvery 1967; 72, 1969, 42-9. Whitwell 1982, 203, well.

**Burgh, Suffolk.**


**Burham, Kent.**


**Burrow-in-Lonsdale, Lancashire.**


**Burton, Lincolnshire.**

**Buxton, Derbyshire.**

**Cadder, Wilderness Plantation, Lanarkshire.**
Britannia 3, 1972, 7, 12, 19; 8, 1977, 365, 433 RIB 2187; 10, 1979, 19, 21, 31, 3 stone-lined drains. Clarke 1933, 62-3. Hanson 1970, 360, comments that there is no known water supply, but that the supply could have come from 'the east, and the existence of a spring cased in Roman masonry was noted on an old estate map of the area'. JRS 41, 1951, 61; 54, 1964, 153; 57, 1967, 175-6, Fig.4. Macdonald 1934, 297-312. RCAHMS Lanarkshire, 1978, 121-4. Robertson 1990, (4th ed.), 81-3, Fig.52, 2 baths, (2) internal within the fort, (6) external to fort. TIRBS 1987, 14, RIB 2187.

**Caerhun, Gwynd, Caernarvonshire, Wales.**

**Caerleon, Gwent, Wales.**
Late in the 1st c. the tabernae were rebuilt in stone and the colonade in brick; a colonade with drain was also now added along the side of the basilica....; an original lead water-main was replaced and the street replaced. At the end of the century the drains became filled, the porticoes were dismantled and the lead pipe dug out; new metalling of the street and the porticoes after AD 330; coin of Valentinian I'. Originally wooden structures from c. AD 74-75, but replaced by stone c. AD 80s. Conjectural whether disused by c. AD 290. So the site dates from c. AD 80s; extensive modifications in late 1st c. and early 2nd c. and coins indicate activity still in 1st half of 4th c.; 20, 1989, 263-4, 342, 345; 21, 1990, 221, 260, 300-7; 22, 1991, 226; 24, 1993, 274-5; 25, 149, 250-1. Glamorgan-Gwent Arch. Trust's Annual Review 1987-8, 8-9. Hanson 1970, 180-1, aqueduct, 4 external baths(p.180), 1 internal, 2 wells, spring, tank and sewer. Stephens 1985b, 223, 229, 'Wooden and lead piping dating from c. AD 80 has been found near the amphitheatre (Wheeler & Wheeler 1928, 144, pl. xx). They imply the existence of an aqueduct. Distribution was by lead mains (Nash-Williams 1929, 145, Fig.5). Nash-Williams 1969, (2nd ed.), 29-33. Zienkiewicz 1986. TIRCGLL 1983, 32, RIB 316-94; important port and legionary fortress, established c. AD 75, gradually rebuilt in stone c. AD 100. Legio II Augusta withdrawn c. AD 293(?) (Silures).

Caernarvon, Gwynedd, Wales.

Arch. Cambr. 109, 1960, 136-72; 111, 1962, 111-24; 123, 1974, 54ff. Arch. of Wales, CBA Gr, 2, 18,1978, 75, 53; 76, 54; 77, 29. Flavian fort, dismantled c. AD 300-25. Britannia 1, 1970, 54 Ant. Itin. 482.5, Segunto; 2, 1971, 127, 128 n.47, 130 n.54; 6, 1975, 208-9; 7, 1976, 292, bath-building, drains, water-pipe, 358; 8, 1977, 288, 299, 356-8, Fig.2; 9, 1978, 404-6, wells; 10, 1979, 30, 60, 269-71: '... in the annexe or ordnance depot WNW of Segontium, in a well containing other leather objects...'. Hanson 1970, 360-1, 'The discovery of an inscription, RIB 430, recording the reconstruction of the fort's aqueduct channels in the early 3rd c.', indicating the fort had an aqueduct water supply prior to this period. JRS 43, 1953, 104; 50, 1960, 236; 53, 1963, 125, 160. Stephens 1985, 228, 230, 'An inscription dating from AD 198-209 (RIB 430) commemorates "riuos aq]uaeducttium uetu(tate cola)bs(os". Use of the genitive shows that there was more than one aqueduct or channel, whilst restoration "uetustate conlabsos" shows that more than one aqueduct or channel also supplied the Antonine fort. No doubt one channel supplied the
fort and a second its extramural bath-house. Wheeler 1924, 110-11, 'The fort could only have been supplied by pipelines'. Y Cymmrodor, 31, 126-7, 1921 excavations; 32, 267, 1922 excavations. CSIR I.5, 1986, Nos.8-10, 43, 48. TIRBS 1987, 15, RIB 429-36. (Ordovices).

Caersws, Powys, Wales.

Caerwent, Gwent, Wales.

Caister-on-Sea, near Great Yarmouth, Norfolk.

Caistor-by-Norwich, Norfolk.


Calne, Studley, Wiltshire.

Scott 1993, 199, SMR SE 302, WZ 43; SMR se 306, WZ 44. VCH Wiltshire 1, 1957, 54. WAM 45, 1930-2, 180, villa with bath and cistern.

Cambridge, Castle Street, Cambridgeshire.

Cantley, near Doncaster, South Yorkshire.

Annable 1960. More than 40 kilns were recorded, a large pottery industrial complex, one well recorded. Britannia 5, 1974, 416, Iron Age and Roman enclosures, pottery kilns; 6, 1975, 237-8 (also Besacarr); 11, 1980, Buckland, et al, 1980, 145-64. JRS 44, 1954, 90-1; 50, 1960, 220. YAJ 37, 1954 12?; 38, 1955 536-45. Gilmour 1955, 536-45, the well was excavated to a depth of 27ft (8.21m) without reaching bottom, and it was c. 5ft (1.52m) in diameter. TIRBS 1987, 16, large pottery works, active from mid 2nd to late 4th. Also workings during Iron Age period. (Corieltavi or Brigantes).

Cappuck, Borders, Scotland

Arch. J., 142, 1985, 216-36, Stephens at p.224, comments '...a "roughly made watercourse channel which had probably once contained a pipe or wooden channel" runs through the courtyard of the central building....This might have formed part of a distribution system, for there are too many water channels for them to have been connected with drainage'. Britannia 3, 1972, 9, 14, 20, 41, period of occupation c. AD 163-196. JRS 61, 1971, 121, large marching camp south of the fortlet at NT 698 209; 63, 1973, 216. Stevenson & Miller in PSAS 1911, 446-83, see p.461 & Fig 3: This figure shows ten unspecified type drains or branches of the main drains marked as such. Three pits are shown, one in the main building and two in the S-E corner just inside the inner rampart; both appeared to have been used as drainage pits. RCAHMS Roxburghshire 2, 1956, 381-3. CSIR I.4, 1985, No.44. TIRBS 1987, 16-7, RIB 2117-9.

Cardiff Castle, South Glamorgan.


Carisbrooke, Isle of Wight.

Carlisle, Northumberland.

Archaeologia 64, 1913, 299-301; Arch. J., 1893, 20-36; 135, 1978, 115-6. Britannia 1, 1970, 42,47, Ant. Itin. 467.2 (Luguvallo), 474.1, 476.6 (Luguvallo), RIB 2015?, 149, 155; 5, 1974, 142, 410-1 water supply; 8, 1977, 376; 10, 1979, 281; 11, 1980, 359-60 hypocausts; 13, 1982, 79-89, 343-4 fort; 15, 1984, 113; 16, 1985, 197-207, at p.202 Stephens states that 'At Carlisle, where a public fountain was still in working order when St Cuthbert visited the city in AD 685, the evidence comprises a wooden pipeline and a fountain'; 21, 1990, 112-3, 360-7; 22, 1991, 235, 299-301, aqueduct, bath building at NY 400 561, drains; 23, 1992, 45-109, excavations of the first Flavian fort, 112-3, 141-58, 319; 24, 1993, 316; 25, 1994, 263. Burnham & Wacher 1990, at p.55 it is stated that 'The famous aqueduct seen working by St Cuthbert remains elusive, but the water tank inside the portico of a building...was presumably fed by it', and presumably the fountain was fed from the tank if it was high enough. TCWAAS(1) 12, 1893, 344-64. Hanson 1970, 361, item 18, 'Even as late as the 7th c. Carlisle possessed a Roman fountain that was still in working order and from the fact that a fountain can only work from a supply of running water it seems fairly safe to assume that Luguvalium had an aqueduct'. JRS 42, 1952, 104; 44, 1954, 88; 46, 1956, 124; 47, 1957, 202, water tank; 48, 1957, 202, 'water tank found in the grounds of the Tullie House Museum implies a working aqueduct. PSAS(2) 14, 1892, 222-4. Salway 1969, 43. Wacher 1975, states that the fort area seems to have grown into a town of about 28ha (70 acres). 'St Cuthbert perambulated its walls in the 7th c., and also saw a fountain': Bede, 'Vi ta Sancti Cuthberti', iv, 27; also 1995, 2nd ed., 21, 32, 88, 421. TIRBS 1987, 17-8, RIB 943-64; Civitas Carvetiorum. Flavian fort (but probably not pre-Agricolan); fort demolished c. AD 100 and rebuilt soon after; held till late 2nd c.; early 3rd c. re-occupation continuing to c. AD 300; S-E an extensive settlement (vicus) (c. 27ha), late 1st to 4th c. (Brigantes).

Carlisle-Old, Northumberland.


Carmarthen, Dyfed, Wales.

Carpow, Perthshire, Tayside, Scotland.
Arch. J. 142, 1985, 216-236, at 217, 223, 229, Stephens comments 'A battery of wooden pipelines entered the fortress through the south gate...Distribution was by both wooden and lead pipes (JRS 59, 1969, 202). A channel measuring 2.6m wide by 0.6m deep has also been traced approaching the S-W angle (JRS 48, 1958, 91) ...This is far too large a pipe trench, which suggests that it was a leat cut to supply the extramural bath-house. (Additional information from Prof J J Wilkes)'. Birley 1967. Britannia 1, 1970, 273; 2, 1971, 248; 3, 1972, 29, 36, 40, 48; 5, 1974, 207, 289-92; 7, 1976, 156, 238, 299, 11, 1980, 351; 12, 1981, 305-6; 15, 1984, 57; 18, 1987, 27; 21, 1990, 310; 24, 1993, 278. Hanson 1970, 'The aqueduct, first recognised from air photographs in 1958 and excavated in 1962, consisted of a ditch 2ft deep and 8.5ft wide. No trace of any lining for this ditch was found, and it would seem therefore that it had contained a pipeline, although no remains of piping were discovered....excavations on the S Gateway in 1969 did reveal "the lines of two channels, running below the passageways....The east one contained fragments of iron collars from a wooden water pipe"' 194-5. Similar iron collars found inside the fort, 3 1/2 inches in diam. (My comment: The 'ditch' described could have been a leat, not usually lined, particularly if it was constructed in clayey soil.) JRS 48, 1958, 86-101, St. Joseph, 1958, at p.91; 52, 1962, 163; 53, 1963, 127, 164; 59, 1969, 202. Leach & Wilkes 1977,

Carrawburgh, Northumberland.

Carsington, Brough Field, Shiningford Farm, Derbyshire.
Britannia 12, 1981, 333-5, Fig.8: well & drains; 15, 1984, 290; 16, 1985, 282; 23, 1992, 233-6; 25, 1994, 270. Occupation appears to have been from Period I c. AD 125-50 to Period III 4th c. A well 'at the N end of the site, a large cobbled yard associated with a timber structure of uncertain size. To the south lay a well which appears to have collapsed soon after completion'. A drainage ditch cut across a building of the 2nd half of the 2nd c. Other drainage ditches during Period III, 4th c.

Carvoran, Magnis Fort, Northumberland.
Castell Collen, Powys, Radnorshire.


Castle Greg, Lothian Region, Scotland.


Castle Hill (1) East Bridgeford, Nottinghamshire.


Castle Hill (2), Nottinghamshire.

Bromhead 99, 1942, 142-51, 183-96, at 144, comments, 'Felix Oswald mentions that a 6ft square hole was dug to water-level in a framing of oak planks, but this was then lined with rammed clay to leave a 0.6m (2ft) diam., circle....That just mentioned was of Claudian age, but on the same site, 3rd century. Wells, filled in about AD 296, were stone-lined'. Oswald 1948; 1952; 1956. *PNRB* 1979, 413-4. Todd 1973, 29, 36-7. *TTSN* 73, 1969, 7-112. Rodwell & Rowley (eds.), 211-5. *VCH* Nottinghamshire 2, 1910, 15-17. Webster 1980, 162. *TIRBS* 1987, 55. (Corieltavi).

Castle Nick, Mile Castle 39, Hadrian's Wall, Northumberlandshire.

*Arch. Ael{(1)}*. 4, 1855, 273. *Britannia* 14, 1983, 290-1 Fig 6; 15, 1984, 280; 16, 1985, 271; 17, 1986, 378-80, Fig.11; 18, 1987, 316,

**Castle-Dykes, North Yorkshire.**


**Castleford, West Yorkshire.**


**Castleshaw, West Yorkshire.**


**Castlesteads, Hadrian's Wall, Northumberland.**

Guide: Hadrian's Wall, at p.7, under 'Castlesteads Roman Fort, gives the Roman name of 'Camboglanna'; this fort is unique, since it was built between the Vallum and the Wall opposite MC 57. The remains of the fort was completely destroyed when Castlesteads House was built in 1779. TIRBS 1987, 20, RIB 1976-2009; fort of Hadrian's Wall (c. 1.46ha). (Brigantes).

Castor(1), Water Newton, Normangate Field (South), Huntingdonshire.


Castor(2), Normangate Field (East), Huntingdonshire.


Catsgore, Somerton, Somerset.


Catterick, North Yorkshire.


Cattybrook, Almondsbury, Avon.

Bennett 1980, 167, drainage channel. Britannia 5, 1974, 448; 6, 1975, 271. (Much of the site was destroyed by quarrying operations before excavations started.)

Caversham, Berkshire.

Britannia 1, 1970, 210; 12, 1981, 271-6; 20, 1989, 319, 333, no.13, pl.26, circular lead tank and timber-lined well, with 4 square timbers each about 1.5 m long supporting vertical sides.

Chalk, Kent.


Chapel Hill, Grampian, Scotland.

Wooler 1917, 190.

Charmy Down, Avon.

Britannia 22, 1991, 278: 'nearby lay a stone watertank and gutter-blocks. Associated pottery suggests a 4th c. date'; 23, 1992, 296, '...further buildings ...examined;...A monolithic cylindrical water-cistern c. 1m diam. found'.

Chedworth(1), Gloucestershire.

Chedworth is probably one of the best known villas in Britain, discovered in 1864 by chance and excavated by James Farrer and the site was recovered by his nephew Lord Elton; now the property of the National Trust, which comments is: "...development from the early 2nd c. to the late 4th c., with evidence of fire in the early and late phases..." The main water supply to the villa was from a spring, S, at N.W. corner of the site; it was channelled into a cistern just outside the suggested N.W. angle of the precinct wall. A roughly circular sinking 6ft across, possibly the site of a wall, occurs at H, some 30yds E of room 12. The villa had two bath-suites, and a latrine, with so far 4 drains identified. A long list of references are given but many relate to small finds and mosaics. McWhirr 1981, 90-12, 150-3. Ross 1967, 50ff.

Chedworth(2), Listercombe Bottom, Gloucester.

Britannia 20, 1989, 309-10. JRS 21, 1931, 240, water pipes and possible bath. Scott 1993, 70, SMR 548, GS 23, Listercombe Bottom is c. 2.8km N of Chedworth villa, further up the valley; Mr C E Key, 1930, 'found fragments of tessalated pavement, a stone-built wall, "90 ft long", pierced by water conduits, a flagged corridor and a small pillared hypocaust'.

Chells Manor, Near Stevenage, Boxfield Farm, Hertfordshire.

Britannia 19, 1988, 455; 21, 1990, 338-9 Fig 20; 22, 1991, 259, well, 4.4m diam at top, narrowing to 1.1m at depth 14.5m. With such a large diameter at the top it appears as if the mouth was enlarge by caving in of the soil.

Chelmsford, Essex.
CBA Gr.7

Cheshunt, Hertfordshire.

Smith 1987, 177. OS NMR, TL 30 SW/5, (personal communication by J Edwards). Well, tile-lined channel capped with stone, c. 4th c.

Chester, Cheshire.

Britannia 1, 1970, 42-3, 54, 65, 469.2, 482.8 (Deva), fortress of Legio II Adiutrix, c. AD 75-87, Legio XX, c. AD 87-4thc.; 2, 1971, 253, 292-3 lead water-pipes; 3, 1972, 313, sewer; 8, 1977, 387; 11, 1980, 58, 318, 364-5, 407-8; 16, 1985, 197-8; 17, 1986, 387-8 Fig.14; 20, 1989, 282-3 baths. Hewitt 1895, 328-9. JCAS 68, 1985, 53-7, 59-69 aqueduct. JRS 45, 1955, 146; 46, 1956, 148; 50, 1960, 221; 57, 1967, 180, 203; 58, 1968, 207; 59, 1969, 235. Hanson 1970, 185-91, 363, comments, 'The (legionary) fortress was supplied by an aqueduct from springs two miles to the east of Chester. Finds of clay piping along the projected line of the aqueduct can probably be taken as indicating the kind of supply system in use and a pipeline would have been necessary to negotiate a rise in ground level near the East Gate of Deva'. Stephens 1985(b), 223, 229, comments, 'The aqueduct was formed of earthenware pipelines...This was almost certainly a multiple pipeline aqueduct fed from springs at Broughton c. 1.5 km away, where a dedication to the 'Nymphis et Fontibus' (RIB 460) has been found; "fons" in the plural suggests that more than one spring was tapped. Distribution was by lead mains dating from AD 79', and in 1985a 206, he comments, '...Thus aqueducts were not essential to the functioning of municipal thermae (see note 12), but it can hardly be a coincidence that the fortress bath-house at Chester, for example, was constructed in AD 79 (RIB 463), the same year that its water mains were manufactured, nor that at Exeter the legionary fortress bath-house and
the service pipes supplying it were contemporary'. Thompson 1965, 51-
2, lead pipe. Wright & Richmond 1955, 48.199, pl.XLIV.199. There is
an extensive literature dealing with Chester, see TIRBS 1987, 22, RIB
445-573, 460, 2434; occupation from AD 79 to after c. AD 330 when
garrison was reduced. (Cornovii).

Chesterholm, Vindolanda, Northumberland.
Arch. Ael. (4th s.) 8, 1931, 181-212; 9, 1932, 216-21; 11, 1934, 127-
276-7 fort; 2, 1971, 249; 3, 304, 306-7; 4, 1973, 275-6, 347-8; 5,
1974, 360-73, 408-9, 471-80; 7, 1976, 342; 8, 1977, 198; 9, 1978, 480-
14, 1983, 347-8; 16, 1985, 199-200, water supply: 17, 1986, 453; 19,
315, 346; 24, 1993, 314. Stephens 1985a, 197-208, comments, `...,
whilst at Chelmsford, the mansio was supplied by a wooden
pipeline...the mansio and external bath-house of the fort were fed by
channels tapping a nearby well or enclosed spring,...' Hanson 1970,
362, item 23, fort/vicus/mansio, 'An aqueduct of channelled stones
that came from a spring just to the west of the fort, refs. RIB 1049'.
See R Birley's new excavation reports(1993). Aqueduct RIB 1049;
drains. There is an extensive literature on Chesterholm or Vindolanda.

Chester-le-Street, Northumberland.
Arch. Ael.(4) 22, 1944, 83-90; 46, 1968, 75ff. Britannia 2, 1971,
street; 15, 1984, 281, 342; 22, 1991, 238, in the N-E room `...a
stone-lined latrine', 342. Hanson 1970, 362, comments 'The aqueduct
at this fort is known only from an inscription attesting its
construction during the early 3rd c., RIB 1049, inscriptive evidence
of the aqueduct. TIRBS 1987, 23, RIB 1043- 50; CIL vii, 1234
inscription; fort (2.52ha), occupied c. 160-400. (Brigantes).

Chester, Northumberland.
Archaeologia 46, 1878?, 1ff: refers to a `finely made stone-lined well
in the principia courtyard..., p.247. Arch. Ael.(4) 8, 1931, 219-340
vicus; 19, 1942, 163-4; 20, 1943, 134ff; Arch. Ael.(5) 7, 1979, 114-
184 n.72, 201 n.6; 3, 1972, 7, 193-5, 197 n.66, 204-5; 7, 1976, 157,
12, 1981, 268; 14, 1983, 289-90; 15, 1984, 278-9 baths; 18, 1987, 45 vicus; 22, 1991, 234. Bruce 4th ed., 1895. He comments on a rain-water tank in the North Chamber of West Gate, with gutter stones still in place, pp.89-90. 'Going along the South rampart we come to one of these (a tower, marked C on the plan) - a square building with a door on its inner side. On this side are a number of gutter-stones for receiving the rainfall from the roof, which were found, when the excavation was made, previously in the position in which they are now', p. 90, 2nd para. Bruce's comments were originally made during the 1850s. Hanson 1970, 243-8, item 7, 363, items 25 & 26, 'The terminal end of a raised aqueduct channel, the channel itself formed of channelled stones, was found entering the north guardchamber of the west gateway where it delivered water into a stone-built tank. As it was inserted into the guardchamber (and was not contemporary with the latter’s construction) it is possible that this is the aqueduct referred to by an inscription RIB 1463, dating to the reign of Severus'; see no.1 p.245. Scott makes comment on a suggested 3rd aqueduct, p.247. JRS 41, 1951, 55; 45, 1955, 146; 47, 1957, 229; 62, 1972, 193. Somers 1984, Fig.8, plan. TIRBS 1987, 23, RIB 430, 1049, 1060, 1448-1495; extensive civil settlement; bridge carrying the wall over the North Tyne; water-mill; fort on Hadrian’s Wall overlying Turret 27A. (Brigantes).

Chesterton(1), Cambridgeshire.

Chesterton(2), Cambridgeshire.

Chesterton(3), Staffordshire.
Britannia 10, 1979, 103-5; 16, 1975, 1-15. JRS 48, 1958, 150. NSJFC 9, 1968, 104-17, bath. VCH Staffordshire 1, 1908, 189. TIRBS 1987, 23, Flavian fort (1.9ha, or more probably 2.2ha); bath-house. (Cornovii).

Chichester, West Sussex.
Britannia 1, 1970, 49-50 Ant. Itin. 477.10 (Regno); 3, 1972, 350-1 sewer; 5, 1974, 457; 6, 1975, 282; 7, 1976, 372-3 baths; 8, 1977, 421-2; 9, 1978, 466-7 wells; 10, 1979, 332-3; 11, 1980, 396-8; 14,

Chigwel, Essex.
Black 1995, 102 Route 9, 118 item 42, 119 Fig 1 position 42, 120 item 18, 121, Fig.2 position 18, mansio with bath. Britannia 1, 1970, 42-3, 65, 73, Ant. Itin. 480.7 (Durolito); 6, 1975, 81, 93 discounted as Durolitum at Romford; 11, 1980, 17. Essex Arch. Hist. 11, 1979, 102. Essex J. 15, 1980, 3; 16, 1981, 4. Gould 1983, 197-8; idem. 1985, Fig.3, bath-house, 2 wells. RCHM 1921, Essex, Central and South-West, 47, 'In each of these two main sites a well has also been found, ...'. Rivet 1964, 147. Rodwell & Rowley (eds.), 1975, 85-101. Scott 1993, 61, SMR 4057, ES 17. VCH Essex 3, 1963, 88. TIRCGLL 1983, 37. (Trinovantes).

Chilgrove(1), West Dean, Wellmeadow, West Sussex.

Chilgrove(2), near Warren Down, West Sussex.

Chipping Warden, Northamptonshire.

Chiseldon, Berricot Lane, M4, Wiltshire.

Churchill, Oxfordshire.

Britannia 13, 1982, 367, spring.

Churchill Hospital, Oxfordshire.

AEx 1972, 63. Britannia 4, 1973, 296; 5, 1974, 436, well. CBA Gr.9 Newsletter No.3, 1973, 30; No.4, 1974, 21-2. Oxoniensia 37, 1972, 10-31; 38, 1973, 207-14, Fig.1 well, belonging to 1st c. occupation; possibly pre-Roman.

Cirencester(1), Gloucestershire.


Cirencester(2), Barton Farm, Gloucestershire.

Scott 1993, 70, SMR 2092, GS 26, wiggled-corridor villa. TBGAS 33, 1910, 67-77, bath(?)

Claydon Pike, Lechlade & Fairfield, Gloucestershire.

Britannia 15, 1984, 312-4, Fig 21 'three wells associated with Roman rectangular timber buildings, one of them entered by steps of which
one was formed of reused timber' (314). 'two (312) deep tanks at back of two rooms'. *Oxford Arch. Unit, Newsletter 9, 1983, Nos 2-4.*

**Clayton, West Sussex.**

**Cliffe House, North Yorkshire.**

**Cnut's Dyke, Huntingfordshire.**

**Cobham, Surrey.**

**Cobham Park, Kent.**

**Coddenham, Suffolk.**
Colchester, Essex.

Arch. J. 123, 1967, 32; 142, 1985, 216-36, 'A possible leat has been identified at the Sheepen site to the west of the fortress'. Britannia 1, 1970, 18 Ant. Itin. 474.4 (Colonia), 480.4 (Camulodunum), 149, 181-2, 258, 290; 2, 1971, 168-94; 3, 1972, 164-81; 4, 1973, 302-4 fortress and colonia; 5, 1974, 210-1; 6, 1975, 79-83, 176, 198-9, 263-4; 7, 1976, 176-7, 180, 182, 189-90, 343-4; 8, 1977, 92-5, 97, 100 water supply, 198-9, 407, 437-8; 9, 1978, 449-51 sewer; 10, 1979, 157-63, 148, 308-9; 11, 1980, 378-9; 12, 1981, 289-90; 13, 1982, 371; 15, 1984, 105, 343; 16, 1985, 178-90, 201-2 water supply, 295-6; 17, 1986, 356-8, 405-7, 442; 18, 1987, 273-4, 332-3; 19, 1988, 196; 20, 1989, 178, 302-3; 21, 1990, 276, 297, 342; 24, 1993, 1-6, 302; 25, 1994, 324-5. Crummy 1977, 65-105, at 100, Figs.11, 20, where distribution by wooden pipelines is attested. Idem. 1984, 5, leat, wells timber-lined, 26-8, water supply as water mains, wells, leat, spring and aqueduct, Figs.84, 96, 99, 101-4, 107-9, 111, 115-7, water-mains and iron collars, tanks 140-2, Fig 102, 104, 106, 131, baths 146; idem. 1992, baths 71, 268, tanks 31, 40, 63, 78, 89-90, 105, 255, 355-6, water-pipe junctions collars 72, 101, 105, 358 and micro-fiche 995, wells 36, 335-6, 365, 388, 390-2, and micro-fiche 799, 820, 876, 879, 970, 1003 1019, 1048, water supply 24, 30, 40, 44, 47, 67, 69, 72, 101, 105, 355-6, 358; idem. 1990-1, bath(7). Dunnett 1966, 27-61, at 31, Fig.2, pl.IIIA; idem. 1975, 128, n.17, it has been conjectured that water was pumped uphill from the Sheepen springs but the aqueduct was most certainly a pipeline aqueduct employing an inverted siphon to convey water from the springs to the south or west. It is conceivable that this aqueduct was first laid to supply the fortress'; idem. 1971, 1-106. Hanson 1970, 35-42, 363. Hawkes & Hull 1947, 73, 76, Fig.13, pl.VI, 106-7, 282-4, pl.XII. This runs at too low an elevation to have supplied the fortress and the fort at Gosbecks. The colonia was supplied by a battery of four wooden pipelines which entered through the Balkerne Gate. These date back to the pre-Boudicean period. Hull 1958, 13, 17; 1963, 147. Swan 1984b, fiche 277, Colchester(7) TL 9865 2517, well V; fiche 286, Colchester (13), well nearby at TL 9874 2566, Sheepen, east-side of Hull's region 4; Colchester (14), Middleborough Castle Market site TL 9926 2556: 3 timber-lined wells in the vicinity of kiln 36, with another well nearby, (6 wells). Wacher 1995, 112-32. TIRCGLL 1983, 39, RIB 63-9; Pre-Roman capital of the Trinovantes, then of the Catuvellauni under
their king Cunobelinus; fort, legionary fortress (Legio XX Valeria),
then colonia AD 49; destroyed by Boudica AD 60; rebuilt and given name
Victricensis; possible capital of the Civitas Trinovantum (cf
Chelmsford); temple of Claudius, and 7 Roman-Celtic temples; walls
enclosed c. 40ha. (Trinovantes).

Cold Brayfield, Buckinghamshire.
Scott 1993, 26, SMR 1280, BU 22: 'head of spring'. Wolverton and

Cold Knap Point, Glamorgan.
Black 1995, 118-9, 179, Fig.60, (?)bath. Britannia 12, 1981, 316; 13,
JRS 51, 1961, 158. RCAHM Glamorgan 1(2), 1976, 120.

Coldharbour, Gloucestershire.
Britannia 16, 1985, 93f.

Colerne, Wiltshire.
(Belgae).

Coleshill, Warwickshire.
Britannia 10, 1979, 300 bath, 3 tanks shallow mortared-lined, c. 1 x
1.5m, drain, imbrex-lined, occcupation from Iron Age, and abandoned by
16, 1985, 183. TIRBS 1987, 24, Romano-Celti temple. (Corieltavi or
Cornovii).

Collingham, West Yorkshire.
well in rock-cut, 2m diam., 17m deep, with substantial well-house,
remains of 8 wooden buckets, stone cisterns; 12, 1981, 330; 18, 1987,

Colliton Park, Dorchester, Dorset.
Britannia 2, 1971, 170, 178, 180; 4, 1973, 158, 171. Dorset Proc. 59, 1937, 1-14; 60, 1938, 51-65; 84, 1963 113, another well at the New Clinic site, 17.33m deep and 1.2m in diameter, of which the upper 2.1m was stained with flint and limestone blocks. RCHM 1970, County of Dorset 2(3), 553-61, 'Colliton Park, Fig. on p.554 shows 3 wells, Fig. p.556 shows two of these wells in vicinity of building I and 3rd well in vicinity of building III: 1) 1.1m (3.5ft) diam., 10.4m (33.5ft deep, lay to N of the S range (p.558a), 2) 'A well to the south over 15.8m (52ft deep had a limestone coping' (p.560a), 3) 'To the N-E a stone well-head of hexagonal plan with circular shaft 0.6m (2ft) diam., contained late Roman material in its partially excavated upper filling, SY 6909 9050'. Page 562, item 190, boiler house at SY 6905 9055; at SY 6904 9053, a stone-lined covered drain (2.13m, 7ft, section); p.561, item 189, well-head, stone-lined, 0.6m (2ft) diam at SY6909 9050. Figure also shows several drains. Colliton Park Villa was situated too high to obtain water from the Dorchester aqueduct.

Colsterworth, Lincolnshire.

Combe Down, Somerset.
VCH 1, 1906, Somerset, 309-10, item 19, probable fort, bath(?). TIRGCLL 1983, 39, RIB 179; villa, courtyard; coins of 4th c. (Belgae).

Comberton, West Cambridgeshire.

Combley, Isle of Wight.

**Compton(1), Pitlands Farm, Upmarden, West Sussex.**

**Compton(2), Surrey.**

**Compton(3), Berkshire.**

**Congresbury, Taylor's Wood, Avon.**

**Corbridge, Northumberland.**
the Stanegate, overlooking the crossing of the Tyne. It still had use when the forts were moved to the Wall, and in time it became an important supply base on the route to Caledonia. It eventually became a small town covering some 40 acres... The civilian areas are in the fields to the west and south of the fort... The water supply is brought down to the site from the North by aqueduct. It fed a great stone cistern in the centre of the fort. The fountain head was the famous sculptured lion, shown with prey... The bath-house was situated nearer the river'. TIRBS 1987, 24-5, RIB 1120-97, 2296-7. (Brigantes).

Corhambry, Hertfordshire.
Britannia 6, 1975, 258 Fig.10, well, bath-suite. Period of occupation from Iron Age to the 1st-half of 4th c., at least 15 phases can be recognised. Original timber structures probably burnt down during revolt by Boudica in AD 60.

Corton, near Lowestoft, Suffolk.
Bromehead 1942, 99, 142-51, 183-96, at 192, Fig.3 opp. p.187 item 5. Well, brick-steined.

Cosgrove, Northamptonshire.

Cotterstock, Northamptonshire.

Covehithe Suffolk.
PSIA 7, 1891, 303-4. VCH Suffolk 1, 1911, (reprinted 1975), 303 well.
Cow Roast, Northchurch, Hertfordshire.


Cowbridge, South Glamorgan, Wales.


Cox Green, Maidenhead, Berkshire.


Cramond, West Lothian Region, Edinburgh.

Britannia 3, 1972, 304 vicus; 5, 1974, 163-224: 7, 1976, 305-6 bath-house; 8, 1977, 368-70 plan bath; 9, 1978, 418 well, c. 3.5m deep, 1.4m diam.; 10, 1979, 278-9; 11, 1980, 354; 2, 1981, 321; 14, 1983, 289; 19, 1988, 429; 23, 1992, 264-5, Fig.7: '...an annexe which may have included an external bath-house', and also 'observed a pipe-line along the N side of Kirk- Crammond road'. Current Arch. 55, v(8), 1976, 241-5; 59, v(12), 1977, 378-81 (2 pictures). Rae A & V 1974, drains and latrine, tank Fig.12. Severan pottery probably indicates earliest occupation, and latest activity was in late 3rd or 4th c. TIRBS 1987, 26, RIB 2134-7.

Croy Hill, Cumbernauld, Strathclyde, Dunbartonshire.

Dalginross, Tayside, Scotland.

Britannia 15, 1984, 55. Crawford 1949, 41-5. JRS 55, 1965, 81; 59, 1969, 109; 63, 1973, 224. Frere & St. Joseph 1983, 129-31. Hanson 1970, 196, 365, item 34, (south camp) comments: 'This Roman fort was reported,..., to have been fed by an aqueduct coming from Roachell Water to the west of the site...'. item 35 (north camp), Hanson further comments, 'the same writer,...also recorded that the subterranean stone-built channel delivered water to the north camp at Dalginross (on OS map) from a stream running to the west of the site'. Macdonald 1939, 253 Fig.2, 'aqueduct from Roachell Water to the West of the site'. Roy 1973, pl.xi. PSAS 97, 163-4, 196-8. Stephens 1985b, 224, comments, 'A "small aqueduct" was observed in the 18th c. This will have been a stone channel, a wooden pipeline would probably not have been recognized, whilst reference to a "subterranean passage" shows that it was not a leat. Undated but presumably 1st c.'.

JRS 55, 1965, 81; 59, 1969, 109; 63, 1973, 224. Frere & St. Joseph 1983, 129-31. Hanson 1970, 196, 365, item 34, (south camp) comments: 'This Roman fort was reported,..., to have been fed by an aqueduct coming from Roachell Water to the west of the site...'. item 35 (north camp), Hanson further comments, 'the same writer,...also recorded that the subterranean stone-built channel delivered water to the north camp at Dalginross (on OS map) from a stream running to the west of the site'. Macdonald 1939, 253 Fig.2, 'aqueduct from Roachell Water to the West of the site'. Roy 1973, pl.xi. PSAS 97, 163-4, 196-8. Stephens 1985b, 224, comments, 'A "small aqueduct" was observed in the 18th c. This will have been a stone channel, a wooden pipeline would probably not have been recognized, whilst reference to a "subterranean passage" shows that it was not a leat. Undated but presumably 1st c.'.


Dalswinton, Dumfries and Galloway, Scotland.

Britannia 2, 1971, 145 fort; 3, 1972, 11, 14; 18, 1987, 1-48. GAJ 4, 1976, 7-11, plan. Hanson 1970, 364, comments: 'An open leat feeding a mill-pond to the south of Dalswinton from the Brandy Burn has been noted crossing the site of the Roman fort. Since the Brandy Burn, which runs directly to the north of the fort, is the nearest source from which the external gravity-fed water supply could have been laid on to the site, it is possible that the leat represents the older, Roman supply system'. JRS 41, 1951, 59; 48, 1958, 89; 51, 1961, 122; 55, 1965, 79; 67, 1977, 131-3, plan. Maxwell & Wilson 1987, 30, with comment: '...Woodhead...It is possible that this was a labour-camp, perhaps accommodating troops engaged in felling timber for the Flavian fort-construction programme. The only comparable site until recently was the southernmost structure of the military complex at Dalwiston (NX 986 839)'. Trans. of the Dumfries & Galloway Nat. Hist. & Antiquarian Soc., 34, 1957, 10-11. TIRBS 1987, 28, Large fort with anexes (3.48ha enlarged to 4,6ha), (NX 933 848).

Darenth, Kent.

Daventry, Borough Hill, Northamptonshire.
JNNHS 26, 1932, 177. RCHM County of Northants, N-W 3, 1981, 62-72, item 18, No.23, Figs.54-58, villa near S-W corner of the northern fort on a small knoll at 191m above OD; stone-lined well S-W of building, Fig.55. Not clear if villa occupied before 3rd c., but went into 4th c. Scott 1993, 142, SMR 223, NH 33. Smith 1, 1848, 113; 3, 1854, 208. VCH Northants 1, 1902, 195. Whitwell 1982, 219. TIRBS 1987, 28, dating from 3rd to 4thc. (Catuvellaunni).

Dean Hall, Gloucestershire.
Britannia 16, 1985, 299-300, Fig.24, paved drain leading from a probable springhead (from 2nd period); 17, 1986, 410-2; 19, 1988, 467. Dating from 2nd to 3rd c., much evidence of Roman occupation around the Hall.

Denton, Lincolnshire.

Derby, Little Chester, Derbyshire.
Antiq. J. 51, 1971, 36-69, Trajanic well at SK 3613 3755; 60, 1980, 8-47. Brassington 1980, 8-47. Britannia 1, 1970, 283, well (SK 353 375); 4, 1973, 285; 5, 1974, 419-20, vicus; 6, 1985, 242-4, 6 wells, showing a variety of of constructional techniques in stone and timber,

**Dersingham, Ingoldisthorpe-Snettisham Bypass, Norfolk.**

*Britannia* 21, 1990, 340, 2 wells with good timber-linings. Occupation from late Iron Age to 3rd or 4th century.

**Desborough, Northamptonshire.**

PSA 22, 1908, 333. RCHM County of Northants, Central, 2, 1979, 33-4, Fig.36, 3 wells. OS Record Cards.

**Desford, Leicestershire.**


**Dewlish, Dorset.**


**Diddington, Little Paxton Quarry, Cambridgeshire.**

*Britannia* 18, 1987, 367; 19, 1988, 450; 24,1993, 296; 25, 1994, 274-5, Fig.11, c. mid 2nd c. to late 4th c., 3 phases identified, 2 wells, tank.

**Dicket Mead, Hertfordshire.**


**Ditchley, Oxfordshire.**

Dolaucothi, Dyfed, Wales.

Doncaster, Yorkshire.

Dorchester(1), Dorset.
by c. 320-60 and a 2nd public bath built after 4th century; 14, 1983, 324-6 water supply; 15, 1974, 320; 16, 1985, 197-207, 199, 201, 203-4, 306; 18, 1987, 345; 20, 1989, 315; 21, 1990, 350-2; 22, 1991, 284-7, 350-2. *Dorset Proc.*, 1952, 152. Frere, 1967, 246. Hanson 1970, 104-10, and at 365 item 38, comments "This open channel aqueduct, about 13 miles long is one of the most impressive structures of its kind in Britain. Allowing for an average fall of only some 0.38m per kilometre or 1 in 2640 (2ft per mile) it followed a circuitous route to bring water from the river Frome to Durnovaria'. Hanson assumes that the start of the aqueduct is as suggested by the early engineers, but which has not been substantiated by later archaeological investigations. *JRS* 30, 1940, 175-6; 35, 1945, 80. Moule 1906, 2nd ed., 27-9, drainage system. *PDNHAS* 77, 1955, 133-4; 78, 1956, 80-3; 90, 1969, 171ff, where at pp.172-3, C J S Green describes his excavation of the aqueduct next to the Poundbury cemetry and the cross-sections he took of the profile of the aqueduct. He concludes that the information obtained from sherds shows a primary phase of the 1st c. AD with a channel of a flat base and sloping sides and lined with clay in the lower portion (confirmed by Bill Putnam 1990-5); and a second phase when it was cleared out in the later 1st century to a new U-shaped profile, but given no clay lining, and remained in use into the 4th c. AD. *PDNHASFC* 22, 1901, 80-3, article by R A Coates with a plan of his original survey and cross-sections; 46, 1925, 1-13, article by P Foster and the plot of his speculated line towards a source for the aqueduct; 59, 1938, 13. *RCHM* 1970, County of Dorset, 2(3), 531-592, esp. 3rd para. at 534, and 585-9. This article gives a detailed description of the aqueduct and includes the map numbered 227a (p.586, pl.221), based on the work of J N Coates in 1900, and P Foster in 1922, both of the Royal Artillary, and the levelling survey of the Royal Engineers in c. 1925, based on the Liverpool datum. Currently (1994-7) Prof. Bill Putnam from University of Bournemouth is excavating to determine the route from the start of Penn Plantation, the last attested section of the aqueduct. He has established its existence into the plantation for about 250m, when it disappears. Wacher 1995, 323-35. Woodward, Davies & Graham 1993, *PDNHAS Monograph* 12. *TIRCGLL* 1983, 44-5, *RIB* 188-90; occupied from c AD 70 to early 5th c. (*Durotigetes*).

**Dorchester(2), Somerleigh Court site, Dorset.**

*PDNHAS* 91, 1970, 182-3, a drainage ditch leading into a quarry; a well, which went out of use c.AD 300.
Dorn, Gloucestershire.


Dover, Kent.


Downshay Wood, Dorset.

Dorset Proc. 60, 1938, 66-72; 69, 1947, 42-4; 70, 1948, 29-59; 75, 1953, 52, 69; 84, 1962, 115. RCHM 1970, County of Dorset, 2(3), 620: 'Of 14 pits examined, 6 were Iron Age date and 2 were of Roman date, one of the latter stone-lined, was possibly a well'. Occupation c. mid 1st c. to late 4th c. AD. Swanage Times 20 Jan. 1954 and info from J B Calkin.

Downton, Wiltshire.

bath-house. TIRCGLL 1983, 45, villa founded late 3rd c., flourished early 4th c., and declined mid 4th c. (Belgae).

**Drayton(1), Leicestershire.**


**Drayton(2), Leicestershire.**


**Droitwich, Hereford and Worcester.**


**Ducklington, Oxfordshire.**

Dunston, West Sussex.

Dunsby, Lincolnshire.

Dunstable, Bedfordshire.

Duntocher, Antonine Wall, Dunbartonshire, Strathclyde.

Durham, Co. Durham.

Duston, Northamptonshire.
Northamptonshire SMR 4946. Swan 1984, fiche 519, 538, wells. Woods
1969, 33. TIRBS 1987, 31, major Iron Age and Roman settlement, wells,
coins from Iron Age to Honorius, but mostly AD 280-300. Occupation c.
AD 50-400. (Catuvellauni).

Earith, Cambridgeshire.
194. VCH Huntingdonshire 1, 1926, 256-7. TIRBS 31, wells; coins 2nd
to 4th c. (Catuvellauni).

East Coker, Chessel's Field, Somerset.
Somerset 1, 1906, 329-31, item 51, very beautiful mosaic Fig 88.
TIRCGMLL 1983, 46, villa, hypocausts, coins mostly from 4th c.
(Durotriges).

East Ilsley, Stanmore Farm, Berkshire.
JBAA 17, 1861, 290-2, 'A deep well, apparently of Roman construction,
was closeby'. VCH Berkshire 1, 1906, 210.

Eastbourne, East Sussex.
Scott 1993, 58, NAR TV 69 NW 9, 42, NE 71, EA 9-12. SXAC 2, 1848,

Easter Happrew, Borders Region.
Britannia 3, 1972, 9, settlement. JRS 47, 1957, 200-1, plan; 51,
1961, 121. PSAS 90, 1956-7, 93-101. RCAHMS Peeblesshire 1, 1967,
169-71, plan, bath.

Easton, Suffolk.
JBAA 8, 1853, 159-60; 10, 1855, 383. VCH Suffolk 1, 1911 (reprinted
1975), 304, well.

Eaton, Leicestershire.
1982, 227, SK 72 NE 8 & 1.
Eaton-by-Tarporley, Cheshire.

Ebchester, Durham.
Arch. J. 142, 1985, 216-36. Hanson 1970, 286, 366. Hunter C, Phil. Trans. R.S.23, date?, 1129-32: 'part of the aqueduct that supplied the baths' south of the fort. Mothersole 1927, 128, 'a line of gutter stones buried in the grass'. Stephens 1985b, 217, 226, 'A stone channel is known at the south angle (Hutchinson 1794, 434), ... probably ...an aqueduct (Steer 1938, 228; Jarrett 1960, 200); undated'. Wooler 1917, 190 bath.

Ebrington, The Grove, Gloucestershire.

Eccles, Aylesford, Kent.

Eckington, Hereford and Worcester.

Elginhaugh, Dalkeith, Lothian, Scotland.
Elsted, Batten Hanger Villa, West Sussex.

Ely, near Cardiff, South Glamorgan.
JRS 11, 1921, 67-85. TIRCGLL 1983, 47; villa with bath; occupied 2nd to late 3rd c. (Silures).

Emberton, Buckinghamshire.

Empingham, Leicestershire

Enfield, Bulls Cross Farm, Burrough of Enfield, Greater London.

Engleton, Staffordshire.

Epperstone, Nottinghamshire.
Ewell, Surrey.

Ewhurst, Surrey.

Exeter, Devon.
Arch. of Exeter, 1983-4, 2-4, p.3, Fig 3, aqueduct of AD 100-1. Bildwell 1980, bath, 52-3, Figs.28, 30, 2 wells at insula iv Fig.31, 53-4; idem. 1979, 1-66, at Figs.7 & 12 the wooden pipeline with the iron collars is shown as the water supply for the bath which required a daily consumption of water of about 320,000 litres. Britannia 1, 1970, 60-1 Ant. Itin. 483.8, 486.8, 486.17; 4, 1973, 313; 5, 1974, 452; 6, 1975, 276; 7, 165, 278-80, 358-60, Legionary defences c. AD 55-75, to early 5th c.; 8, 1977, 415; 9, 1978, 459, 476; 10, 1979, 324-6; 11, 1980, 389; 12, 1981, 358; 13, 1982, 382; 14, 1983, 320-3, Figs.22, 23; 15, 1984, 318; 16, 1985, 201-2 water supply, 276, 303-5; 17, 1986, 72, 441-2; 18, 1987, 343; 19, 1988, 473-4; 20, 1989, 313-4; 21, 1990, 348-50; 22, 1991, 281-2; 23, 1992, 290-7; 25, 1994, 286. Fox 1973, 166-9. Hanson 1970, 111-6, 366, item 41, discusses in detail the uncertainty of the Roman aqueduct as its existence is masked by the medieval water supply to the town. Stephens 1985b, 223, item 9, comments 'The bath-house and a fabrica in the fortress were supplied by wooden pipelines (Selkirk 1973-4, 105; Bildwell 1979, 356, 60). These denote an aqueduct supply. The source was perhaps two springs c. 1km to the N-E, where the medieval catchment basin was situated (Tucker 1858); the basin overlies a 4.2m deep platform of clay, beneath which was found a Neronian coin. If these springs were tapped, the aqueduct was probably a pipeline, even though the civitas-capital was part supplied by a leat (Frere 1938b, 323). Wacher 1995, 335-43, Fig.151, 336 shows the line of the early aqueduct. TIRCGLL
1983, 49-50, a legionary fortress for Legio II Augusta (15.4ha) was established c. AD 55 and probably evacuated c. AD 75; a civil settlement developed c. AD 80 and continued until the 5th c. New baths, basilica and a forum and walls were built in the late 2nd c. enclosing an area of c. 37ha. (Dumnonii).

Exning, Landwade, Suffolk.

Falkirk, Stirlingshire.

Farley Hungerford, Temple Field Farm, Somerset
VCH Somerset 1, 1906, 300, item 1, bath.

Farmington, Clear Cupboard, Gloucestershire.

Farmoor, Oxfordshire.
Britannia 6, 1975, 279-80. Lambrick & Robinson 1979, Oxford Arch. Unit Rep. 2, 1979 (CBA Res. Rep. 32), (1) well, stone-lined (Rep.2, item F43), 0.80m diam. and 1.6m deep; (2) two wells (items F1046 & F1050) Fig.19, stone-lined, 1.06m (3.5ft) & 1.37m (4.5ft) deep respectively, shallow depths, indicating high water table.

Farnham Royal, Buckinghamshire.

Farnham(1), Suffolk.

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Farnham(2), Surrey.

Farnham(3), Dorset.
PDNHAS 104, 1982, 179; 106, 1984, 116: Roman well, depth 28.2m, av. diam. 1.15m, in solid chalk.

Farningham, Franks Villa, Kent.

Farnworth, Cheshire.

Fawler, Oaklands Farm, Stonesfield, Oxfordshire.

Feltwell, Little Oulsam Drove, Norfolk.

Fendoch, Tayside, Scotland.
Fig. p.230, comments 'Part of the aqueduct channel which seems to have contained a water pipeline (probably of wood) was found to the south-west of the fort. The pipeline was required in order to cross a stretch of low-lying ground between the source of the aqueduct - either springs to the south-west of the fort or perhaps the higher reaches of the Fendoch Burn - and the plateau on which the fort was sited', item 42. 

PSAS 72, 1939, 110-154: 112, 138-40, discussion of water supply, aqueduct. Stephens 1985b, 224, ‘The Agricolan fort was supplied by a pipeline aqueduct (Richmond & McIntyre 1938-9, 138-40). The pipe trench is 0.6m wide, which suggests that it held two wooden pipelines’, 224. TIRBS 1987, 34, Flavian fort (1.8ha).

Ffrith, Clwyd, Wales.


Fifehead, Dorset.


Fillingham, Lincolnshire.


Finchingfield, Essex.


Findon, Muntham Court, West Sussex.

Fingringhoe, Essex.


Fishbourne, Chichester, West Sussex.


Flamsteed, Kent.

KAR 16, 1969, 19-20, 'Flamsteed’s Well, Greenwich'. The well shaft is c. 30m (100ft) deep and between 2.1m and 2.4m in diameter, cut through about 18m of upper strata and continuing for more than 10m into chalk.

Fletton, Huntingdonshire.

Peterborough Museum Record Nos. 1520, 1627. RCHM 1926, 95-7, No. 31, item 1, 'The area between the railway-line and Stranground Lode S of the Nene, was occupied early in the Roman period, particularly at a spot 1/2 mile S of St Margaret’s Church…A little south was a
circular, steined stone-lined well, 20ft deep and 3.5ft in external diam...' VCH Huntingdonshire 1, 1926, 249. Whitwell 1982, 233, well.

Folkstone, East Cliffe, Kent.

Fordcroft, Orpington, Bromley, South London.

Foscott, Buckinghamshire.

Foxcote, Buckinghamshire.
RCHME Buckinghamshire 2, 1913, 115. VCH Buckinghamshire 2,1908, 7. TIRBS 1987, 35, villa with bath and lead pipes; coins of early 4th c. (Catuvellauni).

Frampton, Dorset.

Frilford, Berkshire.
Arch. J., 42, 1809, 417-85; 45, 1880, 405-10; 54, 1897, 340-54 Fig. opp. 342, well, and pond with drain. Britannia 7, 1976, 175, 178, 190, temples; 11, 1980, 396, bath-house; 13, 1982, 305-9, 368; 18, 1987, 47. VCH Berkshire, 1, 1906, 207-8, Fig. TIRCGLL 1983, 52, villa with detached bath-house; coins of 4th c. (Atrebates/Dobunni).

**Friskney, Lincolnshire.**
Whitwell 1982, 234, TF 45 NEC. VCH Lincolnshire 1906.

**Frocester Court, Gloucestershire.**

**Funtington, West Sussex.**

**Gadebridge Park, Hemel Hempstead, Hertfordshire.**
Archaeologia 34, 1852, 315, 394-7; 35 1853, 56. Britannia 5, 1974, 464. Herts. Arch. Rev., 1971, 71, bathing pool added by AD 325. At Boxmoor Railway, TL 04 05, a well, SMR 517. HMSO Excavation Reports 1968. JRS 55, 1965, 211-2, Fig.17, original construction c. AD 120, extensive additions include a reconstructed bath in 4th c. and a swimming pool; 56, 1966, 208 Fig.13; 57, 1967, 187-8; 58, 1968, 194; 59, 1969, 221. Neal 1974, 'Winged-corridor villa (AD 140-60) with out-buildings, stockade, bath-house and enclosure ditches. Earliest timber buildings date to c. AD 70; occupation may have extended into 5th c. (SMR 186 & SMR 0088)'. Scott 1993, 93, SMR 186, HT 31, SMR
Garden Hill, Hartfield, East Sussex.
Black 1987, 203, Fig.8. Britannia 4, 1973, 323; 5, 1974, 458; 8, 1977, 339-50, 'The Iron Age Hill Fort and Romano-British Iron-working Settlement at Garden Hill, Sussex: Interim Report 1968-76', Fig.5 & pls.xix & xx, bath, drains, lead-pipe from bath; five periods, 3rd period 1st c., and 5th period end 2nd c. or early 3rd c. ore brought in for smelting; 9, 1978, 467, 481; 10, 1979, 333-4; 11, 1980, 398-400, Fig.23.

Garton Slack, East Riding, Yorkshire.
Britannia 3, 1972, 310; 4, 1973, 28, well. Current Arch. 51, v(4) 1975, 104-116, article by T C M Brewster, shows picture of the well, excavated to 21m depth, likely deeper, half of which was cut originally through chalk. A 2nd well, 150m N-W of the 1st well had been abandoned at a depth of 5.5m after loose gravel sides had fallen in (iv, 281).

Gatcombe, near Long Ashton, Avon.
Brannigan 1975, 175-81, Fig.1; 1977, 246-7, Fig.5 at p.25, pl.15A. Occupation mid 3rd to later 4th c. Gardiner 1976, 168, 172. Greene 1986, 92-5. Scott 1993, 16, SMR 627, AV 53. Possible aqueduct.

Gayton, Northamptonshire.

Gayton Thorpe, Norfolk.

Gelligaer, Glamorgan, Wales.

**Gestingthorpe, Essex.**

**Glenlochar, Dumfries, Scotland.**
Britannia 2, 1971, 145 fort; 3, 1972, 11; 5, 1974, 154 Antonine II occupation; 26, 1995, 45. Hanson 1970, 366, comments, 'In 1952 part of a water channel, or perhaps the channel for a water pipeline, was found during excavations at the Roman fort'; at p.218, a covered water channel or pipeline found in the via decumana, and a stone-built well. Frere & St Joseph 1983, 27-8, plan 126-9. JRS 41, 1951, 60; 43, 1953, 107-9, plan; 55, 1965, 79-80. Stephens 1985b, 224, comments: 'A tank and "a covered water-channel or a pipeline" have been found (Richmond & St Joseph 1951-52, 10). The channel was probably the duct of a pipeline of unknown date', 224 item 21. TDGHNAS 30, 1953, 10-1. TIRBS 1987, 36, Rav. Cos. (Lucotion, var Lucocion). Late Flavian and Antonine fort (3.36ha) on River Dee. Large annexe (12.7ha).

**Gloucester, Gloucestershire.**
functioned in the 2nd c. (Grew 1980, 385) but could be earlier. A 9m-wide tank has been located in the fortress (Wilson 1967, 195); this seems large for a rainwater tank and could easily have been the terminal reservoir of an aqueduct. TEGAS 67, 1946-8, 347-58, Fig 2, pls. I, II, III, well; 87, 1969, 113ff; 93, 1974, 31, aqueduct, well. Wacher 1995, 150-66. Webster 1981, 43-4. TIRCGLL 1983, 54, RIB 119-24.

Goadby Marwood, Leicestershire.
Liddle 1982, 35. TLAS 32, 1956, 17. VCH Leicestershire 1, 1907, 212. Whitwell 1982, 81-2, 86, 237. TIRBS 1987, 36, minor settlement (c. 12ha); stone buildings, wells. (Corieltavi).

Godmanchester(1), Granary Close, Cambridgeshire.

Godmanchester(2), Rectory Farm, Cambridgeshire.

Gorhambury, Hertfordshire.
succeeded by timber house, burnt in 1st c.; early 2nd c. masonry house, later extended and altered in 2nd c. and 4th c. (Catuvellauni).

Goring, West Sussex.

Grafton Estate, Cheshire.
Britannia 1, 1970, 42, 69, Ant. Itin. 469.3 (Bovio); 12, 1981, 333; 14, 1983, 299; 15, 1984, 255-7. Scott 1993, 46, SMR 1768, CH 2, bath-suite, aqueduct. VCH Cheshire 1, 1987, 236. Waddelove 1984, 255-7, do not give an actual positional location, but concludes that Bovium must have been a Roman tile and pottery factory. From the information I conclude that the site must have been at approximately SJ 445 514 near the Carden Brook as he suggests. For it to have been at Holt would have required a crossing of the major River Dee to get to Deva (Chesters) from Holt.

Grandford, Cambridgeshire.

Great & Little Kimble, Buckinghamshire.

Great Bulmore, Monmouthshire.

Great Casterton(1), Rutland, Leicestershire.

Great Casterton(2), Leicestershire.

Great Chesterford(1), Essex.

Great Chesterford(2), Essex.
JBAA 4, 1849, 356-78. Scott 1993, 61, SMR 4915. ES 15, comments, 'A Roman villa excavated close to a Roman "station"...'. Coins of 1st to 4th centuries, double-corridor villa, ?bath.

Great Chesters, Hadrian's Wall, Northumberland.
wide and 280mm deep, with spoil forming a retaining bank on the down hill side'; 21, 1990, 285-9. Birley 1961, 188-92. Bruce 1855, 225ff. Hanson 1970, 367, comments: 'A six mile long water course, consisting of an open leat, is known from Great Chesters and brought water to the fort from a source on the Caw Burn only 2.25 miles away from Aesica in a direct line'. JRS 30, 1940, 161-4; 35, 1945, 80-1 aqueduct, plan. Mackay 1990, 285-9. Stephens 1985b, 226, item 30, comments: 'The fort was supplied by a 9.65km long leat fed from Haltwhistle Burn/Caw Burn 4.4 km to the N-E (Bruce,1851, 257-62, Fig 99; Taylor & Cillingwood 1945, 80). This will have fed an extramural distribution tank from which the extramural bath-house, and presumably the fort itself, were supplied. The leat is undated'. TIRBS 1987, 37, fort (1.38ha) on Hadrian's Wall, built after AD 128, RIB 1736; overlies MC43. Civil settlement, baths, aqueduct, tank. (Brigantes).

Great Dunmow, Essex

AEx 1972, 49. Britannia 2, 1971, 272; 3, 1972, 333, 356; 4, 1973, 304, 'A 3rd c. well c. 7m deep had a timber lining made of oak planks 50 x 300 mm dovetailed at the corners; 17, 1986, 442; 25, 1994, 280. EAA 41, 1988, 'Excavations at Great Dunmow, Essex', a well, Period III, phase 2: 2nd c., c. 6.9m deep, cut through brickearth and iron-bound sand and bottoming on gravel (Fig.4, S11). Construction shaft was c. 1.25m sq., into, which was inserted a caisson 0.76m sq., made of oak planks 300mm x 50mm dovetailed at the corners. It was originally lined with flint and green clay, which collapsed inwards as the wood started to rot', (p.11). Rivet 1964, 147. Rodwell & Rowley 1975, 85-101. VCH Essex 3, 1963, 125. Wickenden 1988, 11. TIRCSG 1983, 55, major settlement. (Trinovantes).

Great Linford, Stantonbury, Buckinghamshire.


Great Staughton, Cambridgeshire.

JRS 49, 1959, 118; 50, 1960, 224-5, Fig.26. Scott 1993, 38, CA 90. Occupation from c. 2nd c. to 4th c. Whitwell 1982, 241, bath. TIRBS 1987, 38, corridor house, found 865 coins of AD 306-62; about 60m S-W of this site another corridor house of 2nd to 3rd c. (Catuvellauni).

Great Tew Beaconsfield Farm, Oxfordshire.
Great Totham, Slough House Farm, Essex.


Great Witcombe, Gloucestershire.


Greetwell Fields, near Lincoln, Lincolnshire.


Greta Bridge, North Yorkshire.

Britannia 3, 1972, 42, work on fort c. AD 205-7; 5, 1974, 413-5, vicus, ?mansio; 6, 1975, 235. Hartley 1971, 58. TIRBS 1987, 38, Fort (1.48ha), late Flavian or Trajanic foundation, early 3rd c., reconstruction. Extensive civil settlement (vicus), ?mansio, i.e. possible bath. (Brigantes).

Grimstead, Wiltshire.

Scott 1993, 202, SMR NW 301, WZ 90. Sumner 1924. VCH Wiltshire 1, 1957, 75. Occupation, from pottery, c. 3rd c. to 4th c.

Grimston, Norfolk.

Grinley on the Hill, Nottinghamshire.

Hacconby, Lincolnshire.

Haceby, Lincolnshire.

Hacheston, Suffolk.
Britannia 1, 1970, 20, 29; 2, 1971, 271 settlement; 3, 1972, 361; 5, 1974, 439, 468; 6, 1975, 261-2, 288: well, lined with oak boards, dated to c. early 1st c. to mid 2nd c., 5.2m deep, and measured 0.83m by 0.76m between the boards; 8, 1976, 403. 20, 1989, 301. Rodwell & Rowley 1975, 85-101. TIRBS 1987, 39, minor settlement, iron working; well; occupation c. 1st c. to late 3rd or early 4th c. from coin evidence. (Trinovantes).

Haddon, Cambridgeshire.

Hadstock, Essex.
Halton Chesters, Hadrian's Wall, Northumberland.

Hales, Tyrley, Staffordshire.

Halstock, Common Lane, Dorset.

Hambleden, Buckinghamshire.

Hamilton, Leicestershire.
Hampstead Norrey's, Berkshire.

Hanham Abbots, Avon.
Scott 1993, 15, SMR 1411, AV 42. Scarth 1864, 125; well.

Hardham, West Sussex.

Hardingstone, Northamptonshire.

Harlow, Essex.

Harpole, Nottinghamshire.

Harpsden, Oxfordshire.

Hartfield, Garden Hill, East Sussex.

Hartlip, Dare Field, Kent.

Havant(1) Near Langstone, Hampshire.
PHFC 10, 1930, 286-7, villa, bath. JRS 12, 1922, 273. Scott 1993, 84, NAR SU 70 NW 10, HA 44. TIRCGLL 1983, 58 corridor villa; coins of Vespasian (AD 69) to Constants (AD 335). (Regni).

Havant(2), Littlepark, Hampshire.

Hayes, Kent.
Black 1987, 145, No.38, Fig 29, p.252 bath-building constructed c AD 100 and apparently disused by c. AD 140. Philp 1973.
Hayton, North Humberside, Yorkshire.

Britannia 7, 1976, 315-6, Fig 11; 9, 1978, 57-114; 10, 1979, 49; 17, 1979, 84. Johnson 1978, 57-114, a 'Timberlined drain acting as an eavesdrop gulley...a large pit within a building; this was probably a watertank' (p.69).

Heath and Reach, near Leighton Buzzard, Bedfordshire.

Beds. Arch. J. 6, 1971, 71-2, well, stone-lined, 3.65m (12ft) deep, 1.06m (3.5ft) diam., dated to not later than 1st half of 2nd c. Scott 1993, 20, SMR 1170, BD 12.

Hemsworth, Dorset.


Heybridge, Essex.

Britannia 26, 1995, 360 item 9, (a) 'a possible public space around a large well... 4 timber-lined wells have been excavated with good preservation of wood', (b) near Langford, at TL 845 082, 'a simple well nearby a burial mound'. TEAH 17, 1986, 7-68; 19, 1988, 243-8, Figs 7 & 9, item 267, well, 2.5m deep with large present opening of 11m due to erosion of the sides; high water table and sandy soil. Wickenden 1986, 7-68.

Hibaldstow, Staniwells, Humberside, Lincolnshire.


High Cross, Leicestershire.

Watling Street and Fosse Way; Roman fort near Wigston Parva, SP 464 894; coins dating from 1st to 4th c. (Corieltavi).

**High Ham, Shropshire.**

**High Legh, Cheshire.**

**High Rochester, Northumberland.**

**Higham Ferrers, Northamptonshire.**

**Hinton Charterhouse, Fiford Plantation, Avon.**

**Holcombe, Uplyme, Devon.**
Holditch, Farm Street, Newcastle, Stradfordshire.


Holme House, Manfield, Piercebridge, Co. Durham, N. Yorkshire.

Britannia 1, 1970, 279-80, Fig.6, bath, dates from c. AD 140s, probably dismantled end 2nd c., drain from the bath indicates that these were no longer in use at the end of the 2nd c.; 2, 1971, 251-2, Fig.5; 3, 1972, 309; 4, 1973, 280, stone bridge; 5, 1974, 255, villa. Clack 1982, 381-4. JRS 41, 1951, 52. MOW 'Excavations', 1969, 51-2; 1970, 58. Scott 1993, 149, NAR NZ 21 NW 28, DU 2, under Cliffe, near Piercebridge. Tyler 1980, 60. YAJ 44, 1972, 220.

Holt, Cheshire.

Britannia 1, 1970, 42, 43 n.29 Ant. Itin. 469.3 (Bovio) (see my note for Grafton Estate); 2, 1971, 127-9, 130 n. 54, 182, 303; 3, 1972, 362; 12, 1981, 395; 15, 1984, 255-60. Davies 1949, 143-55. Hanson 1970, 368, item 51, comments that 'at this military supply depot a water pipeline made of earthenware pipes, and leading to the latrines, ...The source of such a pipeline is uncertain but the Devon Brook to the west of the site seems a possibility...'. Nash-Williams 1969, 42-4. RCHM Flintshire 1914, 72-4. Scott 1993, 47, SMR 1177c, CL 7, bath-house. Waddelove, 1988, 257. Y Cymrrodor 41, 1930, 14-5. CSIR I.5, 1986, Nos. 55, 98. TIRBS 1987, 43, RIB 439-443; pottery and tile works on the river Dee, supplying the legion at Chester; bath-block and many other buildings covering c. 8ha. (Cornovii).

Horncastle, Lincolnshire.


Horningsea, Cambridgeshire.

1970, 200. *RCHM* County of Cambridge 2, 1972, 71-2, 'A mound and a well were dug into', but not clear to me if it was Roman. Swan 1984, fiche 236, well at TL 4983 6348. *VCH* Cambridgeshire 7, 1978, 71-3. Walker 1912, 16, describes the well mentioned by Hughes. TIRBS 1987, 143, pottery works near Eye Hall; active mainly in 2nd c. (Corieltavi).

**Housesteads, Hadrian's Wall, Northumberland.**

Arch. Ael(1) 1, 1822, 263-320; Arch. Ael.(3) 25, 1904, 193-300, at 207, 211, 248-51, 253-4, 255-63; Arch. Ael.(4) 9, 1932, 226-37; 10, 1933, 85-96; 11, 1934, 185-205; 12, 1935, 243-4; 38, 1960, 61-71; 39, 1961, 279-99; 40, 1962, 83-96, 105-15, 117-33, 277-80; 41, 1963, 37-44; 49, 1971, 95-99; Arch. Ael.(5) 3, 1975, 17-42; 4, 1976, 17-30; 7, 1979, 127-43. Birley 1961, 181. Britannia 1, 1970, 153, 276.; 2, 1971, 127, 130 n.54, 153, 276; 3, 1972, 193-6, 202, 306-8, 360; 5, 1974, 410; 6, 1975, 232; 7, 1976, 155, 161, 165, 309, 390; 8, 1977, 263-4, 372-3, 431-2; 9, 1978, 420-1; 11, 1980, 18, 359; 12, 1981, 268; 307-8; 13, 1982, 342-3 bath-house; 14, 1983, 269-70, 348-9; 16, 1985, 270; 18, 1977, 369; 19, 1988, 434 vicus; 23, 1992, 111-2, 315, latrine and fountain. Bosanquet 1904, 207, 248-9, 253, 255. Bruce 1863, 214ff. Bruce 1875, 170, 234. Hanson 1970, 249-55 mentions 5 tanks. Manning 1976, 40.151, Fig 24.151. Stephens 1985(b), comments, 'The extramural bath-house seems to have been supplied by a short line of channelled stones, 226. It is highly probable that the fort was also supplied by an aqueduct, although not from the adjacent Knag Burn (contra Birley 1961, 181). In the Hadrianic period the latrine in the S-E angle was flushed with water conveyed by four 'conduits', or stone channels, from the N and N-E (Simpson 1976, 136-7). One of these may have supported the wooden pipeline whose existence is established by Bosanquet's discovery of an iron pipe collar (Manning 1976, 40.151, Fig.24.151). The pipeline suggests strongly that the fort was supplied by an aqueduct. This could only have been a pipeline aqueduct and Collingwood (1933, 122) surmised that the fountain depicting the three nymphs (Lap. Sept. 170, 234) stood at its terminal point'. 2 Roman external wells at NY 7897 6869 and NY 7918 6894. A third well of later construction is at NY 7909 6857 near and outside the South gate. TIRBS 1987, 43-4, RIB 1594; fort (2.06ha) on Hadrian's Wall, earlier than the Narrow Wall but overlying the demolished foundations of the Broad Wall and Turret 36B; civil settlement and Mitraeum; occupied 2nd-4th c. (Brigantes).

**Hovingham Park, North Yorkshire.**

**Hucclecote, Gloucestershire.**


**Hunsbury, Wootton Hill Farm, Northamptonshire.**


**Huntingdon, Cambridgeshire.**


**Huntsham, Herefordshire.**
Antiq. J. 18, 1938 376, pl.80. Britannia 2, 1971, 261. JRS 51, 1961, 171; 52, 1962, 167, Fig.15, 169, "...two small opus signium tanks partly built into the walls of the larger tank sunk into the floor of the east aisle. The last remained in use after the barn was destroyed, in or before the 4th century...."; 55, 1965, 208, Fig.13; 56, 1966, 205, Fig.11, 206. TWNFC 37, 1961, 179-91. WMANS 12, 1969, 26. TIRCGLL 1983, 60, villa in loop of the river Wye; occupied c. AD 200 to late 4th c. (Dobunni).

Hurcot, Hurcot Farm, Somerset.
VCH Somerset 1, 1906, 322-3, 'a clear spring of water rises at a short distance from the ruins. Traces of hypocausts, baths and mosaic pavements were discovered'. (Uncertainty about location).

Ickham, Kent.

Ickleton, Cambridgeshire

Icklingham, Suffolk

Iford, Wiltshire.
Scarth 1864, 120, claims it was 'a perfect Roman bath', but was covered up after it was investigated. VCH Somerset 1, 1906, 300. TIRCGLL 1983, villa with baths; coins of late 3rd and early 4th c. (Belgae).

Ilchester, Somerset.
Inchtuthill, Tayside, Scotland.

Britannia, 1970, 197, 201; 2, 1971, 123 n.7; 3, 1972, 4, 5, 7, 12-3, 226, 233-4, 241; 5, 1974, 13, 20-1, 27, 33-5; 10, 1979, 21, 27, 51, 12, 1981, 18, 25, 32, 287; 14, 1983, 284; 15, 1984, 55-7; 18, 1987, 27, 19, 1988, 170-1; 21, 1990, 310; 25, 1994, 103, 159. Hanson, 1970, 200. JRS 41, 1951, 63 pl. viii; 43, 1953 to 48, 1958, 91; 49, 1959, 104; 50, 1960, 213; 56, 1966,198. Pitts & St Joseph 1985, discusses the water pipes and trenches which could have been for distribution of water once the aqueduct supplying water to the fortress was completed, and the future bath-house inside the fort. Before these could be constructed the fort was demolished c.AD 85. PSAS 36, 1902, 211, 229, 240. Stephens 1985b, 222: 'The discovery of ceramic water pipes and pipe trenches establishes that the fortress was to have been supplied by aqueduct (Taylor & Richmond 1959, 104; 1960, 213). The aqueduct seems not to have functioned (JRS 1966, 198), probably because of the short period of occupation'. It was not completed, if indeed it was started. TIRBS 1987, 45. Flavian legionary fortress (Plan iv), probably of Legio XX V V (21.74ha). Two successive construction-camps (19.9 and 14.1ha). Constructed c. AD 83, and evacuated c. AD 87.

Inveresk, Lothian, Midlothian, Scotland.

Britannia 3, 1972, 8, 20, 29-30, 42-4, 304, vicus at NT 345 720 examined; 8, 1977, 365 7; 9, 1978, 416-8 Fig.7; 13, 1982, 339-40; 16, 1985, 265. DAES 1977, 22; 1990, 29-30. Hanson 1970, 368, comments: 'In 1956 the remains of a stone-lined channel which had carried a water pipeline (probably of wood) to the Antonine bath-house at this fort was discovered'. JRS 36, 1946, 109; 37, 1947, 165; 38, 1948; 81-2 bath-house; 56, 1966, 199; 57, 1967, 176. Stephens 1985b, 224, item 15, comments: 'One of the extramural bath-houses was fed by a "water-pipe channel" (JRS 1966, 199; 1967, 176). The channel was presumably the support of a wooden pipeline dating from one of the Antonine
phases’. CSIR I.4, 1985, Nos. 59-60. The bath-house is some distance away from the fort, probably in the vicus. TIRBS 1987, 45 at NT 344 721. RIB 2132-3. Fort (c. 2.84ha) occupied twice in the Antonine period; external bath-house and extensive civil settlement.

**Irchester, Northamptonshire.**


**Islip, Northamptonshire.**


**Ivy Chimneys, Essex.**

Britannia 11, 1980, 377-9, plan Fig.14, bath-house; 12, 1981, 350, 379; 13, 1982, 412; 15, 1984, 307-8, reservoir c. 50m x 25m x 2.5m deep from 1st c., springs and well, possible aqueduct. Dating from c. AD 260 to AD 360-400. An area of springs north of the settlement; settlement dates from Iron Age period and Romano-British religious site.

**Ixworth, Suffolk.**


**Jordon Hill, Dorset.**
Keswick, Cumbria.


Keston, Warbank Site, Kent.


**Kettering, Blanford Ave., Northamptonshire.**


**Keynsham, Manor Woods, Somerset.**


**Kings Weston Park, Avon.**


**Kingscote, The Chessals, Gloucestershire.**

Kinneil, Cumberland, Scotland.

Kintbury, Berkshire.

Kirk Sink, Gasgrove, North Yorkshire.

Lake Farm, near Wimborne, Corfe Mullen, Dorset.
Britannia 1, 1970, 299, water tank; 2, 1971, 281; 5, 1974, 7, 455; 11, 1980, 391. PDNAS 89, 1967, 143, Field; 91, 1969, 188-9, Field, ‘Phase I, a timber-lined tank, 20 ft (6.09m) square and 4 ft deep (1.2m) ( c. 10 000 galls, 40,000litres)..., aligned with the aqueduct and causeway entering the camp from the south...Phase II, the 1st tank was reduced to a smaller volume, and tank 2 (8ft x 6ft) of similar construction and likewise aligned with the aqueduct...’. JRS lix 1969, 228, no. 54. Occupation appears to be from from mid AD 40s to 60s. Webster 1970, 179-97, esp. 187.

Lambourn, Maddle Farm, Berkshire.

Lancaster, Lancastershire.

Lanchester, Co. Durham.
Arch. J. 111, 1954, 220-1. Britannia 9, 1978, 475; 14, 1983, 151; 17, 1986, 442; 9, 1988, 492 inscription found in vicus near fort. JRS 28, 1938, 177-8 with pl.xvii (plan). Clack & Gosling 1976, 213-25 aqueducts. Steer 1938, 211-23, where the three aqueducts for the fort at Longovivium (Lanchester) are discussed in detail, which includes the two dams at the sources of the two longest aqueduct channels. All three channels were destroyed during open-cast coal mining during the 19th c. TAASDN 7 1936, 200-15; 9, 1939, 110-22 plan; 10, 1953, 394-5. TIRBS 1987, 48-9, RIB 1072-98. Large fort (2.52ha) established c. AD 140, held till late 2nd c., re-occupied under Gordian III AD 238-244; extensive civilian settlement (vicus). (Brigantes).

Landwade, Exning Parish, Suffolk.
JRS 49, 1959, 123, bath-building.

Langton, Near Malton, North Yorkshire.

Latimer Buckinghamshire.

Britannia 1, 1970, 315; 2, 110, 112, 114, 116; 6, 1975, 197 plan. Branigan 1971, 169. Medieval Arch. 11, 1967, 263; 12, 1968, 1-11, Fig.11, showing Roman bath. Recs. of Bucks. 19, 1973, 340-3. Scott 1993, 26, SMR 400, BU 21. TIRCGLL 1983, 63, villa, timber building c. AD 80 lasting to c. AD 120; replaced by stone house and bath added; complex lasted several reconstructions until c. AD 400, then occupied through 5th c. into medieval period and into modern times. (Catuvellauni).

Lea Cross, Salop, Shropshire.


Leaden Well, Bourton Bridge, Bourton on the Water, Gloucestershire.

Britannia 1, 1970, 126, n.78. Donovan H E 1934, 99-128. RCHM Gloucestershire 1976. TGBAS 55, 1933, 377, pl.1, well, dry stone walling, 2.58m deep, 0.67m diam.; 56, 1934, 99; 57, 1935, 234-59, plan facing p.240 shows water structures, period c. AD 120 to c. AD 370-400. Two cisterns or leaden tanks, c. AD 370-90.; drain and a sump next to the well.

Lease Rigg, Yorkshire.

Britannia 8, 1977, 381; 10, 1979, 287; 11, 1980, 363; 12, 1981, 328, 'A road-side ditch drained into the butt end of of the fort ditch...; a gully ran along the west side of the via praetoria, perhaps leading
to a stone drain immediately behind the north rampart'. Hayes & Rutter
(1.05ha); occupied c. AD 70-120. (Brigantes).

Lechlade, Gloucestershire.
Britannia 22, 1991, 276, villa. Defoe 1742, 244. Scott 1993, 74, SMR
2442, GS 65, bath, SMR 3191, GS 66, well, dating from c. 2nd c.

Leckhampton Hill, near Cheltenham, Gloucestershire.
Buckman & Newmarch 1850, authors refer to a "true Roman well" located
in the centre of the hill fort, p.20. Champion 1971. TBGAS 90, 1971,
5-21. 96, 1978, 22-3, 'Reinterpretation of the dry-stone rampart...
suggests a single period of occupation during the earlier phases of

Leicester, Leicestershire.
Bellairs 1899, 40-4, 2 Figures. Britannia 1, 1970, 38 n.17, 49, 51,
Ant. Itin. 477.4 (Ratas), 479.3 (Ratis), 184, 286; 2, 1971, 155 n.44,
201-2; 3, 1972, 262-4; 4, 1973, 2; 5, 1974, 7 possible vexillation
fortress; 6, 1975, 77-8, 246; 7, 1976, 171, 327-8, 387; 8, 1977, 392,
wells; 9, 1978, 435, 479; 10, 1979, 160-2; 11, 1980, 18; 12, 1981,
336; 13, 1982, 415-6; 16, 1985, 204-5 water supply; 17, 1986, 390,
25, 1994, 271. JRS 49, 1959, 113-4 market precinct. Kenyon 1948,
bath-house. PNRB 443-4. TLAHS 44, 1968-9, 1-10. Wacher 1995, 343-
62, Figs.154, 156, 158. Ratae was established as a civitas soon after
AD 43, but the Coritani was unlikely to have enjoyed self-rule after
the battles of AD 60. Wacher also discusses K M Kenyon's work on the
Jewry Wall, and the so-called Raw Dykes aqueduct, but this is still
not resolved. 2 wells, baths, watertank, drains, and sewer, and later
forum, basilica and amphitheatre/theatre. TIRBS 1987, 49, RIB 244-5,
2244 (A RATIS MP II). Pre-Claudian native settlement on the river
Soar. Possible Claudian vexillation fortress and/or pre- to early
Flavian fort on Fosse Way. Civitas capital of Corieltavi from late
Flavian period. Antonine baths; probable aqueduct (Raw Dykes, not yet
resolved) from late 2nd c. Late 2nd c. market precinct, continued to
present day. Roman occupation to 5th c. (Corieltavi).

Leicester(1), Norfolk Street Villa, Leicester. Leicestershire.
bath-suite; 12, 1981, 337-8, Fig.9. Current Arch. 81, 1981, 314.
EMAB 13, 1979-82, 8-9, 'Leicester: Norfolk Street Roman Villa', SK 575 043, 'villa situated c. 1/2 mile (0.81km) from the western boundary of Ratae Coritanorum'. JRS 29, 1939, 207-9, Fig 13. Scott 1993, 113, SMR SK 50 SE GC, LE 51. TLAHS 50, 1974-5, 58; 55, 1979-80, 83. VCH Leicestershire 1, 1907, 196. The watertank was timber-lined. Occupation c. mid 2nd c. to late 3rd or early 4th c.

Leicester(2), Leicestershire.

Britannia 24, 1993, 290, item vi, (SK 586 045), well; occupation 2nd to 3rd c. EMAB 11, 1977, 8-9, domestic bath-building.

Leintwardine, Hertfordshire.


Leyton, Essex.

London Arch. 7(15), 1995, 397-401. RCHM County of Essex, Cental and S-W, 1921, item 60, 166, Roman Period, 'one or more buildings were found in 1718....Two wells were also found,...'.

Limestone Corner, Hadrian's Wall, Northamptonshire.

No water-related structure recorded.

Lincoln, Lincolnshire.

Report. The aqueduct of encased earthenware pipes in Roman concrete of which many lengths have been recovered. It is c. 2.8km (1.75 miles) long; also drains, sewer, bath, tank and well have been located. Hanson 1970, 43-55, 369. She makes a very positive statement, unfounded, that the aqueduct at its source some 2 km (1.25 miles) from the town is 21.3m (70ft) below the highest point and that water was pumped to the delivery point. EMAB 11, 1977, 30 drain or gully leading to a stone-lined well at SK 9777 7211; 12, 1978, 25, East Bight, distribution tank. JRS 39, 1949, 57-78 fortress; 46, 1956, 22-36 gates and fountain. Jones 1985, in Grew & Hobley, 86-93. PNRB, 1979, 393. Thompson 1954, 106-28. Wacher 1995, 132-50. Wacher (Proc. ICE, 1981, 298-300), proposes a much longer aqueduct with a source in the hills to the N-E of Lincoln. So far no trace has been found of any evidence to support this proposal. There is some evidence of pier supports for a raised pipe in the vicinity of the Roaring Meg area. The Roman earthenware aqueduct’s source has not been resolved yet (1996). Wilford, Lincoln Arch. Unit, 1982, unpublished summary and commentary on the background knowledge relating to the aqueduct. TIRBS 1987, 50-1, RIB 246-73, 2240-1. Fortress dates from c. AD 60 and legionary defences faced in stone during early 2nd c. Colonia founded c. AD 90. Further changes to colonia during 3rd and 4th centuries. Monumental gates constructed early 3rd c. including sewers, aqueduct, castellum aquae, 2 baths, 2 wells, and fountain. (Corieltavi).

Linley, Linley Hall at More, Salop, Shropshire.

Linton, Cambridgeshire.

Litlington, Cambridgeshire.
CA 109, bath. VCH Cambridgeshire 7, 1978, 46. TIRBS 1987, 51. Courtyard villa, said to have at least 30 rooms; bath-suite. (Catuvellauni).

Little Dunmow, Essex.

Little Ponton/Stroxton, Lincolnshire.

Little Waltham, Essex.

Littlechester, Derbyshire.

Littlecote Park, Ramsbury, Wiltshire.
Britannia 10, 1979, 329-30, Fig.17; 11, 1980, 391f; 12, 1981, 1-5 mosaic, 360f, Fig 16; 13, 1982, 387f, Fig.24; 14, 1983, 328f, Fig.29, plan of buildings c. AD 350-70; 15, 1984, 322f, Fig.26 shows development of villa; 16, 1985, 308; 19, 1988, 407-10, Fig.27; 20, 1989, 317f; 21, 1990, 353-4; 23, 1992, 301, Fig.23 shows the final boundaries after excavation project completed. Hoare 1819, 117-21. Lysons 1813-9, Vol.4, pls.9 & 10. Scott 1993, 206, SMR SE 300, WZ 142, as Ramsbury, 3 phases of bath building. It would seem that only one was functional at any given time, dating from c. AD 240 to c.4th c. VCH Wiltshire 1, 1957, 98. Walters & Phillips (1) 1978 (Littlecote 1979); (2) 1978 & 1980 (Littlecote 1981). 3 bath-houses, dating from mid to late 1st c. to 4th c. indicating 8 periods of
reconstruction and modifying of buildings. Well, flint-lined, late 3rd c.; 3 wells: well, unlined c. AD 260; well, c. AD 400, not completed. 3 tanks, timber-lined in the S-E corner with outlet through the wall. TIRCGLL 1983, 65. Villa. (Atrebates).

Littleton, Somerset.

Llanddewi Brefi, Dyfed, Wales.

Llanddowror, Cwmbrwyn, Dyfed, Wales.

Llandough, South Glamorgan, Wales.

Llanio, Cardiganshire.

Llanfrynach, Maes Derwen, Powys, Wales.
Llantwit, Glamorgan, Wales.

Locking, Avon, Wales.

Loddington, Northamptonshire.
RCHM County of Nothants, Central 2, 1979, 105-7, No.39, item 3, well. George 1904, 17.

Loddon, Norfolk.
Scott 1993, 135, SMR 17982, NP 132, bath-house.

London
London Archaeology and TLMAS during the last four decades. During the last decade extensive excavations at the Guildhall Yard has revealed the amphitheatre of Roman London and its elaborate drainage works to drain water which was a problem as a result of the high water table in the area. Three systems of drainage works has been discovered. This work has still to be written up. Wilmott 1982a, TLMAS, 33, 1-31; idem, 1982b London Archaeologist Vol.4(9), 234-42, 4 baths; idem, 1991, LMAS Special Paper 13. TIRCGCLL 1983, 66, RIB 1-40. Town established c. AD 50, destroyed by Boudica AD 60; gradually rebuilt over the next two decades. Residence of the procurator of Roman Britain probably before AD 60. Walls built c. AD 200, enclosing 132ha, and a riverside wall added c. 4th c. A bridge over the Thames linked London to the suburb at Southwark. (Londinienses). London.

Long Melford, Suffolk.


Long Wittenham, Oxfordshire.


Longstock, Stockbridge, Hampshire.


Longthorpe, Cambridgeshire.


Loughor, West Glamorgan, Wales.


Low Borrowbridge, Cumberland?


Low Ham, Somerset.


Lower Slaughter, Gloucestershire.

RCHM 1976, 78-8-, Fig. opp. p.79, 11 wells. Scott 1993, 74, SMR 345, GS 71.

Lufton, Brympton, Somerset.


Lullingstone, Eynsford, Kent.

Arch. Cant. 63, 1950, 9, no.60; 65, 1952, 26-78; 66, 1953, 23f, no.41; 67, 1954, 15-36; 70, 1956, 249-50; 72, 1958, xlvii-l. Britannia 1, 1970, 312; 2, 1971, 169, 176 no.41, 181 no.60, 187, 190, 192-3; 3, 1972, 251f, 270-2, 274-5; 4, 1973, 227; 6, 1975, 196-7; 7, 1976, 171, 175, 186, 189; 9, 1979, 309-13; 17, 1986, 426. Meates 1955(1963). Meats 1979, Vol.I, 'The Site'. Meates discusses the problem of water supply, suggesting that from the well-head outside the bath building a line of wooden pipes delivered water from the well as it was drawn from the well by slaves or others. However the problem is not resolved. Well was 1.83m in diam. and c. 6m deep. Above the chalk it was lined with interlocking oak planks in a 1.22m square framework. It was lined with flint rock to the depth of the chalk..' Scott 1993, 104, 'The "Deep Room" constructed c. AD 80-90; Belgic occupation until
early 5th c. when it was destroyed by fire'. TIRCGLL 1983, 67, unique type villa. (Cantiaci).

Lunt, Warwickshire.


Lydney, Lydney Park, Gloucestershire.


Lyminge, Church, Kent.

Scott 1993, 106, KE 54, bath-house. VCH Kent 3, 1932, 123.

Lymrne, Kent.


Lynch Farm, Cambridgeshire.
Durobrivae 1, 1973, 20-21, (Wild J P); 28-30, (Manning W); 2, 1974, 23 (Challands A). Britannia 4, 1973, 291-3; 5, 1974, 433; 6, 1975, 252. Northants Arch. 8, 1973, 9-12, 2 stone-lined wells; Lynch Farm is low-lying, with lots of flooding seen by numerous enclosures and drainage ditches. Quite an elaborate farmstead of the 3rd-4th c, with a smithy and a fishtank.

Lyne, Peebles, Borders, Scotland.

Britannia 3, 1972, 9, 14, 44-5; 5, 1974, 153. Hanson 1970, 370, comments 'An aqueduct-fed supply system, its source being to the N-W of the site, has been identified at this fort. Originally interpreted as sewers and cesspits the stone-built channels and tanks can be recognised from the excavation report'. Christison, PSAS 35, 1900-1, 154-86, 179-81, Figs.8 & 15, 3 cisterns, 2 drains. Hanson & Maxwell 1983, 148. JRS 41, 1951, 57; 45, 1955, 85; 51, 1961, 121; 55, 1965, 79; 63, 1973, 216-7. FNRB 1979, 300-1. Richmond 1941, PSAS 75, 39-43, stone-lined aqueduct channel; 95, 1964, Steer & Peacham 1959-63', 208-18, plan. RCAHMS Peeblesshire 1, 1967, 173-5, plan. Stephens 1985(b), 224, comments that the aqueduct was a stone-lined channel, and the cisterns were stone-lined. TIRBS 1987, 53, Antonine II(?) fort (2.66ha); two annexes. Antonine I (?) fortlet (0.11ha) 150m to North.

Maidenhead, Berkshire.


Maidstone, Kent.


Malton, North Riding, North Yorkshire.

Hanson 1970, 370, item 59B, comments, ‘A wooden pipeline, probably of mid to late 2nd c. date, was found running down the centre of the main street in the civilian settlement at Malton. It supplied water to the shops and houses on either side of the road’. Mitchelson 1963-66, YAJ 41, 209-61 at, 212-3, Figs.5 & 6, gives details of the well, 5.47m deep, and 1.8m in diameter at the top, narrowing down to 0.6m diam. at c. 3m depth. Robertson 1978. Stephens 1985b, 227, item 45, comments, ‘The road running to the S-E gate of the fort was flanked by a wooden pipeline from about the second quarter of the 2nd c. (Mitchelson 1964, 213, pl.iv). The excavator believed that this pipeline supplied two small buildings in the "hop area" of the vicus. Since the road is military, the chances are that this pipeline supplied official structures, so that the buildings may have been military fabricae. The pipeline could not have conveyed water from the nearby Lady spring. It presumably conveyed water either from the fort, or from an external source from which the fort was also supplied. Another pipeline will have supplied the recently located extramural bath-house (Britannia 2, 1971, 252; Wright & Hassall 1971, 291.9). Periods cover Trajanic, Severan, Constantian and Theodesian dates’. Wenham 1974. CSIR I.3, 1983, Nos.18, 37, 100, 116. TIRBS 1987, 54, RIB 711-9. Possible early Flavian vexillation fortress (c. 8.9ha). Large Agricolan fort (3.4ha), evacuated c. 120-158. Reconstruction early 3rd c.; held till late 4th c. Extensive civil settlement. (Parisi).

Mancetter(1), Warwickshire.


Mancetter(2), Warwickshire.

Manchester


Mansfield Wood House, Northfield, Nottinghamshire.


Market Overton, Leicestershire.


Marshfield, Avon.


Marsworth, Buckinghamshire.


Maryport, Cumbria.

34, comments, 'A sculptured panel of Venus at the Bath (Bruce, Lapidarium Septentrionale 901) may have come from a fountain or cistern (Richmond & Gillam 1950, 167). This might well be indicative of an aqueduct supply in view of the analogous panel from High Rochester and the fountain at Housesteads'. TCWAAS(2) 23, 1923, 142-53; 26, 1926, 415-22; 36, 1936, 85-99, bath-house and well, within fort; 39, 1939, 19-30; 54, 1954, 268-71; 58, 1958, 63-7; 65, 1965, 118; 70, 1970, 42. TIRBS 1987, 55; RIB 808-79. Hadrianic fort (2.58ha), to late 4th c. (Brigantes).

Melandra Castle, Derbyshire.

Methwold, Norfolk.

Middleham, North Yorkshire

Mildenhall, Wiltshire.

More, near Linley, Shropshire.

**Moresby, West Cumberland.**


**Morton Bourne, Lincolnshire.**


**Mountsorrel, The Hill, Leicestershire.**


**Mucking, Thurrock, Kent.**


**Mumrills, Antonine Wall, Stirlingshire, Scotland.**

DAES 1982, 5-6. Hanson 1970, 370, item 60, comments, 'Badly sited, from the point of view of water supply, on a dry plateau the water for the garrison of this fort must have come from the only nearby source, the Westquarter Burn. The water could either have been pumped up from a point below the fort or, more likely, have been piped into the fort by means of an inverted siphon from the higher reaches of the Burn about 0.8km (0.5 mile) to the west'. Macdonald 1934, 194-214. Macdonald & Curie 1929, 396-575. PSAS 1928-9, 396-575; 94, 1960-1,

Munthem Court, West Sussex.

Nantwich, Cheshire.
McNeil & Roberts, 1987, Britannia 18, 1987, 287-8, Fig.5, tank.

Nazeingbury, Nazeing, Essex.
Britannia 7, 1976, 344-5, 3 wells, one c. 1.5m square and 2m deep, with wattle lining; 8, 1977, 407. Occupation later 1st c. to after 2nd c.AD, when it ceased, and reoccurs in 7th to 11th centuries.

Neath, Glamorgan, Wales.

Neatham Hampshire.

Nether Wild Farm, Aldenham, Hertfordshire.

Netheravon, Wiltshire.

**Netherby, Cumbria.**

**Nettleton, Wiltshire.**

**Newcastle, Hadrian's Wall, Northumberlandshire.**

**Newhaven, East Sussex.**

**Newnham, Bedford, Bedfordshire.**

**Newport, Isle of Wight.**

Newstead, Borders Region, Scotland.

Britannia 4, 1973, 150-1; 21, 1990, 313, Fig 7; 24, 1993, 283-3, `...a steep-sided flat-bottomed drain'. Clarke J, 1933. Clarke S, 1995. Hanson 1970, 371, comments, `A line of earthenware pipes carrying water to the external bath-house and nearby latrine from the direction of the fort was uncovered at Newstead. The source of water for the pipeline is unknown, nor was any trace of a water supply found during excavations within the fort'. PSAS 84, 1949-50, 1-38. RCAHM Roxburghshire 2, 1956, 313 Fig 424 & 316 Fig 426. Jones, Clark, Clarke & Rush, The Newstead Research Project, Interim Reports 1989 and 1990, and Preliminary Reports for 1991, 1992 and 1993. Stephens 1985, 224, item 17, comments, `The extramural bath-house was supplied by two ceramic pipelines, one of which appears to run towards the latrine (Curle 1911, 99, 102). These must have been fed by an aqueduct. The fact that the block served only the auxiliary troops of the garrison (Richmond 1949-50, 23), implies wider distribution to the legionary bath-house, and perhaps also to the fort. The system seems to date from Phase III (Antonine I)'. CSIR I.4, 1985, Nos. 45-56, 66. TIRBS 1987, 58, RIB 2120-30. Large Flavian I (4.2'9ha) and II (5.78ha), Antonine I & II (5.95ha) forts; annexe and mansio. Occupation continued after retreat from Scotland (c. AD 163) to c. AD 180(?). (Selgovae).

Norden, Dorset.

Britannia 1, 1970, 299; 4, 1973, 316, two inscribed altars in association with a well with steps. TIRCGLL 1983, 75, shrine, well; coins attesting to occupation from 1st to 4thc. (Durotriges).

Norfolk Street, Leicestershire.

North Leigh, Near East End Farm, Oxfordshire.

North Mundham, West Sussex.
Scott 1993, 188, SMR 0735, WS 62, NAR SU 80 SE 34, Chichester Museum Accessories Register no. 4304, bath.

North Stainley, Ripon, North Yorkshire.

North Wraxall, Truckle Hill, Wiltshire.
Britannia 4, 1973, 334. Scarth 1864, 121-2, bath, well. Scott 1993, 205, SMR NW 304, WZ 130, bath. VCH Wiltshire 1, 1957, 92. TIRCGLL 1983, 75, villa with baths and well within courtyard; well is 20.7m deep, circular and lined with masonry and 1.1m in diameter trimmed to diameter of 1.21m. Coins from Trajan period to Gratian, but mostly from early 4th c. (Belgae).

Northallerton, North Yorkshire.
Bromehead 1942, 142-51, 183-96, at 144, well.

Northampton, Northamptonshire.
Dryden 1885, 53-61. Swan 1984, fiche 538, well.

Northchurch, Hertfordshire.
94, SMR 1859, HT 38, Northchurch Common, Berkhamsted site, bath-suite; another villa SMR 1861, HT 39; a hypocaust, SMR 1334, HT 41, Dudswell Rise; earthworks of Roman building, SMR 1337, HT 42 at TL 00 09, Berkhamsted Golf Course site. TIRCGLL 1983, 26, corridor villa of Antonine period with later development. (Catuvellauni). Occupation c. AD 70, abandoned c. AD 170 and reoccupied AD 339.

Northfleet, Kent.

Northmoor, Oxfordshire.

Norton, Northamptonshire.

Norton Disney, Potter Hill, Lincolnshire.

Norton St. Phillip, Farleigh, Hungerford, Shropshire.

Nunney, Whatley, Coombe/Chessils Field, Somerset.
in the 1st half of the 4th c. ... rooms including a bath-building added...'.

Scott 1993, 170. SMR 23900, SO 45. Somerset Proc. 1, 1851, 38; 21, 1875, 67; 35, 1889, 50. VCH Somerset
1, 1906, 317. TIRCGLL 1983, 75, courtyard villa with bath-suite; probably built c.AD 300 and abandoned c.AD 370. (Belgae).

Nursling, Hampshire.

Britannia 26, 1995, 368: 'excavation of 2.7ha site revealed part of a substantial Roman settlement consisting of enclosures, buildings, pits and wells. Probably part of a large settlement first identified in the 19th c. Site dates from mid-1st c. to mid-2nd c., yielding Gallic and Spanish imported pottery'. Hampshire Field Club and Archaeology Soc. 50, 1995, 35-41. Composite distribution centre. VCH Hampshire 1, 1900, 311. TIRCGLL 1983, 75, settlement, coins from AD 70 to AD 380, mostly after AD 250; wells.

Oakham, Leicestershire.

Britannia 18, 1987, 322, 2 wells; 19, 1988, 447-8, '2 wells, one is c. 1.5m in diameter and c.2.5m deep with footholds in the sides'.

Oakley, Scole, Suffolk.

Britannia 25, 1994, 278, possibly 7 wells reported; 26, 1995, 357-8, item 9, Scole-Sturton By-Pass, 'Pre-Roman phase and two Roman phases: 4 wells, the two earlier had wicker linings, and the two later ones, one square, planked shaft; the other one had pieces of an oak cask dating from the 1st c. to later 2nd c. A causeway set on close-spaced piles (many of them appeared to be young spring-cut oak) crossed a channel of pre-Roman date, probably a meander of the river, dating from radio-carbon, giving dates calculated to AD 454-633 and AD 429-653'. CBA Gr.7 Bulletin 1960, 9, 'a flint-lined well'.

Oakridge, Basingstoke, Hampshire.

Proc. Hants. FC Arch. Soc. 48, 1992, 55-94. Continuous occupation from early to middle Iron Age (6th-4th c. to 3rd-1st c. BC) settlement (period 1), to an expansion of the site in late 1st c. BC to early AD 1st c. i.e. late early Roman times (period 2), to later Roman occupation (period 3), late 2nd c. to late 3rd c. or early 4th c. AD. A large deep well has been reported, see Figs.7 & 7a, opp. pp. 72-77. Deep well, 26.7m (87ft 6in) at a constant diam. of 1.22m (4ft), to 21.95m (72ft) when it widened slightly to a width of 1.52m (5ft).
Water was reached at 22.48m (73.75ft), but dropped to about 23.27m (73.3ft).

**Odell, Bedfordshire.**

_BAJ_ 7, 1972, 1-16. _Britannia_ 6, 1975, 256; 7, 1976, 336; 8, 1977, 400; 9, 1978, 442, Fig.11, 'Farming based on a single family unit engaged in mixed economy'. 2 stone-lined wells in area B, and a wicker-lined well in area A. Tanks, for watering of animals. Occupation from 1st c. to late 4th c. Bedfordshire SMR 2669.

**Odiham, Hampshire.**


**Old Durham, County Durham.**


**Old Kilpatrick, Antonine Wall, Strathclyde, Glasgow.**

Hanson, 1970, 402, well, and refers to buckets and water raising equipment found in well. Miller, 1928, 23, well.

**Old Penrith, Cumbria.**


**Old South Eau, Cambridgeshire.**

Whitwell 1982, 284, RAF 1069/UK 1049, 4437, TF 284 099 - TF 292 094, aqueduct leat.

**Orpington, Fordcroft, Bromley, Greater London.**

_Arch. Cant._ 40, 1928, 46; 71, 1957, xlii, 240; 72, 1958, 210; 73, 1959, 1; 76, 1961; lii; 88, 1973, 223 bath; 89, 1974, 220. _Britannia_

**Orton Longueville, Peterborough, Cambridgeshire.**


**Otford, Kent.**


**Oxford, Churchill Hospital, New Headington, Oxfordshire.**


**Oxford(2), St. Luke Road, South Cowley, Oxfordshire.**


**Pagans Hill, Chew Stoke, Somersetshire.**

well, stone-lined, cut in rock, 5.17m (17ft) deep. Rahtz & Watts 1989, Arch. J. 146, 330-71, Figs.1, 2 & 7. Thomas 1981, Fig.48(map). TIRCGLL 1983, 77, Romano-Celtic temple and well. Built late 3rd c and in use until early 5th c. (Belgae).

Pamphill, King Down/Bradford Down, Dorset.

Paulton, Somerset, Avon.
VCH Somerset 1, 1906, 315-6, item 22, Fig.75, bath.

Pen Llystyn, Gwynedd, Wales.
Arch. J. 125, 1968, 124-6. Britannia 3, 1972, 13 n.56, 66, 69-70, 73-5, 79, 85-7; 5, 1974, 13, 20-2, 27; 10, 1979, 21-2, 27-8, 41, 52-3, 272; 12, 1981, 21, 23-4, 27. Hanson 1970, 371, item 62, comments, 'The wooden pipeline bringing water into the fort from an unidentified source to the N-W of the site has been recently discovered'. Hogg, 1968, 101-92, Figs.19-24 and pl.xii.. At pp.124-6 he describes the water supply to the fort. Stephens 1985, 228, item 51, comments, 'A roughly square channel identified as a water pipe entered the fort through the N-E gate (Hogg 1968, 124-26, pl..XII.B). At fairly regular intervals of about 7.6m , the pipe trench was found to increase from 0.6m to 0.9m in width for a length of about 1,2m; "these sections were solidly packed with clay and presumably correspond to the junctions between pipes". This would denote pipes an unprecedented c. 8.2m long. Although rectangular pipes are known at London (Wheeler 1930, Pl. XII), it is difficult to believe that pipes of this length would have been provided. It is much more probable that this was a simple wooden channel fashioned from planks, rather than a wooden pipeline. The fort is late-Vespasianic but the channel must be later than its foundation since the channel's trench was cut after the 'via decumana' had been metalled (Hogg 1968, 125). Thus the channel probably dates from the reign of Titus (AD 79-81), or the first years of Domitian'. Wilson 1980, 34-6, 50, Fig.40. TIRBS 1987, 62, Flavian fort (1.8ha) and later a fortlet (0.5ha). (Ordovices).

Pen-Y-Darren, Mid Glamorgan, Wales.

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**Pennal, Merionethshire, Gwynedd, Wales.**


**Pentre Ffwrndan Farm, Flint, Flinshire, Wales.**


**Peterborough(1), Fengate, Cats Water, Cambridgeshire.**

Britannia 4, 1973, 294; 6 ,  1975, 253; 9, 1978, 441, 2 wells; 13, 1982, 364-5; 15, 1984, 299. RCHME 1969, Peterborough New Town, 7, ‘Occupation dates from Iron Age (6th c. BC) and most intensive from 3rd c. to 4th c. BC to the first half of the 1st c. AD… briefly reoccupied in the latter part of the 2nd c. AD… The only internal features were two large pits or wells’.

**Peterborough(2), Northamptonshire/ Cambridgeshire.**


**Piddington, Hackleton, Northamptonshire.**

bath. A drain and timber water pipe-line found. TIRBS 1987, 63, corridor villa. (Catuvellauni).

**Piercebridge, County Durham.**


**Pitmeads, East of Dunge, Wiltshire.**


**Pitney, Shropshire.**


**Pitsford, Northamptonshire.**

RCHM County of Northants, S-W, 4, 1982, 204, item 10, well.

**Plas Coch, Wrexham, Clwyd, Wales.**

Britannia 26, 1995, 326, Fig.2, a civilian settlement, dependent on agriculture, with a well.

**Plaxtol, Sedgebrook, Kent.**


**Poole, Dorset.**

Portchester, Hampshire.

Portishead, Avon.

Portland Island, Dorset.

Prestatyn, Glwyd, N Wales.

Puckeridge, Hertfordshire.

Pulborough, West Sussex.
TIRCGLL 1983, 83, villa at Pulborough Farm; baths; coins of 1st c. (Regni).

Pumsaint, Carmarthenshire, Wales.

Putley, Old Rectory, Hereford & Worcester.

Quernmore, Lancashire.

Quinton, Northamptonshire.

Radfield, Kent.
*Britannia* 5, 1974, 459; KAR 14, 1968, 10, 'Romano-British site at Radfield', 2 wells.

Raeburnfoot, Dumfries & Galloway.
*Britannia* 3, 1972, 10; 5, 1974, 148-9, 153, fortlet; 15, 1984, 55. *JRS* 37, 1947, 166; 50, 1960, 214; 51, 1961, 161. *PSAS* 97, 1963-4, 189-9, plan. *RCAHMS Dumfriesshire* 1920, 68-70, plan. Stephens 1985(b) 224, item 20, comments, 'The main N-S road of the Antonine fort was bounded by a stone channel lacking a bottom (Barbour 1898, 23; Robertson 1962, 32), possibly the channel trench was for a wooden pipeline'. *TDGNHAS*
39, 1960-1, 24-49. *TIRBS* 1987, 64, Antonine fortlet (0.64ha), within larger enclosure (0.12ha).

**Rainham, East London, Greater London, Essex.**

*Britannia* 9, 1978, 451-2; 11, 1980, 379; 13, 1982, 374-5, Fig.8, two wells, one timbered- & one flint-lined; 22, 1991, 264.

**Ravenglass, Cumbria.**


**Rayne, Essex.**

*Britannia* 19, 1988, 459. Smoothy 1989, *TEAH* 20, 1-29. The site is c. 1km west of Rayne, Fig.1. Well, 1.42m deep, 1.56 m diam. at top, probably due to erosion of sides.

**Reach, Cambridgeshire.**


**Reculver, Herne Bay, Kent.**


**Redlands Farm, ?**

*Britannia* 22, 1990, 252-4, 2 stone-lined wells.
Reigate, Surrey.

Richborough, Kent.
Britannia 1, 1970, 42-3, 65, Ant. Itin. 463.4, 466.5, 472.6 (ad portum Ritipus), 240-8 date of fort; 2, 147 n.26 (Classis Bratannica), 197-8; 3, 1972, 69, 271-4; 4, 1973, 157-8, 172, 227; 5, 1974, 136, 193, 195, 393-5; 6, 1975, 175, 177, 185-6; 7, 1976, 162-3, 180, 200; 8, 1977, 238, 245, 287-8, 442-3; 10, 1979, 22, 43; 15, 1984, 180; 16, 1985, 178-9; 17, 1986, 427; 20, 73, 178. Bushe-Fox 1926, Vol.I, 19. Hanson 1970, 371, comments, `No trace of an aqueduct channel has yet been found at this site, but the strongest evidence that one existed comes from a fountain or water basin, tile built and hexagonal in shape, and seemingly fed by a lead waterpipe, that was located in the N-W corner of the Saxon Shore fort'. Stephens 1985b, 228, comments: `An hexagonal basin or cistern is known, made of tiles coated with pink opus signinum. It is normally attributed to the Saxon Shore fort (Bushe-Fox 1926, 19, pl. xxxiii; Cunliffe 1968, 248), and is not unlike the much larger but less ornamental fountain in the lower colonia at Lincoln (Thompson 1956, 32-6). In fact the `basin' was probably the font of a late-Roman church (Brown 1971, 227-8)’. SxAC 107, 1969, 102-125. TIRCGLL 1983, 85, RIB 46-65; fort (0.2ha) and bridgehead of Claudius' invasion in AD 43. Later fort of the 'Litus Saxonicum', built c. AD 275-85. (Cantiaci).

Ridgewell, Great Ashley Field, Essex.

Rippingale, Lincolnshire.
Whitwell 1982, 294, TF 12 NW 15, bath.

Rivenhall, Essex.

Rochester, Kent.

Rock, Brightstone, Isle of Wight.
Britannia 7, 1976, 367-9, Fig.25, drain, spring 140m west of house. JBAA 12, 1856, 159f. TIRCGLL 1983, 85, villa; coins of 3rd and 4th c. (Belgae).

Rockbourne, West Park, Hampshire.
Britannia 2, 1971, 179, 181, 183, 187, 190, 193; 3, 1972, 348, Fig.18; 10, 1979, 148 voussoir tiles,168, 174, 176; 11, 1980, 394, date mid 1st c. to c.AD 200, roof collapsed c.3rd c.; 14, 1983, 329f, bath-suite (east wing), c. end 3rd c., perhaps replacing earlier baths; 18, 1987, 348, 16 gold coins, termination c.AD 394, at SU 095 211; 21, 1990, 355, further 4 gold coins. JRS 33, 1943, 75; 35, 1945, 88; 53, 1963, 150, 164; 55, 1965, 217, 228; 56, 1966, 214, 219-20, 225. Hewitt, et. al., 1983, Arch. J. 140, 129-50, 2 baths, 2 wells; west well, c.4th c., first, 0.92m stone-lined, then timber-lined to depth 5.5m, water level at 2.75m; east well 2.3m deep, 0.92m diam., narrowing to 0.6m, and entirely of sandstone blocks, near a corndrier, 7 drains. Hewitt M A T , 1960, Interim Report; idem, 1962, 2nd Interim Report; idem, 3rd Interim Report, 1971; idem, Final Report, 1974. Scott, 1993, 86, NAR 11 NW 11, HA 79.
Rockingham, Northamptonshire.


Rodersham, Kent.


Roecliffe, North Yorkshire.

Britannia 25, 1994, 265-6, fort previously unknown, 2.5 ha (6.2 acres). 3 wells.

Romford, Essex.

Black 1995, 120 site 43, 121 Fig.2 position 43, vicus or roadside settlement and mansio,?bath. Britannia 1, 1970, 52-3, 65, 73, Ant. Itin. 480.7 (Durolito) ( Note: there seems to be some uncertainty about the location of Romford and Chigwell in the Antonine Itinerary, as both sites are given the same location); 6, 1975, 93, identification discounted; 20, 1989, 304. TEAS 7, 1900, 95. VCH Essex 3, 1963 175. TIRCGLL 1983, 86, '? Durolitum', (cf. Chigwell). (Tinovantes).

Rothley, Leicestershire.


Rothwell Haigh, North Yorkshire.


Rough Castle, Stirlingshire.

TIRBS 1987, 67, RIB 2144-5; small secondary fort (0.63ha) and possible earlier fortlet, NS 844 798.

Rousham, Oxfordshire.

Rowlands Castle, Hampshire.
Scott 1993, 87, NAR SU 70 NW 76, HA 80. VCH Hampshire 1, 1900, 310. Bath.

Rudston, Humberside, Yorkshire.

Rushton, Eaton Villa, Cheshire.

Ruthin, Clwyd, N. Wales.

Ryton on Dunsmore, Warwickshire.

Salford Priors, Warwickshire.

Sambourne, Warwickshire.
Scott 1993, 180, SMR 3748, bath, WA 18, 3rd to 4th c.

**Sandringham, Norfolk.**

**Sandwich, Kent.**

**Sandy Lane, Wiltshire.**

**Sapcote, Black Piece Field, Leicestershire.**

**Scampton, Lincolnshire.**

**Scawby, Sturton-by-Scawby, Humberside, Yorkshire.**

**Scole, Norfolk.**

Scunthorpe, Dragonby, Lincolnshire.

Seabegs Wood, Cumberland, Scotland.

Seaton, Honeyditches, Devon.

Selsey, West Sussex.

Sewingshields, Haydon, Hadrian's Wall, Northumberland
Shakenoak, Oxfordshire.


Shawell/Churchover, Leicestershire.


Shepreth, Cambridgeshire.


Shepton Mallet, Fosse Lane, Somerset.


Shipton Gorge, Dorset.


Shireoaks, Nottinghamshire.


Shoreham, Old Shoreham, West Sussex.


Shortlanesend, Cornwall.

Britannia 11, 1980, 389, drain.

Siberton, Silberton in Wansford, Cambridgeshire.

Siddington, Gloucestershire.
RCHM 1976, 101-3, Fig. p.102a, well, discovered accidentally in 1966; still unexcavated in 1976. From pottery it dates to late 1st to 4th c. Scott 1993, 75, SMR 2365, GS 88.

Sidlesham, West Sussex.

Silchester, Hampshire.

Sixpenny Handley, Woodcutts Common, Dorset.
Arch. J. 24, 1867, 168-9; 104, 1947, 42-8. JRS 54, 1964, 62. PPS 24, 1958, 101-19. Pitt-Rivers, Vol.I, 1887, 7-239, 2 deep wells. Pitt-Rivers 1887, Vol.I, 27-8, pls.i, ii, iv, v, 193, 198, (on Roman well shaft sinking). 2 wells, 1) evenly-cut well shaft c. 30.4m (100ft) deep, 1.2m (4 ft) diam., originally located as a depression of 11m (36ft diam., and about 1.25m (4ft) deep. The well had two rows of small cavities, called "put-logs" into which timber was inserted, probably for climbing down and up the shaft. The timber was so located that a bucket could still be lowered down the well. There seems to be some doubt whether there was water at the bottom, but this could be because of the draw-down from modern wells in the vicinity which are deeper than the Roman well. A Roman type wooden bucket was found at a depth of 56.5m (186ft) down the well, probably indicating that in
ancient times it must have yielded water. Pitt-Rivers states that he had a borehole sunk to a depth of 89m (294ft), without finding more than a slight soakage of water,...'. (198) It would appear both these two deep wells were major Roman failures, indicating also that they did not know how to locate water at depth, especially in the chalk. For both the wells water could have been present at the time but that the water table has been depressed during medieval and modern times; (2) small well, 41m (136ft) deep, 0.91m (3ft) in diam. cut smoothly, into chalk. No water was found (193). RCHM County of Dorset 2(2), 1975, 64-72, No.18, item 19, at p.69, 'In phase III,...This enclosure contained a well 1.23m (4ft) in diameter and 57m (188ft) deep,...'.

Slack, West Yorkshire.


Sleaford, Lincolnshire.


Snodland, Church Field, Kent.


Somerford Keynes, Gloucestershire.


South Shields, Northumberland.


Southwark, Redcross Way, Greater London.

Southwark Street, Herefordshire.

Southwell, Bishop's Place, Nottinghamshire.
TIRCGLL 1983, 71, courtyard villa with bath-suite; pottery of 2nd to 4th c. (Corieltavi).

South Witham, Lincolnshire.

Southwick, West Sussex.

Sparsholt, Hampshire.

Spilsby, Lincolnshire.

Spoonley Wood, Gloucestershire.

Springhead, Southfleet, Kent.

St. Mary Cray, Kent.


St. Stephen, Park Street/Bricket Wood, Hertfordshire.


Staden, Lincolnshire.

CBA Gr. 14, 3, 1988, 43-5, bath, occupation 1st to 4th c.

Staines, Surrey.


Stainfield, Lincolnshire.

Stainley North, ??
Wooler 1917, 190. Bath.

Stamford Bridge, North Yorkshire.
Britannia 1, 1970, 40-1, 72, possible association with 'Derventio'; 9, 1978, 79, possible fort; 26, 1995, 345, 'roadside settlement at North Farm, Scoreby. Two rooms of a stone-founded timber structure with a corridor between, and a well. 13ha enclosure adjacent to River Derwent'.

Stancil, Yorkshire.

Standon, Hertfordshire.
Scott 1993, 96, SMR 1101, HT 62, bath, found in 1756, and again in 1890. VCH Hertfordshire 4, 1914, 164.

Stanford in the Vale, Oxfordshire.

Stanton Fitzwarren, Wiltshire.

Stanton Low, Buckinghamshire.

Stanton St. John, Wood Derry/Woodbury, Oxfordshire.
Stantonbury, Buckinghamshire.

Stanwick, Northamptonshire.

Stanwix, Cumbria.
Britannia 1, 1970, 1153; 3, 1972, 249 n. 148; 7, 1976, 106; 16, 1985, 271; 17, 1986, 441; 19, 1988, 499; 22, 1991, 234; 25, 1994, 263-4. TCWAAS(2) 31, 1931, 69-80; 32, 1932, 147-9; 41, 1941, 210-3; 52, 1952, 154; 85, 1985, 53-69. JRS 42, 1952, 90. Birley, 1961, 206, comments that this was the largest fort on the wall and confirms Horsley's observation that the fort must have had a bath-house with an aqueduct water supply. Hanson 1970, 372, item 68, comments, 'Horsley (Britannia Romana, 1732, 155) records that at Stanwix he was shown the remains of stones which "resembled" those from other Roman aqueducts he had seen'. Stephens 1985, 226, item 32, comments, 'A stone channel was observed to the south of the fort by Horsley (1732, 155). Topography suggests that this supplied the extramural bath-house rather than the fort and further, that the channel was the support of a pipeline. It is undated'. Bath, aqueduct channel, water-pipe. TIRBS 1987, 72, RIB 2025-9; large fort (3.98ha) on Hadrian's Wall protected the crossing at the river Eden which was the main route to the west of Scotland. Occupied from 2nd c. till 4th c. (Brigantes).

Stebbing, Essex.
Britannia 9, 1978, 452; 20, 1989, 305. Scott 1993, 65, SMR 1259, ES 66 (Rodwell's no.33). Rodwell 1978, 1-38, at p.31, comments on the social aspects such as status and ethnic origin of the owners of villas which is seldom revealed by excavation of sites. Burials seem to provide the most significant information about the occupants, but the limitations of such details are obvious. In his last paragraph (p.14) he mentions the type of evidence considered for interpreting the early history of a site. Colchester Archaeologist No.2, 1988-9,
VCH Essex 3, 1963, 183 bath-house, drainage channel lined with imbrices; a water system using wooden pipes, of which iron rings survive.

**Stephen Mallet, Somerset.**

*VCH Somerset 1, 1906, 317-8, item 25, well 3.36m deep.*

**Stibbington, Sibson Cum Stibbington, Cambridgeshire.**


**Stockport, Greater Manchester.**


**Stoke D'Abernon, Surrey.**


**Stoke Gifford, Gloucestershire.**


**Stoke Orchard, Gloucestershire**

Britannia 1, 1970, 295, well.

**Stoke Rochford(1), Lincolnshire.**


**Stoke Rochford(2), North Stoke, Lincolnshire.**


**Stoke Rochford(3), Lincolnshire.**
Stone, Buckinghamshire.

Stoney Grange, Lincolnshire.
Britannia 11, 1980, 375, under name Wimblington; 12, 1981, 341; 13, 1982, 365-6, Fig.16; 14, 1983, 305, Iron Age evidence; 15, 1984, 299-300, Fig.16, shows 9 wells and a bath; 16, 1985, 287-9, Fig.20, timber-lined tanks, and stone-lined well.

Stoneham Aspal, Suffolk.

Stonesfield, Oxfordshire.

Storrington/Parham, Lickford, Wigginholt, West Sussex.

Stowe, Church Field, Shropshire.

Strathgeath, Perthshire.

Stretton Bridge, Staffordshire.


Stroud(1), Gloucestershire.


Stroud(2), Hampshire.


Sutton Courtenay, Pen Copse, Oxfordshire.


Sutton Veny, Pit Meads, West Site, Wiltshire.


Swaffham Bulbeck, Cambridgeshire.

Britannia 11, 1980, 375, Roman buildings. RCHM County of Cambridgeshire 2, 1972, 112-3, No.8, item 82, 'The Swaffham Bulbeck Lode', (=leat): 'first recorded in 1279 (Rot. Hund, II, 1818, 484), is probably of Roman origin, an artificial watercourse c. 5.4km (3.3miles) long extending in a direction across the Fens from Commercial End', p.114, co-ords TL 5559 6322 to TL 5219 6725, pl.6, & Fig 104, p.114. In Medieval times it was used as a drain for the Fens.

Swalcliffe Lea Oxfordshire.
Swanwick, Hampshire.
Ashbee 1978, 225. Fox 1928, Antiq. J. 8, 331-6; 10, 1930, 30-33; Fox 1930, Antiq. J. 10, 30-33; Fox 1963, Antiq. J. 43, 286-87. Well, 7.3m deep, 4.25m in diameter at the top, funnel-shaped down to 2.13m at depth 2.74m. Finds seem to indicate that the well had some sort of religious or ritual significance.

Swindon Broome, Manor Lane, Wiltshire.

Tallington, Lincolnshire.

Tarrant Hinton, Barton Field, Dorset.

Templeborough, South Yorkshire.
Britannia 1, 1970 191; 7, 1976, 157; 9, 1978, 379, 382; 10, 1979, 293; 17, 1986, 82. Hanson, 1970, 372, comments, 'A stone-built channel leading from springs to the north of the fort fed the early
external bath-house at Templebrough'. May 1922, 77, pl.xvii; forts I, II, III; forts II, III in succession were built on the foundations of fort I. Aqueduct, stone-lined channel from a springhead; 2 baths, 5 wells, drains, 2 latrines, spring, 2 watertanks.

**Teston, Kent.**
Scott 1993, 108, KE 90. VCH Kent, 1932, 125-6, item 45, Fig 30. Bath, drain.

**Tewkesbury, Gloucestershire.**
Miles & Fowler 1972, Tewkesbury, the archaeological implications of development, well, stone-lined. Smith 1987, 313.

**Thatcham, Berkshire.**

**Theale, Berkshire.**
Britannia 26, 1995, 368, 'excavation revealed Romano-British post-built structure with adjacent well. Two further wells may be of Roman date'.

**Thenford, Northamptonshire.**

**Thetford, Norfolk**
Britannia 12, 1981, 347-8; 13, 1982, 410; 14, 1983, 308-9; 15, 1984, 306; 16, 1985, 190; 22, 1991, 69; 23, 1992, 288-9. EAA 62, 1993, 1-234, at p.45, 10 wells, also Iron Age occupation to 60s AD; EAA 22, 1984, 1-209, at p.14 refers to wells, pits and tanks; comment is made about uncertainty whether some of the c. 500 pits are wells, or not. (This could have been checked by taking undisturbed samples from the lower parts of the pits or by penetrating a deeper with sampling tubes, and checking the degree of saturation. If the degree of saturation was near 100%, it would indicate that the pit had
penetrated the water table, and therefore it was most likely a well). Scott, 1993, 138, SMR 5683 St Helen’s Well, NF 192, SMR 17397, NF 193. TIRBS 1987, 74, buildings within a tripple ditch enclosure (c. 3.6ha). (Iceni).

Thistleton, Dyer, Rutland, Leicestershire.

Thurgarton, Wood Meadow, Nottinghamshire.

Thurlby, Lincolnshire.
Arch. J. 91, 1935, 121, 184, wattle and daub huts, probably native, unlikely to be Roman. LAASRP 9 (n.s.), 1961-2, 21. Lincoln SMR Ref. AA 44347/1 NMR 20813, ?aqueduct, part of Car Dyke in Park Wood, probably built c. AD 125. Section of c. 190m in length, about 175m east of the Roman road, King Street, on the edge of the Fen. Whitwell 1982, 323, TF 11 NW B, well.

Thurnham, Kent.

Tiddington, Stratford, Warwickshire.

Tilston, Cheshire.

Tingwick, Stollidge Field, Buckinghamshire.
Records of Buckinghamshire 2, 1862, 33-50. RCHM 1913, Vol.2, 299, No.208, item 1, '...which was supposed to be part of a Roman bath and hypocaust,...'. Scott 1993, 30, SMR 87, BU 76, bath. VCH Buckinghamshire, ii, 1908, 12-3, plan 13 showing drains.

Titsey, Surrey.

Tixover, Tixover Grange, Leicestershire.

Tockington Park, Avon.
Scott 1993, 13, SMR 1472, AV 2. TBGAS 12, 1888, 159-69; 13, 1889, 196-202, Maclean, comments, 'The hypocaust chambers recently discovered (rooms xxx & xxxi) would indicate some extensive heating apparatus and bath accommodation suitable to so large an establishment', 202. TIRCGLL 1983, 98, courtyard villa. (Dobunni).

Tomen-Y-Mur, Merioneths, Gwnedd, Wales.
Arch. Cambr. 117, 1968, 120. Britannia 11, 1980, 348, further details of the leat-system to the north-east of the fort...‘, tank. Bowen &

**Totternhoe, Bedfordshire.**

**Towcester, Northamptonshire.**

**Traws-Coed, Cardiganshire, Dyfed, Wales.**

**Tremadoc Gwynedd, Wales.**

**Tripontium, Cave's Inn Farm, Warwickshire.**
9.1m (30ft) deep; 3) in dispute; 4) top 3m (10ft) destroyed, total depth below turf level was 11.3m (37ft); 5) largest of the wells, 13.7m (45ft) deep; 6) stone-lined, 12.5m (41ft) deep; 7) stonelined 13.1m (43ft) deep.

**Turf Wall Mile Castle, Hadrian's Wall, Northumberland.**

**Twyford, Hampshire.**

**Twywell, Northamptonshire.**
Northants Archaeology 10, 1975, 31-93, full report. RCHM County of Nothampton, N-E Arch. Sites, 1, 1975, 101a, item 6, a 'Roman Well'.

**Upham, Hampshire.**

**Upmarden, West Sussex.**

**Upminster, Great Stunning, Essex.**

**Usk, Gwent.**
Verulamium, St. Albans, Hertfordshire.


Wadfield, near Sudeley, Gloucestershire.


Wainfleet All Saints, Lincolnshire.


Walesby, Lincolnshire.


Wall, Staffordshire.

Walls, Pucknowle, Dorset.


Wallsend, Hadrian's Wall, Northumberland.


Walton, Radnor, Powys.


Walton Heath, Surrey.


Walton-Le-Dale, Lancashire.

Britannia 13 1982, 352, supply base, drain; 14, 1983, 296-7, large stone-lined well, phase III, c. AD 130-140 to 3rd and 4th c. ; 15, 1984, 284-6, Figs.6, 7, ‘drainage ditches thought to be of Neronian date,...Phase III, as in period 2, the buildings associated with furnaces, 2 wells and industrial pits’. THSLC 109, 1957, 1-46. TIRBS 1987, 79, Flavian to early 3rd c., military supply base(?) (Brigantes).

Walton-on-Thames, Surrey.

Walton-on-the-Hill(1), Surrey.
Black 1987, 134-40, (TQ 23 53) comments that because of the high elevation of both the villas with baths, there exists a problem of source(s) of water that supplied them. Britannia ii, 1971, 114 no.32, 187, 190, 193. Scott 1993, 178, SMR 900, SY50. (on cover marked 1949): Lowther 1950, SyAC 51, 65-81, comments: 'The site proved to have been occupied in pre-Roman times, dating from the latter part of the Iron Age', based on pottery of c. AD 10-43. The bath appears to have become ruined c. AD 270-274 (coin of Titrius II), and reconstructed c. AD 280-300.

Walton-on-the-Hill(2), Staffordshire.
Antiq. J. 14, (2nd s.), 1881-83, 110-1, `...and was, I have no doubt, the position of the bath of the establishment', Edwin Freshfield at the April 1882 meeting.

Wanborough (Lower), Wiltshire.

Wanstead Park, Essex.

Ware, Hertfordshire.

Washington, Lincolnshire.

Wasperton, Warwickshire.
Britannia 13, 1982, 361-2; 14, 1983, 296, "ii) two wells, one timber-lined, the other, stone-lined'.

Watchfield, Little Wellington Wood, Berkshire/Oxfordshire.
VCH Berkshire 1, 1906, 218, 'An ancient well, 15ft (4.56m) deep. Roman pottery and coins found when cleared. 24 coins from reign of Allectus (AD 293-6), on Fox Furlong Farm. A small Romano-British house nearby, at the close of the 3rd c.'.

Water Newton, Huntingdonshire and Peterborough.

Watergate Hanger, West Sussex.

Weekley, Northamptonshire.

Weldon, Northamptonshire.

Well, North Yorkshire.

Britannia 13, 1982, 323-5. Gilyard-Beer 1951. Yorkshire Roman Antig. Com. Res. Rep. 1. Hanson 1970, 373, item 73, comments, 'The baths were fed by a stone-built aqueduct 0.45m (1.5ft) wide by 0.47m (1.58ft) deep which led from the Well Beck, a stream running from east to west to the north of the site'. Tyler 1980, 89-90. Lukis 1882. YAJ 7, 1882, 284-5; 34, 1939, 342-9; 35, 1943, 226; 36, 1947, 250, 465-6, aqueduct, cistern. TIRBS 1987, 81, small corridor villa with baths; built in 2nd c., and abandoned late 4th c. (Brigantes).

Wellingborough, Northamptonshire.


Wellow, Somerset, Avon.


Welton Wold, Humberside, East Riding, Yorkshire.


Welwyn, Hertfordshire.

Wendlebury, The Castle, Oxfordshire.

Wentlooge Level, Gwent, Wales.
Allen & Fulford 1986, pls.i-x; Britannia 17, 1986, 91-117; 19, 1988, 181-2; 25, 1994, 175-211. Fulford, Allen & Rippon, 1994, 175-211, pls.xiva, b, xva, b. The excavation reports provide evidence of large quantities of pottery and other small finds, including some Roman fabric material, which is said to have been well preserved in the anaerobic environment. The pottery dates to c. AD 250 - 400 and seems to have originated from many different parts of Roman Britain. Much agricultural remains have also been recovered and it has been conjectured that the wetland marshes were used as fields for growing fodder for horses for the Roman army. The settlement seems to have been extensive, but not much building remains have been located up to 1992.

West Dean, Wiltshire.

West Deeping, Lincolnshire.
Britannia 26, 1995, 350: '4ha excavation, but enclosures and fields from 0.5ha to 10ha in extent. Many buildings with several rooms each, and some hypocausted, probably indications of bath-structure'.

West Keal, East Lindsey District, Lincolnshire.
Lane & Hayes 1990, SMR 40964, site at TF 36 SE OS. Well.

West Newton, Norfolk.

**West Winch, Setchey, Norfolk.**
Scott 1993, 139, SMR 2262, NF 207, well.

**Westbury, Wiltshire.**

**Westerwood, Cumbernauld, Dunbartonshire, Strathclyde.**
*PSAS* 67, 1933, 277. Robertson 1979, 62-4. Roy 1793, pl.xxxv. *TIRBS* 1987, 81, secondary fort (0.97ha) on Antonine Wall; bath-house.

**Weston Underwood, Buckinghamshire.**

**Wetwang, Wetwang Slacks, Yorkshire.**

**Wharram Grange, North Yorkshire.**

**Wharram Percy, North Yorkshire.**

**Wharram-le-Street, North Yorkshire.**
*Britannia* 10, 1979, 288; 11, 1980, 363, the source of the Gypoxy Race river, a spring.

**Wheatley, Oxfordshire.**

**Whickham, County Durham.**

**Whilton Lodge, Norton, Northamptonshire.**

**Whitchurch(1), Shropshire.**

**Whitchurch(2), Hereford and Worcester, Hertfordshire.**
White Staunton, Shropshire.


Whitebeech, Chiddingfold, Surrey.


Whitford, Clwyd, Wales.

Scott 1993, 48, SMR 2394, CL 18, lead pipe fragment.

Whitley, Derbyshire.

Britannia 26, 1995, 350, 'large amount of tile and stone and stone flags, confirmed the presence of a masonry building, and considerable quantity of box-tile and tufa suggest a bath-house'.

Whitley Castle, Northumberland.

AA(4) 37, 1959, 191-202. Arch. J. 142, 1985, 216-36. Blair R & Carr S, 1925, 249-60. Stephens 1985b, 226, item 35, comments, 'An altar (RIB 1198) seems to have been set over a spring near the extramural bath-house (Blair & Carr 1925, 254). The altar may be of the mid 3rd c. date (Wright 1943, 38). Analogy with the Chester altar suggests that, although a dedication to Apollo rather than the Nymphs, the spring may have fed an aqueduct; if so, this will have supplied the extramural bath-house rather than the fort, since the fort would probably have required a more elevated source'. Wooler, 1917, 190. Wright 1943, JRS 33, 36-38. TIRBS 1987, 82, fort (1.2ha). 2nd to 4th c.; external bath-house. (Brigantes).

Whittington Court, Gloucestershire.

of earlier villa of 2nd c.; latest coins of Honorius, AD 393-423. (Dobunni).

**Whittlebury, Holton Copse, Northamptonshire.**


**Whittlesford, Chronicle Hills, Cambridgeshire.**


**Whitton(1), Castle Hill, Ipswich, Suffolk.**


**Whitton(2), St. Lythans, Glamorgan.**

*AEx* 1970, summary report. *Britannia* 2, 1971, 246, dated after c. AD 200, reconstructed c. late 3rd c. or early 4th c.; 16, 1985, 181. Jarrett & Wrathmell 1981, *Celtic Studies* 5, Fig.2, 40, Fig.23, well, 44, Fig.25 section of the well, 7.4m deep, an octagonal frame over the well with 8 posts. *JRS* 56, 1966, 196; 57, 1967, 174; 58, 1968, 176; 59, 1969, 201, Fig 26. *TIRCGLL* 1983, 105-6, pre-Roman farmstead; original round houses replaced with rectangular buildings in 2nd c.; occupation ceased c. AD 340. (Silures).

**Wickford, Essex.**


**Wigginton, Oxfordshire.**

Wiggonholt, Lickford, Storrington/Parham, West Sussex.

Wilderspool, Lancashire/Cheshire.

Wilmcote, near Stratford-on-Avon, Warwickshire.
Bromehead 1942, 144, Roman well, 2.74m diam., steined with masonry, and penetrated several layers of solid rock. Gentleman's Mag. 1841, ii, 81. JBAA 29, 1873, 41-2.

Wilsford, Wiltshire.

Winchester, Hampshire.

Windermere, Belle Isle, Cumbria.

Wingham, Kent.

Winterborne Kingston, Kingston Down, West Down, Dorset.
Antig. J. 33, 1953, 74-5. Britannia 19, 1988, 476; 21, 1990, 353. Dorset Proc. 11, 1890, 1-6. Bromhead 1942, 143. RCHM 3(2), 1970, County of Dorset, 300-5, item 21, 'Romano-British Well on Kingston Down', excavated by Mansel-Pleydell, J C, in 1890. The well is at OD 200ft (60.8m), and cut into chalk limestone and is 1.1m in diam, and 25.8m (85ft) deep to water level, so it is probably deeper. The well is not precisely located and is roughly situated at SY 845 975.

Winterton, Lincolnshire.

Witchampton, Hemsworth, Wall's Field, Dorset.

Withington, Woods, Gloucestershire.

Wittenham, Berkshire.
VCH Berkshire 1, 1906, 219-222, Fig., p.221, 3 wells.

Wolfhamcote, Sawbridge, Warwickshire.
VCH Warwickshire 1, 1904, 249, well, probably used for ritual purposes, 1.3m square and greater than 13.5m deep, but bottom not reached. At 6.7m 'was a large square stone with a hole in it, on which stood urns of grey ware'; 12 were intact and 12 were broken.

Wollaston, Northamptonshire.

Woodchester, Gloucestershire.
Woodcock Hall, Saham Toney, Norfolk.
Britannia, 9, 1978, 480; 17, 1986, 1-58; 22, 1991, 69; Brown 1986, at p.4 comments 'Fresh water can be obtained from the river, or from wells that need to be no deeper than about 5m (16ft), to draw water from the top of the underlying clay'. The site is along Peddar's Way Roman Road. Appears to be a settlement below a Claudian fort on a nearby hill, apparently confirmed by a find of a bronze petara handle inscribed "Primi C(enturiae) Primi" (Property of the century of Primus), in Britannia, 9, 1978, 480. Smith 1987, 157, comments, 'A small scale excavation by B A Dennis uncovered a pit and what was either a stone path or a wall-footing, 0.76 to 0.91m wide, made of chalk blocks and flints, and also a timber-lined well (Norwich Museum file)'. Norfolk Arch. 37, 1979 220; 38?, 1982, 206-8. Cunliffe 1974, 285.

Woolaston, Gloucestershire.

Woolstone, Oxfordshire.

Wootton Hill, Hampshire.
Britannia 5, 1974, 434, bath.

Worcester, Worcestershire.
evidence of iron smelting during this period; Iron Age occupation evidence; a large house excavated. (Dobunni).

Worth, Kent.

Wortley, Gloucestershire.

Wraxall, Avon, Somerset.

Wroxeter, Salop, Shropshire.
2.43m (8ft) wide and at least 3.65m (12ft) deep, constructed after AD 155, and robbed of its tile lining within the Roman period, probably in the late 3rd century to early 4th century AD; 53, 1963, 7; 54, 1964, 162-3, 165, Figs.14, 15. Wacher 1995, 19, 21, 22, 30, 46, 151, 159, 362-77, 389, 433, Fig.11, bath-house, Figs.165, 166, 168, 167, water supply and aqueduct; Fig.169 baths during 5th c. Aqueduct (369), major sewer 369, bath-house, 2 drains, cistern Fig.11, water distribution channel Fig.167. RIB 291. Webster 1988, 120-44. Webster & Hollingsworth 1957-60, TSAS 56, 133-7; 57, 1962-3, 112-31; 58, 1965-8, 197-219; 59, 1969-74, 24-31; 70, 1975-6, 5-39. TIRBS 1987, 84-5, fortress, civitas capital 1st c; occupied 1st c. to 5th c. (Cornovii).

Wyck, Hampshire.

Wycombe (High), Buckinghamshire.

Wykham Park, Oxfordshire.
VCH Oxfordshire 1, 1939, 331 (sv Banbury), well. TIRBS 1987, 85, building (?); coins from Claudius ii to Valens. (Dobunni).

Wymondham, Gann's Close, Leicestershire.

Wymondley (Great), Wymondley Bury, Ninesprings, Hertfordshire.
Yardley Hastings, Northamptonshire.

Yarwell, Northamptonshire.
RCHME County of Northants, N-E Arch. 1, 1975, 114-5, site 5 at TL 056 985. Scott 1993, 149, SMR 1711, NH 125, site dates from Iron Age through to 4th c. AD, into Late Roman period. TIRBS 1987, 85, (TL 061 991 & TL 066 979). ?bath. (Catuvellauni).

Yatton, Wemberham, Avon, Somerset.

Yeovil, Avon, Somerset.

York, Yorkshire.
1954 to 48, 1958; 50, 1960 to 59, 1969. *RCHME* City of York 1962, 38. Whitwell 1976, 1-55, pls.ia-xvib, which shows the sewer channel of which 44m traced; fall 0.74m, floor elevation 10.3m OD, 0.45m wide by 1m high, covered with Millstone slabs 1.20 x 0.75 x 0.3 m, representing a main sewer with 6 distribution branches and 3 vertical sections, pls.ia to xib; very good B & W photographs of the sewer. See Figs.1, 2 & 3 of the general plan (scale 1:200) and detailed plan (scale 1:100). Sheahan & Whellan, Vol.1, 1855, 308. *PNRB* 1979, 355-7. Stephens 1985b comments, 'A wooden pipeline has been found outside the S-E angle together with a second to early third century cooking pot. Intramural distribution was by lead mains (Taylor & Richmond 1960, 219; *RCHM* 1962, I, 38, pl. 17). The impressive Church Street drainage system suggests that an aqueduct was laid not later than the Trajanic rebuilding. The environmental evidence from that system suggests that the aqueduct may have been a covered channel (Buckland 1976, 16-8, 27-8) - presumably a pipeline'. *CSIR* I.3, 1983, Nos. 1-14, 21-7, 34-5, 38-93, 108, 116-26, 129-32. *TIRBS* 1987, 85-6, *RIB* 640-706; fortress (20.23ha) established c. AD 71; probable headquarters of Agricola (*RIB* 662-3); internal baths; Colonia by c. AD 237; another settlement established west of the river Ouse, which also had a bath. (*Brigantes*).
**APPENDIX 3: DATABASE SITES WITH TYPE AND LOCATIONS**

* A ? indicates that there is some uncertainty either of type, name, or location. A + before a site type indicates it has been specifically discussed in Chapter 6.

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APPENDIX 4: ABBREVIATIONS

AAA or LAAA - Liverpool Annals of Archaeology and Anthropology
AASR - Associated Architectural Society Reports
AB - Archaeology in Britain
AE - L’année épiigraphique
AEx - Archaeological Excavations (HMSO)
AHCAG - Archaeological and Historical Collections of Ayrshire and Galloway
AJA - American Journal of Archaeology
AJLSFAM - Athenaeum Journal of Literature, Science, Fine Arts and Music
AJPh - The American Journal of Philology (Baltimore)
AJSL - The Antiquaries Journal of the Society of London ??
AN - Archaeological Newsletter
AN Lincs. - Archaeological Notes in LAASRP (succeeded in 1966 by LHA)
ANL - Archaeological News Letter
Antiquary - The Antiquary
Antiq. J. - Antiquaries Journal
Ant. W. - Die Antike Welt
App. - Appendix
Arch. - Archaeology
Archaeol. - Archaeologia
Archist. The Archaeologist ??
Arch. Ael, - Archaeologia Aeliana
Arch. Anz. - Archäologisher Anzeiger
Arch. Atlan. - Archaeologia Atlantica
Arch. Camb. - Archaeologia Cambrensis
Arch. Cant. - Archaeologia Cantiana
Arch. Clwyd - Archaeology in Clwyd
Arch. Devon - Archaeology in Devon
Arch. Exeter - Archaeology in Exeter
Arch. Today - Archaeology Today
ASCSA - American School of Classical Studies at Athens
ASMS - The Archaeological Sites and Monuments of Scotland ??
ASSRP - Associated Architectural and Archaeological Societies Reports and Papers
Athen. - Athenaeum, Pavia
Arch.W. - Archaeology in Wales
Arch. J. - The Archaeological Journal

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Archaeom. - Archaeometry
Arch. Rev. - CBA Groups 1 to 13 Archaeological Review
AW - Ancient World
BAA - British Archaeological Association
BAARG - Bristol and Avon Archaeological Research Group
B&J - Berkshire Archaeological Journal
Banwell AN - Banwell Society Archaeological Newsletter
BAR - British Archaeological Reports
BARG - British Archaeological Research Group
BASTP - Birmingham Archaeological Society Transactions and Proceedings
BBAA - Bulletin of the Berkshire Archaeology and Architecture
BBCS - Bulletin of the Board of Celtic Studies
BBOAJ - Berkshire, Buckinghamshire and Oxfordshire Archaeological Journal
BDAS - Berkshire and District Archaeological Society
Beds. Arch. J. - Bedfordshire Archaeological Journal
Beds. Mag. - Bedfordshire Magazine
BIAL - Bulletin of the Institute of Archaeology, London
BLIA - Bulletin of London Institute of Archaeology
BNFAS - Bulletin of the Northamptonshire Federation of Archaeological Societies
Brit. - Britannia
Carm. Ant. - Carmarthenshire Antiqua
CBA - Council for British Archaeology
CIL - Corpus Inscriptionum Latinarum
CJ - The Classical Journal
Clas. Ant. - Classical Antiquity (Berkley, Univ. of California Press)
CLAU - City of Lincoln Archaeology Unit
Com. Rescue Arch. Avon - Committee for Rescue Archaeology in Avon
Col. Archeaol. - The Colchester Archaeologist
Contr. - Contrebis
CUAPS - Catholic University of America, Patristic Studies
Current Arch. - Current Archaeology
CVAHS - Chess Valley Archaeological and Historical Society
CW - Classical World (Journal)
CQ - Classical Quarterly (Journal)
DAJ - Derbyshire Archaeological Journal
EAA - East Anglian Archaeology
EAHS - East Anglian Archaeology and Historical Society
LPRIA - Late pre-Roman Iron Age
Med. Arch. - Mediaeval Archaeology
Mon. Ant. - The Monmouthshire Antiquary
MORG. - Morganny (Wales)
MORGANNWG - Morgannwg (Cardiff)
MOW - Ministry of Works, Archaeology Department
NMR - National Monuments Record
NA - Norfolk Archaeology
NAJ - Norfolk Archaeological Journal
Northants. Arch. - Northamptonshire Archaeology
Not. Dig. - Notitia Dignitatum Occidentis
OAHNS - Oxford Archaeology and History Society News Sheet
OJA or OxJA - Oxford Journal of Archaeology
Ordnance Note Book - Ordnance Survey
Oxon. - Oxoniensia
PAI - Proceedings of the Archaeological Institute
PAS - Proceedings of the Archaeological Society
PBAAAW - Proceedings of the British Archaeological Association at
   Winchester
PBBSAHS - Proceedings of the Bath Branch of the Somerset Archaeology and
   Natural History Society
PBNAFC - Proceedings of the Bath Natural History and Archaeological Field
   Club
PBSR - Papers of the British School at Rome
PCAS - Proceedings of the Cambridgeshire Antiquarian Society
PDAS - Proceedings of the Devon Archaeological Society
PDAFC - Proceedings of the Dorset Antiquarian Field Club
PDNHAS - Proceedings of the Dorset Natural History and Archaeological
   Society
PHFC - Proceedings of the Hampshire Field Club
PIWNHAS - Proceedings of the Isle of Wight Natural History and
   Archaeological Society
Plin. NH - C. Plinius Secundus the Elder, Naturalis Historia
PLPLS - Proceedings of the Leeds Philosophical and Literary Society
PLDLHS - Proceedings of the Leatherhead and District Local History
   Society
PNRB - Place Names of Roman Britain, Rivet A L F and Smith C, 1979
PNHAS - Proceedings of the Northamptonshire History and Archaeological
   Society
PPS - Proceedings of the Prehistoric Society
SxASN - Sussex Archaeological Society Newsletter
Tab. Peut. - Tabula Peutingeriana (The Peutinger Table)
TAMS - Transactions of the Ancient Monuments Society
TARNSFC - Transactions and Annual Report of the North Staffordshire Field Club
TBAS - Transactions of the Birmingham Archaeological Association
TBGAS - Transactions of the Bristol and Gloucestershire Archaeological Society
TBWAS - Transactions of the Birmingham and Wolverhampton Archaeological Society
TCASFC - Transactions of the Carmarthenshire Antiquarian Society Field Club
TCCS - Transactions of the Cambridge Camden Society
TCHAS - Transactions of the Cambridge and Huntingdonshire Archaeological Association
TCHS - Transactions of the Caernarvonshire Historical Society
TCSVFC - Transactions of the Cradoc and Severn Valley Field Club
TCWAAS - Transactions of the Cumberland and Wesmoreland Antiquarian Archaeological Society (also as CW1,2,3 for series 1,2,3)
TDA - Transactions of the Devon Association
TDGNHAS - Transactions of Dumfries and Galloway Natural History and Antiquarian Society
TEAH - Transactions of Essex Archaeology and History
TEAS - Transactions of the Essex Archaeological Society, Colchester
TEHAS - Transactions of the East Hertfordshire Archaeological Society
TERAS - Transactions of the East Riding Archaeological Society
TGAS - Transactions of the Glasgow Archaeological Society
THNHS - Transactions of the Hertfordshire Natural History Society
THSC - Transactions of the History Society of Carmarthen
THSFNC - Transactions of the Hull Scientific and Field Naturalists' Club
THSLC - Transactions of the History Society of Lancashire and Cheshire
TIRBS - Tabula Imperii Romani: Britannia Septentrionalis, 1987
TLAS - Transactions Leicester Archaeological Society
TLCAS - Transactions of the Lancashire and Cheshire Archaeological Society
TLAHS - Transactions of the Leicestershire Archaeological and Historical Society
TL&SSAHS - Transactions of the Lichfield and South Stratfordshire Archeological and History Society
TLMAS - Transactions of the London and Middlesex Archaeological Society
TDNFC - Transactions of the Newbury and District Field Club
TNFC - Transactions of the Newbury Field Club
TNSFC - Transactions of the North Stratfordshire Field Club
TPBAS - Transactions and Proceedings of the Birmingham Archaeological Society
TRAC - Transactions of the Roman Archaeology Conference
TRS or T. Rad. S. - Transactions of the Radnorshire Society
TSAHAAS - Transactions of the St. Albans, Hertfordshire Architectural and Archaeological Society
TSAS - Transactions of the Shropshire Archaeological Society
TSSAHS - Transactions of the South Stratfordshire Archaeological and Historical Society
TTS or TTSN - Transactions of the Thoroton Society of Nottinghamshire
TWAS1 '1', 3 - Transactions of the Worcestershire Archaeological Society (ser. 1,2,3)
TWNFC - Transactions of the Woolhope Naturalists' Field Club
VCH - The Victoria History of the Counties of England
WAM - Wiltshire Archaeological Magazine
WMANS - West Midlands Archaeological News Sheet
WSWHASB - Watford and South-West Hertfordshire Archaeological Society Bulletins
WSWHANS - Watford and South-West Hertfordshire Archaeological News Sheet
YAJ - Yorkshire Archaeological Journal
YAR - Yorkshire Archaeological Register
YASB - Yorkshire Archaeological Society Bulletin
ZPE - Zeitschrift für Papyrologie and Epigraphik, Bonn
APPENDIX 5

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