ROMANO-BRITISH WATERMILLS

R.J. SPAIN

Watermills, by their very nature, are associated with one of the most violent factors of land form evolution, namely water-power. Rivers and streams are the chief agents in the excavation of valleys, and their powers of erosion and transportation are manifest in the ever-changing interface of land and water. If the landscape was viewed from a historic time-lapse the water-margins, especially of the rivers, would exhibit most rapid moving land surfaces. River profiles, gradients and courses are restless under the interacting influences of erosion and deposition. It is ironic that the natural force, which watermills harness for man, is the instrument of their preservation or destruction.

Watermills, probably more than any other building on the early landscape, have suffered most from the forces of nature. Even bridges, although subject to the same forces, have the singular advantage of their position usually being known to the archaeologist. Ancient roads do not move; rivers do. What other type of abandoned building within a valley could be obliterated by the downstream migration of incipient meanders or other manifestations of river flow? One wonders whether, in the study of Roman watermills, British archaeology is at any disadvantage in having a landscape of damp climate and abundant rain, about half of which finds its way to the sea. The Roman countryside of forested and soil-mantled slopes has, in the centuries following, suffered from increasing rates of denudation and intensive agricultural activities. Elsewhere in the Empire buildings, among them watermills, still stand in undisturbed Roman landscapes. However, if we have the disadvantage of climate, it is more than offset by our advances in archaeology.

In order successfully to study ancient watermills, there must be a fruitful reciprocal relationship between the archaeologist and engineering historian. The study of mechanical and hydraulic properties inherent in historic watermill structures and arrangements cannot be facilitated without the primary material provided by the archaeologist. An analogous relationship occurs in our understanding of the making of the landscape, where the historians' studies spring from the geologists' work. So, too, must the engineer depend upon the archaeologist for earth-born historical studies. This is especially true of Roman studies.

But the archaeologist should recognize additional problems germane to watermills. He must be familiar with evolutionary studies of drainage systems and have an understanding of the physical arrangements of watermills, their effect on the landscape and relationship with associated water-courses. The archaeologist will, with advantage to an increased body of knowledge, respect the inter-disciplinary division of responsibilities. The interpretation of the primary evidence for the purposes of engineering analysis, is the prerogative of the engineer.

At the turn of the last century, when Bennett and Elton were busy producing their impressive study concerning the history of corn milling,[1] Romano-British watermill sites were unknown in these islands. Apart from a dubious suggestion by an eighteenth-century historian, that a conduit discovered at Knott Mill near Manchester, may have been the race of a Roman watermill,[2] no archaeological evidence had been identified to support their existence. Many millstones were being discovered in Roman contexts and horizons throughout the nineteenth century, but these were rarely recorded and invariably cast aside and often lost, many museum specimens being unprovenanced. Querns were even more common as a staple artefact of most domestic, military and industrial sites.[3] Unfortunately, the identification of millstones and querns has always caused problems for the archaeologists, and still does, especially when fragmented and degraded.[4] Perhaps understandably then these artefacts are largely ignored in site reports, lost among the volumes of minutiae devoted to the drawings and identification of sherds and other artefacts. The difficulties of interpreting milling artefacts together with a lack of understanding of associated hydraulic and

[1] R. Bennett and J. Elton, *History of Corn Milling*, 4 vols, (1898–1904).

[2] Whitaker, *History of Manchester*, ii (1771), 216.

[3] It has been estimated that there are from eight to ten thousand pre-Saxon querns in the north of England alone. Adam T. Welfare, post-graduate research student, University of Newcastle-upon-Tyne, in correspondence with the author.

[4] In this context the word degradation means the mechanical detrition by man involving the obliteration in part or whole of the original stone by subsequent, different functions, e.g. rotary milling-reciprocating milling-whetting.

[5] Antipater of Thessalonika, Pliny the Elder, Procopius, Strabo, Vitruvius, etc.

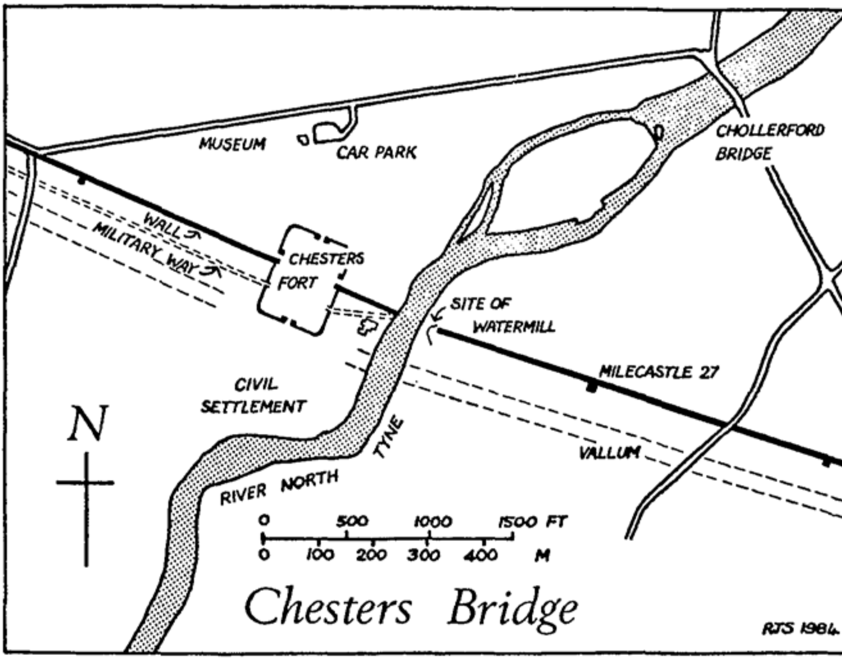

Fig. 1. Chesters Bridge.

mechanical technologies have inevitably retarded studies of watermills in the Roman landscape.

Victorian archaeologists were well aware that the Romans employed watermills; this was attested by the often quoted classical writers[5] and the wealth of codes and edicts associated with Roman law which mentioned watermills.[6]

In 1860 Clayton, excavating the eastern abutment of the Roman bridge just south of Chollerford Bridge, near Chesters fort, discovered a millrace and millstones associated with the tower (Fig. 1).[7] During this and other work on the site in the 1860s the evidence was not identified as a possible watermill.[8] At Chesters bridge the generation of waterpower was facilitated by a stone-lined watercourse passing through the base of the tower (Fig. 2). The source of this water must surely have been the North Tyne, which now flows

[6] Far too numerous to mention here. As an introduction see O. Wikander, 'Water-Mills in ancient Rome', *Opuscula romana*, xii, 2 (1979).

[7] J. Clayton, 'The Roman Bridge of Cilurnum', *AA*[2], vi (1861), 80–5.

[8] *AA*[2], vi (1865), 86; J.C. Bruce, *Roman Wall*, (1867), 148.

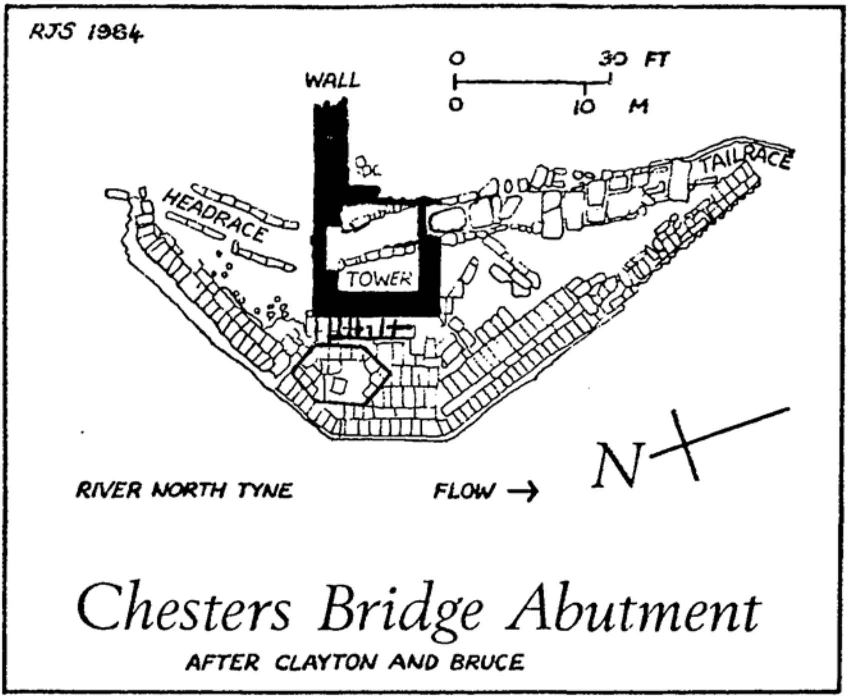

Fig. 2. Chesters Bridge Abutment.

some 25 m. away to the west, but Wilson queried this,[9] probably because it was not proved by archaeological work. The width of the watercourse varies throughout its length from 1.85 to 1.93 m. just before it passes into the tower, to 1.65 m. through the mill and the tailrace.[10] Apparently, it was not possible to identify the level of the original bottom of the course, although the depth of the sides over the stone courses is approximately 0.84 m. A survey by Simpson showed the course to be almost level over its length of 39.6 m., although the bottom of the walls indicated a drop of 11.5 cm.

An exact dating for the working of this mill is difficult. Although clearly within the Roman period, for the Military Way passed over the tailrace, the entry of the headrace through the mill wall is partially blocked by stones, suggesting a crude earlier attempt to

[9] F.G. Simpson, *Watermills and military Works on Hadrian's Wall : Excavations in Northumberland, 1907–13*, (Ed.) Grace Simpson, with a contribution on watermills by Lord Wilson of High Wray (1976), 46.

[10] I am indebted to Mr. F.J. Fuller for the detailed site measurements of the mill and its watercourses made during October 1975.

reduce water flow or an abandonment of water-power during the late Roman period. This possible abandonment could be related to the change in the river course, which moved towards the west during the Roman period. Richmond[11] and Moritz[12] consider the mill to have been operational during the third century A.D. But the abandonment theory must be questioned. An important feature of the plan is the axis of the watercourse through the tower which is skewed and not parallel with the north–south mill walls. Why did they build it thus? Apparently the watercourse does not pre-date the tower structure. The interesting point of the partial blockage is that it was so constructed as to leave a clearway of 0.97 m. wide by 0.53 m. high, the stones arranged to leave a neat rectangular hole low in the watercourse. Of greater significance is the position of this aperture against the east wall of the headrace, which makes the axis of the water through the mill more parallel to the walls. Such an arrangement would have improved the flow conditions through the tower and the application of water to the undershot wheel. It is therefore suggested that the partial blockage of the headrace through the north tower wall existed during the working life of the mill, perhaps installed soon after the building of the mill.

The size of the undershot wheel can be roughly estimated. If we are influenced by the aperture in the north wall and allowing that the skew axis of the water reduces the effective width of application to the wheel, we could expect a wheel from 0.61 to 0.91 m. wide and a diameter of say, 3 or 3.6 m. at the most. Several millstones were found on this site confirming that the mill was used for corn-milling. An unusual barrel-shaped stone with equi-spaced mortices around its girth was found here. Various suggestions have been made as to its use, including a waterwheel hub which it clearly is not, confusing archaeologists for some while.[13] Current opinion favours a mortar operated by several men.

During 1907/8 Simpson discovered and excavated, during this and the following year, the third-century Romano-British watermill at Haltwhistle Burn Head not far from one of the Stanegate forts just south of the Wall.[14] Thomas Smith first noticed some features on this

[11] J.C. Bruce–I.A. Richmond, *Handbook to the Roman Wall*, (1947), 166.

[12] L.A. Moritz, *Grain-Mills and Flour in classical Antiquity*, (1958), 136.

[13] J. Liversidge, *Britain in the Roman Empire*, (1968), 184; S. Holmes, *PSAN*[2], ii, 178 ff.; *PSAN*[3] ii, 283; Bruce-Richmond, *op. cit.*, 79; I.A. Richmond, *Roman Britain*, (1955), 171. A similar stone found at Lincoln in 1950 beneath the east side of the High Bridge was also thought to be a waterwheel hub, which it is not.

[14] F.G. Simpson, *op. cit.*, 26. Simpson published a very brief note of his discovery in *PSAN*[3], iv, 167, 'Discoveries per Lineam Valli'.

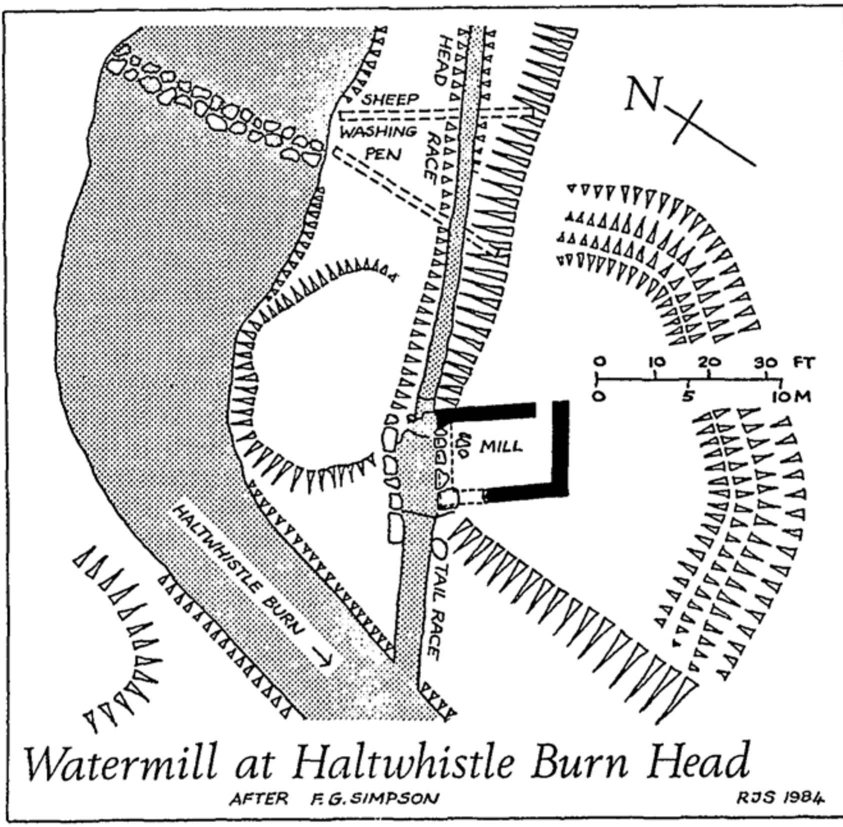

Fig. 3. Watermill at Haltwhistle Burn Head.

site in 1897 and thought them to be the remains of a bridge, but it was Simpson, prompted by J.P. Gibson, who systematically uncovered and recognized the true purpose of the remains he had found. To Simpson goes the singular honour of being the first to uncover and simultaneously successfully identify a watermill in the whole of the Empire. His interpretation of the remains was masterly, surely a reflection of his engineering training, which produced a combination of disciplines most rare among archaeologists (Fig. 3).

Analysis shows that Haltwhistle Mill had an undershot wheel 0.35 m. wide and 3.6 m. in diameter which powered a single pair of millstones. The remains of several millstones were found varying from 0.63 to 0.93 m. in diameter, together with the remains of six querns. An interesting find was a basalt footstep-bearing stone which had supported the millstone spindle. This flattish piece of stone had several circular, tapered-section cavities produced by circular motion of the iron spindle end. The mill building was rectangular in plan with walls 0.83 m. thick faced on both sides with well squared stones. Simpson found from three to five courses *in situ* above a footing course. The floor area was 21.75 $m.^2$ which compares closely with the Chollerford Bridge Mill area of 23.0 $m.^2$ Wilson thought the mill was built of timber on low stone walls,[15] but the external structure could equally have been all stone.

This watermill was well-sited for the headrace gradient increased over its length of 17.5 m. as it approached the wheel position and the later part of its bed was solid rock.[16] This was probably no accident of siting for the scouring velocities that existed in the race necessitated revetment of the headrace banks for most of its length. For the last two metres the water was carried to the wheel by an inclined wooden trough, some remains of which Simpson found in the bottom of the watercourse beside the mill. The wheelpit, with ample clearance for maintenance of the wheel and land-side bearing, was cut out of solid rock as low as possible without causing tail-water under the wheel. Analysis shows that the theoretical impact velocity of 4.5 m/s generated a maximum of 1.1 hp. at the driver gear.[17] Optimum efficiency would have occurred with a gear ratio of four or five to one, which suggests that the driven gear took the form of a lantern gear (Fig. 4). With this arrangement the heaviest top stone, weighing 165 kg., would have revolved at close to 50 rpm. Alternative lighter top stones or well worn stones would have resulted in a balance of power occurring at a stone speed of approximately 90 to 100 rpm.

Palladius, a Roman writer on agriculture, recommended that when there was an abundant supply of waste water from public baths it should be used to drive watermills,[18] thus giving future archaeologists a clear indication of where to look. Evidence of watermills within Roman baths has been found elsewhere in the Empire[19] and Watts has rightly suggested that we should be alert in the city of Bath.[20]

[15] F.G. Simpson, *op. cit.*, 31.

[16] I am indebted to Dr. Grace Simpson for the information she kindly provided from her father's site note-books.

[17] A hydro-mechanical analysis undertaken by the author, part of a thesis, Imperial College, London.

[18] Palladius, *Opus agriculturae*, i, 41, (42).

[19] The remains of building fabric associated with two vertical waterwheels exist under the court of the Baths of Caracalla, Rome; see T. Schoiler and O. Wikander, 'A Roman Water-Mill in the Baths of Caracalla', *Opuscula romana*, xiv, 4 (1983), 64–7. There is slight evidence that a watermill may have operated in the Baths of Mithras at Ostia; see T. Schoiler, *Roman and Islamic Water-Lifting Wheels*, (1973), 138, Fig. 99, no. 6.

[20] In private correspondence with the author, a letter dated 30th November, 1983, from Mr. Martin Watts.

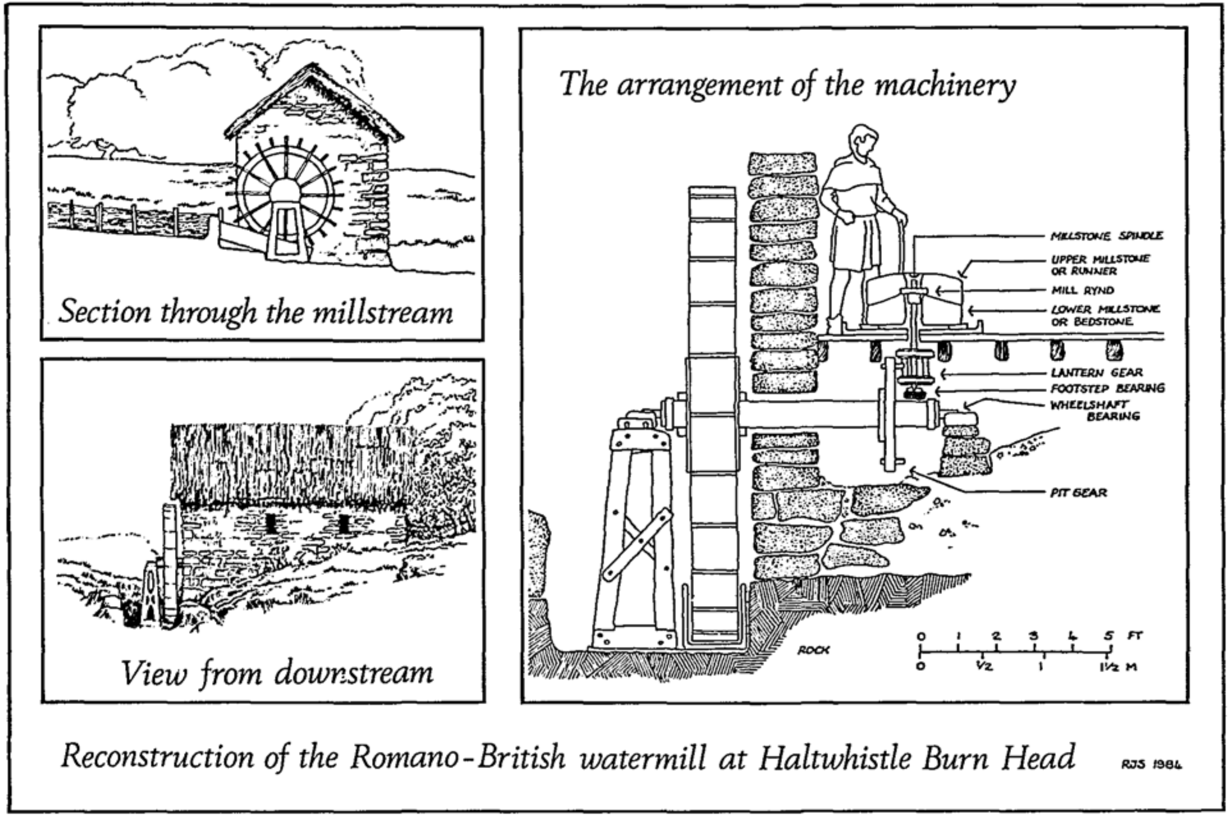

Fig. 4. Reconstruction of the Romano-British Watermill at Haltwhistle Burn Head.

Aware of the permanency of mill sites through the centuries, he points to the existence of an earlier mill in Leland's time powered by the baths' overflow.[21]

During 1923 and 1924, Shaw working on the Roman bridge over the Irthing at Willowford, uncovered evidence of another probable watermill, the third associated with Hadrian's Wall.[22] Running parallel to the 1.7 m. wide channel between the bridge pier and landside abutments, he found two stone-lined water channels, which were understandably interpreted as sluices (Fig. 5).[23] The suggestion that a watermill operated here was strengthened by the finding of millstone fragments.[24] Also found was a reputed spindle-bearing stone,[25] since identified as a socket for a vertical timber. But this interpretation of the Willowford evidence is not without problems and needs further analysis. The sluices, one or both, would have had a negligible effect in relieving the water pressure and flow as a bypass to the wheel because their position and face area on the whole of the fabric normal to the river flow is insignificant. Furthermore, as Shaw noted, the lower courses of the Wall would have been in danger of being undermined in times of flood.[26] To effect control over the volume of water approaching the watermill and to provide a measure of protection, building fabric had to be extended from the pier northwards to create a bifurcation. This would have been terminated at a convenient point upstream where sluice gates could be positioned and operated thus creating a separate water channel and head race for the mill wheel. It is unfortunate that this area north of the pier was not dug by Shaw, however his work gives us a few tentative clues. These are (i) the pavement appeared to extend northwards upstream from the sluices, (ii) the north end of the pier was much disturbed and it was not possible to confirm the original upstream profile,[27] (iii) large stones were found with checks on one surface like those covering the sluices,[28] suggesting that the sluices had been more extensive at some previous period. Such evidence, although helpful, is insufficient to confirm the existence of upstream bifurcation.

[21] P. Rowland Smith, *The Baths of Bath*, (1938), 46; E.H. Bates, 'Leland in Somersetshire 1520–42', *Proc. Som. Arch. and N.H. Soc.*, (1887), 69.

[22] R.C. Shaw, 'Excavations at Willowford', *CW*[2], xxvi (1926), 429–506; see especially 450–77.

[23] *Ibid.*, 467.

[24] *Ibid.*, 485.

[25] L.A. Moritz, *op. cit.*, in note 12, 136, 7; J. Liversidge, *op. cit.*, in note 13, 184; J.C. Bruce–I.A. Richmond, *Handbook to the Roman Wall*, (1966), 16.

[26] R.C. Shaw, *op. cit.*, in note 22, 469.

[27] *Ibid.*, 473–4.

[28] *Ibid.*, 474.

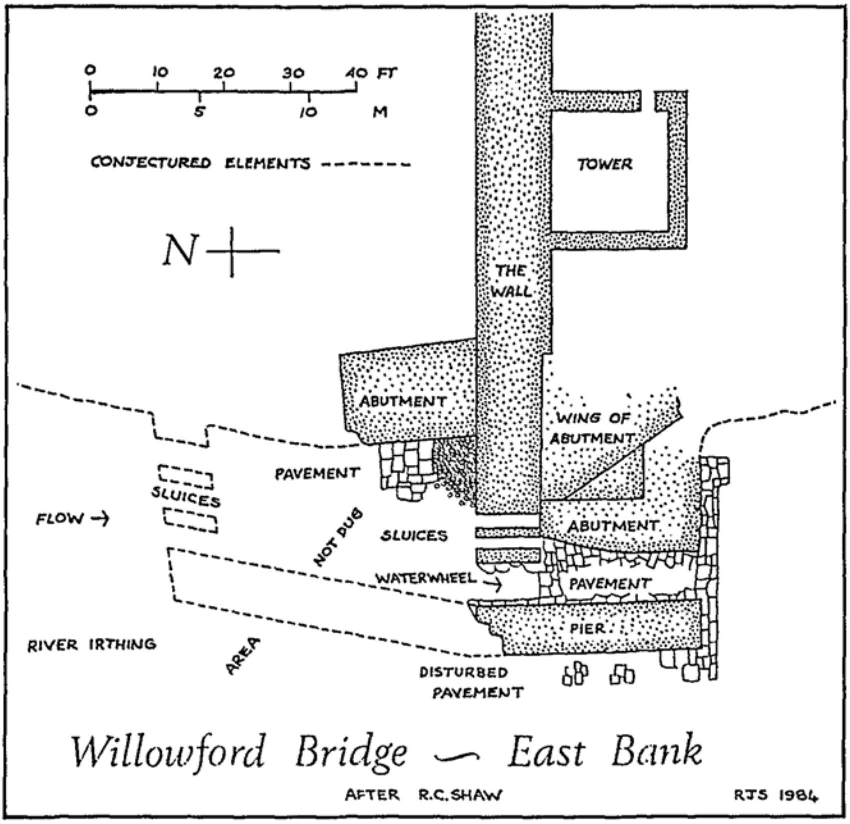

Fig. 5. Willowford Bridge – East Bank.

If the sluice were to operate successfully as a bypass, separate water gates would have been required on both the sluice and wheel channel.

Shaw found a pit or depression at least 5 ft. (1.5 m.) deep in the suggested wheel position, filled with cobbles and loose gravel.[29] This was clearly not a wheel pit for such an arrangement was impracticable and inefficient, so that we must conclude that the cavity was created by natural forces of erosion combined perhaps with stone-robbing.[30]

The mill structure would have spanned between the pier and abutment two and might have carried a footbridge above as a continuation of the rampart walk on the Wall. Mortices for vertical

[29] *Ibid.*, 475.

[30] Shaw noted that stone robbing had occurred around the pier, see *ibid.*, 473, although he would probably disagree with this conclusion. See *ibid.*, 475.

timbers can still be seen on the abutment, although bolt holes are absent, suggesting that the bearings were carried by timber sole plates strapped to the uprights. Allowing for underside clearance, a 2.7 m. diameter wheel is suggested, which conveniently fits the length of the abutment so that it could be enclosed by the mill building. The driver gear would have been at least 1 m. in diameter and mounted on the wheelshaft close to either the abutment or the pier depending on which side the millstones were mounted. It is tempting to suggest that there was one pair of millstones above the pier and another above the sluices operated from a common wheel having a width of between 1.0 and 1.3 m. Tandem drives are unknown in Roman mills, though not impossible, and so if two pairs of stones existed here, it is more likely that they were driven by independent narrow wheels operating within the main water channel. It is not worth going into more detail within the mill itself, it would be conjectural and speculative. Suffice to say that the potential area for the mill is 3.0 m. wide by nearly 7.0 m.[31] Access to the mill would have been from the roadway immediately outside on the downstream side.

During the early 1950s evidence of another Romano-British mill was found at the site of a modern watermill, Spring Valley Mill, just off the old Harwich Road, near Ardleigh in Essex (Fig. 6). Pettit, working with local archaeologists, found numerous Roman artefacts within the tail race, bypass channel and the millpond, including pottery, tiles and millstones. The stones were reputed to have been passed to Colchester Museum, and it is interesting that there are three unprovenanced, typical Romano-British lava topstones on display measuring 64.5, 54.0 and 41.0 cm. in diameter. Unfortunately, no archaeological report appears to have been made of this discovery, but a first-hand eyewitness account is reassuring, confirming that Spring Valley was probably the site of a Roman watermill.[32]

The archaeological evidence which points to the existence of a watermill can take several forms, such as water-courses, wheel fabric or evidence of emplacement and rotation, building remains, millstones, etc. Ideally, all of these primary elements should be present in juxtaposition, but it is not always so. At many sites the evidence is much less, even scant and tantalizing. This is hardly surprising; as time passes we gain a better understanding of watermills, becoming more aware of their existence and the different forms that they and

[31] The length over the pier reaching as far as Wall C in Shaw's drawing.

[32] I am indebted to Mrs. Hilary Dean Hughes for bringing to my notice the information concerning this mill site. Mrs. Dean Hughes lived much of her childhood at Spring Valley Mill, which her father owned and occupied.

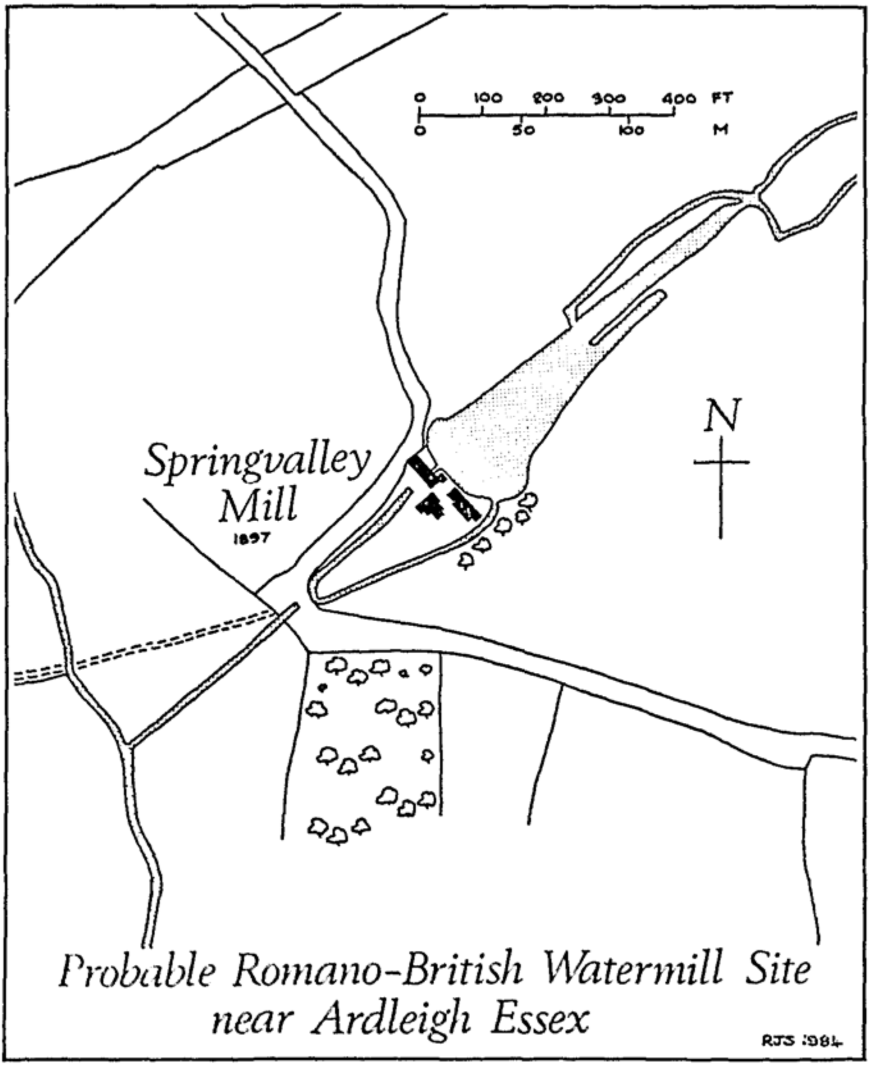

Fig. 6. Probable Romano-British Watermill Site near Ardleigh, Essex.

the evidence can take. It is almost certain that evidence has been uncovered in the past but never recognised or alternatively, considered as not worthy of recording. Searching extant archaeological records for likely Romano-British watermill sites is never-ending. Doubtless, this could be extended to other parts of the Empire but few provinces are as rich in records and have the same intensity of archaeology that Britannia enjoys.

Large industrial sites, such as Heronbridge astride Watling Street on the west bank of the Dee in Cheshire, often invite the suggestion that water-power might have existed. From 1929 onwards excavation work has taken place more or less continuously, revealing traces of workshops involving bronze- and iron-working, a dock flanked by quay sides,[33] corn drying on a large scale[34] and a stream bed artificially deepened and revetted. With all of this activity, in addition to domestic premises on this large site, it is not surprising that a millstone fragment was found.[35] Symptoms yes, but still no positive identification of a watermill.[36]

A smaller industrial site was located on the south side of Muncaster Head in Eskdale, Cumberland, where evidence of iron-working was found. Many such Roman sites are known usually with smelting furnaces and smithing hearths, slag and sometimes roasting pits and mines.[37] At Eskdale additional evidence is provided by the traces of two ponds and water-courses.[38]

Other sites have been identified by archaeologists as possible watermills such as Holeywell Hill, close to the River Ver where a foundation was considered as a possible mill,[39] or at Kimpton in Hampshire where a large Roman building was found beside a dried-up river bed.[40] At Kenchester in Herefordshire, a second-century stone-tower granary and timber-framed building was found close to a stream which showed evidence of being re-cut to a square section with a firm hard base. Within the timber-framed building three millstones were found placed at regular intervals between the posts.[41] Wilmott concluded that the millstones were in store and not

[33] B.R. Hartley and K.F. Kaine, 'Roman Dock and Buildings', *Journ. Chester Arch. Soc.*, xli (1954), 15–38.

[34] (Ed.) F.H. Thompson, J.J. Bagley, *Roman Cheshire*, (1965), 60–5.

[35] W.J. Williams, 'The Roman Ditch at Heronbridge', *Journ. Chester Arch. Soc.*, xxx (1933), 111–7.

[36] There are two sources suggesting that a watermill may have existed here; see T. Garlick, *Romans in Cheshire*, (1973), 52; and I am informed by Dr. G. Lloyd-Morgan of Grosvenor Museum, Chester, that Sir Ian Richmond apparently thought that this was possibly an undershot mill – letter to the author, dated 28th August, 1975.

[37] For a definition of terms and a list of iron-working sites, see Andrew R. Aiano, 'Romano-British Ironworking Sites, a Gazetteer', *Historical Metallurgy*, xi, 2 (1977), 72–82.

[38] A.C. Parker and M.C. Fair, 'Bloomery Sites in Eskdale and Wansdale (Part 1),' *CW*[2], xxii, 22 (1922), 90–7; H.R. Schubert, *History of the British Iron and Steel Industry from c. 450 BC to AD 1775*, (1957), 48–9, 133.

[39] *JRS*, lix (1969), 221.

[40] Hampshire Field Club, *Newsletter*, 4 (Sept. 1976), 9 ff.; R. Goodburn, 'Roman Britain in 1978', *Britannia*, x (1979), 331.

[41] *Britannia*, ix (1978), 438; *Britannia*, ix (1979), 298; *West Midlands Archaeological News Sheet*, 20 (1977), 33–6; *ibid.*, 21 (1978), 69 ff. I am most grateful to Mr. B. Phillips for bringing this site to my attention.

in their working position and that a watermill had worked close by.[42] No evidence of a mill frame or wheel-pit was found, although it should be noted that the archaeologists were not able to excavate all areas of the site, including the stones. However, we should not preclude the alternative explanation that these stones may have been animal-powered. This suggestion is strengthened by the fact that the top millstones were apparently overdriven.

Millstones, usually fragmented, occur at most watermill sites, confirming that water-power was applied almost solely to the milling of corn and pulses. Such finds often give the archaeologists a strong clue as to what he may be uncovering, but care has to be exercised. Fragments of millstones were found beside the remains of a Roman building on the south bank of the River Mithram at Dickets Mead, Hertfordshire in 1963, but there is doubt concerning the function of the building which has tentatively been identified as a bath house.[43]

Between 1978 and 1981, an interesting second-century A.D. site was unearthed near Littlecote Park villa at Ramsbury in Wiltshire. A large timber building 10 by 30 m. containing a corn drier, oak-lined tanks, quern-stone fragments and ovens suggests that a bakery existed there.[44] Outside the building another fragment of a very large quern (millstone ?) was found and in the adjacent stream part of a millstone. The scale of operation combined with the proximity of a large stream makes this a potential watermill site but, as yet, no direct evidence of water-power generation has come to light.[45]

Such a combination of millstones and a suitable stream in close proximity occurred at Barton Court Farm villa near Abingdon in Oxfordshire. In the course of digging a well of the fourth-century A.D. fragments of four millstones were found built into the stone-lined shaft. These stones were obviously brought together for a different function following abandonment for corn-milling purposes. Not far away are several streams whose gradients and flows during Roman times would have been sufficient for the generation of water-power. However, buildings have not been located and whilst

[42] I am indebted to Mr. A.R. Wilmott for passing to me extracts from his forthcoming publication, S.P. Rahtz and A.R. Wilmott, 'An Iron Age and Romano-British Settlement outside Kenchester (Magnis), Herefordshire: Excavations 1977–79', *Trans. Woolhope Naturalists Field Club*, for 1983 or 1984.

[43] R.P. Wright, 'A Graeco-Egyptian Amulet from a Romano-British site at Welwyn Herts', *Antiq. Journ.*, xliv (1964), 142–6.

[44] *Britannia*, xiii (1982), 387–8; xii, (1981), 360, Fig. 16; x (1979), 329, Fig. 17.

[45] I thank Mr. B. Phillips for his patience and the care which he gave to my lengthy communications.

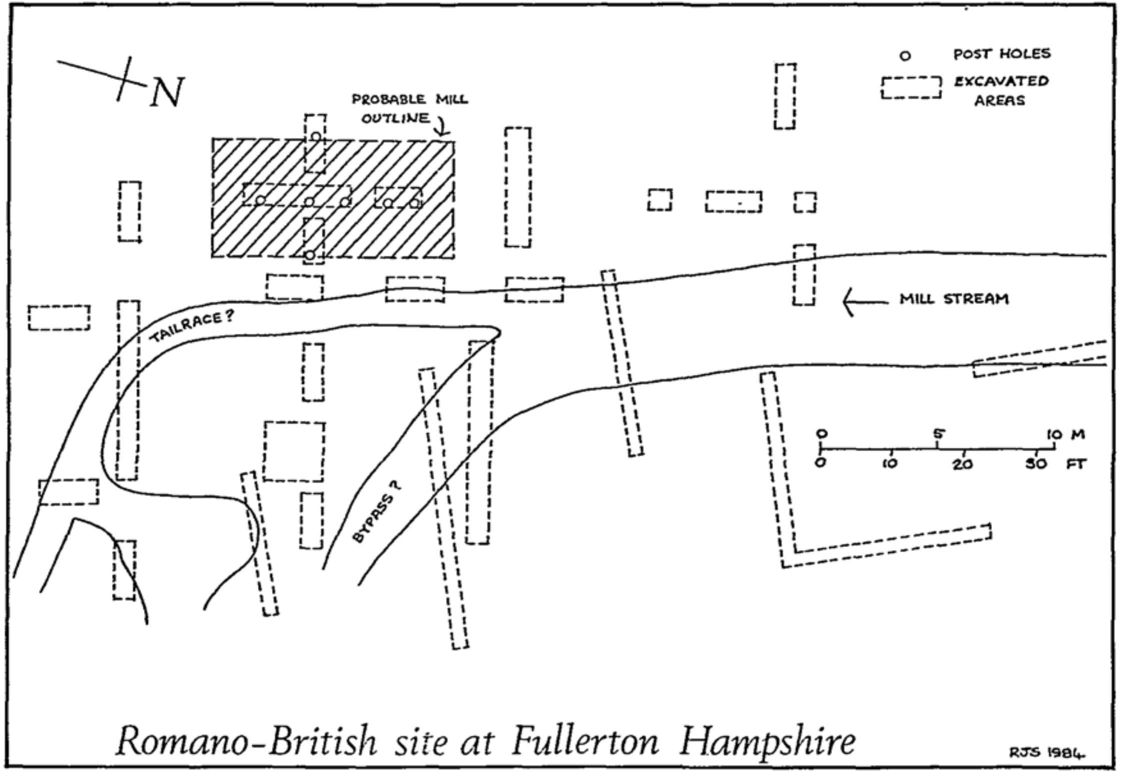

Fig. 7. Romano-British Site at Fullerton, Hants.

the collection of millstones invites the suggestion of a possible watermill in the vicinity we have no site located.[46]

Corn-milling sites have been found where water-power was obviously not used to drive millstones. Two salient features to watch for at such sites are (i) millstones where positioned on plinths, usually indoors, often displaced equidistant so as to provide space for men or animals to walk around driving the stones via a lever and (ii) millstones providing evidence of being overdriven, that is, an arrangement where the millstone rynd cavity is in the top surface of the runner rather than let into the grinding face. In modern corn-mills overdriven stones are not uncommon, especially in windmills, but no example has yet been found related to a Roman watermill. Another feature which might be taken to indicate an overdriven millstone is when the rynd aperture, normally a twin dovetail shape, passes right through the top stone.[47]

An example of an overdriven millstone with a rynd cavity on the upper surface of the top stone was found among millstone fragments at Orton Hall Farm at Peterborough and confirmation of an animate power source was provided by the remains of three stone bases found in one of the buildings. These were made of selected stones arranged to create plinths of 0.75 by 0.6 m., standing at least two courses high. They were between 3.05 and 3.25 m. from each other and all three 1.5 m. from the wall of the building, strongly indicating that in this case man-power was the prime mover.[48] A very similar arrangement existed at Silchester where one establishment was thought to have been devoted to corn-milling on a commercial scale. In one area six masonry plinths, each between 1.2 and 1.4 m. in diameter and 0.6 m. high stood in two rows, each 1.5 m. from the wall.[49]

Sometimes the tracing of a watercourse can reveal other evidence. This occurred when Whitehouse decided to follow, during 1964, an ancient stream course some 7.6 m. wide and 1.2 m. deep running away from Fullerton villa near Wherwell in Hampshire. He came across a bifurcation and on the bank of the man-made branch the remains of a flinty rubble platform some 5 by 7.5 m. long with traces

[46] Correspondence from D. Miles of the Oxfordshire Archaeological Unit to the author dated 11th September, 1979 and 15th October, 1979. Report by R.J. Spain, *Millstones from Barton Court Farm Villa*, dated November 1979. (Oxford Archaeological Unit).

[47] Rahtz and Wilmott, *op. cit.*, in note 42.

[48] Report by R.J. Spain to the Nene Valley Research Committee, dated August 1981.

[49] G.C. Boon, *Silchester : The Roman Town of Calleva*, (1974), 289. Millstones found elsewhere on the site measured 0.71 m. in diameter and *c.* 0.19 m. thick.

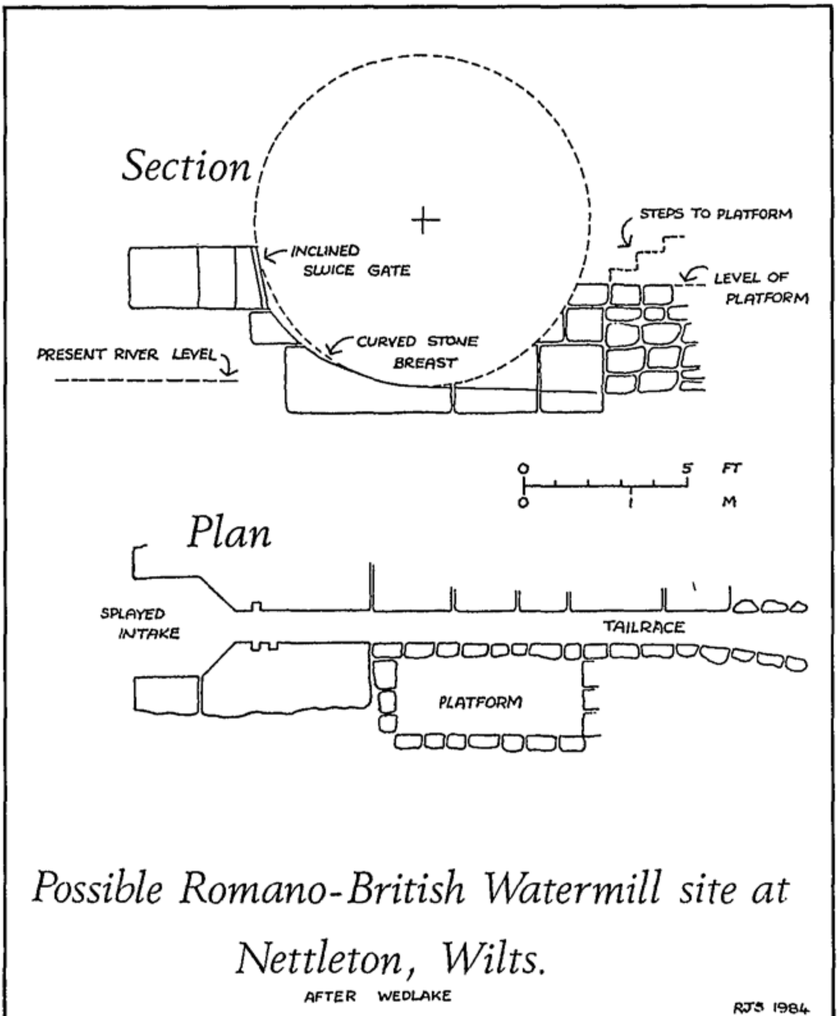

Fig. 8. Possible Romano-British Watermill Site at Nettleton, Wilts.

of seven post-holes (Fig. 7). Fragments of at least two millstones were found here which suggests that this building was most likely a watermill.[50] Unfortunately, time did not permit a more detailed examination of the site.

[50] *J.R.S.*, lv (1965), 199–220; 'Hampshire Archaeologists to search for Roman Water Mill', *Archaeological Newsletter*, 7 (1965), 261.

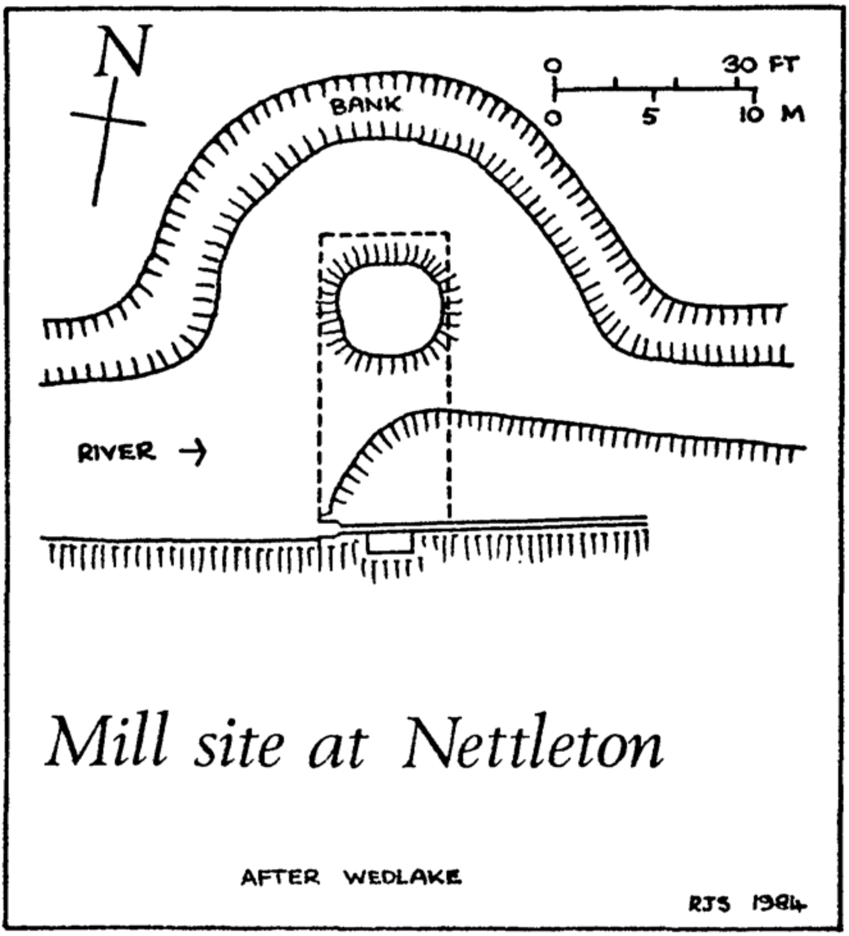

Fig. 9. Mill Site at Nettleton, Wilts.

At Nettleton in Wiltshire a most unusual waterwheel site was found in the banks of the Broadmead Brook.[51] A severe storm in July 1968 had caused flooding and denuding of the river banks which revealed a narrow waterwheel emplacement, some 14 in. wide, formed of well-cut and dressed limestone. The intake to the mill channel was splayed and the wheel emplacement has a curved breast which enables us to determine that the diameter was 2.6 m. A

[51] W.J. Wedlake, *The Excavation of the Shrine of Apollo at Nettleton, Wiltshire, 1956–71*, Society of Antiquaries, London, (1982), 95–98, Figs. 1 and 2.

stone-lined tail race was traced 5.5 m. downstream and beside the wheel-pit a small level platform 0.76 by 1.69 m., reached by a short flight of steps, has been identified as an inspection and maintenance platform (Fig. 8). Both the curved wheel-pit breast and evidence of an inclined sluice gate immediately in front of the wheel appear to be unique to Roman watermills. Wedlake considered this stonework to be co-eval with other third-century A.D. work on the site. Another noteworthy feature at Nettleton is the arrangement of the river adjacent to this mill. The bed of the wheel race is 0.71 m. above the present normal river level and whilst it is quite possible that changes in land or river levels could explain this, a plan of the site suggests otherwise (Fig. 9). Opposite the wheel position the river bank takes a prominent indent landwards with what appears to be a channel passing around an island. This suggests that a weir existed here in order to create a head of water to operate the mill, with a bypass channel opposite the waterwheel.

In a remote valley just north of Leeds village in Kent a fragment of a ragstone millstone 0.63 m. in diameter was found in the bed of a stream in 1951. The stream, a tributary of the River Len, has cut deep into the farmland to create almost a ravine, well graded and ideally suited for the production of water-power. Further excavations made in 1975/6 by Newbury and Grove found numerous sherds and a Roman brooch, together with a possible flint-and-stone wall, all within the ravine. No positive evidence of a watermill was found but the circumstantial evidence is strong. The sherds, which have been identified as first- and second-century A.D., were very water-worn and obviously the Roman horizons have been obliterated and eroded, scattered down the valley.[52]

In the summer of 1974 the remains of two Roman watermills were found at Ickham on the south bank of the Little Stour River east of Canterbury in Kent.[53] Histogram analysis of the coins found at the oldest mill site suggests that it was operating between A.D. 150 and 280.[54] Bradshaw executed an exemplary survey and excavation in difficult conditions to bring an unusual specimen to light.[55] He found an earth-fast timber-framed mill building astride an ancient water-

[52] There are no published records of this archaeological work. I am grateful to Mr. D.B. Kelly of Maidstone Museum and Art Gallery for his observations and dating of the sherds.

[53] C.J. Young, 'Excavations at Ickham', *Arch. Cant.*, xci (1975), 190–1.

[54] I wish to thank Mr. K.G. Elks for his help in identifying and analysing the coins.

[55] I am indebted to Mr. J. Bradshaw who directed the work undertaken on the earlier mill-site. The patience and care with which he replied to the numerous and detailed enquiries from the author are much appreciated.

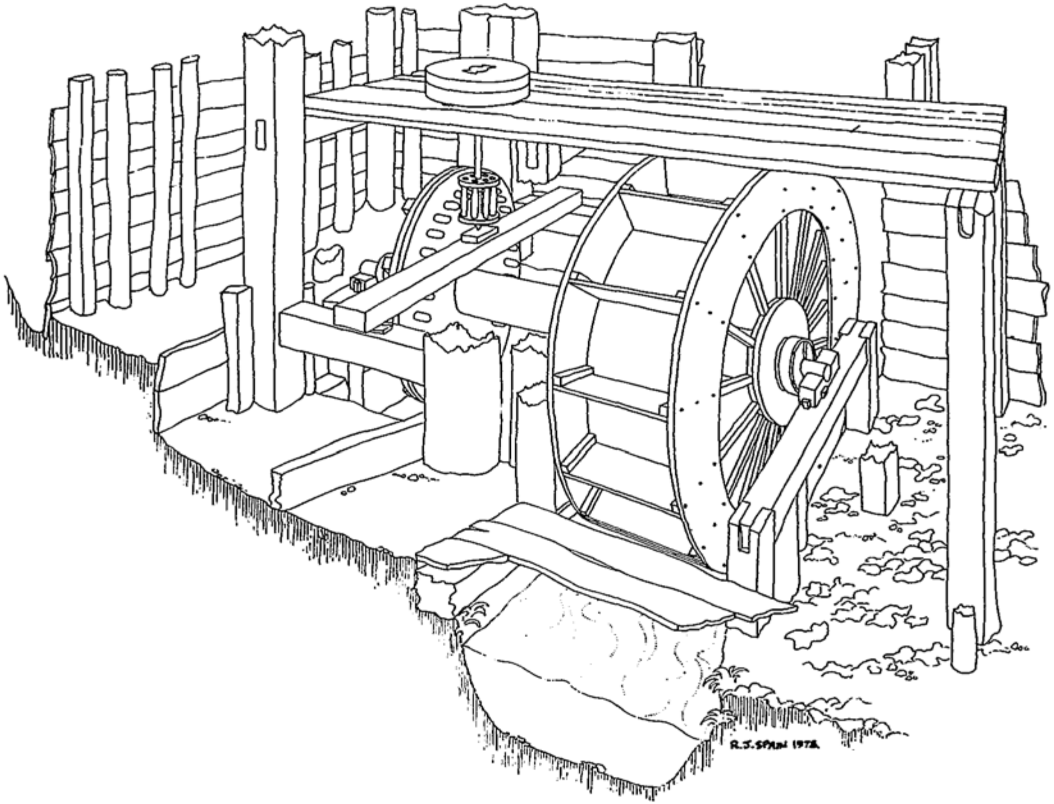

Fig. 10. Reconstruction of Millstone Platform at Ickham.

course. Analysis of the linear and group post clusters has facilitated a probable reconstruction of the machinery and building frame.[56] This mill frame was not identical to traditional mill hursting, for the support functions of the bridge tree and millstone platform were not completely integrated (Fig. 10). This small rural corn mill was probably extended at least once during its life and modifications to its structure have been tentatively identified as attempts to arrest settlement. It was ill-sited close to estuarine land and suffered from deposition in the tail race. Its foundations were laid out rather inaccurately, the post and space-frames associated with the machinery were surprisingly asymmetrical and the selection of the scantling in relation to their function somewhat haphazard. All this suggests that the military or Roman involvement was limited and the most probable explanation is that it was executed largely by native labour under a minimum, perhaps even an absence, of Roman supervision. The small undershot waterwheel, 2 m. in diameter by 0.6 m. wide was totally enclosed within the mill.

During the same summer another watermill was found and excavated by Young, some 140 m. upstream from the other mill.[57] This proved to be a third- and fourth-century structure with a similar earth-fast timber frame beside a revetted channel of the Stour. An improved arrangement is evident here, for the *c.* 3 m. wide mill-race was lined with planks on the bottom and sides over a length of at least 28 m. and the remains of a substantial wooden sluice gate was found in a bypass channel, revetted with hurdles, to the south of the mill. No machinery remains were found, except millstones, but the building length of 13 m. alongside the stream suggests that more than one waterwheel may have existed here. Some of the millstones found at this site were dressed for clockwise operation and others the opposite direction, and although alteration to the gearing arrangement during the life of the mill could explain this, it might also support the suggestion of two or more waterwheels in simultaneous operation.

In addition to corn-milling considerable evidence of metal-based industrial activity was found on this site and an interesting find was a large iron hammer-head with mechanical deformation on one face indicating a possible water-powered trip-hammer. Large quantities of pewter, iron and bronze, some of it in the form of belt buckles and

[56] R.J. Spain, 'The second and third Century A.D. Romano-British Watermill at Ickham', in (Ed.) N.A.F. Smith, *History and Technology*, forthcoming.

[57] My thanks to Dr. C.J. Young for providing me with information concerning this and the earlier watermill. A structural and mechanical analysis and reconstruction of the late mill is currently being attempted.

fittings, *ballista* bolts and lead seals, has prompted the theory that this was an official depot or works associated with the Roman forts of Reculver and Richborough, situated at either end of the nearby Wantsum Channel.[58] Some eighty fragments of millstones and querns from both sites were found, most from the later mill, including three bearing stones. No whole stones were recovered and many exhibited varying amounts of degradation. The degree of fragmentation and degradation, including evidence of reciprocal grinding, leads one to suggest that these stones continued to be used long after the abandonment of water-power.[59]

Although we know that the Romans apparently used water-power for non-milling purposes,[60] no mill sites have yet been discovered that prove this beyond doubt. The late Roman mill at Ickham may have used water-power for iron-working, but further analysis of the evidence needs to be done to support the suggestion. When considering other industries mining should be given some attention. Numerous man-powered drainage wheels have been found in Roman mines throughout the Empire[61] including a fragment from a Welsh gold mine at Dolaucothi.[62] Here the Romans brought water to the mines by four aqueducts including the Cothi of 11 km. length and the Annell of 7 km., which together with the water-courses and storage tanks, querns and a mortar associated with crushing and grinding, are mute reminders of the power-intensive processes involved.[63] It was earlier thought that hydraulic methods of excavation had been

[58] C.J. Young, 'The Late Roman Water-Mill at Ickham, Kent, and the Saxon Shore,' in (Ed.) A. Detsicas, *Collectanea Historica, Essays in Memory of Stuart Rigold*, (1981), 32–9.

[59] R.J. Spain, *An Analysis of the Millstones and Quern Fragments from Ickham, Kent*, (1977), an unpublished report.

[60] For a late fourth-century A.D. reference to water-power saws for cutting marble see *Ausonius*, trans. H.G. Evelyn White, (1919), 1:253, bk. 10, *Mosella*, lines 361–64; see also Vitruvius, *On Architecture*, trans, F. Grainger, (1931), Book x, chapter v.

[61] Rio Tinto, Tarsis, Logrno (Spain); Leon, Tharsis (Huelva); San Domingos, Minos dos Mouros (See note 65)(Portugal); Rudo, Verespatak (Transylvania). See R.J. Forbes, *Studies in Ancient Technology*, vii (1963). The well-preserved remains of a specimen from Rio Tinto, at the British Museum (accession no. 1889 6–22.1) is worth close attention.

[62] G.C. Boon and C. Williams, 'The Dolaucothi Drainage Wheel', *JRS*, lvi (1966), 122–7.

[63] A.E. Annells and B.C. Burnham, *The Dolaucothi Gold Mines*, (undated but between 1980–1983); see also A.E. Annells and K.P. Williams, *The Dolaucothi Gold Mines, Guided Tours*, (1983), both booklets available from the Department of Mineral Exploitation, University College, Cardiff. *Royal Commission on Ancient and Historical Monuments*, 5, Carmarthen. I am grateful to Mr. Nigel Clark of Canterbury for bringing these publications to my notice. P.R. Lewis and G.D.B. Jones, 'The Dolaucothi Gold Mines 1: The Surface Evidence', *Arch. Journ.*, xlix (1969), 244–72.

practised, but this is now considered most unlikely.[64] The scale of some Roman undertakings is so large as to make it diffiult for us to believe that they relied solely on men and animals, especially when copious supplies of water were bought to most sites.[65] At Dolaucothi no positive evidence of a watermill has yet appeared although symptoms exist and much archaeological work remains to be done.[66]

When evidence of more than one millstone is found this strengthens the possibility that they are close to their working position, but care should be taken to confirm, if possible, that they are not present in a workshop, especially a smithy.[67] The presence of whole millstones, in apparently good condition, within a workshop suggests that a new mill-rynd was perhaps being fitted or its emplacement being deepened. Another possibility is that the grinding face was being re-dressed. This involves re-cutting the furrows with hardened and tempered mill bits and picks, serviced by a furnace close by. In such circumstances corroborating evidence should be sought and by far the most important factor would be the presence of a water-course.

When well-worn millstones are found within an ancient water-course this suggests that their rejection follows either fragmentation in use or their being too thin for work. In either event the likelihood of a mill nearby is greatly increased.

In their exploitation of native stones millers no doubt became aware of the properties required for corn milling such as durability, hardness, homogeneity, coarseness, porosity, etc. Such stones were useful for other purposes as bearings, whetstones and for grinding other materials. When the miller rejected his stones, other trades often made use of them. The analysis of such fragments is not easy especially with the subject confounded by the terminology peculiar to millstones and their dressing. Essentially, the classification of fragments depends on the identification of the surfaces and determining whether or not their shape and symmetry have resulted from dressing, reciprocal or rotational wear, or natural erosion subsequent to its abandonment. Additionally, the geometry of the grinding face furrows, handle, rynd and other cavities need definition. Even when a fragment is identified as having evidence of rotational wear and its

[64] Boon and Williams, *op. cit.*, in note 62, 122.

[65] Consider for example the scale of ancient mining at Mouras along the Gralheira mineralized zone in Portugal; see F. Harrison, 'Ancient Mining Activities in Portugal', *Mining Magazine*, xlv (1931), 137–45. Another example of large-scale working is Las Medulas.

[66] A suggestion of a possible watermill has been made by P.R. Lewis and G.D.B. Jones, 'The Dolaucothi Gold Mines', *Bonner Jahrbuch*, 00 (1971), 297.

[67] An example appears to have occurred at Caerwent. See T. Ashby *et al.*, 'Excavations at Caerwent', *Archaeologia*, lxii (1910), 1–20.

original size is known, it still may not be possible to decide whether it is a quern or millstone. Their diameters and weights overlap to a degree. The archaeologists should also be aware that querns are often found in watermills,[68] although we are not sure as to what use they were put. Perhaps for processing small quantities of grain for some customers, or testing grain for hardness and moisture content preparatory to millstone work. Other suggestions are the further refinement of a product or to provide a quality control datum for the main milling work.

The mechanics of millstones are abstruse and the artisan skills embodied in their design and working little understood. A satisfactory study of the typology and evolution of Romano-Britsh millstones has yet to be published,[69] and the relationships between querns and millstones require analysis. To facilitate these studies full records must be kept and these stones should receive the meticulous attention given to other artefacts.

As a valuable re-usable material, wrought iron is rarely found *in situ* on Roman sites. We have much to learn concerning the design and fabric of early watermills, but we can anticipate that iron was probably used for wheelshaft journals, hoops (both on shafts and gears), millstone spindles and rynds, staves in lantern gears in addition to nails, bolts, straps and brackets. Very few mill sites have yielded identifiable iron-work. Some iron was found in the watercourse beside Haltwhistle, thought to be straps, but it was much too corroded to have a positive identification.[70] Ickham yielded masses of iron which is hardly surprising in view of the site's industrial nature. A great deal of slag and corroded conglomerates of iron were found, some of which appeared to be collections of bolts and nails – perhaps the raw material for re-processing.

Four iron millstone spindles have so far been found in the Empire, three of them with two- or three-winged mill-rynds attached (Fig. 11). Two were found at the bottom of wells in Zugmantel, one of the forts on the Germania-Superior *Limes*, one of the spindles complete with a gear attached.[71] These forts are high in the Taunus mountains,

[68] This occurred at Haltwhistle, Ickham and the Athenian Agora sites.

[69] See D. King, *Petrology, Dating and Distribution of Querns and Millstones: the Results of Research in Beds., Bucks, Herts and Middlesex*, unpublished B.A. dissertation, Institute of Archaeology, London, (1982).

[70] F.G. Simpson, *op. cit.*, in note 9, 35.

[71] Both spindles, complete with two-winged rynds, came from Zugmantel. The one with a gear still attached was found at the bottom of a well of a *vicus* house and has been dated to the second half of the second century A.D. I am grateful to Dr. D. Baatz of the Saalburgmuseum for helping me with enquiries. See H. Jacobi, 'Romische Getreidemuhlen', *Saalburg-Jahrbuch*, iii (1912), 75–95, 89, Fig. 43; also *ibid.*, 'Kastell Zugmantel, die Ausgrabungen', 54, Abb. 17 and 18.

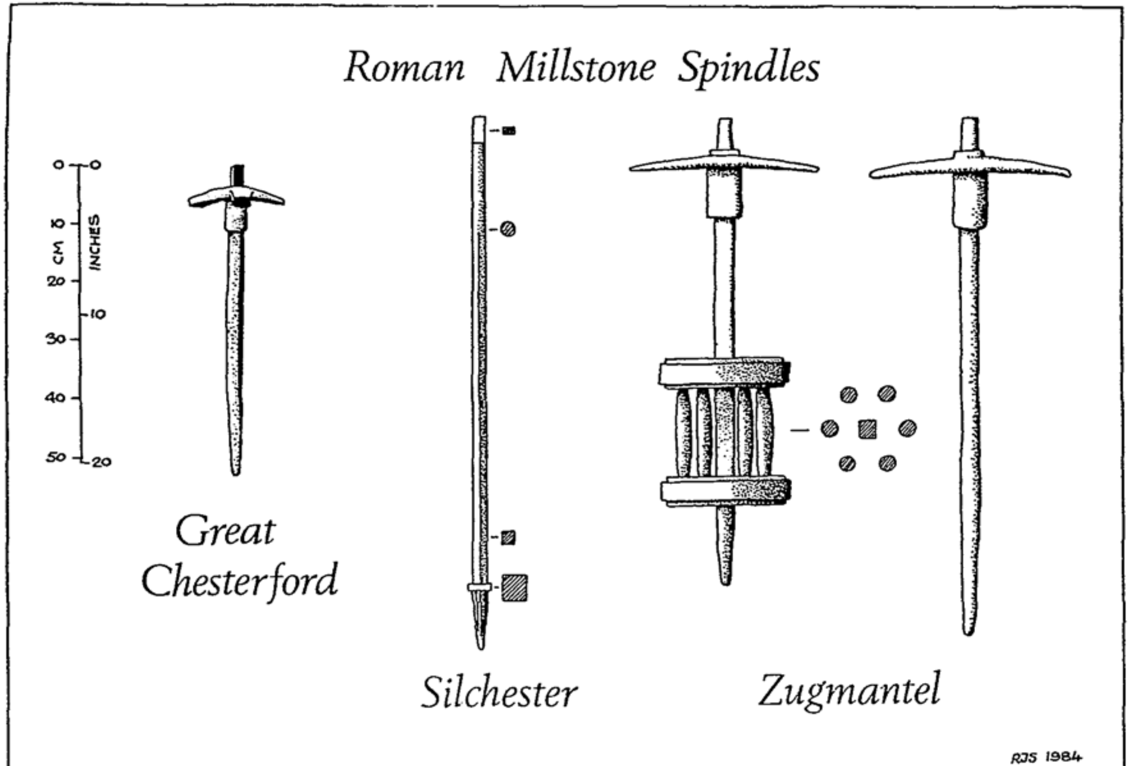

Fig. 11. Roman Millstone Spindles.

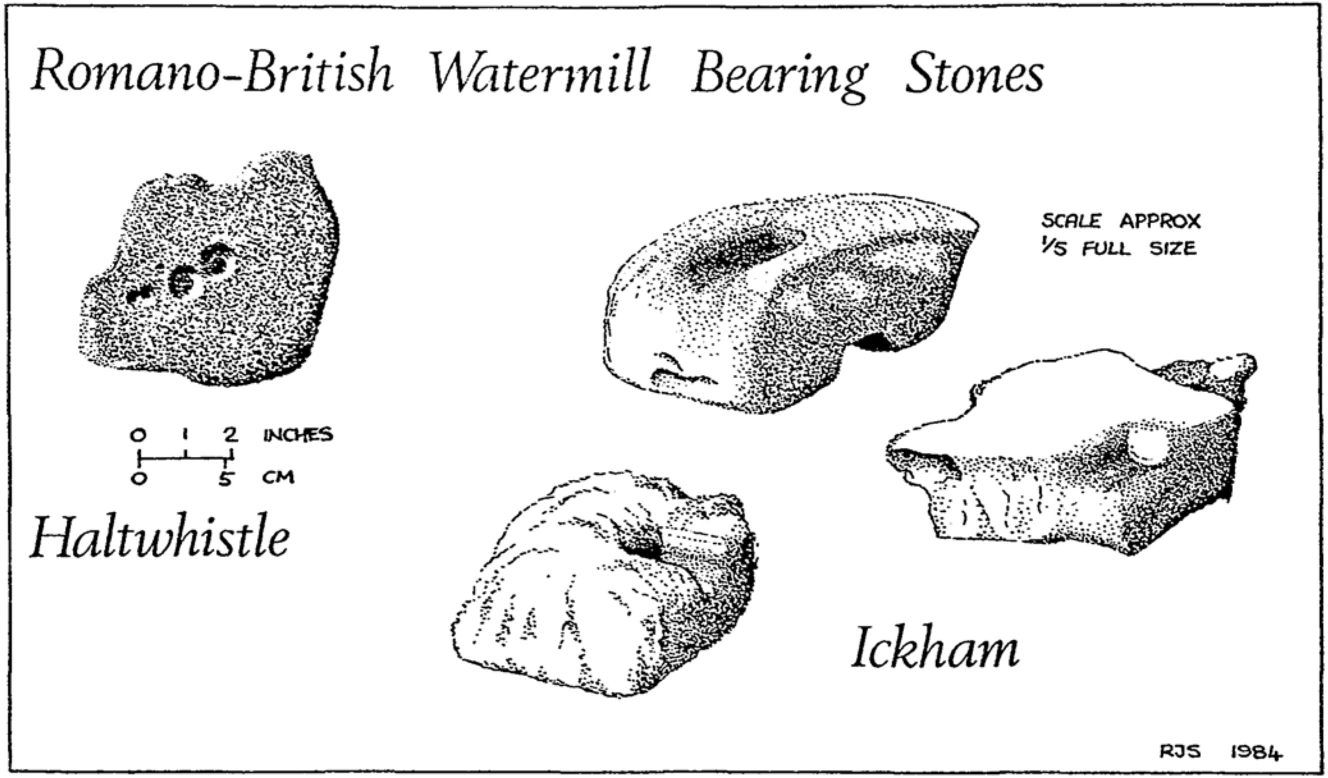

Fig. 12. Romano-British Watermill Bearing Stones.

where no suitable streams exist so that the spindles must have been man- or animal-powered. The other two spindles, which are British specimens, are not related to known watermill sites.[72] Retrospective searches of Roman iron-work hoards might reveal further specimens.

Other artefacts which the archaeologist may come across are bearing stones. The three found at Ickham were all intended for journals,[73] whilst the single example from Haltwhistle was a footstep bearing stone (Fig. 12). Another specimen was apparently found at Dolaucothi, but neither the type or age has been identified.[74] A stone from Orton Hall was thought to be a footstep bearing.[75] Fragments of millstones were often used for bearings and care must be taken not to misinterpret other cavities sometimes found on millstones as bearings.[76] An iron footstep bearing was found at the Saxon watermill at Tamworth,[77] but no parallel Roman specimen has yet come to light. Several stone footstep bearings from Ireland are known but they belong to later periods.[78]

This brief survey of Romano-British watermills shows that there is a growing incidence of sites where the interpretation of the evidence is uncertain and therefore subject to individual opinions, invariably optimistic, of all types of historians. Care must be exercised when classifying such examples lest we inadvertently distort both the numbers and types of possible mills. At every site each element of potential evidence needs assessment in isolation and then in synthesis to determine the probability of a watermill having existed. The best way to achieve this is to adopt a more formal process of assessment

[72] One was found in a hoard of iron-work at Great Chesterford in Cambridgeshire, see *Arch. Journ.*, xiii (1856), 9, 13, no. 28; J. Liversidge, *op. cit.*, in note 13, 184. The other specimen was found with a hoard of iron-work in a well at Silchester. See W.H. Manning, 'A Mill Pivot from Silchester', *Antiq. Journ.*, xliv (1964), 38–40; J. Evans, *Archaeologia*, liv (1895), 141, Fig. 2.

[73] Made from fragments of greensand millstones. Their cavities suggested spindle diameters of 3.0, 5.5, and 3.3 cm.

[74] P.R. Lewis and G.D.B. Jones, *op. cit.*, in note 66.

[75] See note 48.

[76] See note 46.

[77] (Ed.) D.M. Wilson, *The Archaeology of Anglo-Saxon England*, (1976), 89, 90, 276; *Current Archaeology*, 3 (1971), 165–8; P.A. Rahtz, 'Medieval Milling', in (Ed.) D.W. Crossley, *Medieval Industry*, (1981), 1–15, C.B.A. Research Report no. 40; E.M. Trent, 'Examination of Bearing from Saxon Water-Mill,' *Historical Metallurgy*, 9, (1975), 19–25.

[78] A.T. Lucas, 'The Horizontal Mill in Ireland', *The Journal of the Royal Society of Antiquaries of Ireland*, lxxxiii (1953), 1–36; see the stones from Ballyshannon, Co. Donegal, *ibid.*, 15, and from Morett, Co. Laoighis, *ibid.*, 24; R. MacAdam, *Ulster Journal of Archaeology*, iv (1856), 6–15; J.P. O'Reilly, *Proceedings of the Royal Irish Academy*, 24 (1902–4), 55–84.

and site classification, but this is beyond the scope of this paper.[79]

The *Britannia* corpus suggests that there are two categories of watermills; those which can be viewed as serving *official* establishments, and the remainder, which might be conveniently described as serving *domestic* demands (e.g. Spring Valley, Leeds, Fullerton and probably the older Ickham Mill). The incidence of this latter category could prove critical. If this type of watermill can be identified as essentially a private enterprise, especially if rurally based with villa-estates, native villages, etc., then its potential incidence could be considerable and distribution wide. Time will tell. If the traditional momentum and intensity of British archaeology is sustained, it is likely that a much clearer picture will emerge within say, a decade, certainly by the end of this century. Until we have *quantum sufficit* for analysis it would be incautious to suggest how many watermills existed in Roman Britain.[80] Nor can we postulate on their structure and hydro-mechanics in an Empire-wide historical context.

[79] The author and Dr. N.A.F. Smith are currently examining and developing this classification method.

[80] One other way to view the growing evidence and attempt to elucidate this question of how many watermills existed is to compare the incidence of water-power millstones with all other millstones and querns using an output or populace datum. Whilst such a view is clouded with uncertainties, it might provide us with an alternative, albeit crude, corroboration. The major problem would be identifying the millstones as originating from either water or muscle-powered mills which in many cases can only be indicated by the archaeological context provided by other mill artefacts. The calculations would be confounded by the great number of unprovenanced, and thus, undated millstones that exist.