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REPORT

THE ROYAL GUNPOWDER FACTORY

WALTHAM ABBEY, ESSEX

BUILDING RECORDING

BY

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FOR

THE MINISTRY OF DEFENCE

Cotswold Archaeological Trust

THE ROYAL GUNPOWDER FACTORY
WALTHAM ABBEY, ESSEX

BUILDING RECORDING

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SUMMARY

A programme of recording was undertaken on an area known as Millhead at the Royal Gunpowder Factory, Waltham Abbey. The study area comprised a section of canal, the foundations of an incorporating mill, and a sluice system.

The recording programme showed that the study area had three distinct phases of construction with three associated phases of alteration or repair.

A wooden platform at the south end of the study area was the earliest recognisable phase, and may have been related to an earlier mill, thought to have been located in the southern part of the study area although no firm evidence was available to prove this. The mill is documented as having been in existence in 1590. The Gunpowder Factory was taken into Royal ownership in 1787. Records show that the production facilities were further developed; and it is thought probable that the second phase of construction at Millhead also takes place at this time. The improvements appear to have been a widening of the canal on the western side and the canal walls being revetted with brickwork. Two extra sluices are added, one of which was intended for use with a water wheel.

The third distinct phase identified is the construction of the incorporating mill on the eastern edge of the sluice system. This is likely to have been built *c* 1860 when the site is further developed. Various repairs or alterations were noted and could be related to the individual construction phases.

1. INTRODUCTION

1.1 In May 1995, Cotswold Archaeological Trust (CAT) was commissioned by the Ministry of Defence's (MoD) Consultant Archaeologist (Steve Chaddock) at the Royal Gunpowder Factory (RGPF), Waltham Abbey, to undertake a programme of archaeological recording.

1.2 The study area (NGR TL37600 01800) (Fig 1), which lies within an archaeologically rich area, was subject to recording as it was thought to represent some of the earliest remains on the site.

1.3 The site lies at 19-21m OD, on the sand and gravel terraces of the east side of the River Lea's broad flood-plain. The study area is flat with raised artificial earthworks forming the banks of the canal system.

1.4 The finds and the site archive will be deposited with The Royal Gunpowder Factory. A copy of the project report will be deposited with the Sites and Monuments Record at Essex County Council.

2. PROJECT BACKGROUND

2.1 The site was recognised by English Heritage and the Royal Commission on the Historical Monuments of England (RCHME) as an important and unique archaeological resource. A full survey of the site by RCHME resulted in two areas of the site becoming Scheduled Ancient Monuments and the listing of 21 buildings.

2.2 After the decommissioning of the site by the MoD, a decontamination programme necessitating the removal of large quantities of material was initiated. This programme posed a threat to large scale archaeological features, which has been recognized by the MoD who instigated a programme of archaeological monitoring and recording, of which this study forms a part.

2.3 The decontamination programme revealed the foundations of an incorporating mill and a sluice system located at the end of a man-made canal known as Millhead Stream. Historical record showed the area may have some of the earliest, and potentially the most archaeologically sensitive remains on the site. A programme of recording was initiated in advance of preservation or consolidation work. In June of 1995 CAT recorded all of the features specified by the consultant archaeologist.

3. PROJECT AIMS

3.1 The aims of the project were to create a record of the excavated structures prior to any conservation or consolidation.

3.2 The record was to consist of:

(i) A summary of the documentary / cartographic evidence for the study area.

(ii) A single 1:100 plan of the study area (Fig 3).

(iii) A 1:20 plan of the southern end of the study area including the sluice system and incorporating mill (Fig 4).

(iv) All elevations within the area covered by (ii), at a scale of 1:20. (Fig 7,8,9,10).

(v) All structural features to be recorded and numbered in a stratigraphic manner, noting repairs and alterations.

(vi) Five sections to be drawn through the sluice and the mill system (Fig 5-6).

(vii) A full photographic record comprising black and white prints and colour transparencies.

(viii) A written report containing a history of the area around the Millhead sluice system, the possible operation of the machinery and sluice system, and its probable evolution and phasing.

3.3 All site drawings compiled at a scale of 1:20 have been reproduced in this report at 1:50.

4. METHODOLOGY AND FIELD RECORDING

4.1 A visual analysis of the canal and sluices, together with the incorporating mill, was undertaken in order to establish the primary construction sequence and subsequent repairs.

4.2 Plans from Milton Keynes Surveys, originally commissioned by the Consultant Archaeologist on behalf of the MoD in 1995, were checked and annotated.

4.3 Notes and context sheets were compiled in accordance with the CAT *Field Excavation Manual.*

4.4 Elevations of the canal and sluices were drawn at a scale of 1:20. A plan and sections through the incorporating mill were also drawn at a scale of 1:20.

4.5 A full photographic record was made of all relevant features and elevations. Black and white prints and colour transparencies were used where appropriate.

4.6 All drawings and photographs were registered using the CAT *pro forma* sheets.

4.7 Buildings and features within the study area are referred by name and by number. The numbering system relates to the RCHME survey report of 1993. The report identified several features and buildings, not included in the MoDs numbering system. These features and buildings are prefixed with 'RCHME'. All other numbers refer to the original MoD system.

5. HISTORIC OVERVIEW AND PROJECT BACKGROUND

5.1 The valley of the River Lea has ideal conditions for milling, and several mill sites have been recorded in the southern part (Fairclough, 1985, 11). Thus, this area has been recorded as a site for the manufacture of gunpowder for over 300 years. The course of the old River Lea would have flowed through the Waltham Abbey area on a north-south alignment. The water supply through the area was likely to have been plentiful and consequently encouraged the growth of industries using water power.

5.2 Waltham Abbey replaced an earlier Saxon church of uncertain date. The church appears to have been rebuilt in 1060 by Harold, Earl of Essex, and added to in 1090 and 1150. The Abbey was refounded as an Augustinian priory in 1177. Similar to most monastic foundations it had its own mill and also a complex of fish ponds. Both a mill and fish ponds would have required water management schemes. Cornmill and Millhead streams are thought to be artificial channels, which may have medieval origins (RCHME, 1994, 108). Cornmill Stream is likely to have been dug for the exclusive use of the Abbey mill and fishponds. Millhead Stream may also originally have been dug for use by the Abbey and subsequently fell into the hands of private enterprise after the dissolution; or it may have been a private scheme by local millers. Fairclough shows that a fulling mill is documented in the area of Millhead as early as 1590 (Fairclough,1985,14). The fulling mill was converted to an oil mill, and finally became a gunpowder mill in 1669 (op. cit.).

5.3 Waltham Abbey had two advantages as an industrial area. Firstly it had a good consistent water supply, and secondly it was within a reasonable distance of London. Communication with London as a major port would have been important both for exporting of goods to the continent, and for the importation of raw materials. The River Lea would have provided a safe and efficient system of transport for the gunpowder, from Waltham to London and the major magazines. Thus the geographical location of Waltham Abbey was almost certainly one of the prime factors in its development as a major centre for the production of gunpowder.

5.4 From 1650 until 1787 gunpowder production in the Waltham area was in private hands. It is known that John Walton had become one of the most important gunpowder manufacturers in the area by 1713. He seems to have single handedly expanded production during the early eighteenth century, supplying both the needs of government and private purchasers. The business was passed down through the Walton family to the great grandson of the founder, who finally sold the factory to the government.

5.5 In 1787 because of the unreliability of private manufacturing the Waltham Abbey site was purchased by the nation and became the Royal Gunpowder Factory. This is a good

reflection of the importance of the site in the history of gunpowder production. After 1787 the site developed as production was increased to supply military needs during major wars. The factory ceased to produce explosives during the second World War when it's location made it vulnerable to German bombers.

5.6 In the post-war period the Royal Gunpowder Factory became a research establishment specialising in explosives and propellants. It finally closed in 1990.

5.7 The study area is sited on an artificial south-north aligned watercourse known as Millhead Stream [212]. Millhead Stream had a dual role in the production of gunpowder. It was used as a canal for the transportation of materials between the various stages of production, and as a source of power for the mills. The study area is located on what would have been the lowest point of the production line. The sluices would have prevented barges going any further south. The channel was constructed of raised banks of earth, creating a head of water for the mills. It seems likely that Millhead Stream has always had raised banks as this would have been the only way of providing a sufficient supply of water.

5.8 The process of producing gunpowder involves the milling of charcoal and a form of milling known as incorporation. The incorporation process is based on large stone wheels grinding the three elements of gunpowder (charcoal, sulphur, and saltpetre) into a fine powder. Without this grinding process the powder would separate into its three constituent parts.

5.9 The site of a former incorporating mill, on the eastern side of the canal, known as Smeatons Mill [198/197] has been identified and recorded (Bascombe and Smith,1973). The building is thought to date to 1700. This building was replaced by a charcoal mill which appears on a map of 1888. Several mills are recorded as having used Millhead, although the exact location and construction dates are not clear. Maps relating to the area are held by the Public Record Office and have been cited by RCHME in their survey. A lithograph of 1735 shows several mills on a stretch of water thought to be Millhead. Two of the mills listed as 'stamping mills' are thought to occupy the south eastern corner of the study area. The RCHME cartographic survey lists 'Head mills' from 1783 which then become 'incorporating mills' in 1865. The Head mills are likely to have been incorporating mills, and only called Head mills because of their location.

6. SURVEY RESULTS

6.1 THE NORTHERN CANAL WALLS AND BASE [RCHME 212] (Fig 7,8,9,10)

6.1.1 The banks of the canal to the north of the sluices are revetted by a bonded brick wall. The brickwork, although obscured by silt and calcification, appears to be laid in a Flemish bond. The bricks appear to be red, hand made stocks, un-frogged and soft, and are bonded in what is thought to be a lime-based mortar. Later areas of brick patching could be detected along the length of the walls. In some cases single bricks and in other cases larger patches up to 4m x 2m in size. The wall stands to an average height of 2m. In places the top courses have been removed. The true height of the walls can only be conjectured as the top edge has not survived at any point. Given the height of the coping stones on the sluice walls it is presumed that the walls of the canal are not far short of their original height. It seems unlikely that they would have been any higher than the sluices. The ground level behind the canal walls is of a similar height to the copings of the sluices, and may indicate the overall height of the walls. It seems likely that the top edge of the wall would have had some form of finishing block, possibly large cut stones or even a timber runner. At the base of the walls, some of the original timber piles had been exposed by the excavation of the main channel. The piles appear to be on average 150mm diameter stakes placed at 400mm intervals. The tops of the piles appeared to have been packed with chalk rubble.

6.1.2 At the south end of the canal, within 4m of the sluices, is a modern sewer cut aligned east-west. The cut has destroyed all of the brick work for 2m on both sides of the canal and also destroyed the timber piling.

6.1.3 On the eastern side of the canal, 6m north of the sewer cut is a small (0.5 x 0.3m) timber framed opening in the brickwork. The opening appears to have been part of the main construction as the bonding pattern around the edge had not been disturbed. The opening appears to go through the brickwork into the earth behind the revetment. The original depth is uncertain due to a partial collapse. The opening may have had a timber lining which has rotted away, but it was almost certainly not brick or stone lined as this would have survived.

6.1.4 On the eastern side of the canal 25m north of the sluices, is an opening which forms an outlet at right angles to the canal. The base of the outlet is formed by a continuous timber kerb at the same level as the timber piles. On both sides of the opening the brickwork is bevelled back to form a lead into the outlet channel. Behind the bevelling are metal runners which almost certainly formed a sluice.

6.1.5 On the western edge of the canal, the revetment is featureless apart from several courses of bricks corbelling out at the northern end. The brickwork appears to have been designed to project, as all of the lead course has been created from headers. The purpose of the alteration is almost certainly to act as a rubbing strip to stop barges fouling on the underlying shoulder in the brickwork. This feature may have been a later alteration.

6.1.6 The western side of the canal also displayed an obvious patch of repair work, to the south of the corbled brick (Fig 7).

6.1.7 The base of the canal contained a black silt which had been excavated to the top of the piles. The depth of the excavation was arbitrary and was not thought to be the true base of the canal cut. As the ground was thought to be an artificial level of imported material, the true base of the cut would be very difficult to detect (RCHME, 1994, 141). The base of the piles are unlikely to have been left exposed and are likely to indicate the intended depth of the canal.

6.1.8 Several features were observed in the silt. Two planks embedded on their edges are angled away from the sluiced opening on the eastern edge (Fig 3). Only the top edges were visible above the silt, and appeared to be cut rather than eroded.

6.1.9 On the western edge of the canal base was a visible line of crushed chalk running parallel with the western edge. The line was 17m from the northern end of the sluices and 1.5m from the western side. The crushed chalk looked to be the same as the consolidation associated with the foundation piles on the east and west sides. It also appeared to be on the same alignment as the timber arm observed under the central pier wall of sluices B and C (Fig 3).

6.2 THE SLUICE SYSTEM. [RCHME 135]

6.2.1 The sluice system consisted of four separate channels divided by brick walls. These walls are constructed of soft red stock bricks laid in a Flemish bond with lime mortar. In places, later repairs of yellow brick similar to the bricks used in the northern end of the canal were detected. The walls at the south end are topped with fine Portland Stone capping finished at 100mm. At the north end the capping stones have been replaced with York Stone slabs. The two central channels (B and C) appear to have been intended for water management.

6.2.2 The water was controlled by sluices at the northern end. Slots and iron runners could be detected for both the control and maintenance gates. The two outer channels (A and D) were dedicated to mill wheels. On the south side of the operating sluices were shaped Portland stone wheel housings. The wheels were obviously designed as breast shot, because of the height of the entrance relative to the wheel base. Sluice A had been blocked at some later date with a brick wall where the sluice gates would have been. This sluice seemed to have been the principal sluice for two reasons: firstly, it is located on the eastern edge of the known incorporating mill, and secondly, large cut stone mounting blocks are set into the wall at points where the bearings for the wheel would have been placed. At the top of the shaped wheel block several fixing bolts were apparent. These features did not appear around sluice D. Without the mounting blocks on the western edge it is hard to explain how the wheel would have operated. It is possible that the wheel on the western side may have been of much lighter construction and used for some auxiliary function such as operating the sluices.

6.2.3 All of the sluice walls appeared to be built off a stone base 0.3m high. Metal tie-rods could be seen at various points on the eastern wall of sluice D. The wall had been re-capped with a brick soldier coping. The tie-rods and the new coping may indicate a possible failure of the wall.

6.2.4 The central pier wall appears to sit on a laid brick surface which forms the floor at the

northern end of the channels. The northern end of the brick pier wall had several iron objects attached to it. The exact purpose of these objects is unclear, it is presumed that they relate to some form of later sluice apparatus.

6.2.5 The bases of the channels A and D appeared to be made from stone. The bases of channels B and C may have been constructed from bricks laid on their edges, this was not entirely clear because of standing water in the leat. Directly behind the sluices (except in the case of sluice D) were bricks laid on their edge. Where the western edge of the brick surface ended in the mouth of sluice C a cordite filter was found trapped between the bricks and an underlying timber baulk. On the eastern side of the canal, inset into the brick surface, is an east-west aligned baulk of timber. The timber has three mortice cuts visible in the surface.

6.2.6 Behind the brickwork in the mouth of sluices A and B was a platform constructed of wooden planks. The planks fanned out to form a continuous surface between the central pier and the eastern revetment wall. The brickwork directly behind the timber platform on the eastern edge of A and B showed signs of disturbance. A semi-circle of bricks appeared to have been removed. The appearance of the broken brickwork suggested a wall edge. This may indicate that the eastern wall of the canal has either been rebuilt on a new alignment, or has been moved back as part of a re-modelling.

6.2.7 On the western side of the central sluice pier is a series of stone blocks with a timber beam, which extends beyond the final block on the same alignment. The timber surface appeared to run up to the western edge of the blocks and is therefore thought to be part of the same sequence of building. Beyond the northern limits of the sluices and surfaces are a series of posts or piles. One discreet group of posts can be related to piling beyond the limits of the central sluice pier wall. The other stakes or piles cannot be related to any particular structure, but may relate to an extension of the timber surfaces.

6.3 THE INCORPORATING MILL [211a]

6.3.1 The body of the incorporating mill stands on the eastern side of the sluice system. It consists of brick-built walls and stone slab surfaces. The building is rectangular and measures 17m by 7m. Its western and southern walls are also the revetment walls of the sluice system (Fig 4). A central channel to the body of the building, is orientated on a north-south axis and contains two circular pits. The northern pit had been fully excavated to reveal seven steel studs set into a smooth concrete or stone base. The floor of the central channel is made from well cut slabs of sandstone. At the southern end of the channel one of the slabs had fractured, revealing a void. The void formed an undercroft to the main channel with an outlet through the brick wall into Hoppit Pool, it is likely to have served as a drain or sump.

6.3.2 On the south-western edge of building, cutting through the wall of the southern wheel pit are the remains of a solvent store constructed during the early part of this century [A292]. It was constructed of hard red bricks bound in a cement based mortar. Two distinct bands of asphalt-type damp proof courses could be observed in the vertical joints.

6.3.3 On the western side of the wheel pits were several walls. One wall is on a north-south orientation and seems to form a main external boundary. Other smaller walls create divisions between the main outside wall and the central channel.

6.3.4 On the north-eastern corner of the main boundary wall are the beginnings of two walls aligned towards the east. Only the first 0.4m was visible.

6.3.5 In the centre of the building is a large stone block with the remains of five studs in it. The block is rectangular with the longer axis on a north-south orientation. Cut into the eastern edge of the block are two segmental scoops. On the north and south sides of the block is a slot constructed of brick. The full depth of the slots could not be determined as both are partly filled with demolition debris. A section of brickwork on the eastern side of the stone block had been partially degraded by machinery.

6.3.6 On the western side of the stone block is a brick built channel, extending from the stone block to sluice A and terminating above the large cut stone block set into the sluice wall. All of the various slots and scoops around the stone block are almost certainly related to the gearwheels connecting the water wheel to the grindstones.

6.3.7 On the south-eastern side of the southern wheel pit is a sunken area with a stone slab floor. The eastern wall has a vertical joint 2.5m from the southern corner, and another vertical joint 2.5m from the south western corner. The bricks on the northern side are yellow stocks, similar to the bricks in the other walls. The bricks on the southern side are soft red stocks similar to the bricks in the walls of the sluices.

7. THE STRUCTURAL SEQUENCE AND DISCUSSION

7.1 The study area can be divided into at least six phases (Fig 3).

7.2 Phase 1: The earliest phase consists of the timber baulk and vestigial limestone wall on the western side of the extended pier of sluices B and C (Fig 4). The alignment of the timberwork appears to indicate that the canal has been widened to allow for the construction of a four sluice outlet. The timberwork and wall can also be aligned with the chalk rubble observed on the north-western side of the canal (Fig 3). The chalk is presumed to be part of the original foundations of the canal wall. A small semi-circle of broken brickwork on the eastern edge of the canal conforms with the timber base but not the canal wall (Fig 4). This may indicate that the original eastern canal wall was further to the west.

7.3 Phase 2: This phase comprises the widening and revetting of the canal and the construction of the four sluice channels. The brick in the canal walls and in the sluices is very similar suggesting they are contemporary. It would appear that the existing walls of the canal and the brickwork in the sluices are also part of the same phase. The timber baulk with the three mortice cuts may have been a device to stop barges being drawn into the sluices. The function of the opening observed on the eastern wall of the canal was unclear. It's relative height would probably put it above the water level, although this is not certain. It may have housed a mooring ring, or a lantern point to guide barges using the basin. The sluice opening on the eastern side of the canal can be associated with the planks visible in the silt. These planks are thought to have performed one of two functions: either they created a baffle which smoothed out excessive turbulence in the mouth of the leat, or they stopped

barges being drawn into the mouth of the sluice and impeding the flow of water to the mill.

7.4 Phase 3: The third phase is the building of the incorporating mill (Incorporating Mill No1) and the repairs to the canal walls. The incorporating mill is built of yellow stocks and all of the repairs are of the same type of brick. The yellow bricks used in the walls of the incorporating mill differ from the walls of the canal. The red brick found in both the walls of the sluices and canals are identical and thought to be part of the same sequence. The yellow brick used in the incorporating mill is also found in dateable buildings on other parts of the site and is thought to be *c* 1860.

7.4.1 The incorporating mill appears to have been directly powered by a wheel sited on the western side of the building. The shaft from the wheel would have entered the incorporating mill in the centre, the power then being transferred through a gearbox to the millstones sited in the north and south of the building. Evidence for the method of gearing can be gained from the residual mountings. The shaft would have sat in a bearing block secured to the stone block by studs and nuts. A gear wheel on the end of the shaft would have driven two other gear wheels set at right angles to the main shaft. This would have formed a differential arrangement. From the secondary gears, a short length of shaft would have connected the power source to a much larger gearwheel running in the brick slots on the north and south side of the bearing block (Fig 4). The effect at this point is to gear down and produce a much lower speed with a greater torque ratio. The larger gearwheel from this point may have driven a shaft to supply power at the top and the bottom.

7.4.2 A picture depicting an incorporating mill (Fairclough, 1985, Fig1) shows it to be overdriven. It would seem reasonable to assume that the arrangement in mill [211a] would have been the same. If the mill had been underdriven it would have had to be driven through a series of gears. Because the base of the last gear wheel runs in a slot, the drive would have had to have come from the side and be transferred through gears to the edge of the grindstone gear wheel. Given the arrangement of the primary gearing it seems unlikely that the mill was underdriven. It seems reasonable to suppose that the base stone was static with the two wheels moving around a central pivot (Fig 11). A pivot shaft would have dropped through the central stone into a pivot bearing. The central channel could have allowed access for lubrication and maintenance of the bearings.

7.5 Phase 4: comprises modifications to the sluices. The brick floors at the northern end of sluices B and C are increased or re-built and the central pier wall is extended northward. A map of 1865 amended in 1888, shows the piers as all having the same length. The existing pier wall is 7m longer on its northern end than the other walls, suggesting that it has been extended since 1888. The brick work does not show any obvious signs of alteration and it is possible that it has been re-bonded and then weathered in producing an even unbroken effect.

7.6 Phase 5: is the blocking of sluice A, with the same yellow brick used in the incorporating mill

7.7 Phase 6: is the construction of the solvent store in the south-western corner.

8. CONCLUSIONS

8.1 The evolution of the study area may be broadly related to the evolution of the factory itself. An increase in the demand for gunpowder is marked by an upgrading of the means of production.

8.2 The timber arm that identifies the first phase of construction may be linked with the early stamp mills and possibly goes back as far as the fulling mill mentioned by Fairclough. Unfortunately no firm dating evidence is available to support such a theory.

8.3 It seems very likely that the dating of the second phase of the canal may coincide with two historic events. The outlawing of stamp mills in 1772; and the takeover of the factory by the Government in 1787. Part of the reason the factory was bought by the government was probably due the increase in demand for gunpowder created by the Napoleonic War. The old stamp mill may have been out of use for some fifteen years and both the mill and the sluice system may have been in a bad state of repair. Because of the need to increase production the old mills may have become the focus for improvements. The canal was widened to improve the head of water and allow a greater number of barges to bring raw material in and transport the finished product out. The provision of four sluices may be an indication of an intention to build another mill or processing plant on the western side of the canal. Sluice D has a shaped stone wheel base similar to sluice A but with no obvious sign of bearing blocks, indicating a possible intention to use it at a later date. The existing stamp mill may have been redesigned as an incorporating mill.

8.4 In 1816 at the end of the Napoleonic War gunpowder production was reduced. The stamp mills on the eastern side were demolished and the site left empty (RCHME,1993,115). Once again war was the impetus for development, and by 1850 gunpowder production had to be increased to satisfy the demand created this time by the Crimean War. A new mill was built to service the increased demand and becomes Incorporating Mill No 1. It would seem from the evidence of the bricks in the revetment walls that the canal undergoes a certain amount of refurbishment at this time. A map from 1865 shows that the mill was in existence by that date. Later corrections to the map show two changes. Firstly, the northern extension of the pier between B and C sluice did not exist in 1888, secondly some form of structure obscures sluice A. The structure may have been a cover for the wheel. The map of 1888 does not show a wheel in operation on the western side of the sluices, which begs the question as to the purpose of the second wheel housing.

8.5 Incorporating Mill No 1 carries on producing gunpowder until the turn of the century when gunpowder is replaced by cordite.

8.6 The intentions of this survey were to record and analyse the structures revealed by decontamination work at the Royal Gunpowder Factory. The aims of the project were met and brought to a successful conclusion.

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10. ACKNOWLEDGEMENTS

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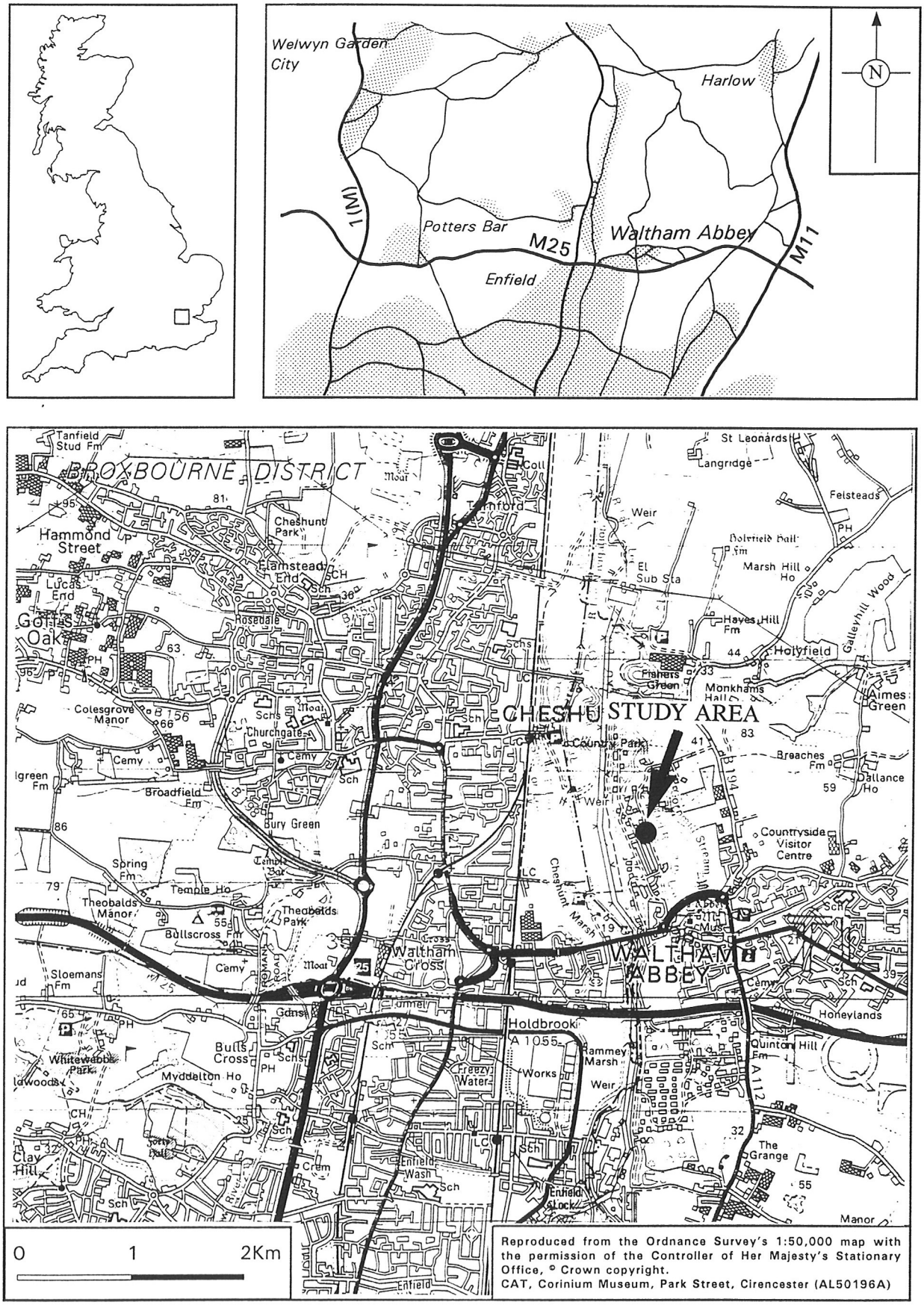


Figure 1: Location plan

Figure 2: 1865 Historical plan of study area (revised 1888) *Not to scale*

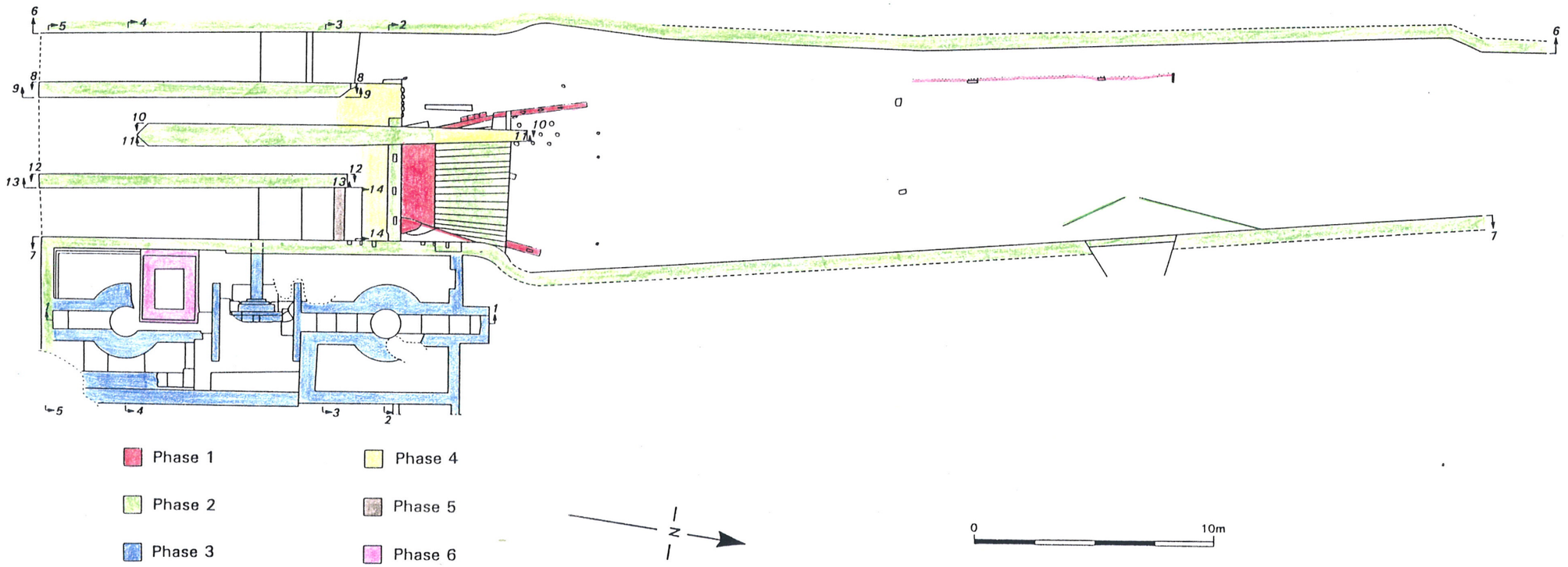


Figure 3: Phase plan of site

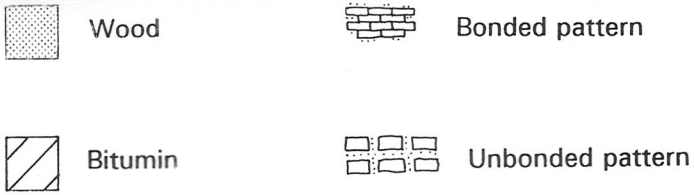


Figure 4: Plan of incorporating mill and sluice system

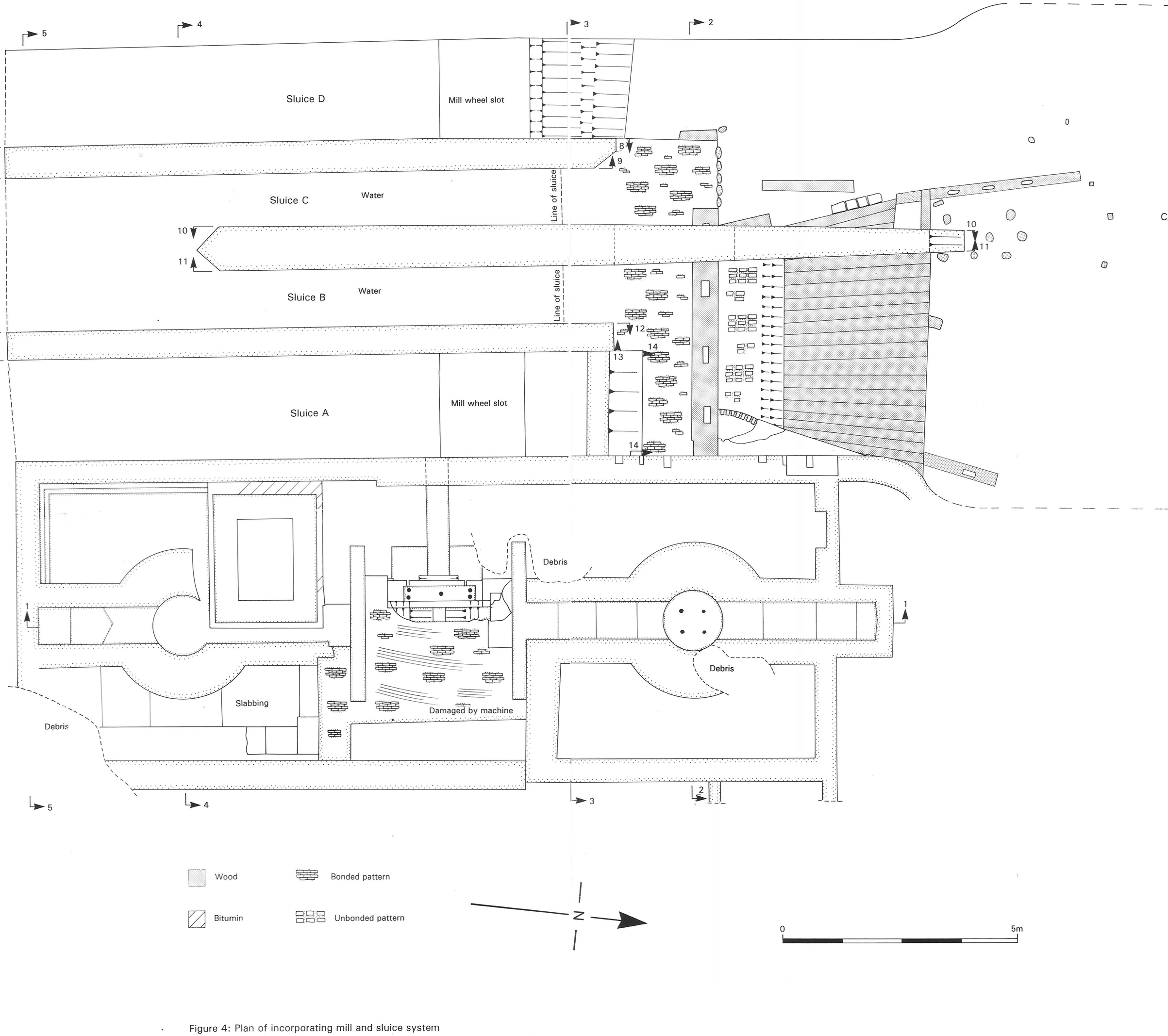
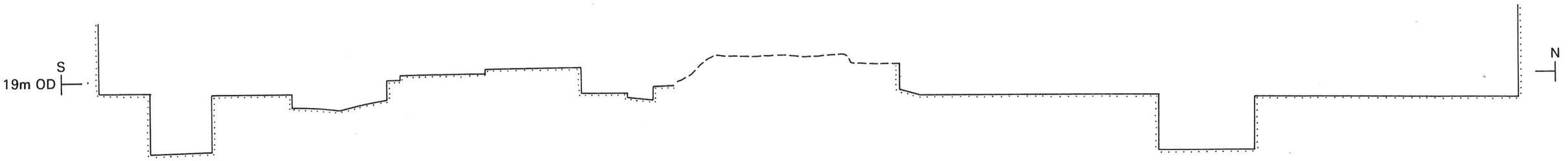
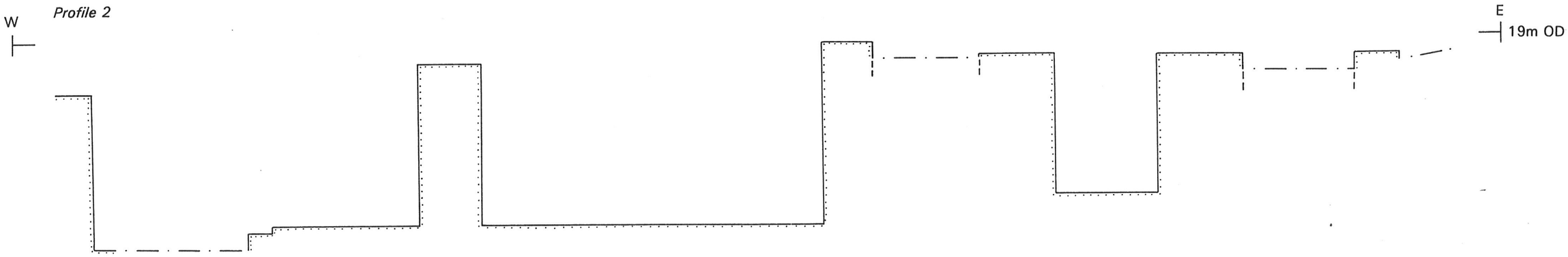


Figure 4: Plan of incorporating mill and sluice system

Profile 1



Profile 2



Profile 3

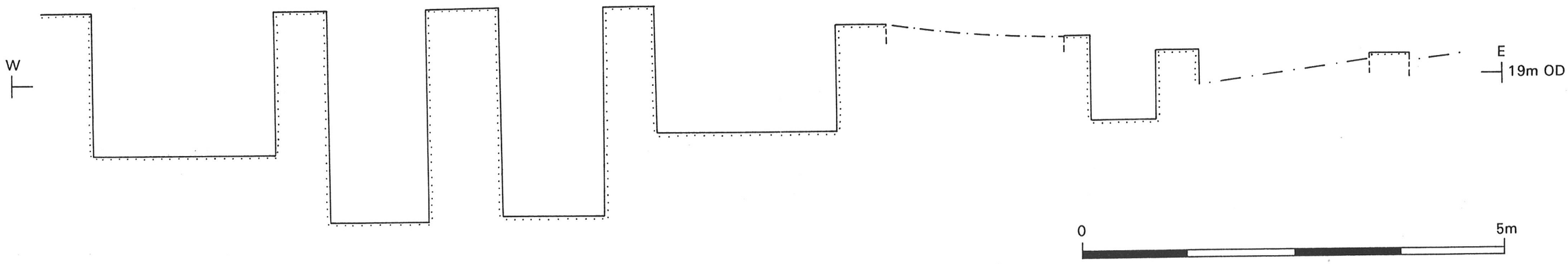
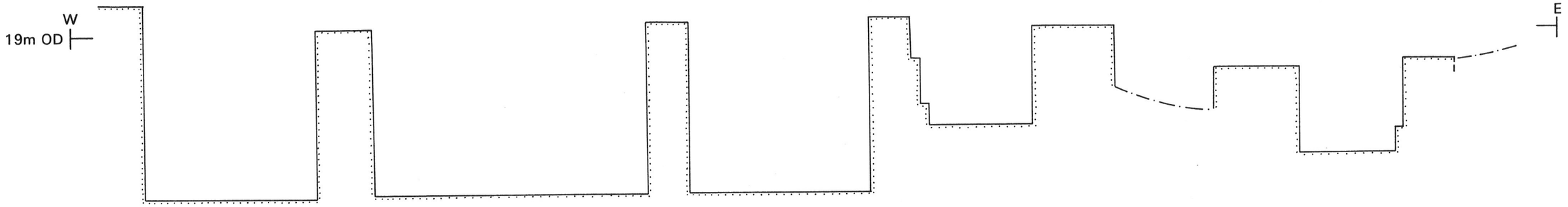


Figure 5: Profiles 1-3

Profile 4



Profile 5

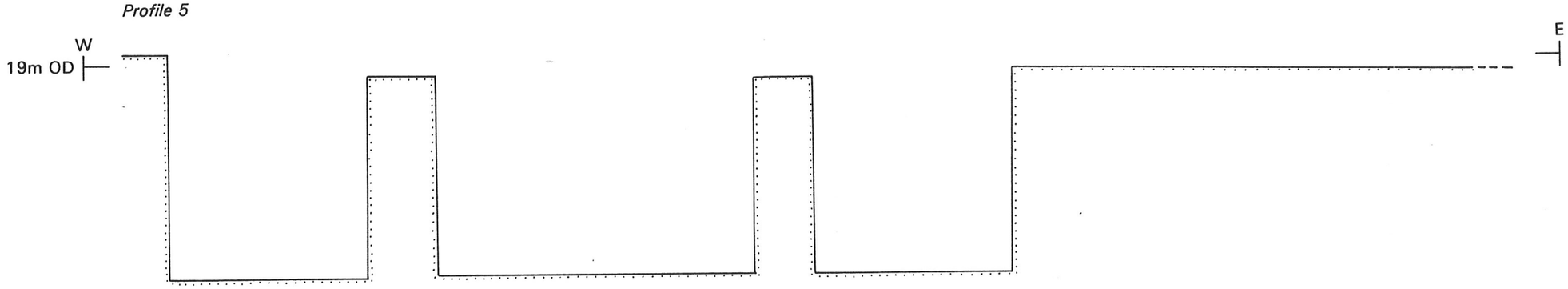


Figure 6: Profiles 4-5

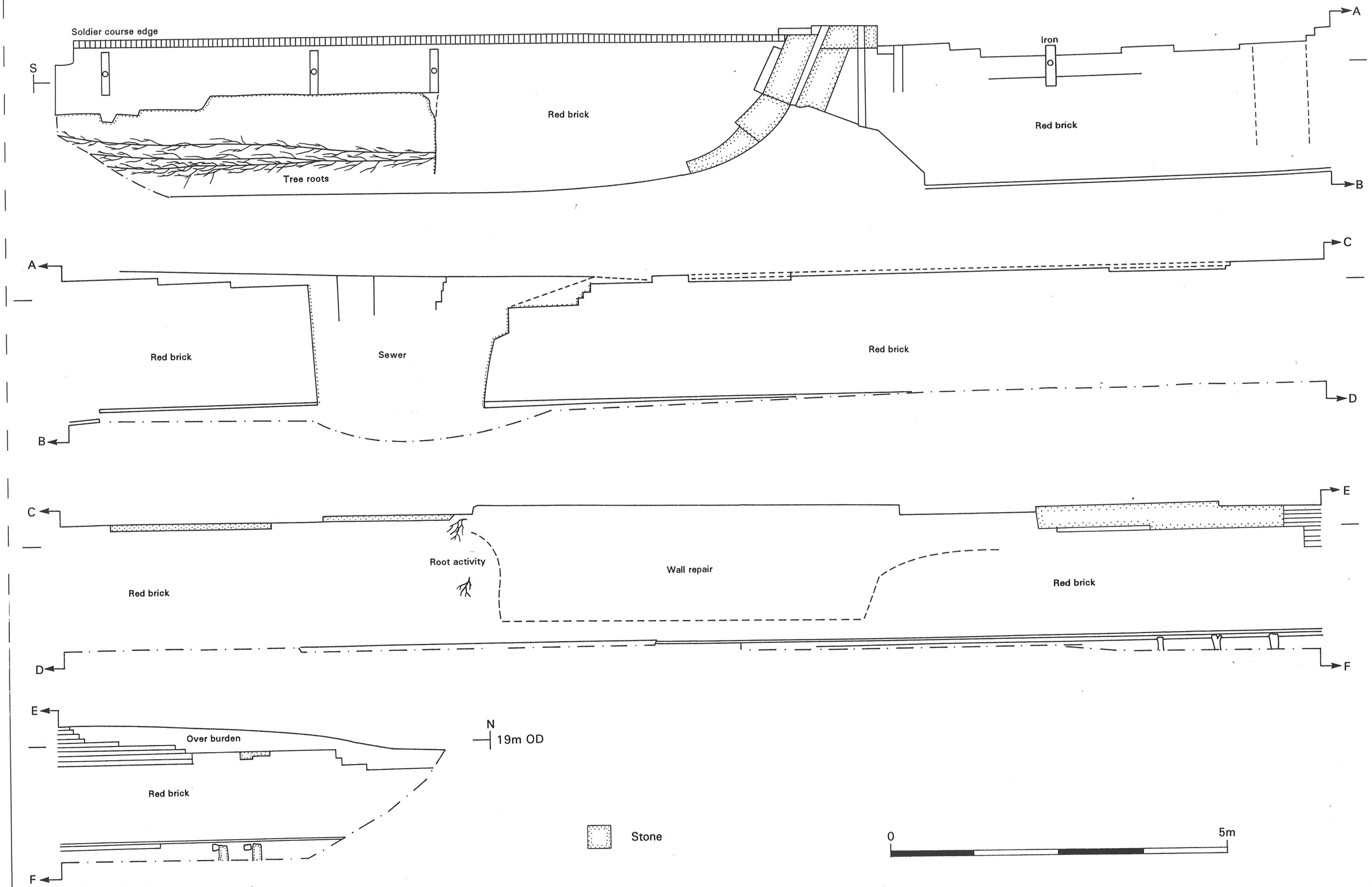


Figure 7: Canal elevation 6

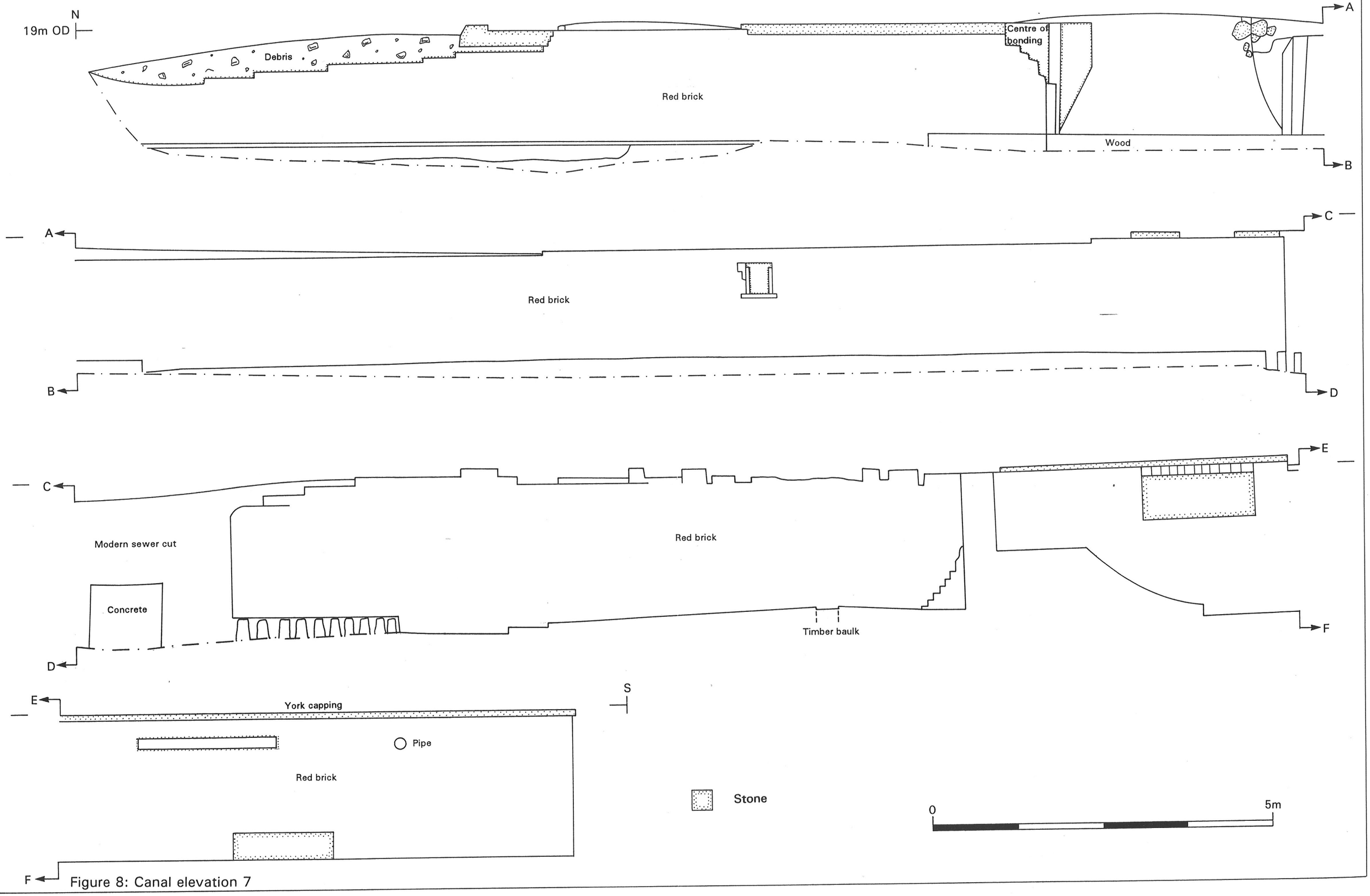
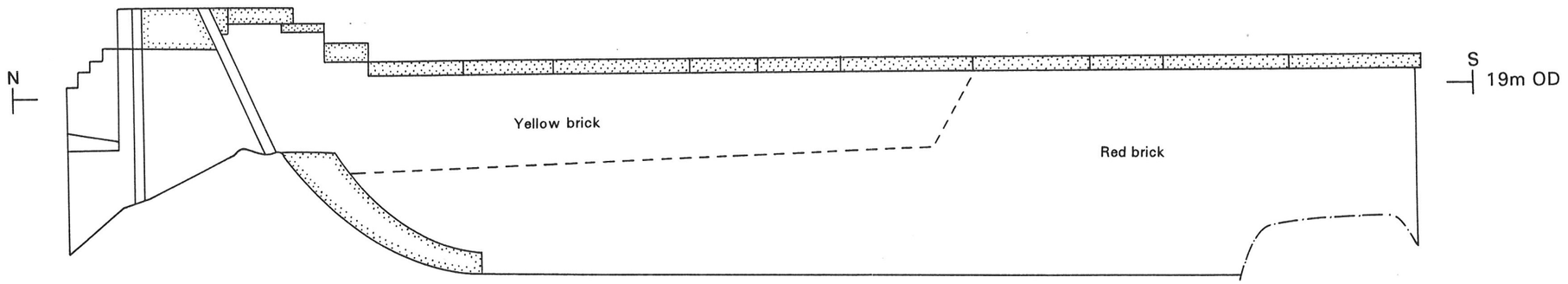
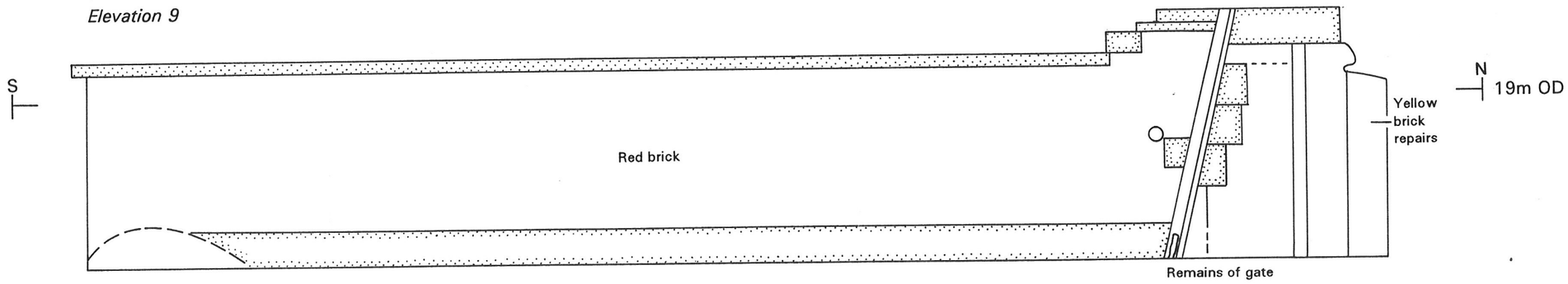


Figure 8: Canal elevation 7

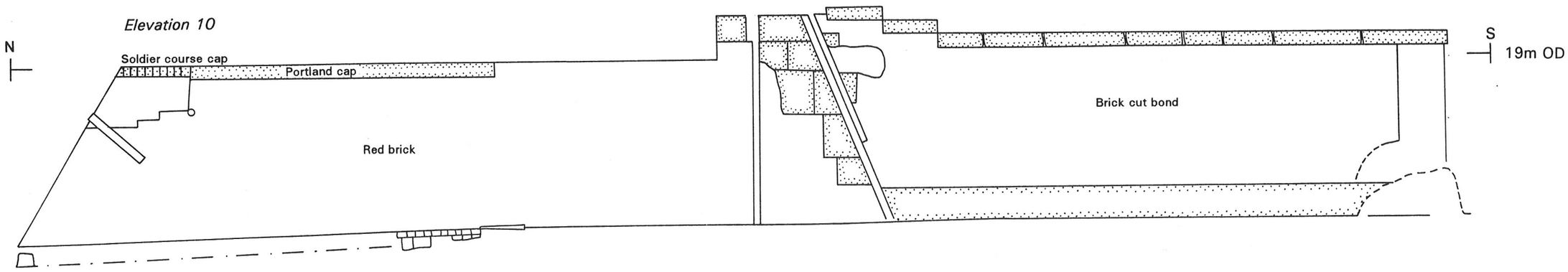
Elevation 8



Elevation 9



Elevation 10

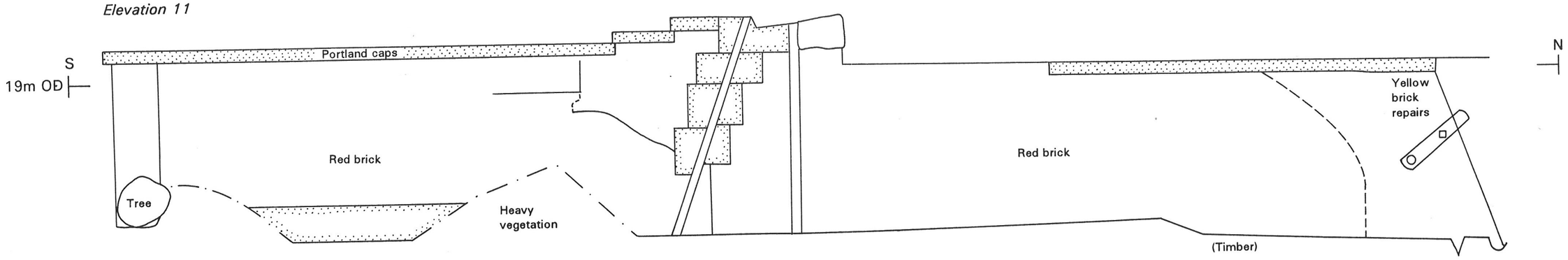


Stone

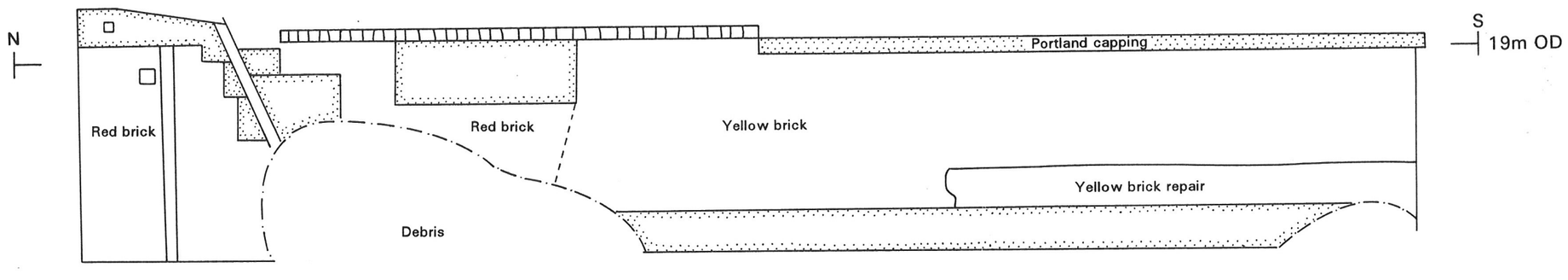
0 5m

Figure 9: Canal elevations 8-10

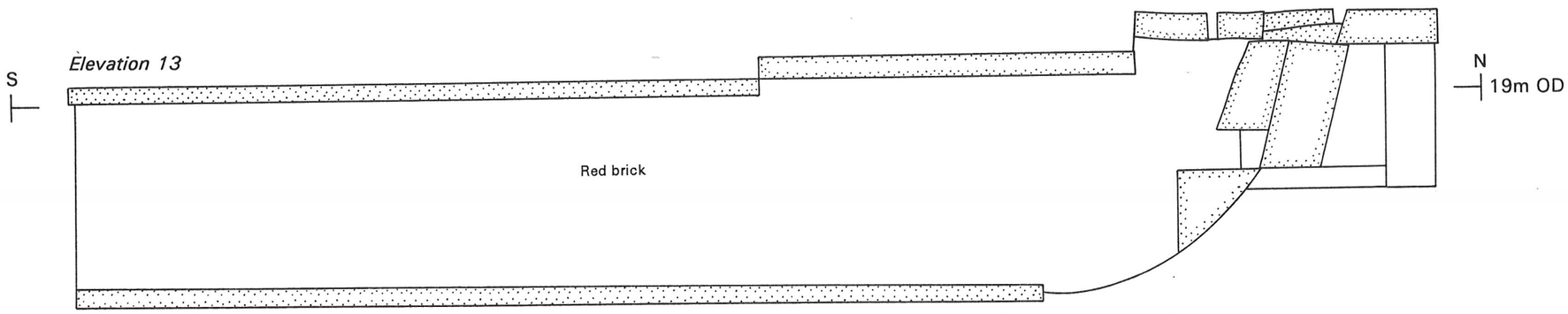
Elevation 11



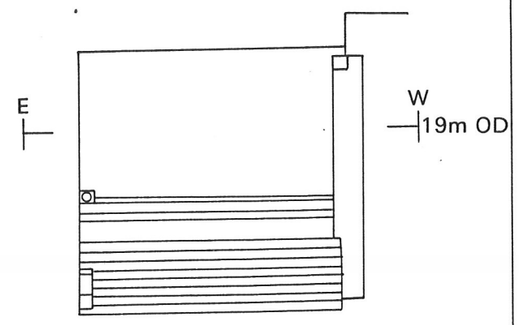
Elevation 12



Elevation 13



Elevation 14



Stone

0 5m

Figure 10: Canal elevations 11-14

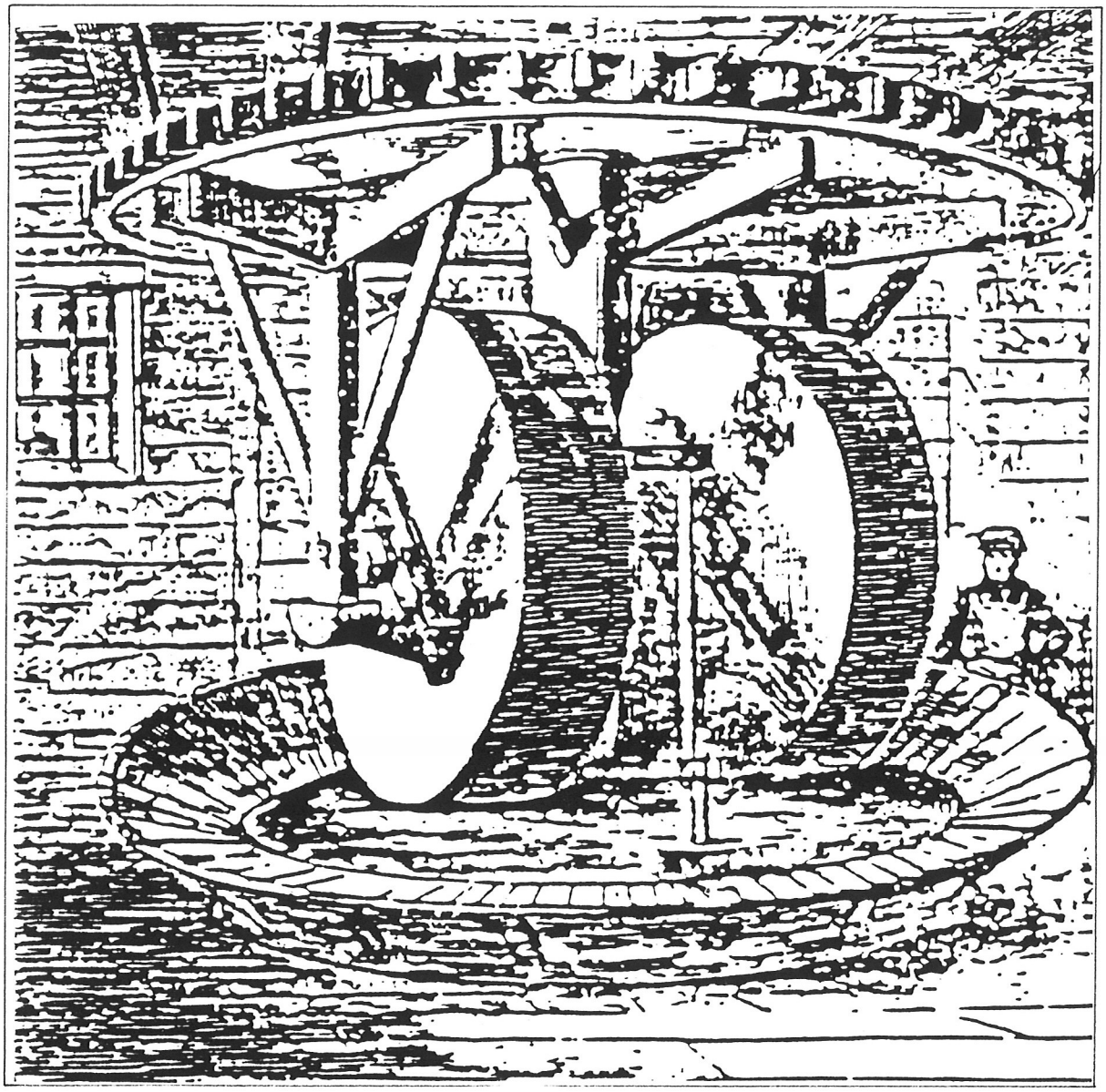


Figure 11: Illustration of an incorporating mill (Essex record office)