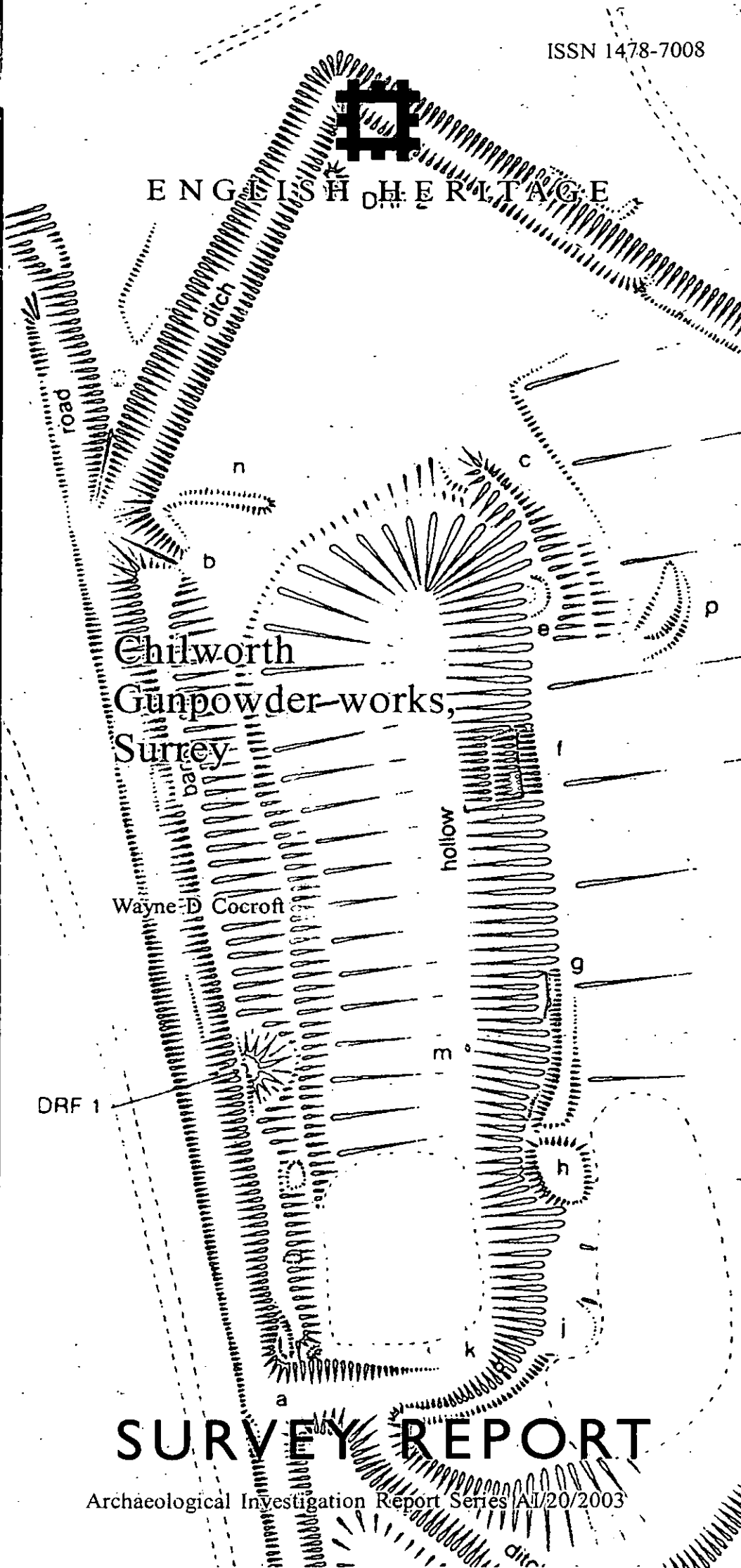
ISSN 1478-7008

ENGLISH HERITAGE

Chilworth Gunpowder–works, Surrey

Wayne D Cocroft



SURVEY REPORT

Archaeological Investigation Report Series AI/20/2003

ENGLISH HERITAGE

CHILWORTH GUNPOWDER WORKS, SURREY

ISSN 1478-7008
Archaeological Investigation Report Series AI/20/2003

County:	Surrey
District:	Guildford
Parish:	St Martha
NGR:	TQ 032 476
NMR No:	TQ 04 NW 9
SM No:	31397
Date of survey:	February 2003
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The Tilling Bourne valley at Chilworth viewed from the west, the gunpowder works occupied the woodland to the centre left (NMR 23016/7). (c) English Heritage

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1.INTRODUCTION

To many casual walkers the section of the Tilling Bourne valley, formerly occupied by the powder works, might appear as a piece of unspoilt natural woodland, an untouched haven for wildlife. It is, however, an entirely manmade landscape - an industrial landscape. From the early middle-ages the Tilling Bourne was harnessed to power corn mills, and later fulling mills used in the manufacture of cloth. The industrial use of the Tilling Bourne grew rapidly from the sixteenth century and in the following centuries it supplied power for a variety of industries, including saw-milling, knife grinding, paper making, wire making, and gunpowder manufacture (Brandon 1984, 75-103). The digging of millstreams and header ponds, in which to store water, has transformed the natural hydrology and topography of the valley. This in turn destroyed old habitats and created new environments for the valley's wildlife. During the working life of the gunpowder mills most of the works was tree covered. Some of the wood was burnt for charcoal, although the works could never grow enough to be self-sufficient. Tree growth close to the process buildings was also encouraged to act as a flexible blast screen in case of accidental explosions. Today vestiges of this woodland management regime still forms an important component of the valley's vegetation cover.

From its establishment in 1625 by the East India Company, the Chilworth gunpowder works was one of the largest in the country and one of the most important suppliers of gunpowder to the government. In 1885 the works was acquired by a consortium, including a number of leading German powder-makers, to produce a new type of gunpowder known as brown or 'cocoa' powder, for use in the largest guns of the day. By the end of the decade, and after extensive rebuilding, contemporary commentators regarded the factory as of world class standing. It was also at the forefront of the development of new chemical propellants and in 1892 the first commercial cordite factory in the country was erected at Chilworth. It underwent further expansion during the First World War when the Admiralty funded an extension to the cordite section. The massive downturn in the demand for explosives at the end of the war resulted in amalgamations and contractions in the industry, leading to the closure of the factory in 1920. Subsequently, many of the factory buildings were converted into dwellings, and a small community known as 'Tin Town' lived in the valley until the early 1960s.

Guildford Borough Council owns the central section of the factory, the majority of which is also a Scheduled Monument, and there is open public access across the area. In May 2001, the Council commissioned English Heritage to undertake an archaeological survey of the former Chilworth Gunpowder Works site. Survey work was carried out over two seasons, between November 2001 and March 2002, and between

December 2002 and January 2003. This report describes the results of the survey work and the remains of the powder works and later chemical explosives factory, which may be followed for approximately 2km along the Tilling Bourne valley. These remains are of particular significance as the layout of almost the whole factory can still be traced through its earthworks, watercourses, ruins and standing buildings.

Organisation of the report

The main body of the report is divided into three independent sections, the Historical background, Description, and Phasing and Analysis. They have been written as stand-alone pieces of text, which may be read without reference to other sections of the report, for this reason a little repetition may be found. This text is supported by a collection of component sheets or 'professional papers', copies of these have been deposited with Guildford Borough Council and the National Monuments Record Centre, Swindon. The 'professional papers' comprise detailed individual recording sheets for all the main features on the site, including standing buildings, ruins, buried structures, and bridges. Where it has been possible the original factory numbers have been retained; these have primarily been taken from a copy of the 1922 sale map in the possession of Albury Estate. These numbers are identical to those shown on an 1890s map of the Smokeless Powder Factory, a copy of which is held by the Surrey History centre (Z10). Some of these, however, differ from the number sequence shown by Warner in his 1976 article. In these instances both numbers are shown thus, for example [30/73], the first referring to the 1922 Albury Estate map and the second to the number given by Warner. No original numbering sequence has been found for the First World War Cordite Factory and these have been given numbers prefixed (A). For features where there are no original numbers they have been given an English Heritage (EH) number, bridges and culverts are prefixed (BR), millstones are prefixed (S), and Second World War military remains are prefixed (M).

The component sheets are roughly arranged according to geographical location, the buildings numbered 1-72 may be found in the area of the Lower and Middle Works. The Smokeless Powder Factory refers to an area to the east of Lockner Farm Road built during the 1890s, and the Admiralty Cordite Factory to an extension built about 1915. The bridges and culverts are found across the entire site, as are the military features built during the Second World War and the features prefixed by EH. The identifying numbers used on the component sheets are correlated with those on the site plan.

For ease of use the site plan has been broken down into eight A3 sheets and these should be consulted in conjunction with the written description. For the purposes of this report the track between Lockner Farm and Chilworth Manor is referred to as Lockner Farm Road, following an

annotation which appears on the 1922 sale map of the site. The Tilling Bourne is written as two words following the form used by the Ordnance Survey.

2. PREVIOUS RESEARCH

The story of gunpowder manufacture at the Chilworth gunpowder works, and, indeed, in Surrey, has been the subject of modern historical research for almost one hundred years. The earliest account was published by the Victoria County History (1905, 306-329). More recent interest in the site began in the 1970s with two articles published in *Surrey History* by D W Warner (1975 and 1976). These, in turn, stimulated interest in the mills by Glenys and Alan Crocker, resulting in a number of publications produced under the auspices of the Surrey Industrial History Group, including *Chilworth Gunpowder* (Crocker 1984), *A Guide to Chilworth Gunpowder Mills* (Crocker 1985), and *Damnable Inventions* (Crocker and Crocker 2000). In 1990 they published a general account of the gunpowder industry in Surrey (Crocker and Crocker 1990). Alan Crocker has also written an article on the late nineteenth century tramways and their archaeological remains (Crocker 1994). During the late 1980s and 1990s detailed documentary research by Keith Fairclough threw further light on the early history of the works (Fairclough 1996, 1999, 2000a, 2000b: Crocker and Fairclough forthcoming). A volume of documents produced by the Surrey Record Society *Gunpowder Mills: Documents of the Seventeenth and Eighteenth Centuries* (Crocker *et al* 2000) also contains further valuable information. Glenys Crocker (2001) has also written a short article on the history of Thomas Steere's wire works, which occupied part of the powder works site in the early seventeenth century.

Despite the extensive research carried out on the history of the site, very few contemporary photographs have been found, and none of which show the manufacturing buildings. The publicity generated by a series of articles published by the *Surrey Advertiser* (Rose 2002a and 2002b), on the small community of 'Tin Town', which occupied the site of the abandoned powder works, did, however, encourage people to look out some old photographs, and these were published by the newspaper. The Royal Commission on the Historical Monuments of England photographed the powder works' principal buildings in 1994, a number of which appeared, alongside a brief description, in *Dangerous Energy* (Cocroft 2000).

Most of the research to date has relied primarily on documentary evidence rather than the detailed recording and analysis of the extant field remains as their main source of information. One notable exception was the 1:500 scale survey of the First World War Admiralty Cordite Factory undertaken as a student exercise by the Department of Civil Engineering, University of Surrey in 1983. In the late 1980s, the Surrey Industrial History Group carried out some recording work on the late 1880s **Incorporating Mills** [52] and the adjacent **Mixing House** [51], probably to coincide with the consolidation of the Incorporating Mills by

Guildford Borough Council (Goddard 1989, 180; Evans 1990, 204). One of the 1880s swing bridges for the tramway [BR 16] has also been drawn (Crocker's 1994). In 1995 archaeological evaluation trenches were excavated by Wessex Archaeology during the redevelopment of the area around Postford Mill and in the following year further trenches were dug. One of the primary objectives of these excavations was to attempt to locate any remains of seventeenth century powder mills in this area. No remains attributed to these mills were found; although sections of nineteenth century brick walls and some prehistoric remains were discovered (Wessex Archaeology 1996). In 1997, further monitoring of the ground works associated with the development was carried out. No structural remains were found and the only artefacts recovered were of nineteenth and twentieth century date (Wessex Archaeology 1997). In May 2001, in preparation for the repair of the 'Packhorse Bridge', the Surrey County Archaeological Unit carried out an archaeological watching brief during the excavation of a by-pass channel. No archaeological features were seen. The artefacts recovered included a large concrete roof section and bricks, which were probably derived from the demolition of the **Expense Magazine** [60] (Robertson 2001). Attempts were also made to collect charcoal embedded in the bridge's mortar to provide a radiocarbon date for its construction. Unfortunately insufficient uncontaminated material was retrieved to allow a radiocarbon date to be ascertained.

The present survey is the first detailed archaeological recording and analysis of the site's surface remains and of its significant buildings. It was commissioned by Guildford Borough Council, which owns a large part of the central section of the site, as part of the long-term management plan for the site.

3.HISTORICAL BACKGROUND

As has been described in the previous section a considerable amount of historical research has been conducted into the early history of Chilworth gunpowder works. The following account is based on this research, with particular attention being paid to sources that throw light on the topographic development of the works. Readers wishing to pursue any of the themes in greater depth should consult the sources noted in the preceding section.

Early history

Records of milling along the Tilling Bourne may be traced back to the Domesday Book (1086). Its waters were harnessed for a number of tasks, and nine mills predating 1500, principally engaged in corn milling and cloth finishing or fulling, have been identified (Brandon 1984). From the sixteenth century there was a marked increase in industrial activity along the valley and a further thirteen mills were established for a variety of activities, including an iron forge, set up at Abinger Hammer in 1577 (Crocker 1999, 10). Gunpowder manufacture was first established in the area by the Evelyn family probably in the 1560s at Tolworth. They and their partners also set up powder mills at Abinger and Wotton, and at Godstone on the River Eden (Crocker 1990, 134-58; English and Field 1992, 91-95). These enterprises represented a considerable investment in mill buildings, their machinery, and watercourses. Given the large capital costs of setting up a milling site, once established, they tended to remain as fixed features in the landscape although their function might alter. Topographical constraints also determined the most appropriate sites for mills, as did legal rights to use the stream for milling or fishing, as these could be valuable assets.

At the beginning of the seventeenth century the manufacture of gunpowder was a royal monopoly and the Evelyn family held the contract for the supply of gunpowder to the Ordnance Office. Once their obligations to the crown had been met they were also permitted to sell powder to private customers, who might also acquire powder from abroad. Historical records also indicate that there were a number of unlicensed powdermakers in operation.

The East India Company and the beginnings of the Chilworth gunpowder industry 1626-1636

One customer for gunpowder was the East India Company, formed in 1601 to trade with the East Indies. In so doing, it came into conflict with established Dutch and Portuguese merchants and an assured supply of gunpowder for its ships' guns therefore became crucial to the Company's success. Until the early 1620s, when war with Spain

threatened, the Company had been able to obtain adequate supplies of powder from the licensed mills. As the country prepared for war, more gunpowder was diverted to government magazines and saltpetre became a scarce commodity. One solution to this shortage of supplies was to import saltpetre from India, with the understanding that it could then be made into gunpowder for the Company's use. In February 1624, the Company made plans to begin to import saltpetre and by the end of the year decided to take matters a stage further by entering into manufacture of gunpowder. This immediately brought them into dispute with the Evelyn family, who wished to maintain their monopoly. While negotiations with the government proceeded, the Company began investigations into suitable mill sites to establish its own powder works. The first location they identified was a corn mill, Trumpsmill, on the Bourne, a tributary of the River Thames near Thorpe. Work began in May 1625 to adapt it for the manufacture of gunpowder, but was halted in August of that year when it was alleged that they were disturbing the king's deer in Forest of Winsdor. Petitioning by the Company appears to have brought it a temporary reprieve and by the early summer of 1626 the mills were in operation. However, by the end of June, Sir John Coke, a Secretary of State, had instructed them to pull down the mills. This might partly have been due to continued complaints about the deer being disturbed or through lobbying by Evelyn.

The Company immediately petitioned the Privy Council for a new licence to manufacture gunpowder. In August 1626 it received letters patent granting permission for it to manufacture gunpowder using only imported saltpetre. It was also prohibited from selling powder to private customers. By September, the Company had identified a new site at Chilworth and signed a lease with its owners John Sotherton and Sir Edward Randyll. The site they chose corresponds with the causeway that carries Blacksmith Lane across the valley floor. It was an established milling site, with a corn mill, perhaps dating back to 1086, and a fulling mill recorded in 1589; there had also been a short-lived wire mill, which was forced to close in 1606 (Crocker 1999, 2-16; Crocker and Crocker 2000, 11-13). One gunpowder incorporating mill was erected on the site of the fulling mill, with one adjacent to it and another on the site of the corn mill. While Chilworth was brought into operation, brimstone (sulphur) and charcoal continued to be milled at Thorpe. To hasten the commissioning of the new works and to keep costs to a minimum, buildings and equipment at Thorpe were dismantled and brought to Chilworth for re-erection. The new works suffered a serious setback in May 1627 when a breach in the bank of the mill pond brought work to a halt. The following month the capacity of the works was raised from 20 to 30 barrels a week with the installation of 'bottome brassess' in bowls or mortars of the third mill. An auditor's report in November 1628 noted that the mills had cost £1,000 to establish.

The new works apparently got off to a good start and in November 1627, the Company was able to return 100 barrels of gunpowder that it had borrowed from the City of London, and in January 1629 sold £7,000-£8,000 worth of powder to the king. Nevertheless, there were concerns that the works was not being run as efficiently as they might be, and perhaps linked to Company's financial difficulties, in late 1628 it was decided to cease direct production. The Company, nonetheless, retained the main lease to the mills and the official letters patent to permit manufacture. Production was continued by one of the former managers, Edward Collins, who undertook to pay a rent of £200 per year to produce new powder using saltpetre supplied by the Company and to repair decayed powder. His operation suffered a serious setback in the autumn of 1630, when three mills were seriously damaged in an explosion. Legal notes of the period indicate that the layout of the works had been altered. The mills on the site of the former fulling and corn mills had been rebuilt, and that a new mill had been built on Steersland, probably on the site of the wire mill, which closed in 1606. During Collins' tenure it is recorded that at the Company's expense he also erected a new storehouse and converted an old house at Chilworth for his family's use.

This new enterprise lasted until 1632 when the Company lost its right to manufacture gunpowder, after complaints that it had been selling gunpowder to private customers, resulting in a loss of revenue to Evelyn and the king. Powder had probably come on to the market in 1632 due to Collins' dire financial circumstances when he had pawned a number of barrels of powder. The enforcement of the letters patent at this point was probably partly due to the king's need to raise revenue through the sale of gunpowder coupled with the unpopularity of the Company amongst the king's circle of advisors.

From the autumn of 1632 the mills were idle, but in March 1634 the Company succeeded in obtaining permission to operate the mills to rework decayed powder. In December they applied for authorisation to recommence manufacture, but this was quickly rejected as the king intended to take exclusive charge of gunpowder manufacture and its sale. The powder monopoly passed from Evelyn to Samuel Cordwell and George Collins. Gunpowder manufacture recommenced at Chilworth in the summer of 1635, while this new enterprise was established Evelyn's contract was extended to October 1636. Beyond this date though it was not renewed and between 1636 and 1640 Cordwell and Collins became the sole gunpowder producers in the country based at Chilworth. The East India Company also gave up its interest in the site and by March 1637 Cordwell was in possession of the main lease (for above *see* Fairclough 2000, 95-111).

Samuel Cordwell and Edward Collins 1636-1650

In April 1636, Cordwell and Collins proposed to supply the king with 240 lasts of gunpowder per year. One last is equivalent to 24 hundredweight, or 2688 lbs (1219.28kg), in terms of production it would require the mills to produce just over 120 barrels of gunpowder per week, a barrel holding 100lbs (45.36kg).

The capacity of the three mills at Chilworth was just 30 barrels per week. However, in early 1636 it is doubtful that they could have achieved even this. Only two of the mills had been reinstated to restore decayed gunpowder in 1634, other sections were in disrepair. As part of their proposal to the king, they requested a loan of £2000 towards the building costs of mills, work houses, stoves, stores house and for utensils. Judged against the original cost of the works of £1000, which provided 3 mills, this appears to be a reasonable amount to construct the seven extra mills they required to bring production up to 120 barrels per week.

This development marked a major expansion of the works. To the west of the original mills (on what is now Blacksmith Lane) new mills, later referred to as the Lower Works, were built and fed by a millrace on the southern side of the valley; a survey of 1677 refers to seven incorporating mills in this area. An entirely new site, the Upper Works, was also set up, to the east, at Albury, around what is now known as Postford Pond. This was later described as complete works by itself and comprised about six incorporating mills (*see* Figure 38).

The Chilworth mills were now equipped to be the king's exclusive suppliers of gunpowder. In 1637, the king further consolidated his control of the market by forbidding the import of gunpowder without a special license and by establishing a system of licensed retailers. Nevertheless, some illicit manufacture did continue. The new arrangements at Chilworth appear to have served the king well, the agreed amounts of gunpowder were generally supplied and it was of good quality. Where problems did occur it was with the supply of saltpetre from the domestic producers.

The gunpowder monopoly was just one of a number of monopolies which caused resentment due to the high prices charged to merchants. It was, however, the king's worsening financial position that caused the final collapse of the monopoly, by summer 1640 he owed Cordwell £4000, which he was unable to pay. By November 1640, it appears that Cordwell had ceased supplying the king with gunpowder, and that he had begun to sell to private customers in clear breach of his contract. In August 1641, the monopoly was repealed and it became legal for anyone to manufacture or import gunpowder.

As the owner of the only operative and newly built gunpowder works in England, Cordwell was in a strong position and for the immediate future the legislation had little effect on him. The Commons negotiated a new contract with him in 1642 to supply the Ordnance Office with 500 barrels of powder and he was also able to supply his private customers.

The Civil War 1642-49

Cordwell, along with John Berisford who had erected some new gunpowder mills along the River Lee, Essex, were the principal suppliers of gunpowder to Parliament throughout the Civil War. This was not without risk, and in November 1642 as the king's army advanced on London; to prevent the Chilworth mills falling into royalist hands they were pulled down and the raw materials removed. Instructions for further destruction were then given as the royalists withdrew from the captured area. By the following March the mills were working again, but a few months later they were again under threat when Chilworth was raided by the royalists. Although at that time there is no evidence that any damage was caused. For the remainder of the Civil War Chilworth remained as one of the main suppliers to Parliament, despite continuing fears about royalist attacks. Samuel Cordwell died in late 1647 or early 1648. The running of the business passed his brother Robert, who ran it for the benefit of Samuel's widow and children. In 1649 the original 21-year lease on the land on which the mills stood expired and Vincent Randyll, the landlord, assumed that they were now his and let them out on an annual basis.

The 1650s and the Dutch Wars

By early July 1650 Robert was also dead and the administration of the estate was given to his widow Mary. She ran the business for a short while until she sold her stock to a group of merchants. Josias Dewye, a relative of Mary Cordwell and a partner in the gunpowder works at Temple Mills, Essex, probably headed the group of fellow merchants who gained control over the mills. It is probable that this group operated the mills from late 1650, although the earliest documentary reference to their presence is a petition of March 1653 requesting an advance of £200 to build another drying stove, after one had blown up in the previous year. It was around this time that the works underwent another large expansion with the addition of a set of mills later known as the Middle Works. They lay to the east of the original works on Blacksmith Lane and by the 1670s comprised four incorporating mills and other buildings. Their construction represented a significant investment in the mills, their machinery and associated watercourses. To power the mills a new millrace about 1.5 km in length, shown later as 'New Cott or New River' (referred to hereafter as 'New Cut'), was dug along the southern side of the valley from Postford Pond.

Dewye obtained a new contract from the Ordnance Office in February 1653, but in the following month Vincent Randyll wrote to the Board of Ordnance informing them that the merchant's lease had expired, and that he was seeking a contract in their place. To operate the mills he entered into a partnership for twenty-one years with George Duncombe and John Woodroffe. Both were from local landed families, but lacked any experience of gunpowder manufacture. They sought this expertise from an agent William Wyche, but there were obviously problems, and there are no records of the supply of gunpowder to the Ordnance by Wyche. However, in January 1655, Wyche was summoned to appear before the Admiralty Commissioners to explain why his powder was of such poor quality, he claimed in his defence that he was no longer engaged at Chilworth.

In June 1655 the partners brought in a fourth member, Colonel Grosvenor, who had served in the Civil War, perhaps in the hope that with his connections with the army that he could bring in more orders for the mills. In 1657 the partners received a contract for the reworking of decayed powder, but when proof tested a high percentage failed, which probably explains why the partnership didn't secure any more contracts during the late 1650s. A number of documentary references also seem to indicate that Josias Dewye retained an association with Chilworth until he took over the Carshalton gunpowder mills in 1661. There is the suggestion (Fairclough & Crocker, in preparation), that Dewye may have continued working the new Middle Works, while the partnership operated the Lower Mills, on Blacksmith Lane and the Upper Mills, at Postford Pond, as a separate concern.

From the time of the restoration of the monarchy in 1660 no further mention is found of the other partners and Vincent Randyll appears to have worked the mills alone. His next contract for the supply of gunpowder was not signed until 1 February 1665 in the lead up to the Second Dutch War (1665-1667). Perhaps due to problems in bringing the mills back into working order, he only supplied about ten per cent of the Ordnance's needs. After the end of the war the call for gunpowder experienced a periodic downturn and the works was occupied in reworking old powder and saltpetre refining. From 1670 demand for new powder began to rise, in particular from 1672 with the outbreak of the Third Dutch War (1672-1674). During this conflict the Chilworth works once again became one of the most important suppliers to the Ordnance Office, when Randyll agreed to supply 900 barrels a month, jointly with Richard Richardson of Hounslow.

In February 1672 Vincent Randyll negotiated an agreement with the Ordnance Office to rent the mills for eleven years to manufacture gunpowder. The reasons for this agreement are unclear, the government may have wished to secure the future of one of the most important gunpowder works in England. They might also have been concerned

about Randyll's age, and perhaps, failing health, for in December 1673 he died and production halted, the mills then remained idle until 1677 (for above *see* Fairclough and Crocker, forthcoming).

The late seventeenth century

Gunpowder production at Chilworth was revived in 1677, stimulated by conflict with France. In that year, Sir Jonas Moore, the Ordnance surveyor, reported that at Chilworth there were seventeen overshot watermills in very good condition, capable of producing 1,000 barrels of gunpowder per month. He also noted the favourable location of Chilworth, which was able to continue working both through dry periods and great frosts, and was well placed to deliver powder to London and Portsmouth. Sir Jonas described the mills in some detail (quoted by Crocker and Crocker 2000, 25-7). The Lower Works, which were situated on Blacksmith Lane and to its west, comprised Chilworth Mill with two troughs and Copps Mill with two troughs. Below these, moving westwards, were a mill for grinding coal and brimstone (sulphur), Wood Mill and Dust Mill each with two troughs, Double Mill with three troughs, and Chattering Mill and Shifford Mill each with two troughs.

Also in the Lower Works were two storehouses, a dwelling house and a 'square convenient by place where all Offices for refining Salt Petre, and other Labourers about Corning and making Powder are built'. In the Middle Works were Lower Mill with three troughs (blown up), The Cole and Brimstone Mill, and three mills each with three troughs, Midle Mill, Randills Mill (blown up), and Upper Mill. The Upper Works he described as 'once a Compleat Work of itselfe, had its watch-house, Stove, and Corning-house, and wanted nothing but a Coale and Brimstone Mill'. In addition to two watch houses there were six mills, each with three troughs. Two, Twist Mill and Lower Mill, were on Mr Randill's (Randyll's) ground. The first on the parson of Aldbury's ground, was noted as being blown up, two other mills described as the second and third, also lay on the parson's land, and Upper Mill was on Mr Randill's ground (Crocker and Crocker 2000, 25-7).

Probably in response to that survey, Sir Polycarpus Wharton and John Freeman, both of whom were closley associated with the industry, took a twenty-one year lease on the Chilworth mills. Wharton was the son of a Board of Ordnance official and operated a powder works at Wooburn, Buckinghamshire. Freeman, was a London merchant who had supplied gunpowder to the Ordnance Office from 1644, and from the 1650s had manufactured gunpowder at Sewardstone, Essex. There is, however, the suggestion that after a number of years of idleness the Chilworth mills were not in as good condition as described and Wharton later claimed he had to spend £1,500 on repairs.

John Freeman died in 1684, in his will he left Sir Polycarpus his share of the stock at Chilworth. In addition he left, Wharton's son, also Polycarpus, his gunpowder mills on the River Lea at Sewardstone, Essex and Naked Hall, Enfield, Middlesex. The son was a minor so the father took over the mills in trust until his son came of age. A survey in 1687 by the Board of Ordnance (recently constituted in 1683) confirmed Sir Polycarpus as its principal supplier and Chilworth as the largest gunpowder works in England. Regardless of his pre-eminence he was experiencing serious financial troubles over his late father's accounts when he was treasurer and paymaster to the Board of Ordnance and over his own contracts for the supply of gunpowder. These were partly solved by a payment of £2000 by the Board of Ordnance in December 1687. He evidently invested some of the money in three new incorporating mills at Chilworth.

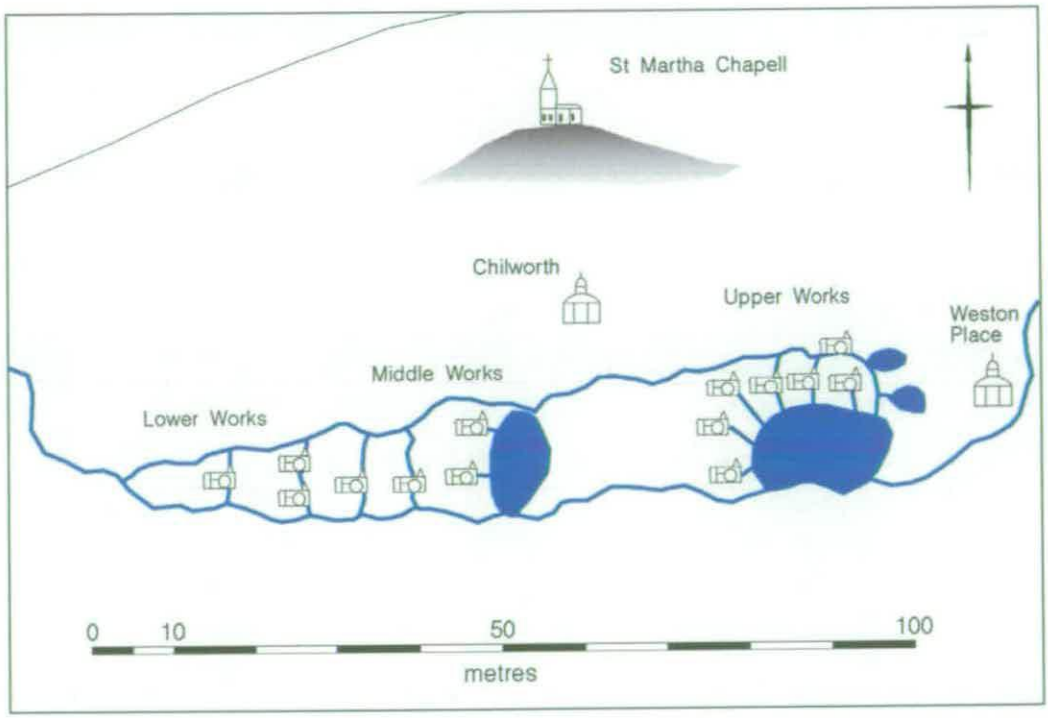


Figure 1
Chilworth gunpowder works around 1690 (after John Sellers)

John Aubrey provided a description of the mills around this time (*see* Figure 1).

> In this little pleasant Valley, the Springs serve not only to water the Grounds, but for the driving of 18 mills, 5 whereof were blown up in a little more than half a Years time. 'Tis a little Commonwealth of Powdermakers, who are as black as Negroes. Here is a nursery of Earth of the making of Salt-Petre. There is also here a Boyling-House, where the Salt-Petre is made, and shoots: a Corneing House, and separating and finishing Houses, all very well worth the seeing of the Ingenious. I had almost forgot the Brimstone Mill, and the engine to search it. *History of Surrey* (vol 4, 1718-19, 56-57)

During the 1690s Sir Polycarpus continued to be beset by serious financial problems. He claimed that they were largely caused by the

failure of the Board of Ordnance to provide enough money to pay his rent and charges, and by it not meeting its contract to purchase the agreed number of barrels of gunpowder. Records indicate that Sir Polycarpus was supplying gunpowder until at least 1697, when the Treaty of Ryswick brought The War of the League of Augsburg, (1688-1697) to an end. Perhaps because of the increasingly deteriorating relationship between Sir Polycarpus and the Board of Ordnance, his lease was allowed to expire in 1698. At this time the Chilworth gunpowder works was the largest in country, comprising three separate sites, The Lower Works, The Middle Works, and The Upper Works, with a productive capacity of 1200 barrels of gunpowder per month. The end of the lease did not mark the end of his financial problems and in 1701 he claimed that the Board of Ordnance had charged him with arrears of £9573 6s 6d, while he had suffered losses of £24,000 on his lease of the Chilworth mills. So serious were these debts that in 1710 he was thrown into a debtor's prison. Correspondence carried on without resolution between the two parties until at least 1723, his exact date of death is unknown, but it was before 1741.

The early and middle eighteenth century

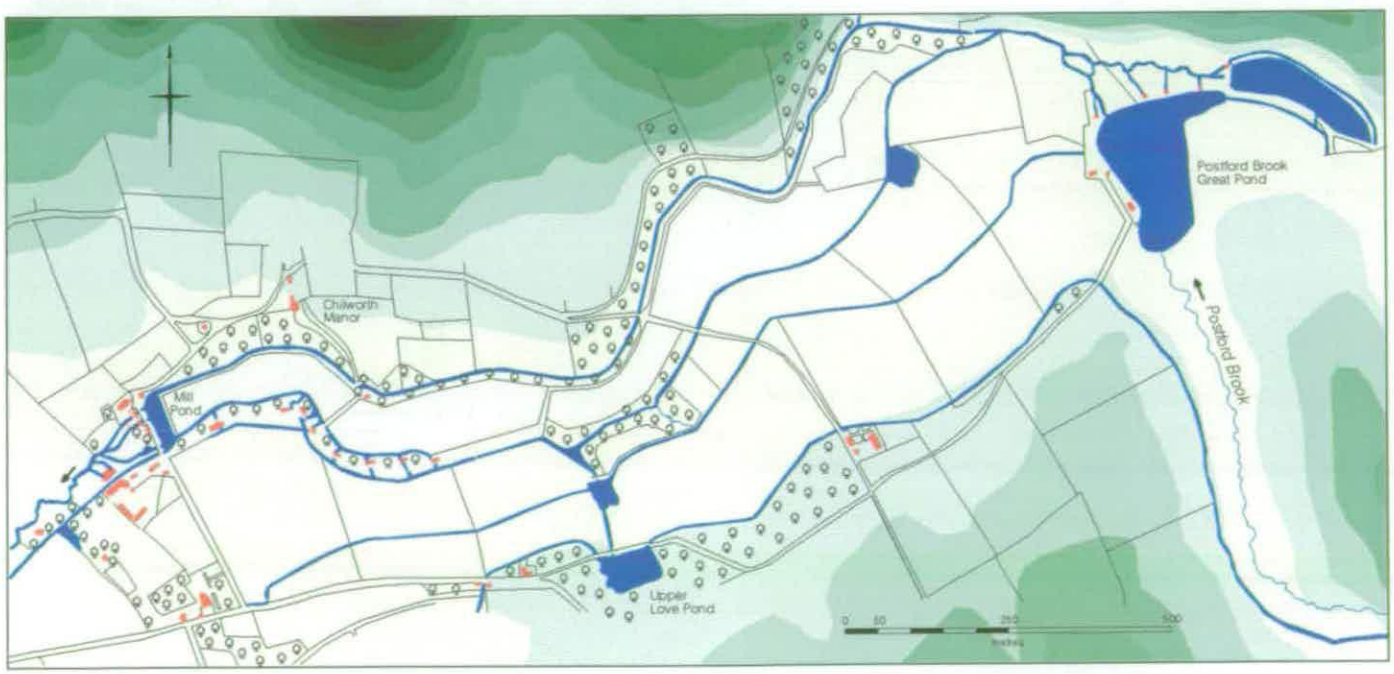


Figure 2 *Chilworth gunpowder works 1728 (By permission of the British Library, Althorp Papers P4)*

Given both the importance of the works and outbreak of the War of Spanish Succession (1701-1714), marking a periodic upturn in the

demand for gunpowder, its history during the early eighteenth century is surprisingly sketchy. Francis Grueber, the son of a Huguenot immigrant and one the country's largest gunpowder manufacturers, was recorded in the Chilworth area in 1716 and took out a lease on the mills in 1719. It is probable that Grueber had managed the Chilworth mills prior to that date, but it is also possible that they were operated by Samuel Shepheard from 1705-1714, when he was recorded as a supplier to the Ordnance but without any known mills. It is also likely that the Upper Works was kept in use until the end of the War of Spanish Succession (for above *see* Fairclough 1996). From its prominence at the end of the seventeenth-century, a survey undertaken in 1728 revealed a diminished works. The Upper Works was described as derelict, the Middle Works had just four working incorporating mills, corresponding with the four mills shown on a 1728 map (Althorp Papers P4). Furthermore, in 1704 the Lower Works, along the Blacksmith Lane causeway had been converted to manufacture paper.

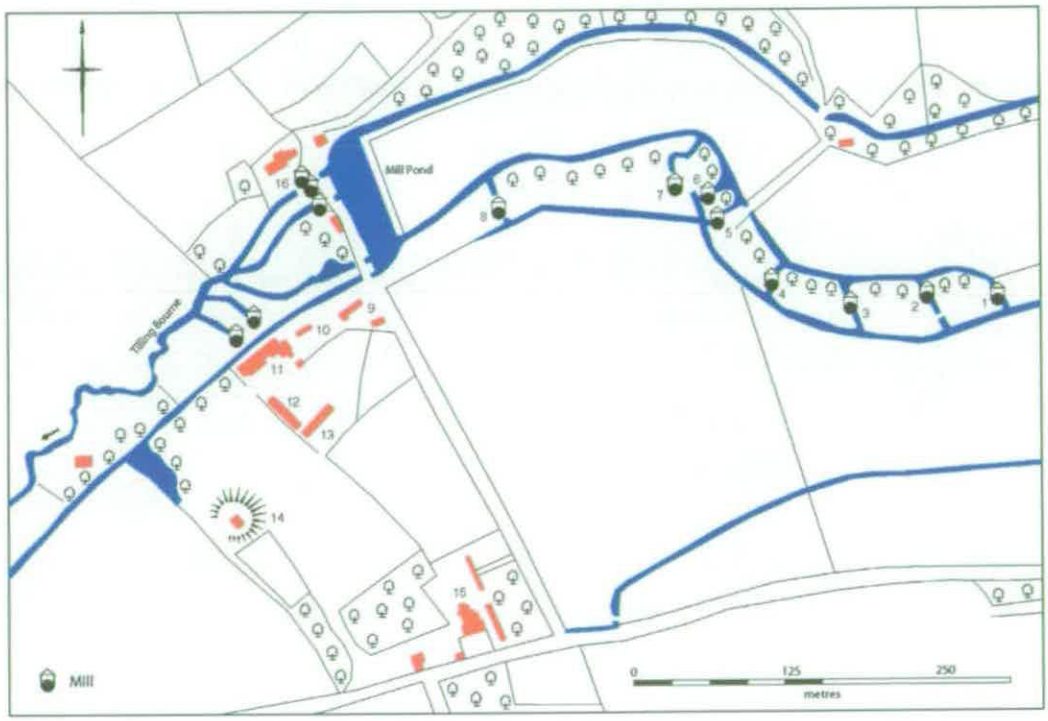


Figure 3 Chilworth, 1728, detail of the Lower and Middle Works (By permission of the British Library, Althorp Papers P4)

1	Powder Mill	2	Powder Mill	3	Powder Mill
4	Powder Mill	5	Powder Mill	6	Coal & Brimstone Mills
7	Charcoal House	8	Corning Mill	9	The Cooper's Shop
10	The Workhouse	11	Saltpetre Boiling Shop		
12	Saltpetre Earth House	13	Workhouse	14	Stove
15	Dwelling House				

In 1728, a survey was undertaken of the land owned by the Duchess of Marlborough at Chilworth and in adjacent parishes. This map which is preserved at the British Library (Althorp Papers, P4) is the earliest detailed representation of an English gunpowder works (Figure 2). It also provides a very clear picture of the form of the works, which essentially remained unaltered from this date until the massive expansion of the late nineteenth century. By 1728 the works had contracted back to what was known as the Middle Works (Figure 3). In essence they were divided into two by Blacksmith Lane, then known as Paper Mills Lane. To the west of the lane was the Great Paper Mill, comprising a dwelling house, the mill powered by three water wheels, the drying house and a rag store. The Little Paper Mill was located to its west along the south side of the valley, probably occupying the position of at least one of the former powder mills. Its water wheel was fed by a leat from the east and by one flowing from the opposite direction, which collected water from the streams used to flood the fields. Associated with this mill was a drying house (Crocker and Crocker 2000, 41-47), which survives as a pair of cottages.

To the east of the lane were the water powered gunpowder mills and other process buildings, at the eastern end a proposed mill was shown, to its west were four powder mills, a charcoal and sulphur mill, a charcoal house, and corning mill. The buildings to the west of the lane were primarily associated with the preparation of the raw materials. In this area was a cooper's shop, saltpetre boiling house, saltpetre earth house, workhouse, gunpowder drying stove, watch house, and a dwelling house. The paper works on the Lower Works site continued in use as such in 1728. By this date the Upper Works were derelict, but the positions of the four mills on the northern side of Postford Brook Pond and an additional mill on the outflow, from Pens (now Waterloo) Pond were shown.

Around the time of the 1728 survey, Francis Grueber was working in partnership with Thomas Coram (1668-1751) a former ship owner, who is better known for the establishment of the Royal London Foundling Hospital in 1739. In addition to the Chilworth mills Francis also manufactured powder at Faversham, Kent. Grueber's business had been running into financial problems and it is probable that Coram was brought in to clear its debts and bring in his business expertise. He was ideally placed in London to meet with government officials, acquire saltpetre for dispatch to Chilworth and Faversham and to attend the proofing of powder at Greenwich. The partnership was short-lived and after Francis Grueber's death in 1730, Coram broke his association with the partnership. Grueber's widow and son, also Francis, inherited the business, but it was in financial difficulties and may have even stopped production.

Meanwhile, Chilworth manor had passed from Vincent Randyll on his death in 1673 to his son Morgan. In 1720 he sold it to Richard Houlditch,

a director of the South Sea Company. When it failed his assets were seized, including the manor, and in 1723 Sarah, Duchess of Marlborough purchased the estate. John Spencer, her grandson, inherited the manor on her death and it remained in the Spencer family until 1796 when it was sold to Edmund Hill, a gunpowder maker from Hounslow, Middlesex. After Hill, John Fish owned it for a short time between 1810 and 1812, before it was sold again in 1813 by his executors to William Tinkler, who had leased the mills since 1790. The estate then passed to his son, also William, and remained in his hands until 1845 when he sold it to Edmund Drummond. As part of the marriage settlement of Drummond's daughter to Lord Lovaine, later 6th Duke of Northumberland, the manor became a part of the Northumberland estate until it was sold at auction in 1922 (Crocker 1984, 12).

By autumn 1731 Thomas Pearse had acquired the Chilworth mills. In 1733 Francis Grueber sold him the gunpowder mills along Faversham Creek and, two years later, his remaining interest in the magazine on Barking Creek, Essex. Thomas Pearse was a Commissioner of the Navy Board in 1729 (Crocker *et al* 2000, 85), he died in 1743, and was succeeded by his son, also called Thomas and another Navy Board official; it appears that father and son were involved in the management of the works.

In 1740 Pearse renewed the lease on the works for another 21 years. This also marked a cyclical upturn in the mills' fortunes with the outbreak of the War of Austrian Succession (1740-1748). During the conflict, Pearse and his partner William Stevens, who joined him in 1746, were recorded as supplying about 30 percent of the powder supplied to Board of Ordnance, although some would have also been delivered by his Faversham works. After the end of the war in 1749 they also received a large contract for reworking unserviceable powders. In 1753 Pearse and Stevens were joined by a third partner Benjamin Pryce.

One consequence of the new partnership was that a detailed inventory was made in 1753 of all the company's assets (Crocker *et al* 2000, 104). At Chilworth it listed all the buildings and their contents, providing a rare glimpse of the technology of gunpowder manufacture in the mid-eighteenth century. It listed, for example, the number of millstones within a mill and associated fittings. In the corning house, where the powder was forced through different sized sieves, a shaking frame, which held the sieves, was noted along with a press, although its place in the production process is still uncertain. The use the press was put to is unclear and remains a source of much discussion amongst gunpowder historians. By the nineteenth century pressing was used to increase the density of the powder and to compact the three ingredients (saltpetre, charcoal, and sulphur) together to prevent separation during transportation. But by this time corning or granulation was generally

done by means of rollers rather than the corning sieves. In the mid-eighteenth century the press may have been used to compact dust produced during the corning process for re-corning.

By 1754 Thomas Pearse was in severe financial difficulties and assigned his estates and effects over to Benjamin and Edward Pryce. Benjamin was recorded as supplying gunpowder from 1755 until 1759, when he sold the Faversham mills to the government, and from that date Edward Pryce supplied gunpowder from Chilworth until the end of the Seven Year War (1756-63), but by 1765 the mills were in disrepair. In 1766 he entered into a new partnership with Isaac Dent and later negotiated a new lease on the mills which began in October 1768. From 1780 Dent was working alone and operated the mills until his death in 1790 when he left the business to his manager William Tinkler.

The late eighteenth and early nineteenth centuries

A fascinating insight into the management of the mills in the late eighteenth century is provided by the William Tinkler 1790-1791 letter book, or copies of correspondence, held at the Surrey History Centre (G.132/1). They may be broadly divided into three groups: letters relating to his role as Dent's executor; correspondence with customers or their representatives; and notes concerning the management of the business, the latter group offering useful asides on the mills and manufacturing process (Crocker *et al* 2000, 106-165). Due to uncertainties about his tenure, Isaac Dent had carried out little maintenance work and when Tinkler came into possession of the mills in 1790 there was a considerable backlog of repairs to be undertaken. Many of the earlier letters refer to the restoration of the works, including the employment of masons to refurbish the edge-runners and to the repair of a bedstone. Letters also refer to the repair of a gudgeon and a water trough at the new mill and the lower mills, and the ordering of horse hides, perhaps to renew floors. Another one noted the construction or repair of a barn. He gave advice on the repair of the water wheel at the corning house, the type of mortar to be used in water troughs, the kinds of sieves to be used in making different types of powder, and how to make good charcoal. In addition to the repairs, a new mill was also erected in 1790 (Crocker 1984, 6).

Tinkler was also concerned to keep up-to-date with new developments and instructed his manager at Chilworth, Mr Harrison, to find out about by the new method being used in the Royal Gunpowder Factories to manufacture charcoal. This was the technique developed by William Congreve during the 1780s to produce charcoal in iron retorts rather than earthen clamps. The process allowed a uniform charcoal to be obtained, which in turn produced a more powerful and consistent gunpowder (Cocroft 2000, 43-46). By 1813, a cylinder house had been erected in the raw materials processing area to the west of Blacksmith

Lane. A building for refining brimstone (sulphur) was also been brought into operation at Chilworth around this time, probably in response to the increased attention being paid to raw materials processing at the government factories. The main manufacturing area to the east of Blacksmith Lane, known as the Middle Works, now comprised five incorporating mills, each driven by waterwheels 24ft (7.4m) in diameter and 3ft (0.91m) wide, a brimstone house, corning house, dusting house, charcoal house, and a watch house (Crocker and Crocker 2000, 77-78).

In 1791, Charles Ball, from a Northamptonshire paper making family, took over the Chilworth paper mills in association with Captain Wilcocks, with whom he worked until 1793. At this time he set up a new paper mill at nearby Albury, using a former corn mill. In the first decade of the nineteenth century two new paper mills were built at Postford Pond, which had been devoid of mills for nearly a century. The mills were managed by his sons, Charles, Edmund and Richard. To the south of Dorking Road he also built Postford Hill, now Postford House (TQ 0394 4762). One mill was sited at the head of Postford Pond and the other to its north below Paynes Pond, also known as Pens Pond (now Waterloo Pond) (Crocker and Crocker 2000, 62-73). From 1803, Hugh Rowland, sometimes in partnership with others, worked the Chilworth Great and Little Paper Mills on Blacksmith Lane. The Great Paper Mill was powered by a breast-shot waterwheel 17ft (5.2m) in diameter and 8 ft (2.4m) wide, internally it had two vats, two beating engines, and drying lofts over the mill; close by were sizing, rag and cart houses, and a stable. The Little Paper Mill was powered by an overshot wheel 17ft (5.2m) in diameter and 7ft (2.1m) wide, and comprised two vats, two beating engines, a sol (or finishing room) and drying lofts. The mills were either brick and tiled or boarded and tiled (Crocker and Crocker, 2000, 74-6). In the early 1820s Hugh Rowland also worked one of the Postford Pond mills, but by the end of the decade he was bankrupt, although his son appears to have carried the business on for number of years. After Hugh Rowland and his son left in the early 1830s, the Little Paper Mill appears to have gone out of use. Subsequently the mill was demolished but its drying house was converted into a pair of cottages, ***The Old Cottage*** and ***Rose Cottage*** survive. The Great Paper Mill, however, appears to have been re-equipped to manufacture machine-made paper and when it was opened by Edward White in 1836 it was described as a new mill. A sale notice, which appeared in the *London Gazette* in 1855 described the mill as being brick-built, with a slate roof and strongly timbered. Two 17ft (5.2m) diameter waterwheels drove the mill, as well as washing and beating engines, they also powered two hydraulic presses used during the finishing processes. Surrounding the main mill was a foreman's dwelling, rag house, rag dusting room, drying loft with ventilating sides, boiling house with team raising plant, a smith's shop, a principal residence and many other ancillary buildings. The paper mills ceased operation in 1870 and were bought shortly afterwards by the Unwin Brothers, a London printing firm, who

proceeded to convert the mills into a print works (Crocker and Crocker 2000, 88-92). This factory was destroyed by fire on 26 November 1895 and its site now forms part of the garden of Old Mill House. It was probably shortly afterwards that the Hambledon Rural District Council built a turbine-powered pumping station to the south of Waterworks Cottage and a smaller pump house on the site of the printing works in the grounds of Chilworth Old Mill. These were used to pump water up to a reservoir high on the hillside below St Martha's church.

During the 1830s the Postford Pond paper mills underwent a radical transformation. The Upper Mills below Postford Pond were dismantled and automated Fourdrinier papermaking machines were installed at Postford Mill, marking the end of hand papermaking at Chilworth. Some of the materials from the Postford Pond mill may have been reused in a new mill (TQ 0394 4773) which was built on a tributary of Postford Pond to the south of the A248 Dorking Road. During the 1850s, a succession of owners were forced into bankruptcy and in 1865 the mills were auctioned on the orders of the Sheriff of Surrey. The notification of the sale provides a detailed description of the mills at this date. It had two ten horse power high-pressure vertical steam engines, six rag engines, a 60-inch papermaking machine with three stuff chests and a cutting engine, a 52-inch papermaking machine and other machinery. It had two waterwheels 12ft (3.66m) in diameter and 11ft 6ins(3.50m) wide. At the mill, close to Postford House, was a 17ft (5.2m) diameter 6ft (1.8m) wide water wheel, which drove two washing engines. This mill probably ceased operation at this date, its use in the late nineteenth century is unknown, but around 1920 a water turbine replaced its waterwheel and the mill was converted into a saw mill; the mill and the turbine survive.

By the early 1870s, Postford Mill had undergone considerable modification to manufacture a patent felted furniture fabric, made from animal and vegetable fibres macerated in rag and beating engines, and chemically treated before being fed through paper rollers. The mill now had three waterwheels, which were capable of generating 70 horse power and two steam engines rated at 120 horse power. The mill was also fitted with steam-powered lifts to link the floors and a suspended overhead railway on each floor, which was equipped with points and turntables. Despite these extensive alterations the business was in liquidation by 1876 (Crocker and Crocker 2000, 82-88). It was subsequently used as a flock mill, where woollen rags were torn to produce stuffing for mattresses and furniture, but it was destroyed by fire in 1886 (Crocker and Crocker, 2000, 126). In 1909, Postford Mill later known as Albury Mill, below Postford Pond, was taken over by the Botting family, corn millers, who installed new roller milling machinery. This mill and its machinery survived until the early 1990s when it was demolished and its site cleared for offices and a housing development.

In 1819 the gunpowder mills were leased to John Sharp who was later joined by his brother Thomas and then by John's son Samuel, the

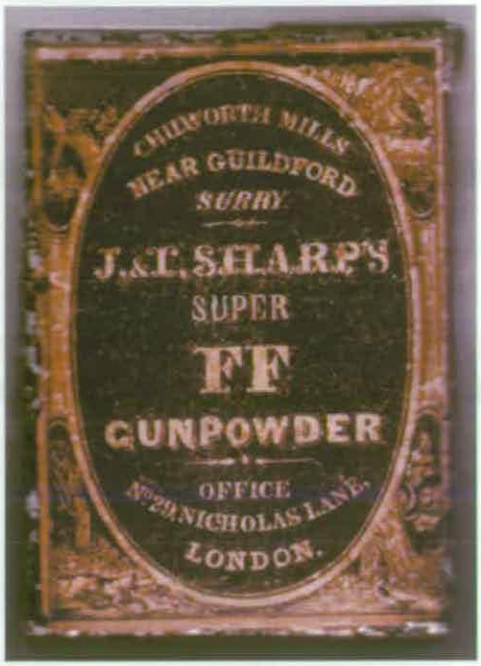


Figure 4
J & T Sharp's powder tin (c) Jim Buchanan

company subsquently traded under the name of J T & S Sharp (Figure 4). The quantities of powder sent up to London were recorded in the Wey Navigation records, and they show an increase during the Crimean War (1854-56), and beyond, into the 1860s. This later rise may perhaps be attributed to the introduction of the steam-powered mills, which were in operation by 1865 (Crocker 1984, 11-12).

In 1875 a new Explosives Act was passed, one of its requirements was that all existing explosives factories should be issued with continuing certificates, Chilworth was given certificate No.11 on 20th March 1876. Two amending licenses were issued to Marcus Westfield between 1876 and 1883, indicating that some alterations to the works were carried out at this time (Explosives Inspectorate 1883, 3). The mills remained in the Sharp family until 1881 when they were sold to Charles Marcus Westfield, at that date they were one of 28 gunpowder mills working in Britain (Guttmann 1883, 455).

New owners, new directions 1885-1914

In 1885, Marcus Westfield sold the works to the newly formed Chilworth Gunpowder Company and became one its directors. This sale marked a fundamental change in the ownership and organisation of the factory. No longer was the business run by an owner manager; instead it was now a limited company answerable to shareholders. One of the consequences of the new ownership was that large sums of money - the company had a share value of £100,000 - were available to invest in the works.

The transformation of the works in the late nineteenth century may be directly attributed to the enormous increase in the propellant charge sizes required for military ordnance. The largest gun in British service in the late 1880s, the mammoth 110-ton breech-loading gun, required a charge weighing up to 800lbs (363kg) of gunpowder to disgorge its 2,000lb (907kg) projectile. Such large charges presented many challenges to both the gun and powder makers. The powder makers needed to design an explosive that was both relatively slow burning and which would exert a consistent pressure on the projectile as it travelled up the barrel of a gun. If standard powder grains were employed in very large charges, there was the danger that the whole charge would ignite

at once, perhaps shattering the gun. Conversely, part of the charge might be expelled from the barrel unburnt. A scientific law established in the early nineteenth century by a Frenchman, Piobert, stated that an explosive burns on its outer surface and recedes inwards as it burns, similar in effect to peeling the skins from an onion. Using this law, it was possible to moderate the rate of burning by varying the surface area to mass ratio of the powder.

An empirical understanding of this principle had been known since at least the eighteenth century, and generally slower burning large grain powder had been selected for cannons and faster burning fine grained powders for pistols and muskets. The development of larger guns in the late nineteenth century led to new experiments. In place of loose grains, powder was moulded into a variety of shapes, including small spheres, pellets, and prisms. Alternatively, slabs of pressed powder were cut to form cubes, known as pebble powder and this type was favoured by the British during the 1870s. By the late 1870s a typical piece of prismatic powder was hexagonal in shape and might measure 40mm from corner to corner and stood 25mm high. It was pierced by a single central hole 9.5mm in diameter at its base and tapering to 9mm at its summit. To assemble a charge the prisms were carefully stacked together allowing the ignition flame to be transmitted up the central channel. As the prisms burned the ratio between the surface area and mass remained fairly constant, allowing a consistent pressure to be exerted on a projectile as it travelled up the barrel of a gun.

In the early 1880s two German powder makers Johan Nepomue Heidemann of the *Vereingte Rheinische-Westphalische Pulverfabriken*, Cologne and Max Duttenhofer (1843-1903) of the *Rottweil Pulverfabriken*, near Hamburg developed a new type of prismatic powder. To further moderate the burning rate of the prisms they substituted lightly charred rye straw for wood charcoal. This had a further advantage in eliminating the minute air pockets left in even the most finely crushed charcoal, which could act as burning surfaces within the powder. The resulting powder was termed 'brown' or 'cocoa' powder. In the early 1880s Heidemann and Duttenhofer were invited by the British government to instruct the Royal Gunpowder Factory, Waltham Abbey in the manufacture of prismatic powder and by 1885 brown powder manufacture had begun there (*see* Cocroft 2000, 77-83). Such were the benefits derived from this new type of powder that virtually every government adopted it for use with large bore guns.

An assured supply of brown prismatic powder was now of vital strategic importance and provided a new commercial opportunity for its inventors. The ascendancy of German powder makers was widely recognised and in May 1888 *The Standard* stated 'in the development of gunpowder Germany has for some years past shown a tendency to go in advance of England' (SHC G132/5/6). In 1885, The Chilworth Gunpowder Company

Limited was formed to manufacture brown powder specifically for the British government and the colonies. Such an arrangement provided an entry into the British market for the German manufacturers, while safeguarding their established continental interests. The list of directors for The Chilworth Gunpowder Company Limited given in the 1885 share prospectus (SHC G132/3) provides an interesting insight into the links that were being forged between the explosives and armaments makers across Europe. The chairman, Lord Sudeley, was also a director of Sir William G Armstrong, Mitchell and Company, and investors were assured of the large contracts which would be forthcoming from Armstrong's. Four of the board members were either board members, or directors, of German powder works, which had in turn links with the giant armaments firm of Krupp and to the Nobel companies. Also on the board was Edward Kraftmeier, a merchant, who was the London agent of the German powder makers and machinery manufacturers, and had close links with the Nobel companies through his directorship of The Alliance Explosives Company (BT 31/14780/20308; PRO Supply 5/789).

In addition, to cocoa powder by the late 1880s the Chilworth Gunpowder Company had also developed what was described as 'Chilworth Special Powder' for use in quick firing guns (SHC G132/5/10 and 11). The recommendation for its use by both Armstrong's and Krupp's illustrates the close links between the armaments manufacturers and the powder maker fostered by its board members. The Italians also carried out trials of this powder on their ship *Piemonte*.

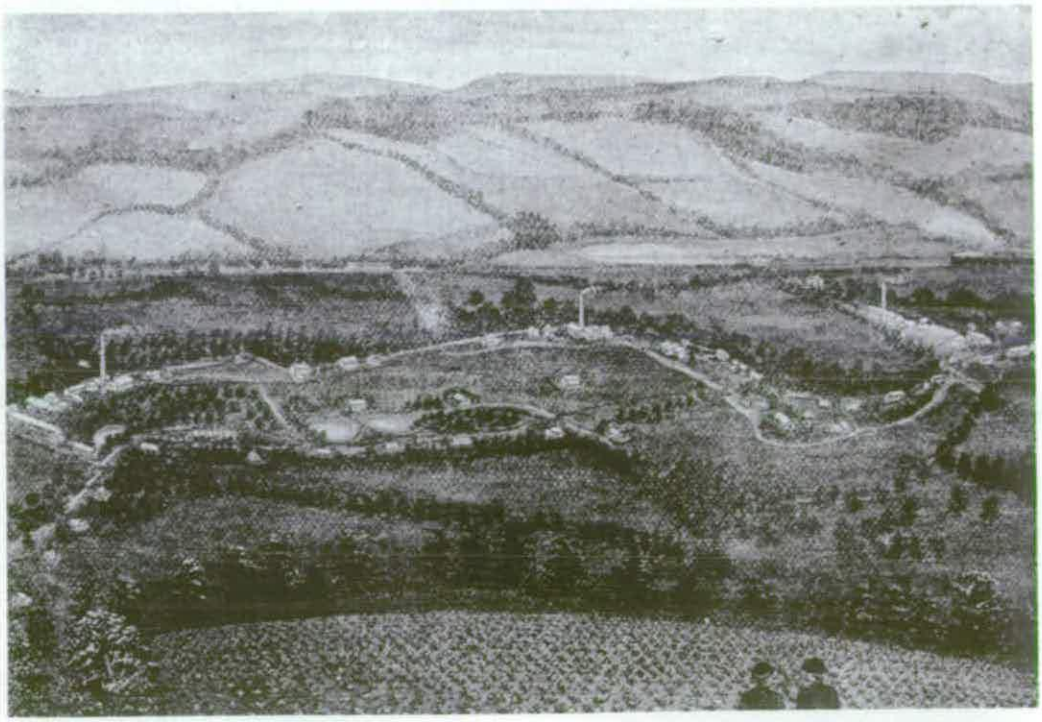


Figure 5
Chilworth 1887, looking south from St Martha's Hill, from Wyman's Encyclopedia, London By permission of the British Library

Under the leadership of the new company the works was extensively remodelled, becoming the second major supplier of gunpowder to the British and colonial governments, second only to the Royal Gunpowder Factory Waltham Abbey (Wyman's 1887, 297-8) (Figure 5). Soon after its establishment in 1885, the company quickly commenced rebuilding the factory and its transforming it into one of world-class standing. It was so successful that further extensions were necessary through the late 1880s and into 1890 (SHC G132/4/5 and 7). Some, or all, of the building work was undertaken by the Dove Brothers of Islington. In 1888 it was recorded that they had built a new factory and magazines at Chilworth to the value of £2,095 (Braithwaite 1981, 24). It is unclear if this refers to one of the additional building programmes, or the whole building project. By late 1885, it was producing brown powder and reached full production in March 1886 (SHC G132/4/3). Amongst the many technological innovations introduced by the new firm were steel suspended edge-runner incorporating mills (Figure 6). A Friederick Krupp Grusonwerk catalogue from 1894, which survives in the Hagley collection at Wilmington, Delaware, confirms that six mills were supplied to Chilworth in 1885 (Eleutherian Mills, Hagley, pamphlet vol.35 no.5). Their design allowed the edge-runners to safely rise up and over any obstructions on the powder bed. This arrangement would later permit the amounts of powder to be milled at any one time to be greatly increased, ultimately reducing the number of mills required. Another technological innovation, probably influenced by the German associations was the introduction of cam presses. These were employed to mould the brown powder into hexagonal prisms for use in large artillery pieces. Cam presses, which were devised by the Russian, Professor Wischingratzki, had been widely used in continental factories since the 1860s, but they were rare in Britain where hydraulic presses were more commonly used. In a cam press, the compression was applied by means of a cam or eccentric on a shaft driven by water or steam power. They worked automatically, and very rapidly, pressing six prisms at a time. It was claimed that they produced a superior prismatic powder, due to the enormous pressure exerted in short space of time. The resulting prisms displayed a very hard, smooth finish, which had the practical effect of reducing the initial pressure on ignition compared to prisms produced by hydraulic presses which had a rougher finish. Four cam presses were set up at Chilworth

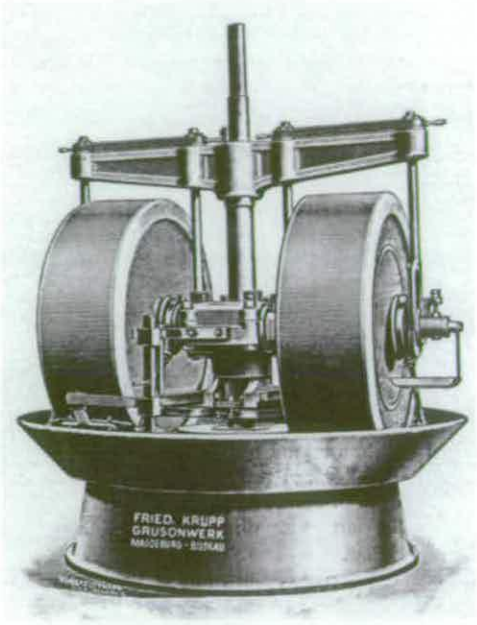


Figure 6
Late nineteenth century suspended edge-runner gunpowder mill

in 1886; a year before those at the Royal Gunpowder Factory, Waltham Abbey were installed (Cocroft 2000, 82).

New standards were also set in the manufacture of gunpowder to ensure the uniformity of the powders produced for use large bore guns. Standards of testing more usually associated with the chemical explosives industry were introduced, including a chronograph range, densimeter microsopes, a polariscope and other devices. It was probably at this time that a new test range was established to the north of ***Longfrey***, comprising a hollow (TQ 0323 4803) which probably housed the target (Ordnance Survey 1896, Surrey Sheet XXXII.2).

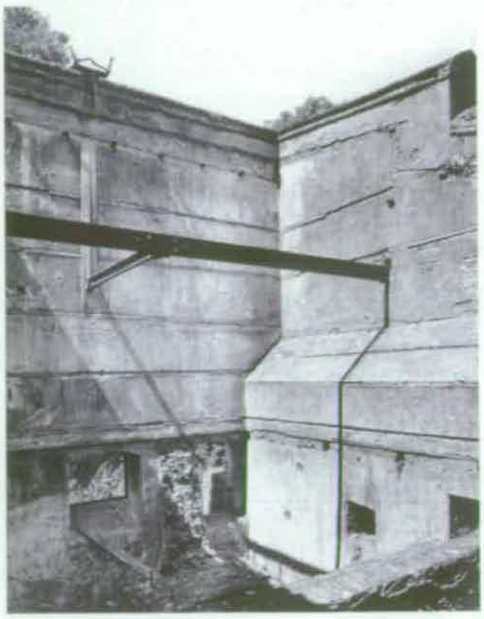


Figure 7
1880s gunpowder incorporating mills showing the Burbach steel channels (BB94/10119). (c) Crown copyright.NMR

Testing was also carried out of the raw materials and during thirteen different stages during manufacture (Wyman's 1887, 298). In addition to the new brown powders the company also continued to manufacture a variety of other military and sporting powders. For the construction of buildings they imported rolled steel channels from Germany. In the 1885 gunpowder incorporating mill, a number of beams survive marked 'Burbach 1884', and as such they are the earliest recognised surviving rolled steel channels in the country (Figure 7).

To oversee the production of the new brown powder, and to safeguard the secrets of the manufacturing methodology, the factory was managed by a retired Prussian army captain Otto Bouvier, who was described as a managing director in 1887 (Kellys, 1099). Bouvier was described as a 'genial and popular manager' by the local press (SHC G132/5/12), a quality which is evident in his photograph with the 1893 cricket team (Crocker and Crocker 2000, 117). By 1891, he was resident with his wife and six children close to the factory at the Old Manor House, Chilworth Road (Figure 8). Two German foremen, Theodor Fischer and Heinrich Wirths, were also employed. Both lived within the factory at ***Longfrey*** (Figure 30), where Theodor lodged with Heinrich and his wife Emily (PRO RG 12/573). The production of brown powder remained a closely guarded secret into at least the late 1890s, when the official War Office treatise on ammunition still described the process as confidential (HMSO 1897, 3). In addition to the production of brown powder, the factory continued to manufacture a variety of traditional black powders (Figure 9) these included fine sporting powders and coarser powder used in mining (Warner, 1975, 105).

Figure 8
The Old Manor House (BB94/10124). (c) Crown copyright.NMR

The supply of brown powder to the British and other governments provided the company with a lucrative income, producing profits of over £19,000 in 1889 (see Table 1). The new company was so successful that by 1888 it had acquired the gunpowder works of the Williamson family at Fernilee in Derbyshire (Winfield, 1996, 14). The acquisition provided new opportunities for the Chilworth workers and a number moved up to Derbyshire (Winfield 1996, 41). In a similar pattern to Chilworth the works were extensively remodelled, but this may have been curtailed in 1889 as the company became concerned by the development of new chemical based smokeless powders as rivals to its patent brown powders (SHC G132/4/7).

Figure 9
Chilworth Gunpowder Company, gunpowder cannister for Sporting Gunpowder No.4. (c) Jim Buchanan

From the middle of the nineteenth century across Europe, chemists had been searching for new chemical explosives to replace traditional saltpetre based and mechanically milled gunpowder (*see* Cocroft 2000, 129-31). This work became more urgent during the 1880s with the introduction of both small quick firing guns and large bore guns. These required propellants which were both nearly smokeless and contained more energy for a given mass. Despite the success of brown powder the German producers were not complacent, and Duttenhofer had developed a guncotton based chemical propellant known as 'Duttenhofer powder'. As early as March 1887, the Chilworth Gunpowder Company supplied samples of Duttenhofer powder to the

	Profit*	Dividend
1st Annual Report year ending 31-12-1885	£944.17s.2d	
2nd Annual Report year endin 31-12-1864	£4,702.1s.0d	6%
3rd Annual Report year ending 31-12-1887	£11,314.12s.9d	10%+5% bonus
4th Annual Report year ending 31-12-1888	£14,903.15s.7d	10%
5th Annual Report year ending 31-12-1888	£19,300.32s.1d	10%
6th Annual Report year ending 31-12-1890	£18,143.6s.7d	10%
7th Annual Report year ending 31-12-1891	£17,692.5s.7d	10%
8th Annual Report year ending 31-12-1892	Missing	Missing
9th Annual Report year ending 31-12-1893	£853.18s.1d	10%
10th Annual Report year ending 31-12-1894	£656.12s.11d	5%
11th Annual Report year ending 31-12-1895	£3820.3s.9d	5%
12th Annual Report year ending 31-12-1896	£7,559.13s.5d	10%
13th Annual Report year ending 31-12-1897	£7,234.9s.5d	10%
14th Annual Report year ending 31-12-1898	£7,502.1s.7d	10%
15th Annual Report year ending 31-12-1899	£7,360.18s.7d	10%

Table 1
*Annual Reports and Balance Sheets *declared profit for year, may include monies carried forward from previous year (Surrey History Centre G132/4/3-16*

British government for consideration. In the following year the government established the Explosives Committee, under Frederick Abel, to investigate 'new explosives agents' – essentially smokeless powders. Duttenhofer powder was tested by this committee, but was found to be inferior to other types of smokeless powder (Mauskopf 2003, 9-10). The supply of Duttenhofer powder in 1887 by the Chilworth Gunpowder Company raises the question of whether it was being manufactured at Chilworth, or if the company was acting as an agent for its German partners.

In 1891, the company exhibited at the Royal Naval Exhibition. Amongst its exhibits were displays of new smokeless powders, which pointed to the future direction of the company (SHC G132/5/2). Nevertheless, the adoption of cordite, as the main British service propellant in 1891 (Hogg 1963, 1414), had devastating effects for the company. By 1893 profits had fallen to just over £853 and in following year fell to around £656. The board recognised that it was the end of an era and at a dinner in May 1891 the chairman, Lord Sudeley, told the workforce 'that it was a transition phase and black and brown powders would be things of the past' (SHC G132/5/12). The company quickly embraced the new technology and in 1892 began to erect the first private cordite factory in the country (Hodgetts 1909, 346). The new smokeless powder, or

cordite factory, was built to the east of the original main factory area, to the east of Lockner Farm Road, on the valley floor below ***Longfrey***. By exploiting its close links with Nobel's it was able to acquire cordite paste, a mixture of guncotton and nitroglycerine, from Ardeer in Scotland, which was then finished at Chilworth. This involved incorporating the cordite paste using the solvent acetone in a machine similar to a bread dough mixer. This mixture was then extruded by a hydraulic press into strands of the required thickness, the larger pieces being cut to length while the thinner strands were wound onto reels. The cordite was then gently heated to drive off any excess acetone vapour, which was recovered before final drying. In contrast to other explosives companies who wished to enter the cordite market, which usually involved heavy investment in chemical plant, this arrangement allowed the Chilworth Gunpowder Company to enter the cordite market with minimal expense. For the Nobel Dynamite Trust it also maintained a clear distinction between the propellant and high explosive makers. For once a company had acquired a nitroglycerine plant it had the capability to manufacture a variety of commercial blasting explosives, including dynamite, gelatine, and gelignite (Cocroft 2000, 146-7).

Notwithstanding the exemplary nature of this factory by the end of the nineteenth century, explosives manufacture was still a dangerous business. On Tuesday 12 February 1901 the black powder **Corning House** [12] was destroyed by an explosion, which resulted in the deaths of six workmen. The subsequent enquiry determined that it was probably a spark from one of the men's boots which had caused a powder cart to explode, which resulted in the destruction of the corning house (Explosives Inspectorate 1901; Warner 1976, 144). By the end of the decade, the Nobel Dynamite Trust Company effectively controlled The Chilworth Gunpowder Company. In 1910, the Alliance Explosives Company, held the bulk of the shares in the Chilworth Gunpowder Company, in turn Nobel's owned almost all the shares in the Alliance Explosives Company (BT31/14780/20380; BT31/14793/20935). The link between the two firms being formed by Edward Kraftmeier, who held directorships in both companies.

As one of the largest employers in the area, with a work force of 300-400 people, many of whom were ex-servicemen, the powder works played a prominent part in community life and took pride in itself as a benevolent employer. A photograph held by the Blackheath Cricket Club shows the powder work's cricket team in 1893, the works also had a football team and sick club. The powder works also contributed, jointly with the Unwin's printing works on Blacksmith Lane, to the construction of the Greshambury Institute (1896) in Chilworth village for the benefit of their workforces (Figure 10). William Seth-Smith (1852-1928) designed the building in arts and crafts style; it survives and is now St Thomas's church (Duckworth Gray 1985, 324). In common with most other powder works the company provided little accommodation for its workforce. The

Figure 10
St Thomas' Church, Chilworth, formerly the Gresham bury Institute (AA044465). (c) English Heritage

Old Manor House (Figure 8), formerly known as Powder Mill House, at the southern end of Blacksmith Lane, was often the residence of the owner or manager of the powder mills. The original date of this much altered house is unknown, although above the north doorway is a, perhaps, spurious date stone of 1609. In the 1720s it was split into two, half was the dwelling of the Little Paper Mills. By the nineteenth century it seems to have been a single residence inhabited by the Sharp family, and at the end of the century it was occupied by the German manager

Figure 11
Magazine Cottages (BB94/10130). (c) Crown copyright.NMR

Otto Bouvier and his family until his death in 1906. To the west of the Old Manor House is a row of cottages, known as Magazine Cottages, which were probably constructed during the 1880s (Figure 11). They were built

on the northern side of the old main road, which had been truncated by the railway by this date, and whose route had been diverted across the present level crossing . The 1901 census records a handful of other workers living scattered across the parish (PRO RG13/620). The majority must have lived in adjacent parishes or commuted from further afield by foot, bicycle, or rail.

The First World War 1914-1919

The outbreak of the First World War in August 1914 created an unprecedented and unplanned demand for explosives of all kinds. Chilworth's main products were the propellants ballistite and cordite, and various types of gunpowder. Ballistite was a smokeless powder developed by Alfred Nobel during the 1880s, like cordite it was mixture of guncotton and nitroglycerine, but used a less highly nitrated form of guncotton known as collodion.

Despite being displaced as the principal military propellant and burster charge by more powerful chemical explosives, black powder was still employed for a variety of military purposes, including burster charges for shrapnel shells, signalling rockets, as an igniter for cordite, and for charging time ring fuzes. The latter needed to be manufactured in a very carefully controlled manner to ensure that it burnt at a known rate. During the war Chilworth supplied black powder to a number of firework companies, for the manufacture of signal rockets, and finely milled powders for use in time fuzes to Armstrong Vickers, and the Coventry Ordnance Works (PRO MUN4/3186).

Across the country in the early months of the war, explosives production was principally boosted by increasing the capacity of existing factories. In the first instance this might be achieved by using plants more intensively, by extending working hours and the numbers shifts worked, all of which would leave no trace in the physical form of the factory. The workforce also grew to around 600 during the war (Warner 1976, 146). To boost production new buildings were required and in 1915 it was proposed to increase cordite production by the construction of an extension to the existing cordite section to be known as the Admiralty Cordite Factory, and a few buildings were added to the 1890s Smokeless Powder Factory. This factory covering 9 hectares (22 acres) was laid out in fields to the north of Lockner Farm and to the west of Postford Mill. Following established practice within the factory, this section was designed to finish cordite paste manufactured elsewhere. The range of buildings found in this section was therefore very restricted compared to that found in other cordite factories.

Increased wartime activity by the company was reflected in 1916 by a resolution to double its share capital to £200,000. The disentangling of the Nobel Dynamite Trust, whose commercial interests crossed the

divide of the combatant powers, resulted in Nobel's Explosives Company becoming a wholly British owned concern (Cartwright 1964, 133). With the loss of the German directors from the board, Nobel's influence on the board became more evident by 1916 with the appointment of Harry McGowan, Francis Shand and Lord Cockrance of Cults, all of whom were closely associated with Nobel's Ardeer factory. Their connections in turn linked Chilworth with an even wider circle of armament and allied explosives companies (PRO BT31/14793/20935). The allegiance of individuals in this Anglo-German concern was also tested. Some such as the London agent Edward Kraftmeier, had long associations with Britain dating back to the 1880s; in June 1915 he anglicised his name by deed poll to Edward Kay and remained on the board of directors until his death in early 1917 (BT31/14780/20308). Others, who had made their home at Chilworth, such as the factory chemist, Willi Fischer were interned for the duration, he later returned to live in Chilworth (personal communication). The son of one of the German foremen, Heinrich (by this date anglicised to Henry) Walter Wirths (born 1894 at Chilworth), died in January 1918 while serving as a mechanic in the Royal Flying Corps, and is commemorated on the Chilworth war memorial (www.cwgc.org.uk). The war also brought other social changes to the factory. Prior to the war, few if any women had been employed in the works. Women were certainly employed in the new Admiralty Factory, where a separate Women's Mess Room was provided. Some of the women formed a football team known as 'Pioneer Ladies FC, Mr Hammond's team' (Crocker and Crocker 2000, 122).

From the autumn of 1914 the factory was guarded by the Royal Defence Corps, drawn from time expired soldiers of the Queens West Surrey Regiment, who were based in a guard hut and were provided with sentry boxes around the perimeter of the site (Parker 1947, 55-6). The First World War presented the British mainland with a new menace – attack from the air. As early as 1908 a committee under Lord Esher had considered the dangers posed to the country by airships and aircraft. At the outbreak of war, they presented little threat. Contemporary anti-aircraft guns were equally rudimentary and only around twenty-six guns were emplaced across the country by August 1914 (Dobinson 1996, 15). With the first bombing raids by German Zeppelin airships in January 1915, the system was expanded and by the summer a mobile 1-pounder pom-pom gun was available to protect Chilworth. In February 1916, the whole of the anti-aircraft defence system was reorganised and placed under the control of the War Office, the defence of Chilworth falling under Eastern Command. By June 1917, Chilworth was defended by two 18-pounder anti-aircraft guns, one sited somewhere in Albury and the other on high ground to the west known as the Chantries (Dobinson 1996, 18, 30, 33). A Zeppelin airship attacked the factory on one occasion, when a number of bombs were dropped; the only casualty was a swan (Parker 1937, 105). Eric Parker, a local writer and for two and half years

commander of the factory guard, noted other measures taken to safeguard the factory from air attack. He described buildings being 'camouflaged with all the colours of the rainbow' (Parker 1937, 105) and that the local landmark of St Martha's church and churchyard was disguised with 'boughs and bushes' (Parker 1947, 66).

The inter-war years 1919-1939

Prior to the armistice of November 1918, which brought fighting to an end on the Western Front, the private explosives manufacturers had recognised that after the end of the hostilities there would be a massive over capacity in the industry. In 1918, largely under the driving force of Harry McGowan, most of the leading British explosives manufacturers joined together to form Explosives Trades Limited, in 1920 becoming Nobel Industries Limited (Cartwright 1964, 14).

On 16 June 1920 the Chilworth Gunpowder Company informed all of its employees by letter that the works were to close, and at the end of the month the company was put into voluntary liquidation. In addition to the termination of government contracts, the company also cited high taxation and foreign competition from Belgium and America. Ironically, one of the reasons for its failure was the massive expansion of the American explosives industry that had been partly subsidised by the British government to provide explosives for the British war effort. The final winding up meeting of the company took place on 27 October 1927, when it was resolved that all of its records should pass to Nobel's Explosives Company Ltd (PRO BT 31/14793/20935). The land on which the powder works stood was sold by auction in July 1922, as part of a wider sale by the Duke of Northumberland. The factory was divided into three main lots, the western raw materials area, the central section, including the former Middle Works between Blacksmith Lane and Lockner Farm Road, and the cordite factories to the east (GMR TG 460; *Surrey Advertiser and County Times* 22 July 1922). On closure many of the buildings were probably fired, the most effective way of decontaminating former explosives buildings. The works' saleable assets, which included machinery, were sold by auction, some being bought by an Argentinian company (Crocker and Crocker 2000, 122-3). Four of the gunpowder incorporating mills were dismantled and transferred to the Oare Works at Faversham, Kent, where ICI was concentrating its black powder manufacturing activities in the south of England. At the Oare Works four sets of edge-runners were reused in a new set of incorporating mills erected in 1926 and were known as the 'Chilworth' mills (Cocroft 1994, 22-6; Patterson 1995, 6). These may also have been some of the mills which were on the closure of the Oare Works in 1935, moved to ICI's new black powder plant at Ardeer in Ayrshire.

After the sale not all the process buildings were cleared and soon after the closure some were converted to dwellings, forming the core of a

small community. Many of the dwellings were either constructed from, or roofed by, corrugated iron, which gave rise to the local name of 'Tin Town'. Buildings which were converted, included the First World War Admiralty Press House and Recovery Stove at the eastern end of the factory. *Longfrey*, was by the time of the sale occupied as three cottages, the western two being held by Mr Worth, perhaps a misspelling

Figure 12
One of the process buildings [EH 18] which was converted into cottages during the 1920s (BB94/ 10097). (c) Crown copyright.NMR

or anglicisation of Wirths, (*Surrey Advertiser and County Times* 22 July 1922). To its south an unidentified process building [EH18] (Figure 12) was converted into two cottages. Mr Roach bought the central part of the factory adjacent to the tramway swing bridge [BR 16] and built a number of timber-framed bungalows (Crocker and Crocker 2000, 127). Living conditions in many of the houses were basic, most had no mains electricity or drainage and the toilets, which consisted of a bucket emptied by the council twice a week. Perhaps due to the primitive domestic arrangements other Chilworth residents discriminated against the residents of 'Tin Town'. Air photographs taken after the Second World War reveal approximately seventeen dwellings in this area, either newly built or on the site of former factory buildings. The last residents left 'Tin Town' in 1963; subsequently most of the buildings were cleared, often leaving no surface trace, except perhaps for a scatter of broken bottles and pottery (Rose 2002a and Rose 2002b).

The Second World War 1939-1945

In the summer of 1940, after invading German forces had swept across Europe to the channel ports, the invasion of Britain appeared imminent. In June, the British Expeditionary Force was evacuated from Dunkirk, minus most of its vehicles and equipment, and overhead the Battle of Britain was beginning. Fears that an invasion was at hand were confirmed by aerial reconnaissance, which showed that invasion barges were being prepared in the ports of northern France.

General Sir Edmund Ironside, Commander in Chief Home Forces, quickly prepared a plan based on a protected 'coastal crust' - a series of defences designed to hamper and delay any invading forces. If this line was broken bands of defended stop lines were to be created to further impede the German advance. Where possible the stop lines were placed to take advantage of natural and manmade features, such as river valleys, canals and railway lines, these were further strengthened by the construction of pillboxes, anti-tank blocks and other defences. The principal anti-tank line was known as the General Headquarters Reserve Position or the GHQ Line. One arm of this countrywide system stretched from Bristol to the south of London; to the south of Guildford it followed the northern escarpment of the Tilling Bourne, part of it passing through the powder works site (Alexander, 1998 15-19: Collyer and Rose 1999, 43-45).

The Tilling Bourne valley was ideally suited to delay any advance from the south, with steeply rising high ground to the north and the leats of the former gunpowder works providing further obstacles. Responsibility for construction of the fixed defences in this area was given to John Mowlem Ltd. Initially, the Army wanted standard hexagonal Type 24 shell-proof infantry pillboxes, Mowlems argued that a circular pillbox using metal shuttering would be quicker to construct (Figure 13). To cast each pillbox a floor slab 6.4m (21 ft) was laid, a circle 6.0m (20 ft) scored into the wet concrete and steel reinforcing rods pushed into it to key to the walls. The following day the shuttering and wooden formers for the embrasures were bolted together and scaffolding erected to allow wheel barrow loads of concrete to be tipped in. Internally the pillboxes were identical to the standard hexagonal Type 24 pillboxes. About twenty of these drum-shaped pillboxes were constructed by Mowlems along the River Wey and Tilling Bourne valleys.

Figure 13
Circular pillbox [M3] (AA044445). (c) English Heritage

In the eastern area of the former factory the pillboxes are standard brick faced hexagonal Type 24 infantry pillboxes. Two are sited along the track leading to ***Longfrey***, commanding the ground to the south. Another is dug into the earthwork traverse of a former factory building and a fourth is sited to the west of the site of Albury Mill on the inner angle of a leat.

Pillboxes and anti-tank blocks were sited to defend the main route ways across the valley. Blacksmith Lane could be obstructed by an anti-tank block which was covered by a now demolished fortified position in the southern end of shed adjacent to Powdermills Cottage (Alexander

Figure 14
Road Block [M4] Lockner Farm Road (AA044449). (c) English Heritage

1990). At the eastern end of the site Mill Lane was also barricaded by anti-tank blocks, which have also been removed, but one block does survive on the Lockner Farm Road (Figure 14). This obstruction was covered by a pillbox to the north-east and to the north-west by a Home Guard Section Post. This may have made use of one of the traverses from the factory and might also be associated with a series of amorphous earthwork scoops to its rear. In addition to the pillboxes and anti-tank blocks access across the valley could also be slowed down by flooding. In Mud Wood, immediately to the west of the works, the Canadian Army felled trees to create further obstacles (Alexander 1998, 100-102).

Post-War 1945-2002

By the 1950s the central part of the powder works, between Blacksmith Lane and Lockner Farm Road, was owned and administered by Guildford Rural District Council. Many of the dwellings in the small community of 'Tin Town' were still without running water and electricity and by April 1963 the final plans were in place to rehouse the tenants. A contract was also placed with Messrs Roads, Drives Construction and Surfacing Company to demolish and clear the remaining buildings on the site. After this operation was completed new trees were planted across the area. One of the few buildings to escape demolition was the **Expense Magazine** [EH 6], which was made available to the Chilworth and District Old People's Welfare Committee for the storage of firewood. It was proposed to build a youth centre on the cleared land but in March 1964 it was decided not to proceed with the scheme (SHC 5026). An air photograph (NMR11432, OS/64012, 27 April 1964, frame 087) confirms that most of the dwellings in the former powder works had

been cleared by 1964. Also by this date to the east of Blacksmith Lane a new estate, Halfpenny Close, had been built and a detached house ***Longfrey Cottage*** built on the northern side of the track leading to ***Longfrey***. The central area of the factory, in the ownership of Guildford Rural District Council, became a public open space. Around 1980, a large fishpond was excavated to the east of Blacksmith Lane in a field which by the 1960s was known as Waterworks Field. With the demise of Guildford Rural District Council in 1974, Guildford Borough Council assumed responsibility for the management and upkeep of the central part of the powder works. In addition to maintaining the footways and watercourses, in the early 1990s they funded the consolidation of the 1880s incorporating mills and the amenity value of the area was improved by the provision of picnic benches and notice boards. More recently in 2001 they have funded the restoration of the 'Packhorse Bridge' over the Tilling Bourne.

Most of the area of the works owned by Guildford Borough Council became a Scheduled Monument (Surrey 177) in 1982. This area was extended in 1999 (SM31397/01) when the land to the east containing the late nineteenth century smokeless powder works and the First World War Admiralty Cordite Factory were also scheduled (SM 31397/02) (DCMS 1999).

4.SITE DESCRIPTION

Introduction

The site of the former Chilworth gunpowder works lies 3km to the south-east of Guildford town centre. Chilworth is the most westerly of four villages situated along the Tilling Bourne valley, it is also a relatively modern creation. At the beginning of the eighteenth century the settlement comprised just two buildings, the Old Manor House at the southern end of Blacksmith Lane and a cottage on the site of the Percy Arms. The greatest concentration of structures was along the river valley representing the powder and paper mills, and on the lower slopes of St Martha's Hill to the north-east of Chilworth Manor. At the beginning of the nineteenth century the settlement had hardly altered and despite the coming of the railway in 1849 the village had expanded little by the end of the century. The only additions during the nineteenth-century had been a school, a row of terraced houses opposite the Percy Arms, and a pair of semi-detached houses at the end of Blacksmith Lane. By the beginning of the Second World War, however, there had been considerable suburban development between the Percy Arms and Blacksmith Lane and both sides of the road were lined with bungalows and houses. In addition many houses had also been built within the former powder works boundary. The expansion continued in the post-war period when the Halfpenny Close estate was built off Blacksmith Lane.

To the north the village is dominated by the steeply rising slopes of St Martha's Hill and at its summit the medieval church of St Martha's. On the southern side, the valley rises more gently towards Blackheath and Wonersh. The wide valley floor of the Tilling Bourne is an important east-west route and carries the A248 Dorking Road (formerly known as Sample Oak Lane) and the nineteenth century Guildford to Redhill railway line. The development of the through route eastwards to Albury appears to be a relatively modern creation, for in the early eighteenth century the main line of the road swung southwards towards Blackheath, on a road that retains the name Sample Oak Lane. At this time a lane led from the Percy Arms to the mills around Postford Pond, but not beyond.

Most of the floor of the valley, where the works stood, is covered by a deep, stoneless, loamy soil with a tendency to seasonal waterlogging, giving way to well-drained sandy soils on the valley sides (Soil Survey 1983). Observations during an archaeological watching brief confirmed that the valley floor is covered with silty topsoil about 40cm in depth, beneath which are mixed clay deposits (Robertson 2001, 1). For successive mill-owners this deep sandy loam has enabled them, with

relative ease, to modify the landscape by creating causeways, excavating new leats and channels, and raising protective mounds around buildings. The earthwork remains of this activity are, as a result of the local topsoil conditions, relatively fragile. Without support or vegetation cover, any features built from this sandy soil quickly decay and are easily spread, hastened by the activities of burrowing animals, in particular badgers, foxes and rabbits. Similarly falling trees can easily pull up this loosely bonded soil.

Historically, the valley floor was given over to hop gardens and the steeply rising valley sides to the north of the Tilling Bourne to coppiced woodland. The more gently sloping fields along the southern side of the valley were either pasture or water meadows. On the slopes above the river valley a variety of crops were grown, including barley, turnips and wheat (SHC G85/2/1 (2).

The site description begins with a brief account of the watercourses in this section of the Tilling Bourne valley, which provide the basic framework to the factory. The site report has then been broken down into four main topographic units - The Lower Works, along and to the west of Blacksmith Lane; The Middle Works, between Blacksmith Lane and Lockner Farm Road; and two areas to the east of Lockner Farm Road - the 1890s Smokeless Powder Factory and the First World War Admiralty Cordite Factory.

The Watercourses

The powder works are laid out in the valley of the Tilling Bourne, which rises at Friday Street, about 10 km (6 miles) to the east of Chilworth; from Chilworth it flows westwards for a further 3km (1.9 miles) until it meets the River Wey at Shalford, itself a tributary of the River Thames. The watercourses not only provided the powder works with power and a means of internal transport, but also determined the layout of the factory.

One of the reasons for the longevity of the Chilworth gunpowder works, despite the financial difficulties faced by many of its owners, was the reliability of its water supply. When Sir Jonas Moore carried out his survey of the works in 1677 for the Ordnance Office he commented that it 'could be worked in dry years as well as during the greatest frost' (Fairclough 1996, 127). As the Tilling Bourne passes through this section of its valley between Albury and Chilworth it is fed by a number of natural springs. Water was also harnessed for agricultural purposes and probably in the late seventeenth or early eighteenth centuries, a complex water management system (*see* Figure 2) was created to allow the fields in the valley to be flooded to encourage early grass growth (Crocker and Crocker 2000, 31). To the east Postford Stream was taken off Postford Brook, which tips into Postford Pond. This stream then linked a number of ponds, including Luff's Pond (formerly Upper

Love Pond) to the south-east of the Percy Arms. To its north, and to the north-east of the Percy Arms, are another two man-made ponds; the upper one is separated from the lower by an earthwork bank, but both empty into New Cut. A section of Postford Stream remains as an open ditch to the rear of the Percy Arms and then enters a culvert to take it to Tangley Mere. Smaller channels were also taken off this Stream and used to flood the fields, their courses are visible in the fields between the southern boundary of the powder works and the Dorking Road A248. To the west is the largest of the ponds, Tangley Mere, and at one time its outflow fed a stream leading to the mills on the southern side of the Lower Works.

Two streams provide the main structure of the works, one natural the Tilling Bourne to the north, and the other to the south, a man-made leat called New Cut. The original course of the Tilling Bourne is difficult to determine, but given the gradient of the valley prior to alteration it was probably a relatively slow flowing stream that meandered across its valley floor. Its flow, and the volume of water passing through it have been decreased by the excavation of 'New Cut' (see below). Probably since at least the 1650s the course of the Tilling Bourne has been constrained to a channel along the foot of the valley along the northern side, which was shown as the 'Old River' on the 1728 map of the works. To the east, in the area of the 1890s Smokeless Powder Factory, its southern edge is partly retained by a low earthwork embankment. Flowing westwards it passes through an ironstone culvert beneath the causeway that carries the Lockner Farm Road across the valley. Further westwards, to the west of the site of the **Expense Magazine** [63], the course of the stream was altered in the late nineteenth century. In this section its course may be followed as an earthwork channel that is overlain by the traverse of the **Cutting, Blending and Sorting House** [56]. Beyond, its line is followed by a series of disconnected ponds and linear earthworks, before its original route is picked up again to the south of the former **Blending House** [54]. To the west the stream passes beneath the ironstone **Packhorse Bridge** [BR 12], and then the stream continues along the foot of the northern hill slope. At its western end the stream fed into Chilworth Pond which was retained on its western side by the causeway over Blacksmith Lane, and unusually, by an earthwork embankment on the opposite side to prevent the pond flooding the valley floor. This pond provided the motive power for the mills on the western side of Blacksmith Lane.

The course of the Tilling Bourne was considerably altered, probably during the 1960s, when a new channel was dug to the south of its original course for approximately 200m from the **Cutting, Blending, and Sorting House** [56] to the **Blending House** [54]. The next major alteration to the watercourses in this area occurred in about 1980 when the large angling pond to the south-east of **Powdermills Cottage** was excavated. The pond against Blacksmith Lane was partly filled, but also

extended eastwards. It was probably also at this time that a new bypass channel was dug at the easternmost end of the pond linking the Tilling Bourne to the tailrace of the powder mills to the south, roughly between the later temporary bridge [BR11] and bridge [BR10]. The irregularly shaped angling lake is fed through a sluice on the western side of this channel, and is drained at its western end through a culvert that runs beneath the original pond, Chilworth Pond. In 2001, at the eastern end of the lake, in preparation for the restoration of the **Packhorse Bridge** [BR12], another bypass channel about 35m long and up to 3m wide was dug to the west of the site of the **Expense Magazine** [60]. Its function was to link the 1980 bypass channel to the Tilling Bourne.

To the west of the causeway, which carries Blacksmith Lane across the valley floor, were the sites of the corn and fulling mills, which predated the powder works. In 1603 a wire mill was established to the west of the causeway and a new millrace was dug, and this may be marked by the earthwork scarp to the north of ***The Old Cottage*** and ***Rose Cottage***. The wire mill was forced to close in 1606, but the leat was probably reused by a number of powder mills in the 1630s, and subsequently by the **Little Paper Works** [EH 4], which operated until about 1830. After this date the leat probably went out of use and has been partly filled by material dumped from the south.

In the 1650s a new leat about 1.5km in length was taken off the Tilling Bourne to the north-west of Albury Mill to provide power for the mills of the Middle Works. The new leat represented a considerable engineering achievement, and in places is retained by an embankment up to 2m in height. In addition to the water it takes from the Tilling Bourne, New Cut, is also fed by a number of small streams that flow in from the south. In the Middle Works water was directed through brick-lined wheel pits to power the mill wheels, and then tipped into a newly excavated tailrace that flowed towards the pond to the east of Blacksmith Lane.

This configuration of the watercourses remained virtually unaltered until the early nineteenth century, when a new channel was dug towards the eastern end of New Cut. This was fed by a brick overflow weir, and tipped into the tailrace to the west of the **Traverse** [11]. In the 1860s, to the east of the Middle Works, two new water-powered mills were added, the **Corning House** [39] and **Glazing House** [40]; their construction necessitated the excavation of a tailrace at the foot of the New Cut's embankment. During the major remodelling of the works in the 1880s, as described above, the Tilling Bourne was partly channelled through culverts beneath some of the new structures. New channels were also dug at the eastern end of the works to the west of the new **Incorporating Mills** [52] for drainage purposes. Similarly when the Smokeless Powder Factory was built in the 1890s to the east of Lockner Farm Road, drains were dug

across the previously featureless valley floor. The pattern of the watercourses in this area then remained undisturbed until a large pond was excavated to the south of ***Longfrey***, some time between April 1964 (NMR 11432, 27 Apr 1964, Frame 087) and 1972 when the Ordnance Survey map was revised. Shortly afterwards another pond was created at the eastern end of the First World War Admiralty Cordite Factory. This pond occupies a natural valley orientated roughly west to east, its western end is, however, blocked by the seventeenth century embankment that carries the New Cut. Water from the valley was originally channelled beneath the embankment and emerged in a channel on the opposite side to the north of the **Drying Stove** [24]. The pond appears to have been created either by the deliberate blocking or restriction of this channel, an air photograph shows that the pond had formed by 1988 (NMR 13316, OS/88204, 7 August 1988, frame 402). A pond was, however, shown here on a number of eighteenth and early nineteenth century maps (Crocker and Crocker 2000, 70). It is likley that it had been drained by the publication of the 1871 Ordnance Survey map, and it is not shown on any subsequent maps. The site of at least one building from the First World War cordite factory may lie beneath its waters, and concrete fence posts can be seen protruding above the surface of the pond.

The Lower Works - see plan Sheet 1 and Figure15

Figure 15
The Lower Works area, viewed from the south west, Blacksmith Lane is to the right (NMR 23016/ 04). (c) English Heritage

The Lower Works may conveniently be further sub-divided into two, the wooded valley to the north and the former raw materials processing area to the south.

The causeway, which carries Blacksmith Lane across the valley, also formed a dam for the Chilworth Pond to the east. It was the site of the earliest milling activity at Chilworth, later activities have, however, covered any surface trace of the earlier mills, although they may be represented by buried archaeological deposits. The general arrangement of the water management in this area has probably remained virtually unaltered. Two culverts were used to carry water through the dam to power two mills and were originally fed by the millpond to the east. Today the northern culvert [BR 3] is mainly fed from the fish-pond to the east, the southern culvert [BR 4], which was last used to power the Hambledon Rural District Council pumping station, is closed. To the south the former overflow [BR 5], or by-pass channel, carries water beneath the road and through a pipe to the southern stream from the tailrace of the mills of the Middle Works to the east. About 80m to the west of the road the two streams converge and the Tilling Bourne becomes a single stream, flowing westwards to the River Wey.

There are three properties on the western side of the Blacksmith Lane causeway, ***Chilworth Old Mill***, ***Halfpenny Cottage***, and ***Waterworks Cottage***, none of which have been subject to detailed analysis. The division of the properties known as ***Chilworth Old Mill*** and ***Halfpenny Cottage*** appears to be comparatively recent in date, the 1934 Ordnance Survey map names the whole building as ***Chilworth Cottage***. Between it and ***Waterworks Cottage*** was the site of Unwin's St Martha Works [EH 2], the printing works and former paper mill, which was destroyed by fire in November 1895.

The garden to the west of ***Chilworth Old Mill*** was remodelled in late 2002. The most striking feature of the new design is a large irregular-shaped pond to the west of the house. This is fed by a small tributary stream, which formerly fed into the Tilling Bourne. Soil from the excavation of the pond has been spread over the lower part of the garden, resulting in alterations to its levels. Some of the historic form of this area, such as the terrace leading westwards from the house has been retained, while above this, a large scarp has been redefined and the eastern side of the tributary stream has had spoil tipped on to it. Between ***Old Chilworth Mill*** and ***Waterworks Cottage*** was the site of the paper mill and later print works [EH 2]. The mills were originally water-powered from the header pond, Chilworth Pond, to the east of Blacksmith Lane, with water being channelled beneath the road in a brick-lined culvert [BR3]. The 1896 Ordnance Survey map shows the printing works at its maximum extent, although it had been destroyed by fire in November 1895. At this date the works straddled the northern

stream with buildings to either side. On the southern bank are traces of brick foundations and immediately to the north of ***Waterworks Cottage*** there is a section of wall about 2m in height. This wall was heavily overgrown and inaccessible for survey. To the north, apart from the wall that retains the leat, no foundations were seen, and the site of the works is covered by modern gardens. A recent bridge [BR2], on the site of an earlier structure, crosses the northern stream to the south bank. To the west of the bridge is a large diameter pipe, which crosses the stream and on the northern bank enters a small brick **Pump House** [EH 1] with a mono-pitch roof. It has recently been restored and retains original machinery within its basement. This structure is not shown on the 1896 map, but its position may be equated with a view of the 1895 explosion (Crocker and Crocker 2000, 116), which shows a bridge, a large pipe, and the under floor area of this small building.

Waterworks Cottage was probably built in the late nineteenth century, although a building had existed on this site in the early eighteenth century and had subsequently been demolished. The western extension to the cottage, producing its current L-shaped plan, was added some time after 1934. To the south of the ***Waterworks Cottage*** is a former water pumping station which dates to the turn of the twentieth-century and pumped water into the reservoir below St Martha's Church. The pumping station is a single-storey, brick-built structure with a tiled roof. Water to power the pumps was channelled through the northern culvert [BR4], above which is a stone plaque inscribed with 'W.T. 1842'. Water entered the turbine pit at the southern end of building; the turbines remain in place but all the other equipment has been removed and the building is used as a store. To the south of this building a by-pass channel [BR5] is taken beneath the road.

On the opposite side of the leat is a small gated platform, which is used as a car park. A building, probably a garage, was shown here in 1972, its site can be traced as brick footings. The semi-detached dwelling to the west ***The Old Cottage*** and ***Rose Cottage*** is probably early eighteenth century in date and was originally the drying house for the **Little Paper Mills** [EH 4]. The water-powered paper mills, established in the early eighteenth century on the site of a number of seventeenth century powder mills, were located to the west of the cottages on the valley side. These mills stood until the early nineteenth century when they were presumably demolished, since this date material has been dumped and pushed on the valley slope, and this has obscured its original form. Immediately to the north of the cottages, alongside the southern bank of the stream, short lengths of brick footings may indicate a buried building. To the west a narrow terrace about 2m-3m in width runs parallel to the modern fence line. On the floodplain below are two roughly rectangular areas, each about 18m by 30m in this area. Two low scarps set perpendicular to the valley side define these areas.

Figure 16
Factory office and laboratory [47] (BB94/10125). (c) Crown copyright.NMR

The area of land to the south, above the valley floor, was used from at least the early eighteenth century for the preparation and refining of the ingredients of gunpowder (saltpetre, sulphur and charcoal) and various ancillary workshops. In the late nineteenth century, activities were extended to include offices and test facilities. The buildings are either in residential use or are occupied by small businesses, and a number occupy former gunpowder works buildings. Survivals include the **Saltpetre Refinery** [3], **Charcoal House** [4], **Store** [5], and the **Factory Office and Laboratory** [47] (Figure 16). A study of historic maps reveals that there are potentially many buried archaeological features in this area, their approximate locations are marked on the plan.

Beyond the survey area there are a number of residences associated with the powder works, but these were not investigated in detail. At the junction of Blacksmith Lane and Dorking Road is The Old Manor House, formerly known as Powder Mill House (Figure 8). Historic maps show that a house has been on this site since at least the beginning of the eighteenth century; its origins are, however, puzzling. Above the north doorway is a date stone of 1609, the Dutch-style gables might indicate a date a few decades later. By the eighteenth century the house was sub-divided and part of it was the dwelling house of the **Little Paper Mill** (Crocker and Crocker 2000, 98-99). The ground plan of the house remained unchanged for most of the nineteenth century, until the acquisition of the works by The Chilworth Gunpowder Company in 1885, when it was considerably extended. It was probably also at this time that the house became known as the Old Manor House. This was perhaps on the insistence of the new German manager, Captain Otto Bouvier, who was recorded living there by the 1891 Census with his wife and six children.

To the west of the Old Manor House the line of the old road, truncated by the railway, leads to Magazine Cottages (Figure 11), which take their

name from the magazine to the north. They comprise two pairs of three brick-built cottages, built between 1871 and 1896 and possibly erected by the company to house some of its workers. Also associated with the powder works, but further away, is the former Greshambury Institute, now St Thomas's Church (Figure 10), which is situated on the north side of New Road, Chilworth.

The Middle Works - see plan Sheets 1, 2, 3, and 4

The central section of the gunpowder works lies between Blacksmith Lane to the west and Lockner Farm Road to the east, most of the area is a Scheduled Monument and is open public access land owned by Guildford Borough Council. Topographically, this section of the works occupies the valley bottom of the Tilling Bourne and its lower valley slopes. The watercourses on the valley floor have been managed for many centuries. The Tilling Bourne stream flows along the northern side of the flood plain, its natural tendency to meander has been partly controlled by canalisation and the creation of fixed bridging points. To the east of Lockner Farm Road is carried over the valley bottom on an earthwork causeway, at its western end is an ironstone conduit [BR 20],

Figure17
Packhorse bridge [BR 12] (AA04444). (c) English Heritage

beneath which the Tilling Bourne is channelled. The Tilling Bourne is also bridged about 500m downstream of this causeway by the so-called '**Packhorse Bridge**' [BR12], which was restored in 2001 (Figure 17). This bridge is built of local ironstone and it appears that the facing stones have either fallen away or been removed to leave the core of the structure. In this condition the form of the bridge reveals little evidence about its date, which might be late medieval or post-medieval. The route of the track which this bridge served can be followed northwards, roughly along the line of the present boundary leading to Chilworth Manor. To the

south, however, later alterations associated with the factory have removed any trace of it.

Figure 18
New Cut looking west from bridge [BR 15] (AA044438). (c) English Heritage

On the southern side of the valley the principal watercourse is a carefully engineered leat known as 'New Cott', 'New River', or 'Powder Mill Cut' (referred to hereafter as New Cut), which was probably dug during the 1650s (Figure 18). It sits above the valley bottom and was the header leat, providing the water to power the mills of the Middle Works. To the east of Lockner Farm Road it has been partly terraced into the hillside and an embankment was created to the north with the resulting spoil. The leat was originally between 5m and 8m in width, wide enough for powder punts to ply its length. In recent years its width has been reduced to about 3m in an attempt to speed the flow of water to prevent the build-up of silt. To the west of the **Corning House** [39] the leat's embankment is more clearly distinguishable. Beyond the **Expense Magazine** [37] the gradient of the hillside is less steep and the form of the leat changes into a simple channel cut into the hillside.

The historic core of the Middle Works lies to the east of Blacksmith Lane between **West Lodge** [46] and the modern footbridge [BR15] at the end of the footpath leading from Chilworth School. This section of the site occupies the shallow southern slope of the Tilling Bourne valley and is less than about 45m in width. The construction of the powder works has heavily altered the natural contours of the valley side. The works in this area was originally developed during the early 1650s under Josias Dewye and his partners. This represented a significant investment; it was at this time that the millrace known as New Cut was dug along the southern side of the valley to provide power for the four new incorporating mills that were in operation by the 1670s. The mills were

set into the hillslope, which acted as a natural blast screen, and water was channelled from New Cut through the mill wheels to a tailrace at the foot of the slope. The densest concentration of archaeological remains survive in this area. The former mill sites are readily distinguishable by their brick foundations and associated earthworks, and the traces of other buried buildings. The latest phase of activity is most visible on the surface, but in most instances the later mills overlie the earlier mills. This area appears to have been relatively little altered by the extensive remodelling of the works in the late 1880s, and there is a good correlation between the field remains and the mills depicted on the 1871 Ordnance Survey map (Surrey, XXXII.5).

Figure 19 *West Lodge, Blacksmith Lane, to the right is the 1920s extension (BB94/ 10128). (c) Crown copyright.NMR*

Access to this area was gained via Blacksmith Lane by **West Lodge** [46] (Figure 19), a small late nineteenth century building, which was originally a small single storey gatehouse. It was not shown on the 1871 Ordnance Survey map, and was perhaps built in response to a requirement in the 1875 Explosives Act for the searching out of materials that might cause a fire or explosion (Health and Safety Executive 1985, 15). During the 1920s a brick extension was added to the east to create a small bungalow, which remains in residential use. Adjoining **West Lodge** to the north is a double leaf iron gate with a pedestrian access next to the lodge. Following the path eastwards the remains of two large buildings can be seen. To the north-east of **West Lodge** are the remains of the **Cask Store** [45], traceable as a level platform about 7m wide, and at least 12m in length, at its western end are the remains of brick wall and some roughly built steps. About 50m to the east are traces of the **Dusting House** [8], which again are visible as short lengths of brick foundations. Between these two buildings were three small buildings, which have left no surface trace. At the eastern end of the **Cask Store** [45] was an **Expense Magazine** [10] and at the western end of the **Dusting House** [8] and its **Wash House** [9]. The **Dusting House** was probably water-powered and it marked the western extent of the millrace New Cut. This is observable to the east of the **Dusting House** as an earthwork hollow with a bank to the north. The southern side of the leat forms the site boundary and the rear boundary of properties in Halfpenny Close. The maximum width of the leat was about 5m, but this has been reduced in places by the tipping of garden refuse.

The modern track aligned east-west follows the line of the late-nineteenth century tramway that terminated at the small **Expense Magazine** [10]. As the line of the tramway headed eastwards it deviated northwards to avoid the **Dusting House** [8]. Here, its route is marked a long artificial

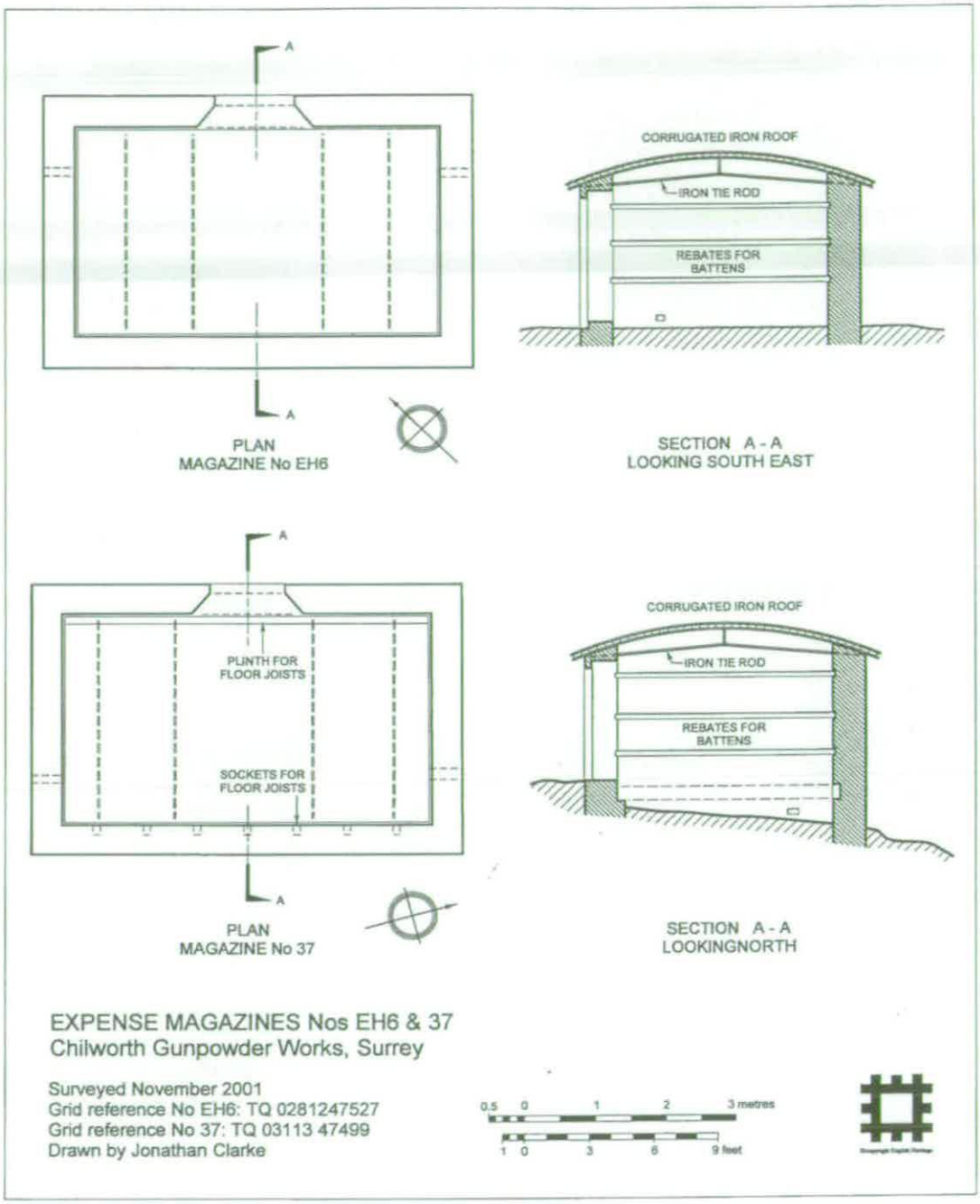


Figure 20
Expense magazines [EH6] and [37]

slope that leads to a brick culvert and then returns towards the present track where the tramway passed over a culvert [BR 8]. To the south-west of the culvert is an **Expense Magazine** [EH 6], which although still standing, was not numbered on the 1922 sale plan (Figure 20). The magazine is sited on the north side of New Cut with its entrance facing the leat, indicating that it was originally served by the powder punts. The magazine is brick-built and measures 6.1m by 4m with 0.5m thick English-bond walls and a corrugated iron/brick-vaulted roof. The roof is of an unusual construction comprising a single layer of bricks sandwiched between two convexly-curving sheets of corrugated iron. An angled tie-rod, slung at its mid-point from a short length of rod in the roof apex is firmly secured in the brick walls. Internally it was lined with matchboarding to facilitate cleaning, evinced by the timber battens let into the brickwork, and both were provided with a ventilation hole in the gable walls. On its rear wall the date '187?' is executed in blue-brick diaper work. It is nearly identical in form to the **Expense Magazine** [37] which lies to the east.

To the east of the **Expense Magazine** [EH 6] are the remains of an over weir for New Cut, comprising a curved rear brick wall and a brick wall on its western side. In operation, excess water would flow over this wall and then be channelled through a pair of earthenware pipes set into the brick culvert [BR 8]. On the northern side one of the channels is brick vaulted, which probably indicates that the ceramic pipes are part of a later refurbishment of the structure. It was perhaps during this refurbishment that the concrete wings to the north and the tubular steel handrails were added. About 8m to the east of the weir, a leat formerly led to the **Press House** [12]. This channel has been filled although its course may be marked by a short length of brickwork immediately to the south of the path. In the angle of land created by New Cut and the leat was a **Packing House** [13], no surface traces of this building are visible. To the east of the weir New Cut remains as a water-filled feature, its southern boundary is formed by the rear boundaries of the houses in Halfpenny Close. Along its north side is a low bank about 4.5m wide, which may represent the former towpath. In the area of woodland to the north of this bank and to the south of the main track no features were seen, and no features are shown on historical maps of this area.

To the north of the track are the remnants of the **Press House** [12], which was served by a spur off the main tramway that delivered powder to the upper and working floor. The **Press House** was terraced into the hillside and a basement area was created by a revetment wall on its southern side; the western side of the basement was also revetted by a brick wall, which incorporates either the wheel or turbine pit that was used to power the press. This was powered by water channelled down a now filled leat from New Cut. Its course may be followed as a brick-lined and earthwork channel to the north of the wheel-pit. The interior of the building originally measured about 10m east to west and 9m north to

south and there are wall footings within the basement area. The working floor was supported by a number of cast iron brackets, some of which survive on the revetment wall. This method of construction probably allowed the valuable hydraulic pumps to be housed in the basement with the presses above. Immediately to the west of the **Press House** was the **Brick Traverse** [11], brickwork adjacent to the stream may mark its northern edge. To the east of the **Press House** is a curving mound, about 5m in width, which was thrown up to shield the **Press House**, either from explosions in other buildings or to protect them should it explode. The hollow to its west is probably the borrow pit from which material was excavated to build the mound. To the north a scarp defines a level area, which marks the route of a footpath between the **Press House** and the **Incorporating Mill** [16] to its east.

Figure 21
Wheel pit of incorporating mill [16], this feature is typical of the remains in this area (AA044432). (c) English Heritage

Brick foundations and exposed wall faces mark the site of the **Incorporating Mill** [16] (Figure 21). The remains indicate that the mills were asymmetric with one bay to the south of the wheel pit and two bays to the north. At their southern end is a brick and concrete channel that carries most of the water from New Cut into the former tailrace. To the south of this channel the ground rises steeply and is capped by a row of four yew trees, which may have been planted to act as a blast screen. To its south are the remains of another mill structure [14 and 15]. These exhibit the standard plan form of a gunpowder works mill with a central wheel pit and a bay to either side. The last recorded function of this feature was as a **Charcoal Store** [14] and **Mixing House** [15]. The foundations of mill [14], includes some pieces of ironstone, which may indicate parts of one of the early mills survives within its fabric. To the north-east of this mill are three millstones [S5, S6, and S7], which may have been removed from it. Further to the north of these stones is a brick bridge [BR 10], which crosses the tailrace.

Due south of the bridge are the remains of the **Press and Engine House** [18] and **Watch House** [19]. In common with the other mills in this section the structure was dug into the hillslope, which would act as a protective blast screen in the event of an explosion. To the south-west and rear is a brick revetment wall to retain the hillslope, and to the north-west and south-east there are artificial banks to provide further shielding. This mill was originally water-powered and a now filled inlet from New Cut is shown on nineteenth century maps. The position of this channel is

marked on the brick revetment wall by a rectangular brick box-like feature about 2.0m by 1.0m, which may represent part of the original wheel pit. Within the area of the mill building there is a brick plinth, on which a machine was mounted, and other mounting bolts are visible within its interior. The 1871 Ordnance Survey shows this building as what may be regarded as a standard gunpowder mill, with a central wheel-pit with machinery bays to either side. Such an arrangement could have been used to accommodate a press house, with one side being occupied by a hydraulic pump and the opposite side being used to accommodate the press. Alternatively it may have been a gunpowder incorporating mill at this date, which was subsequently converted into a press house.

To the south of **Charge House** [17] on the bank of New Cut are the foundations of another building [EH 8], it survived until the late nineteenth century, but had been demolished by 1922. About 30m to its east is the site of steam-powered **Incorporating Mills** [20, 21 and 22]. In common with the other mills in this section they were set into rear of the leat's embankment and for the ease of loading and unloading the working level of the mill was at the same height as the top of the embankment. These mills probably occupied the site of an earlier water–powered mill, but it is unclear whether or not any of the surviving brick footings are associated with the earlier structure. The outline of the steam-powered mills are sufficiently complete to suggest their general arrangement. The boiler and engine house was sited to the west, where substantial brick remains survive, including a fallen arched tunnel that might have housed the boiler. There were two mills to the east, to the west the mill bed of brick and mortar survives, it is 2.27m in diameter with a central hole 0.42m in diameter, it is 0.42m thick. This was probably the foundation for a cast iron mill that has subsequently been removed. To the east is broken mill stone [S29], this might have been the actual bedstone, alternatively it may have been used as the foundation for an iron mill, both are set over a tunnel which formerly carried the underfloor drive shaft. To the rear the floor was supported by six brick piers, which survive, and this would have created a basement area to provide access for maintenance to the drive shaft and underfloor gearing. To the north of these remains, on the northern bank of the tailrace, are the remnants of the spark arrestor [EH 27] from the mill's chimney. This comprises an iron framework 1.15m in diameter, which is lined with bricks set in mortar. A report on an explosion at the **Press House** [31] by the Explosives Inspectorate in 1879 provides some further details about the **Incorporating Mills**, including that the walls were made of canvas and that the mills were protected by drenching tubs. Two yew trees at eastern end of this building may represent the remains of a blast screen.

On the New Cut side of the mills, eight stone gunpowder edgerunners [stones 21-28] have been set vertically as a decorative feature. It is not known when this was created, but its construction would have involved

considerable effort, given that each stone weighs 2-3 tons. Also in this area, adjacent to New Cut, is a small brick structure, which might have been where the **Incorporating Mills** [20, 21 and 22] drew water for their boiler house. To east are the foundations of two buildings; the first [EH 9] measures 4.5m by 1.5m, its function is unidentified, the second measures 4.0m by 3.0m and is the site of **Charge House** [28]. Again, to the east more small buildings were set along New Cut. No surface remains of the **Lavatory** [29] are visible but to its east is the site of the **Charge House** [30], its position indicated by a length of its foundation wall showing in the side of the New Cut. About 4.0m to the east of [30] the tramway from the raw materials processing area to the east crossed New Cut. On the northern bank is a brick abutment [BR13] and a cast-iron pivot, which probably indicates that it was identical in form to the surviving swing bridge [BR16], 200m to the east. To the south-west of the Bridge [BR13] the line of the tramway may be traced for about 35.0m as a shallow hollow approximately 2.5m in width.

To the east of the **Incorporating Mills** [20, 21 and 22] are the remnants of another steam-powered **Incorporating Mill** [24 and 25]. Its site is defined by a steep scarp at the rear and a platform adjacent to the tailrace that housed the mill building. At its western end stood the **Engine and Boiler House** [23], of which an L-shaped brick foundation remains. To the east were the **Incorporating Mills**, two stone edge runners [S12 and S13] mark the site of the mill building. Above mills these to the southeast is the location of what was described in 1922 as the **Site of Old Water Mills** [26 and 27]. These mills were powered by water from New Cut; the position of the wheel race is marked by a right-angle turn in the line of the northern edge of New Cut, which led to the brick-lined wheel pit of the mills. To either side of this pit there are two brick-lined basements, above which the mills were sited. From the wheel pit the water was discharged northwards into the tailrace. These mills had probably been demolished by the middle of the nineteenth century and do not appear on the 1871 Ordnance Survey map.

As part of the remodelling of the factory in the late 1880s, a hydraulic **Accumulator Tower** [69] was built to the north of [26 and 27] to power the adjacent press [31]. The foundations of the **Accumulator Tower** measure 6.0m by 5.0m, and to its east is an earthwork bank that was perhaps added to shield it from the **Press, Breaking-Down Press and Mill Cake House** [31] with a **Wash House** [32] attached to its southern wall. A brick leat may be followed from New Cut indicating that the **Press House** was water-powered. The description of the building suggests that powder from the incorporating mills (mill cake) was brought to, and stored in, the building before it was reduced in the breaking down machine into coarse grains and then loaded into the press.

Either side of New Cut, between the **Press House** [31] and the **Glazing House** [33], are the remains of another bridge [BR14]. On the southern

bank it may be traced partly as an earthwork embankment, which corresponds with a former hedgeline to the south, at the stream's edge the bridge abutment is formed from ironstone. On the northern bank is a corresponding ironstone abutment and raised area, the original route northwards from the bridge may be indicated by a linear earthwork about 20m to its north.

The remains of the **Glazing House** [33] lie on the north bank of New Cut and comprise a brick-lined central wheel or turbine pit. In this channel a cast iron sluice manufactured by Filmer and Mason, Guildford, survives. The western bay of the structure is marked by a level platform against the leat, the eastern bay is better defined and sections of brick foundations may be traced and at its eastern end are the remains of a denuded blast mound. The **Packing House** [34], where the glazed gunpowder was weighed in to barrels, lay to its east. No surface traces of this building were found. To the east, beyond the remains of the tramway bridge [BR16] was a drying **Stove** [35] and to its rear a **Boiler House** [36]. The position of the **Stove** alongside New Cut is marked by occasional pieces of concrete and iron tie rods protruding from the ground, a short fragment of brick foundations indicates the position of the **Boiler House**.

After the closure of the works in 1920 many of the process buildings were converted into dwellings and a number of small cottages were built within the area of the former powder works. The 1934 Ordnance Survey map and air photographs taken in 1947, show that the **Glazing House** [33] and the **Packing House** [34], or at least their sites, were occupied as cottages, with a third cottage to the east. Similarly, the **Stove** [35] and its **Boiler House** [36] were also occupied as dwellings. To the north of the **Glazing House** and **Packing House** were a further three cottages. Today, this area is flat and featureless apart from a brick-lined drain, no surface traces of the cottages were found. Deliberate demolition and clearance of the cottages during the 1960s may explain the absence of surface remains; the ground in this area is also waterlogged, which has encouraged the build up of vegetation that has further obscured the form of the surface.

By the late nineteenth century the mills of the Middle Works were linked by the 800mm gauge tramway. The line of the tramway roughly followed that of the modern track, from about 30m to the east of **West Lodge**, but few traces of the tramway survive in this section. Another branch of the tramway led from the **Packing House** [41] and raw materials preparation area at the far west end of the site, across an open field to the east and entered the works complex to the south of the steam **Incorporating Mills** [20,21,22]. Here, an earthwork hollow 34m in length indicates its route, although, at its eastern end the path of the tramway is again lost. The line is then picked up on the northern bank of New Cut where there is a short section of embankment and a concrete

bridge abutment [BR13] with a pivot pin. This is almost identical to the abutment beneath the surviving bridge [BR16]. The former course of the tramway is then taken up by the modern footpath. Immediately to the north of the **Packing House** [34] was a junction with a branch of the tramway leading northwestwards towards the **Press House** [71], whose line may be followed as a well-formed low embankment. About 70m north-west of the junction the line split into two. The southern branch ran roughly parallel to the tailrace and terminated in a dead end. The other branch led to the open northern side of traverse surrounding the **Press House** [71], a kink in the line of the embankment indicating where the tramway turned towards the building. The tramway ended at the **Press House** and to its west the embankment follows the route of the footpath. The spread remains of a blast mound marks the site of the **Press House** [71]; to the west is a low, irregular linear mound and to the east a low sub-rectangular mound. To its north-east was the site of an **Expense Magazine** [61], no surface remains of this structure were seen and it may have been removed when the Tilling Bourne was canalised. To its east was another **Expense Magazine** [62], its position indicated by a partly exposed piece of concrete adjacent to the riverbank and to the east a gently curving scarp, marking the line of the tramway. A third **Expense Magazine** [60] was sited 110m further westwards. This is marked by a decayed Chilworth mound and close by to its north and west are two large blocks of mass concrete. These formed parts of its roof, and during an archaeological watching brief a number of bricks were recovered, which were likely to have been derived from the magazine (Robertson 2001). It is this building, which is probably shown in a pair of photographs published in the *Surrey Advertiser* (Rose 2002a, 14). The views taken during the 1950s show the building after it had been converted to a dwelling in the 1920s, mass concrete roofs are shown over the magazine and its porch (Figure 22).

Figure 22
1950s view of ?magazine [60], showing its thick mass concrete roof. (c) Mr & Mrs Moseling

To the north of the Middle Works is a commercial angling lake. The area is defined to the south by a stream, which is the former tailrace of a number of the powder mills. To the north the northern arm of the Tilling Bourne marks its boundary and from the stream's northern bank the land rises steeply towards the lane. This valley side is densely wooded and is featureless except for a few modern drains cut perpendicularly to the slope. This area was known as Kiln Coppice (SHC G85/2/1(2)), which may indicate the presence of former industrial activity, perhaps a pottery or brick kiln, or simply the coppice where wood was felled for the kilns.

At the north-western corner of this area is a row of cottages, known as ***Riverside Cottages***. Cartographic evidence shows that there has been a building on this site since at least the early nineteenth century. Presently the building is split into two residencies ***Chilworth Cottage*** to the west and ***Kingfisher Cottage*** to the east. Associated with these cottages is a small free standing outbuilding which backs onto Blacksmith Lane. At its southern end was a fortified Second World War defence position, or pillbox, which commanded the lane to the south. This feature has been demolished within last decade.

The irregular shaped angling lake was excavated in 1980 (Robertson 2001, 2). Prior to this date this area, known as 'Waterworks Field'; historic maps show that the field was used as hop gardens during the eighteenth and nineteenth centuries and remained as open land at least into the 1960s. Before the excavation of the lake a single drain ran down the centre of the valley, fed from the east by the Tilling Bourne, and controlled by sluices which were sited close to the temporary bridge [BR 11] to the east of the site of **Expense Magazine** [60]. Before the new lake was dug water to power the mills to the west was held directly against the eastern side of the Blacksmith Lane causeway. In 1980 when the angling lake was created this pond was partly filled with earth and a new pond dug to its east into which the tailrace and Tilling Bourne now drain. Water passes beneath the causeway through existing channels [BR3] to the north from the new pond and through a culvert [BR 4] beneath the southern end of the causeway, another duct [BR 4] which led to the pumping station is closed. The angling lake is drained from its western end by a pipe that passes beneath the new pond, thereby allowing it to be periodically emptied. At the eastern end of the pond, it was probably at the time of the excavation of the angling lake that the channel (roughly between temporary bridge [BR 11] and the bridge [BR 10]) was dug to link the Tilling Bourne to the mills' tailrace. More recently, when the **'Packhorse Bridge'** [BR12] was being restored in 2001, a new by-pass channel was dug to west of the site of **Expense Magazine** [60]. An archaeological watching brief during the excavation of this channel revealed no *in situ* archaeological features. Some building debris was recovered from the topsoil, including a large section of concrete roof and hand-made bricks, which were probably derived from the **Expense Magazine** [60] (Robertson 2001).

Until the expansion of the factory in the late 1880s gunpowder manufacture was restricted to the Middle Works. In the remodelling of the late 1880s the factory expanded to cover most of the valley floor and the northern valley side. Previously, with the process buildings concentrated along New Cut, part-finished explosives were moved between buildings by punts along New Cut and possibly also on the lower tailrace. To link the new buildings, and to bring coal to **Engine, Boiler and Wash Houses** [53] to the rear of the new **Incorporating Mills** [52], a tramway system was installed. Remains of this network, in

the form of low earthwork embankments up to 5m in width, may be traced across the valley floor. The material used to create these embankments, and some of the protective mounds, was derived from a number of borrow pits, which survive as sunken marshy areas, to the south of [56] and [57], and one to the north of the **Engine, Boiler and Wash Houses** [53].

Prior to the 1880s the area to the north of Tilling Bourne was unoccupied by the gunpowder works and comprised a marshy valley floor and steep valley side. This area is bounded to the north by a modern post and wire fence, which runs roughly along the top of the valley side. This line appears to be slightly north of the original powder works boundary line, which is marked by isolated metal fence posts. For most of the length of this boundary it is a lynchet, a build up of soil washed down from the field above. At its western end, close to the **Pillbox** [M3], a slight counterscarp bank may indicate that it was once also a hedged boundary. At the eastern end, by the modern stable, the boundary turns through a right-angle northwards and may be followed as a low earthwork bank. Occasional metal fence posts along the top of this bank again mark the original boundary line. On the slope, to the south of the stable, a bank about 11m in length follows the line of the boundary, and may indicate that it once ended at the stream. To its east the ground falls towards the stream, two slight scarps running across the slope may also mark the positions of lynchets. Alternatively, they may represent lines of natural soil slippage of this loose sandy soil.

The buildings in the northern area were used mainly for the storage of finished explosives. At the western end the company made the most efficient use of the topography by cutting building platforms into the slope for **Magazines** [56-59]; behind the individual buildings the slope is retained by dwarf concrete walls. Their floors are buried by a couple of centimetres of leaf mould and other vegetation but may be traced by probing. At the westernmost **Magazine** [59] banks were extended forward to provide extra protection. To its east the position of **Magazine** [58] is marked by a low concrete retaining wall. Both of these magazines, or at least their sites, were occupied by cottages from the 1920s until the 1950s, and their demolition and clearance has probably resulted in the loss of surface remains in this area. The domestic use of this area is confirmed by scatters of mid-twentieth century rubbish, including metal bed frames, glass and pottery.

To the east the site of **Magazine** [57], remains substantially intact (Figure 23). It too was cut back into a hill slope that was retained by a low concrete wall, which in this instance was also extended to revet the bases of the sides. The sides and the front of the building were protected by a corrugated iron Chilworth Mound, which was entered through a narrow opening in its south east corner. The walls of the mound have battered sides and are reinforced by narrow rolled steel

Figure 23
Site of Magazine [57] surrounded by a typical 'Chilworth mound' (AA044446). (c) English Heritage

channels. The interior, which measures 16m by 9m, is flooded and covered by fallen trees, it is presumed that a free-standing, probably timber-framed, building stood in the centre of the traverse. The surrounding mounds although largely intact have been badly disturbed by burrowing animals, rabbits and badgers, and by scrubby vegetation.

Magazine [56] to the east is a more substantial construction. It was also dug into the hillslope, which was revetted by a low concrete wall capped with blue engineering bricks; to its rear the steep slope has been terraced. The western end of the magazine has a loading bay revetted by concrete walls. Running around the top of the magazine is a low bank which has been continued down the slope to protect the magazine's eastern side. A large Chilworth Mound that stands about 3m high protected the front of the magazine. It is supported by two rows of corrugated iron sheets bent to form cylinders and placed on top of one another. The mound is heavily overgrown, and has been disturbed by burrowing animals and by toppled dead trees whose root balls have dragged material away from the mound.

Beyond this magazine the next building [63] was sited on a level platform partly revetted by a Chilworth Mound on the southern side. This position was also occupied by a 1920s cottage, which may have resulted in the alteration of the original form of this area. To its east a short brick foundation [EH 13] 3m in length with a return at its west end, marks the site of a small unidentified structure.

The relative ease in which the soil of this sandy hillslope can be quickly excavated is most dramatically demonstrated by **Magazine** [54]. This magazine was entered from the east across the Tilling Bourne, via a tramway bridge whose concrete pier survives against the northern bank, and then along a dog-legged passage. Its walls are of battered concrete and the floor surface is about 2.2m below the ground surface. The

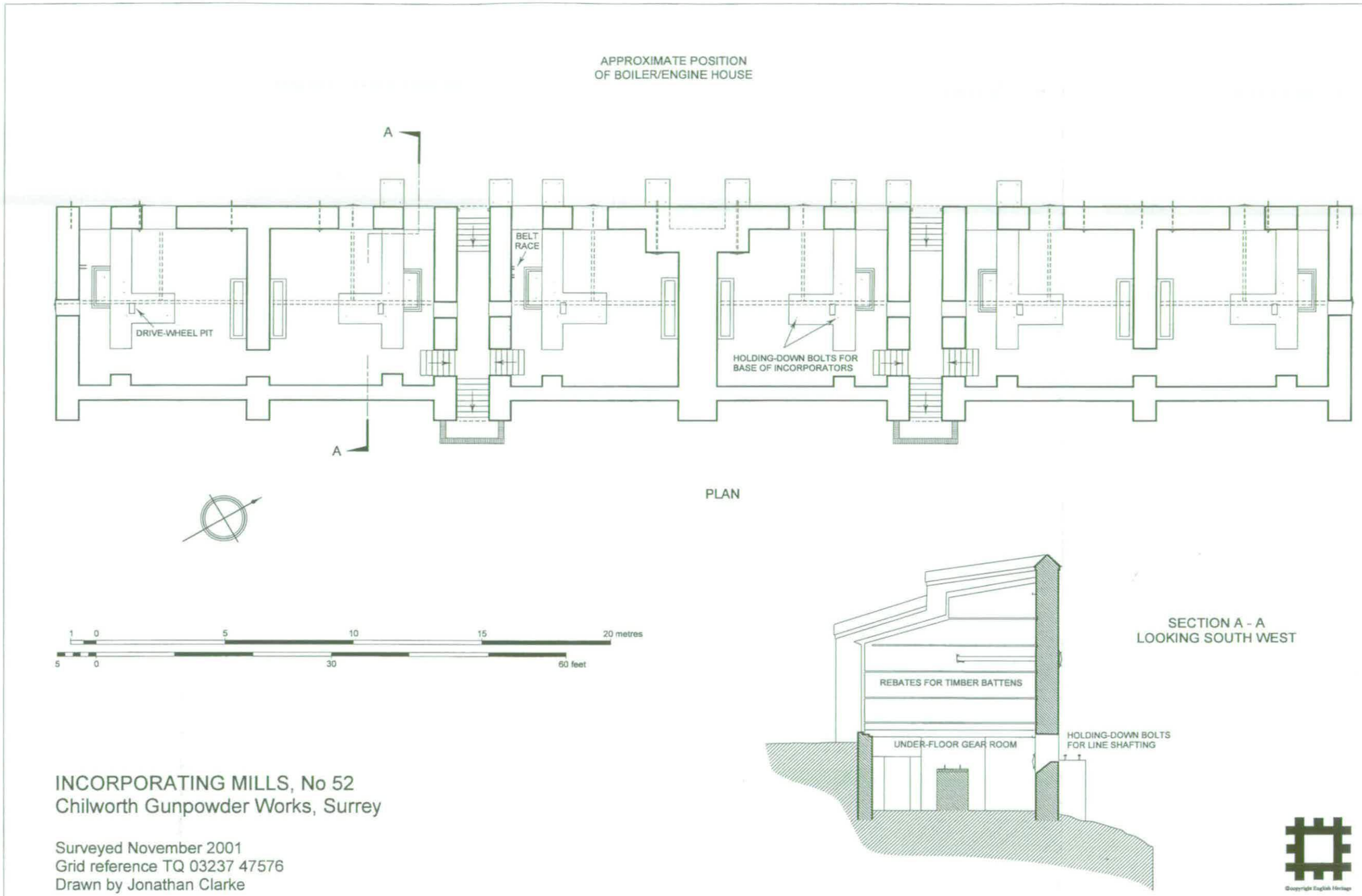


Figure 21
1880s gunpowder incorporating mills

available floor area in the magazine is 18.5m by 8m, although the building was probably slightly smaller to allow access around its exterior. The surrounding retaining walls are also of battered concrete and stand about 2.2m tall. The north and west sides of the magazine are defined by a steep scarp, while on the southern side a linear bank has been dumped on to the hillslope.

To its north was a further **Magazine** [21], which stood on a platform measuring 14m by 9m defined by low concrete retaining walls on three sides. A large Chilworth Mound about 2m in height protected the eastern side of the building. Access to the building was from the west and across a bridge over the stream; a concrete abutment on the stream's bank marks the position of the bridge. Entry to the magazine was then along a dog-legged passageway. From the bridge a terraced walk along the stream's bank leads back to **Magazine** [54]. To the west of the site of **Magazine** [21], a well defined north to south scarp may mark the extent of quarrying and two small mounds in the area are probably the result of casual dumping. At the southern end of this scarp is a hollow measuring 6m by 8m and some associated irregular earthworks. It is unclear if these are the result of quarrying and dumping, or represent the remains of a Second World War Home Guard **Section Post** [M5], see below.

The largest complex built during the reconstruction of the factory during the late 1880s was a range of gunpowder **Incorporating Mills** [52] and associated buildings (Figure 24). These were sited at the eastern end of the Middle Works fronting on to New Cut, on a piece of previously unoccupied land. The mills are 49.9m (164 ft) in length robustly constructed from mass concrete and brick, and are divided into six self-contained bays by thick axial walls. Each self-contained bay or chamber, powered by a drive-shaft fixed to the rear of the building, was operated independently from the relative safety of tunnels between the bays or from the outer end walls. Lightweight roofing and front walls, designed to direct any blast away from the structure and machinery within, and a sophisticated drenching mechanism that automatically doused all cells in the event of an explosion in any one, reflect the overriding concern with protecting both men and machinery (Figure 25). The surviving structure almost wholly constitutes the more robust, 'blast-proof' components of the original range. Only traces remain of the deliberately flimsy roof and upper front walls of the individual bays, each of which was originally numbered from west to east 1 to 6. For the most part mass concrete, bulked out with a coarse aggregate of pebbles and stones, was used to form the *c.*0.93m (3ft) thick cell and tunnel walls. The lower portion of the front (south) walls of each cell, enclosing the under-floor gear rooms, were executed in English-bond brickwork. Similarly, in the eastern two cells (Nos. 5 and 6), red English-bond brickwork was employed in the upper portions, above the level of the under-floor gear room. The change from brick to concrete may reflect

Figure 25
1880s gunpowder incorporating mills [52], note the remains of the drenching mechanism on top of the rear wall (AA044443). (c) English Heritage

the intention to build the whole structure in brick, which after building had commenced was changed to mass concrete. It is unlikely that it represents rebuilding after an accident, as no explosions were recorded in these mills. The upper portion of each axial bay wall, the end walls, and the two tunnels are finished in brick, hipped with red ridge tiles.

English-bond brickwork was also used to provide platforms for the machinery within and without the complex. Inside each of the 6.4m by 6.2m (20.9ft by 20.3ft) bays, a 1.6m (5.2ft) high T-shaped brick platform provided stable anchorage for the circular cast-iron bed on which two runners revolved. A taller brick platform opposite, abutting the axial walls/cross passages, provided a foundation for a cast-iron plate, which still survives in bay 5. Outside the building, rectangular brick piers abutting the rear (north) wall served primarily to support the horizontal line shaft powering each of the mill bays, but also provided buttressing against the sloping ground. Taken together, this broad distinction in materials suggests a three-phase construction for the incorporating mills. In the first phase, the basic cellular construction was executed in concrete and brick. In the second, the power-transmission bases were built-up to the requisite dimensions, with the machinery being hoisted into position onto projecting iron studs. Inside the bays, the ground-floors were inserted, and the incorporating mills installed. The upper walls were lined with painted matchboarding, to ensure a 'non-stick' surface that prevented particles from collecting and falling inwards into the machinery below. Little of this timber covering survives, but horizontal depressions in the concrete, into which timber battens were affixed, testify to its former existence throughout. In the third and final phase, the front of the individual bays were walled in timber, and the sloping galvanised metal covered roofs erected.

The incorporating mills are notable for their comparatively early use of structural steel sections. In each bay, a deep rolled-steel channel with a

web-flange dimension of 26m by 8.5 cm (10.2in. by 3.3in.) was built into opposing dividing walls, transversely spanning the 6.4m. The principal function of these overhead beams was to support the vertical drive-shaft component of the incorporating mills. However, they also supported a secondary axial beam (a smaller channel, measuring 17.5cm by 6cm), extending from the mid-point of the rear wall. This secondary beam was used to support the iron tub of the drenching mechanism. Steel, with its superior flexural strength over both cast and wrought iron, was especially suitable for absorbing the vibrations of heavy moving machinery. Some of the primary beams exhibit the rolling mark 'BURBACH 1884', others 'BURBACH 42 43'; the former advertising the German manufacturer and the year it was rolled. For added stability, the outer ends of the smaller channels were bolted into the rear wall via substantial cast-iron or steel spreaders. The terminals of the main channels in the two end bays are secured in the same manner, and it seems likely that plates embedded (and concealed) in the thickness of the dividing walls perform the same function throughout the range. Channels seem to have been used in place of the more usual I-sections because, in this context, the deep webs offered a vertical bolting face from which to suspend machinery. It was not until 1886 that a British manufacturer began commercial production of structural steel, so at this time the material had to be imported from the continent.

The mills were designed around a new, improved type of mechanical incorporator, patented by H. Gruson of the German company Grusonwerks Buckau-Madgeburg (later acquired by Krupp). It differed chiefly from earlier types by suspending the edge runners from a vertical drive shaft. The edge-runners were mounted so that they were able to rise up and over any obstructions on the bed of the mills thereby minimising the risk of an accidental explosion (*see* Figure 6).
Nothing remains of the six Grusonwerk incorporators, but there are traces of the attendant fixtures and fittings in the gear rooms. In each bay, the vertical drive-shaft extended between the overhead channel and the brick plinth, where it rested in a bearing box/bedplate affixed to the brickwork. The four holding-down bolts of this bearing box/bedplate remain. The bedplate incorporated a rectangular cut-out that accepted a bevelled drive-wheel (a curved depression in the brickwork denotes its former position). This drive-wheel, which turned the vertical drive-shaft was powered by a horizontal drive-shaft which, through a bevel gear, communicated with a presumed belt drive. Upstanding bolts in the brick axial wall that helped support the former ground-floor, and bolts in the stepped brick plinth abutting this in the 'belt-race', relate to this belt drive.

The weight of the cast-iron (or steel) runners and bed was taken by the ground floor, the position of which is denoted by a depression in the concrete side walls and a wall plate to the front wall and steel angles projecting from the rear wall. It seems likely that this floor was of relatively

light timber construction since most of the weight of the incorporators was transmitted directly to the axial wall below. No substantial sockets are evident that might have suggested the position of steel joists. The two axial passages provided remote, safe control of the machinery in the inner four bays. They were reached on the front by a threshold of blue engineering bricks and a short flight of brick steps. Timber jambs show that originally the tunnels were fitted with doors. Within the tunnels, traces of painted instructions relate to the operation of the geared machinery: 'SLOW', 'FAST', and 'CLUTCH'. Associated slots in the wall, with paired bolts above, relate to former levers that communicated with the gear room. The outer two bays were controlled from behind their respective exterior walls, which preserve similar evidence for remote control via iron levers. There is no evidence to suggest that those working these end bays were ever sheltered from the weather with a lean-to structure.

Both the tunnels and the end bay walls probably also enabled 'manual overide' of the automatic drenching-tub mechanism. In each bay, a metal rotating arm affixed to the top of the rear wall acted as a pivot-point that, via connecting rods, could tip over the tubs located beneath the roof. This rotating arm may have been remotely movable by (former) levers sited in the tunnels and on the gable walls, so that in the event of the automatic system not working, they could be brought into play manually. Loops set into the upper corner of each bay suggest this feature, since they may relate to a control wire rather than anchorage for a possible lightning conductor. Because each rotating arm was interconnected in series at roof height, engagement of one would have resulted in the simultaneous tipping of all tubs – the basis of the automatic system.

Figure 26
1880s incorporating mills [52], showing the piers that supported the rear drive shaft (BB94/10121). (c) English Heritage

The **Incorporating Mills** [52] were powered by a large detached boiler and engine house [53] located to its rear. An arched recess at the centre of the rear wall flanked by brick buttresses, probably relates to where the main horizontal drive shaft from the power house terminated and meshed (via a toothed bevel wheel) with two secondary drives that ran along the rear of the building. Projecting brick piers supported each of these drive shafts which turned the six presumed belt drives serving each bay (Figure 26). Marks on the surface of the rear wall indicate that the drive shafts were protected from

rain by an overhanging roof or awning. That belt drives, and not the more conventional line-shafting, were used at this stage in the power transmission system is suggested by the inclined sills of the openings, which permitted sag in the endless cloth or leather belts. Clutch wheels in the belt race, controlled via the tunnels or end walls, would have allowed disengagement when an incorporator was not in use (for a more detailed description of the mills and the Burbach iron and steel works *see* Section 10).

Historic maps show that the detached power house to the rear [53], described as **Engine, Boiler and Wash Houses**, was a large L-shaped building measuring about 22m by 26m. Its site is heavily overgrown and is covered by scrubby woodland and brambles, although it is not possible to determine the full extent of the building, brick foundations, machinery plinths and wheel pits mark its site.

Most of the charcoal used by the works was prepared in the **Charcoal House** [4] and **Charcoal Kiln** [6] at the western end of the site. It is, however, uncertain how or where the rye straw charcoal was prepared for use in the manufacture of brown powder. There is also the possibility that this lightly charred rye straw was imported directly from a German factory. Ordinarily, wood charcoal would be brought, probably by tramway, from the western end of the works to the **Charcoal Store** [64] that was located to the rear of the **Incorporating Mills** [52]. As a safety precaution charcoal was stored in a separate building as, although not an explosive, it was susceptible to spontaneous combustion. A mound, partly composed of broken bricks, marks the site of the **Charcoal Store**. Before the charcoal was taken to the **Mixing House** [51] it needed to be crushed to form a fine powder in the **Charcoal Mill** [40]. The **Charcoal Mill** was dug into the rear of New Cut's embankment, and is retained by a brick wall along its eastern side. The floor of the mill was probably at the same height as the towpath alongside New Cut and may have been supported on two piers whose footings remain close to the lower leat or tail race; adjacent to these piers are their tumbled upper sections. As in the incorporating mills most of the mill gearing was probably installed beneath the floor on which the mill stood. A building is shown in this position in 1871 with a leat falling from New Cut to the tailrace, which probably powered a waterwheel or turbine. It is unclear if this method of powering the mill was retained after the construction of the new **Incorporating Mills**. An alternative source of power would have been from one of the adjacent engines houses [50 or 53]. If power was taken from one of these a variety of transmission methods may have been used, including horizontal drive shafts or raised wire drives; neither of which would leave any archaeological trace.

Before the gunpowder was taken to the incorporating mills, the ingredients were first blended into the correct proportions to form a mix known as the 'green charge'. The saltpetre and sulphur were prepared

Figure 27
Mixing House [51], showing the curved roof scar and possible position of the raised floor level (BB94/ 10117). (c) Crown copyright.NMR

in the refineries at the western end of the works and brought, probably by the tramway, to the **Mixing House** [51] to the north-east of the **Incorporating Mills** [52]. The **Mixing House** (Figure 27) was a large rectangular building, its western end dug into the rear of the embankment of New Cut, the embankment being supported by a concrete retaining wall. The building was divided in two by a concrete axial wall, which survives along with the rear wall of the western bay. The length of the western bay is 10.3m which probably indicates that the total length of the building was about 22m, including the axial wall. Scars on the axial wall and the rear wall of the western bay may be analysed to reveal something of the form of the structure. On both sides of the axial wall a curving scar shows that the building was covered by a barrel-shaped, metal, probably corrugated iron roof. This was supported by T-irons and was lined on the underside by a chicken-wire and plaster ceiling, below this are traces of the original plaster and whitewash wall finish. A brick scar, 0.6m in width, set 1.36m back from the front (south-west) edge of the axial wall marks the position of the front wall of this building. The roof scar continues over this wall and the surviving rear wall indicating that it may have also covered a porch or a drive shaft alley. In narrow trenches parallel to the front and rear walls a number of fixing bolts are visible, marking the position of supports for bearing boxes of a horizontal drive shaft. The rear wall is strengthened by metal plates and is pierced by three square holes, each originally measuring 0.45m by 0.45m. These holes have all been smashed at the top, perhaps to remove metal fittings. It is likely that they contained bearing boxes and were used to transmit power from external drive shafts to machines within the **Mixing House**.

At approximately head height, on the eastern elevation of the axial wall is a horizontal scar, which might indicate the position of a raised walkway or floor level. Most of the floor at ground level is covered by undergrowth; the only details visible are a section of smashed concrete flooring and occasional protruding fixing bolts for machinery.
To the east of the axial wall is a leat that was formerly taken in a culvert beneath the building. The eastern bay has been demolished and its rear wall apparently deposited in a large heap. However, protruding through the undergrowth are floor lines and concrete blocks for mounting machinery which may indicate that the presence of further archaeological remains.

The **Mixing House** was powered by an **Engine House** [50] sited at its western corner. Air photographs reveal that a roofed building stood at this position at least until the late 1940s, which may suggest that the **Engine House** was later reused as a dwelling. There are no surface remains at this location to indicate the site of the **Engine House** or later dwelling.

To the north-east of the **Mixing House** is the site of the **Charge House** [72]. The function of this building was probably to hold the green charge before it was taken to the incorporating mills. The **Charge House** was also dug into the rear of the embankment, which in this instance is revetted by corrugated iron sheeting. The three remaining sides are protected by a corrugated iron Chilworth mound, which stands about 2m high. The foundations of the **Charge House** measure at least 5.5m by 4m, but may have once extended further northwards. North west of the **Charge House** was a **Store** [67], its site marked by a sub-rectangular hollow, which steps up to the west. Part of it may also be covered by the embankment which carries Lockner Farm Road across the valley bottom. Beyond it, and close to the modern gate, was the **East Lodge** which was later used as the **Densimeter and Examining House** [48], no surface trace of this structure is visible. To the west, and set against Lockner Farm Road was the **Saltpetre and Sulphur Store** [49], its position is defined to the east by a concrete wall built to retain the causeway and to the west the line of its concrete floor slab is visible. This building, or one on its site, was used as a dwelling until at least the late 1940s.

To the west of the **Incorporating Mills** [52] and the **Mixing House** [51] is a deep leat which is cut about 1.0m below the present ground surface. While the factory was in operation this leat was partly channelled through a covered culvert, which has subsequently been dug out. Running along side the culvert to the west was one of the main tramway routes through the site whose course may be traced as an earthwork embankment and which is used by the modern path. The main course of the tramway was eastwards but adjacent to the western corner of the **Engine, Boiler and Wash Houses** [53] a subsidiary line led off the main tramway route

towards **Magazine** [54]. To the south-west of this embankment is an overgrown brick drain and to its north-east a linear embankment probably delimiting the line of a footpath across this low-lying ground. Again to the north-east there is a sub-rectangular hollow which marks the site of a pond. Opposite the north-western end of the **Mixing House** [51] there was a complicated tramway junction where the main route continued north eastwards and short branch lines led to the **Saltpetre and Sulphur Store** [49] and to the north side of the **Mixing House**. A further line doubled back on itself to the north-east of the pond and returned south-westwards on an embankment alongside the Tilling Bourne. The embankment then diverged from the stream to take the tramway to the south of **Press and Engine House** [55]. Two large brick foundations, on which the engines or presses were mounted, mark its site. To the west of the **Press and Engine House** the tramway passed over a bridge above a narrow culvert, whose position is marked by brick revetment walls.

To the east of New Cut, and opposite to the **Incorporating Mills** [52], is the site of the nineteenth century **Blending House** [65]. In this building different batches of gunpowder after drying and glazing were mixed together to ensure a uniform product. The **Blending House**, sited in a small natural valley was powered by a small stream which rises to the east. It is unclear if the stream was originally channelled beneath the building to power a waterwheel or turbine. When the building was demolished, the debris, comprising large pieces of smashed concrete blocks, was pushed southwards over the stream. The **Blending House** was surrounded by a traverse, but it is uncertain if these large blocks once formed part of the traverse or another part of the structure. Gunpowder was brought to the **Blending House** by the tramway which crossed New Cut on a timber bridge [BR23], whose timber supports and one beam survives. On the southern side of New Cut an embankment, which survives as an earthwork, carried the tramway to the **Blending House**. The **Blending House** survived as a roofed structure into the late 1940s and may have been reused as a dwelling. To its north-east is a sub-rectangular platform [EH 14] which measures about 10m by 4m. Scatters of mid-twentieth century domestic rubbish in this area, including pottery and glass, may indicate that it was the site of an inter-war dwelling or shed. Below this area is a level linear feature which may either represent a lynchet or track. This feature is truncated a linear bank and ditch oriented north-west to south-east which marks the line of a nineteenth century hedgeline. A linear scarp, 78m to the north-east and parallel to this, may represent another field boundary. Dense scrub, woodland, and fallen trees covers the valleyside in this area. The surface is featureless except for a single scarp oriented south-west to north-east, which probably represents a lynchet. To the west of Lockner Farm Road the boundary of the powder works is marked by a sinuous fence line. The original line was a post and wire fence, of which occasional metal fence posts remain.

On the valley side, to the south west of the **Blending House** [65], there are a series of linear scarps, which in part represent lynchets. One that lies parallel with the crest of the valley side may be followed for 95m; a bank on its northern side, probably indicates that it was once a hedged boundary. At its western end it turns to follow the crest of another subsidiary valley. About half way up this valley, which lay outside of the survey area, there is an earthwork dam. It is not known if this marks a mill site or whether this valley accommodated a series of storage ponds to feed the powder mills in times of water shortage. To the west of the mouth of the valley the factory boundary is very close to the southern bank of New Cut and the intervening ground is covered by dense scrub.

To the south-west of the Incorporating Mills are the remains of the **Corning House** [39]. A building powered by the water from New Cut is shown in 1871, with a smaller building, the **Wash House** [38] to its west. The mill was dug into New Cut's embankment, which is retained on three sides by a brick wall with a rectangular wheel pit at its western end. Adjacent to New Cut is a mass concrete revetment wall, which marks the position of the loading bay for the building. The upper floor was level with the towpath and probably contained the corning machines with the sieves beneath, which graded the powder into different sizes. Along New Cut, 60m to the west of the **Corning House** is an **Expense Magazine** [37] (*see* Figure 20). It is set on the northern embankment of New Cut and its single door facing the leat indicates that it was served exclusively by powder punts. It is almost identical in form to the other surviving **Magazine** [EH 6] (described above), the only difference is that it had a raised floor to compensate for the local ground fall. The **Magazine** was probably built during the 1870s; a development, perhaps, in response to the passing of 1875 Explosives Act, which laid down new regulations for the operation of powder works.

Smokeless Powder Factory - see plan Sheets 6 and 7, (Figure 28)

The Smokeless Powder Factory was established in 1892 to manufacture the propellant cordite (a mixture of guncotton and nitroglycerine blended together with acetone), which by this date was rapidly replacing gunpowder as the principal military propellant. The production of cordite required different skills and machinery to those required for gunpowder to manufacture. A common feature was, nonetheless, the need for a disciplined workforce familiar with working in a carefully regulated manner.

In the early 1890s cordite was a new explosive, recently developed by Sir Frederick Abel, the chief War Office chemist, and his colleagues. The Chilworth Gunpowder Company was therefore faced with the challenge of laying out a new factory to produce a novel product with little experience from other manufacturers to draw from. The financial outlay by the company to enter the cordite market was, however, relatively

modest. Through its links with the Nobel company it was able to obtain cordite paste, a mixture of nitroglycerine and guncotton, from the Nobel factory at Ardeer in Scotland. This saved the Chilworth Gunpowder Company the expense of erecting large nitroglycerine and guncotton factories and their associated chemical plants. This arrangement also suited the self-interest of the Nobel companies, for it prevented other propellant companies gaining nitroglycerine plants, which would have let them enter the lucrative high explosives business.

Figure 28
The area of the smokeless Powder Factory looking southeastwards, to the right is Lockner Farm Road and to the top is Postford Pond (NMR 23016/22). (c) English Heritage

Cartographic evidence indicates that the new factory was essentially a single-phase construction of the 1890s, with a few additional buildings being erected during the First World War. It was laid out in the valley bottom of the Tilling Bourne to the east of the established gunpowder works (Figure 28). The new area was bounded to the west by Lockner Farm Road and to the south by the millrace New Cut. The northern boundary was less well defined. At its western end it followed a boundary that ran along the crest of the valley side and then turned eastwards to the rear of ***Longfrey*** [83]. To the east is Lidwell Copse, a very steep valley side subject to land slips. At its lower level a terraced track, which predated the factory, cuts through this area heading eastwards towards Colyers Hanger.

Figure 29
Cottage (BB94/10096). (c) English Heritage

Prior to the construction of the Smokeless Powder Factory, the valley floor was open pasture. The Tilling Bourne flowed along the base of the northern scarp in a partly man-made cut, to a stone-lined culvert [BR20], which takes it beneath the causeway that carries Lockner Farm Road across the valley floor. In the valley bottom was small stone built **cottage** [85] (Figure 29), which is probably early nineteenth century in date. The 1871 Ordnance Survey map showed a featureless valley floor except for a boundary between ***Longfrey*** and Lockner Farm Road. This boundary may still be traced as a deep water filled ditch with a linear bank of upcast material along most of its eastern side. The valley floor is cut by many other drains, it is, however, uncertain whether they were cut prior to the laying out of the new factory and were perhaps too insubstantial to be depicted by the Ordnance Survey, or whether they were dug when the factory was built.

Along the northern side of this area the factory retained the existing terraced track along the valley side to Colyers Hanger. Access into the factory from the western end was through a pair of iron gates hung on brick piers, which may date from the extension of the factory. Between the entrance and ***Longfrey*** four new explosives buildings were constructed along the valley side and were widely spaced at 50m (164 ft) intervals. To accommodate the structures platforms were dug into the hillslope and revetted to the rear by a low concrete wall. If additional protection was required this was provided either by mounds of unsupported earth or by the characteristic corrugated iron Chilworth mounds. None of the buildings survive, but most were probably timber or iron-framed and covered in corrugated iron.

On entering the northern part of the factory from Lockner Farm Road the first building encountered was the **Packing House** [14/74]. Its site is now occupied by ***Longfrey Cottage***. This two storey 1960s detached house, was built on the platform created for the **Packing House**; to the rear of the house the low concrete revetment wall remains. At the beginning of the Second World War the Tilling Bourne was used as a Stopline against the threat of German invasion. As part of these defences a brick-faced **Pillbox** [M6] was built at the north-east corner of the former **Packing House** floor, and has been subsequently incorporated into the house. Other features on the hillslope to the west and east of the 1960s house may be attributed to gardening activities. To its north was **Factory Magazine** [15/75], now marked by a concrete platform revetted on three sides by a low concrete wall; on its eastern side a decayed Chilworth Mound survives. The interior is occupied by a builder's yard. Beyond this **Factory Magazine** [16/76], was set further

back from the track and sat on a platform dug into the hillside. In the angle of the fence was **Factory Magazine** [17/77], its rear dug into the hillslope and the front protected by a Chilworth mound. On the track between [15/75 and 17/77] is another brick faced **Pillbox** [M7].

Figure 30
Longfrey (BB94/ 10114). (c) English Heritage

The house ***Longfrey*** [83] sits on a southerly facing platform, in part excavated to accommodate the house (Figure 30). Architectural and cartographic evidence suggests that ***Longfrey***, a large house, was originally erected as four dwellings, probably built during the late 1860s. To its west is a timber framed **barn** [84], which might predate ***Longfrey***, and to its south a modern **garage**. The earthworks in this area represent garden terracing and perhaps more extensive former orchards or vegetable plots.

To the east of the house is a terraced track that bears northwards through a piece of woodland known as Lidwell Copse, it predates the extension of the powder works into this area and is shown on the 1871 Ordnance Survey map. During the construction of the factory the track was made up with hard core and given an asphalt surface and in parts was supported by mass concrete revetment walls.

Construction of the new buildings in this area took full advantage of the local topography and geology. The valley side is composed of virtually stone-free sand deposits and this allowed for the relatively easy excavation of large hollows in which the danger buildings were placed. The resulting spoil was used to fill the surrounding corrugated iron sided Chilworth mounds. The disadvantage of these local conditions is that the area is susceptible to landslides after periods of heavy rain, and this has resulted in the loss of part of the track between the **Blending**

Houses or Expense Magazines [4/79] and [5/80]. Five buildings were positioned along the valley and were regularly spaced at 60m (65yd) intervals.

The westerly two structures, **Blending/ Packing House or Expense Magazine** [5/80] and the **Magazine** [82], were accessed from the track. As described above a hollow for the **Blending/ Packing House or Expense Magazine** [5/80] was excavated into the slope and on the downward side the building was shielded by a Chilworth mound. The original shape of this feature is distorted by soil slippage from above. To its north-east are the remains of the **Magazine** [82]. This too was constructed by digging into the hillslope; against the slope the north-western side is retained by a mass-concrete wall and the opposite side of the building was shielded by a Chilworth mound.

The remaining three structures were placed on the valley floor on platforms partly quarried into the hillslope. The southerly structure was an **Expense Magazine** [78], its north-western and south-western sides were excavated into the hillslope, and the open easterly sides are protected by an L-shaped Chilworth mound; the interior has been obscured by tipping. To the north was another **Blending House or Expense Magazine** [4/79] and this too was dug into the hillslope. Its north-western side was retained against the hillslope by a mass concrete wall and an L-shaped Chilworth mound protects the open east side. Adjacent to the entrance to the mound is a square concrete platform, 3m by 3m, which probably marked where the tramway crossed the Tilling Bourne, and where the explosives were then carried into the building. To its north-east was **Factory Magazine** and later **Paste Sieving House** [6/81], which is of a similar construction with a mass concrete rear revetment wall and an L-shaped Chilworth mound facing the stream. In front of its entrance is an irregularly shaped concrete floor slab and on the opposite bank a piece of concrete indicates the position of the tramway bridge.

Adjacent to the Tilling Bourne between [4/79] and [6/81] are the remains of a circular brick hydraulic **Ram House** [EH22], which predates the development of the Smokeless Powder Factory and originally sat within its own fenced enclosure. Also to the east of the **Factory Magazine** [6/81] are a number of features associated with water management. Immediately to its east is **Lid Well**, which survives as a partly collapsed brick vault, to the south there is a small rectangular brick manhole, and further south, a small collapsed brick structure which may have contained another hydraulic ram. To the east of these features, and at the limit of the survey, a scarp marks one side of an engineered terrace, which is shown as the 'Top of Old Cam' on the 1871 Ordnance Survey map. It appears that in the early nineteenth century, water was taken from **Lid Well** to Postford Mill (to the south east) by the papermakers who occupied the mill at that time (Crocker and Crocker 2000, 83).

Prior to the construction of the Smokeless Powder Factory the valley bottom was open pasture, although it was being used as a hop garden in the early nineteenth century (Crocker and Crocker 2000, 70). On the valley floor was a small stone **cottage** [18/85], which was later used by the factory as a **Package Store**. The first building erected in this area by the gunpowder works was the **Incorporating Mill** [1] on the western side of the New Cut close to Lockner Farm Road. It was probably built between the acquisition of the works by the new consortium in 1885 and the construction of the Smokeless Powder Factory in 1892. The remains of the mills may be traced as heavily overgrown brickwork and although robbed they are similar in form to the surviving concrete **Incorporating Mills** [52]. To accommodate the **Incorporating Mills** a platform was dug into the embankment of New Cut, its eastern basement brick wall supporting the embankment. In plan the mills were originally T-shaped with a rear boiler and engine house. In the centre of the mills is a section of ruinous brickwork about 5m in height. To its rear an arched recess is flanked by brick buttresses of almost identical dimensions to a similar feature on the surviving mills. This suggests that they were powered in the same way, with a horizontal drive shaft running along the rear of the building. The recess representing the place where the drive-shaft from the engine house meshed with the drive shaft running down the rear of the building. The remains show that there were eight self-contained bays and in each of their basements are the remains of the brick piers, which supported the incorporators and their gearing. Footings for additional brickwork against the axial walls indicate that the weight of the machinery was transmitted to the walls in a similar manner to the surviving mills. The working level of the mill floors was the same height as the top of the embankment and as in the surviving mills, two pairs of steps gave access to axial corridors which led to the rear. It is presumed that the upper structure of this mill was brick, with a flimsy timber front wall and roof.

A tramway ran along the western side of New Cut in front of the **Incorporating Mills**, the bank directly in front of the mills being supported by a concrete revetment. Entry into this new area was controlled by the **Foreman's Office** [22] which was sited on the eastern side of Lockner Farm Road. Apart from a very slight widening of the top of the embankment at this point, there is no surface evidence for the site of the building.

The operational life of the gunpowder **Incorporating Mills** was probably very short, for in the 1890s the new chemical explosives replaced the traditional black and more recent brown gunpowders. The boiler and engine house was retained to raise steam and perhaps to generate electricity. Parts of the **Incorporating Mills** were reused as a **Boiling House** [11], a **Distillery** [11a], and a **Separating House or Packing House** [10]. Eastwards, beyond this building, the main group of new factory buildings was placed along the northern side of New Cut and

STOVE No 2
Smokeless Powder Factory
Chilworth Gunpowder Works, Surrey

Surveyed November 2001
Grid reference TQ 03383 47765
Drawn by Joanna Smith

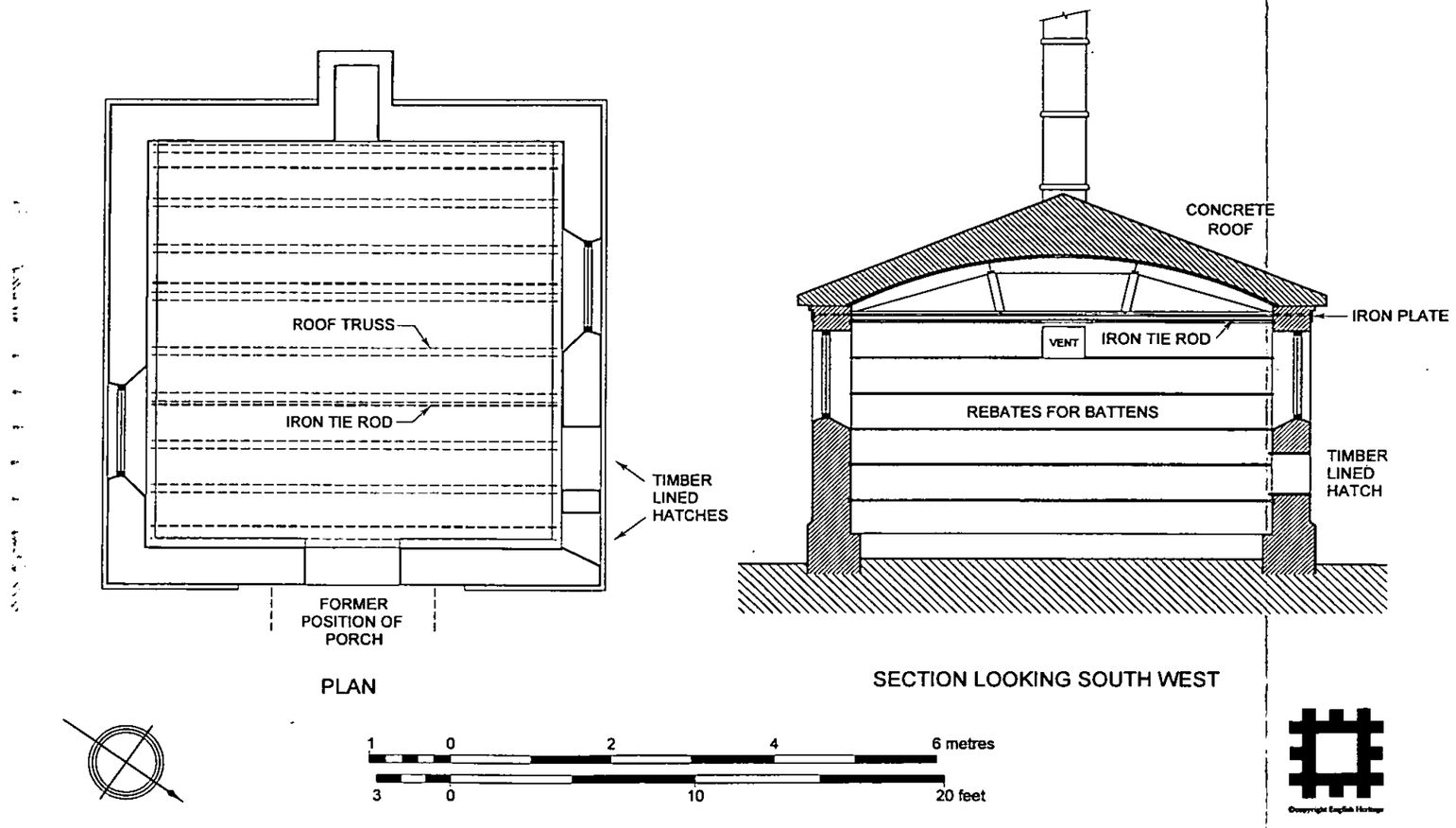


Figure 31
Stove no. 2

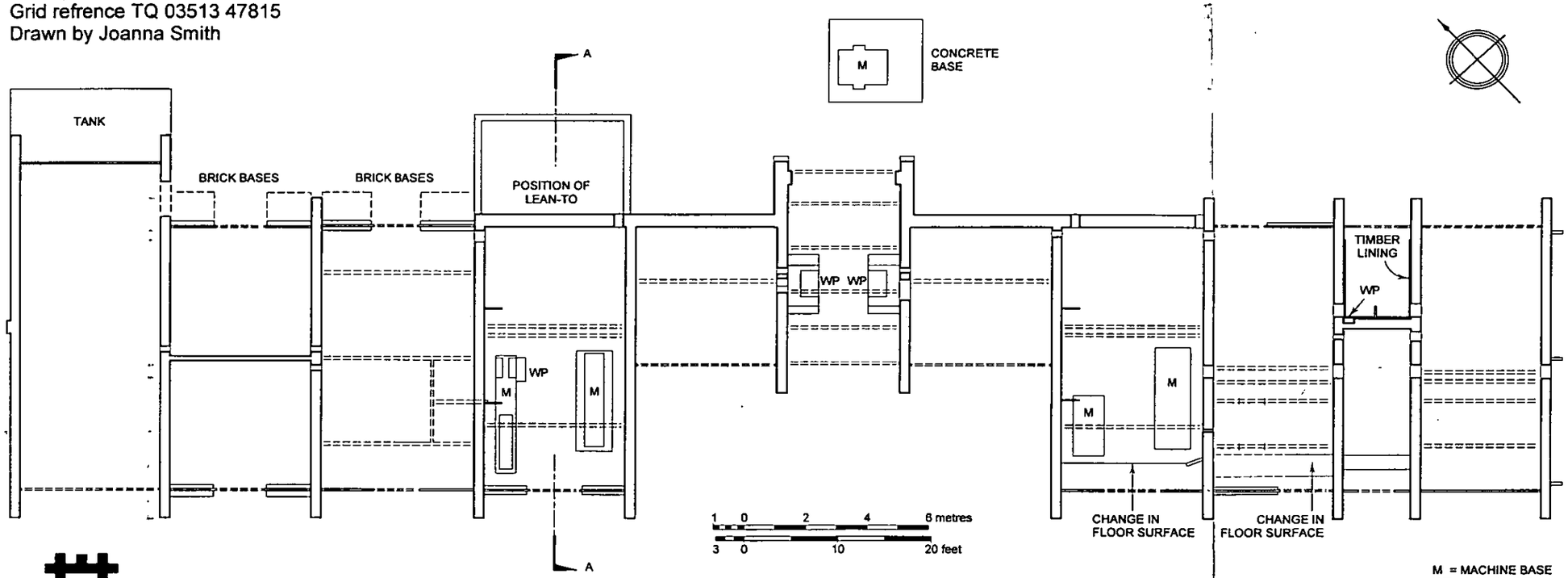
most survive as standing structures. It appears unlikely that New Cut was used for transport as a tramline was laid along the embankment to link the buildings together. To the east of the **Incorporating Mills** are two **Stoves or Expense Magazines** [2 and 3], they are single-storey brick-built structures with mass concrete roofs (Figure 31) sited at the base of the embankment and were shielded on their northern sides by Chilworth mounds. Access was via central doorways on the east. These were originally provided with brick porches that have subsequently been removed. The buildings were lit by windows in their north and south walls. On their northern walls two timber-lined hatches allowed for the delivery of materials without entering the building, a common safety feature in many explosives handling buildings. These openings were apparently provided with a canopy, for which only the joist sockets remain. Internally, their floors consisted of a raised wooden floor above the concrete foundation slabs and were supported by a brick plinth and dwarf walls. The internal walls, and probably, the ceilings, were lined with close fitting wooden boards. The buildings were warmed by steam heating pipes and were well-ventilated with openings at the floor level and larger vents set high on the walls; on their western wall are substantial external brick flues. Above the apex of the roofs the vents are formed from large diameter glazed ceramic drainage pipes.

Between the **Stove or Expense Magazine** [3] and the **Kneading and Press House** [30/73] are the ruins of a small two cell brick-built structure [EH 19], each bay was entered by a doors on the north side of the building. It survives to 1m in height and is partly buried by vegetation. Its function is unknown.

To the east is the cordite **Kneading and Press House** [30/73], the largest surviving building in this section of the factory (Figures 32 & 33). In this building cordite paste, a mixture of guncotton and nitroglycerine, was incorporated with mineral jelly and acetone to form cordite dough, which was then pressed into long cord-like strands. The 165ft (50.3m) long single-storey building is built of red brick, divided by substantial 0.35m (13¾ in) thick cross walls into eleven bays. The gabled cross walls project dramatically above the varying roof lines and extend beyond the front and rear walls on most bays to create a building that steps up and down and in and out to picturesque effect. The corrugated iron roofs of each bay are supported on rolled steel joists, whose German manufacture is indicated by the rolling mark 'BURBACH' still visible on the web of several of the joists. The central bay is open-sided, the northern ends of its side walls reinforced with battered buttresses on the inner and front sides. In most bays the front and rear walls are of lightweight construction, steel-framed with large windows of unreinforced glass and corrugated iron infill panels on low brick plinths and corrugated iron doors. The two bays to either side of the centre are the only exceptions, having brick walls to their north sides.

CORDITE KNEADING, PRESSING, MOTOR & ENGINE HOUSES, No 30
Smokeless Powder Factory
Chilworth Gunpowder Works, Surrey

Surveyed November 2001
Grid refrence TQ 03513 47815
Drawn by Joanna Smith

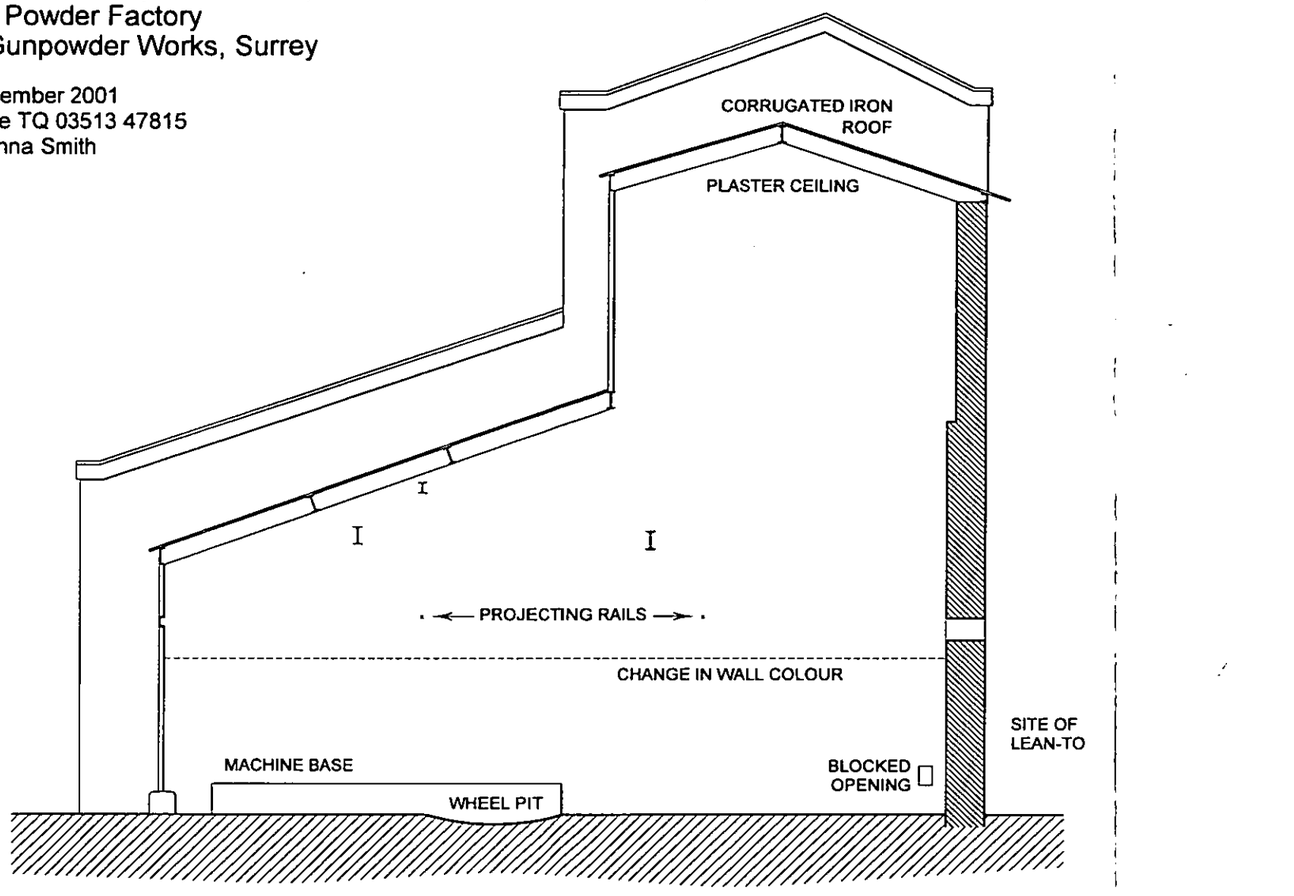


PLAN

Figure 32
Cordite kneading, pressing, motor and engine house [30/73]

CORDITE KNEADING, PRESSING, MOTOR & ENGINE HOUSES, No 30
Smokeless Powder Factory
Chilworth Gunpowder Works, Surrey

Surveyed November 2001
Grid Reference TQ 03513 47815
Drawn by Joanna Smith



SECTION A-A LOOKING NORTH WEST

Figure 33
Cordite, kneading, pressing, motor and engine house (section) [30/73]

Figure 34
Cordite, kneading, pressing, motor and engine house No.30 / 73 (AA038373). (c) English Heritage

The single-bayed arrangement of the kneading and pressing house was characteristic of this type of structure and was dictated by functional needs and safety concerns, which required the separation of individual processes (Figure 34). To lessen the danger of accidents the building was protected by lightning straps fixed to its wall by small copper plates. The high cross walls were intended to direct the force of any explosion upwards and to contain the blast and the relatively flimsy walls and roofs were designed to blow out to reduce damage to the machinery. Corrugated iron had the additional advantages of being a cheap, light and non-flammable building and roofing material. The overall disposition of the spaces in the building - almost symmetrically arranged with four differently sized bays mirrored to either side of the centre bay - and the good quality brickwork, laid in English bond and finished with coping tiles, suggest a concern with appearance beyond the strictly functional.

Although the structure remains substantially as built, it has suffered some depredations. A lean-to once stood against the westernmost bay; the purpose of this corrugated iron clad structure is now unclear but it stood over a deep sunken tank with a concrete cover that still survives. This space was apparently inaccessible from the end bay so a doorway for this compartment was provided in the east cross wall, originally with an iron door (now replaced). A similarly finished lean-to structure, possibly a later addition, abutted the fourth bay from the west. This structure covered a tank supported on brackets in the north wall of the building, still standing in 1994 but subsequently removed.

When in operation the pressing and kneading house had a detached engine house to the north of the centre bay, of which only the asphalt-covered floor and concrete engine bed now remain. It is unclear what type of engine was used, but possibly an oil-fired engine powered machinery within the open-sided central bay. Evidence of this survives in the form of shallow wheel pits to the east and west sides and associated wall openings, as well as damage to the top of the inner buttresses

resulting from the removal of metalwork. Power was transmitted through the pressing and kneading bays by overhead line shafting, indicated by bearing box openings in the cross walls (some now blocked). The tall compartments in the fourth and eighth bays appear to have functioned as hydraulic accumulator towers. The type of artificial lighting used in this building is unknown, as all the remains of electrical power supply appear to be secondary. The evidence of low openings in the bay walls indicate that steam heating pipes were used to regulate the temperature within the building, a necessary safety precaution given the product.

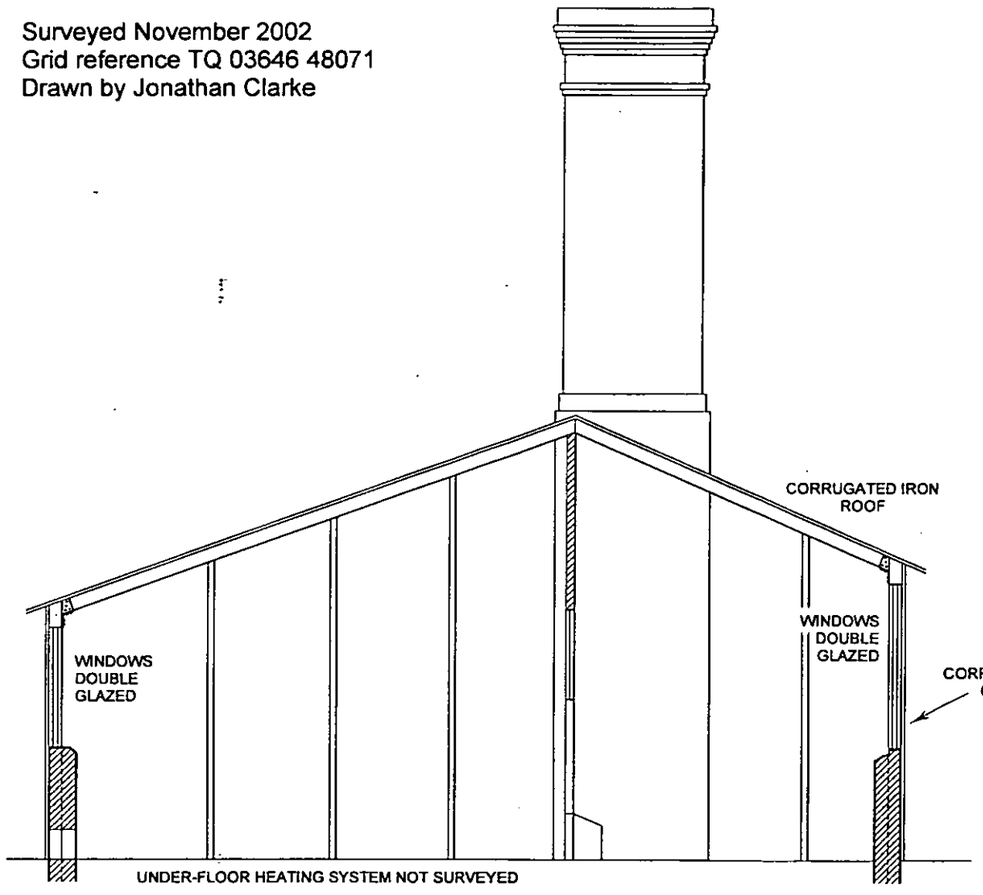
The interior of all the walled bays were finished in identical fashion, with painted walls, in two shades; a dark pink in the lower part and cream for the upper sections and ceilings. This gave an easily cleanable surface and thereby lessened the risk of explosions by reducing the amount of dust in the building. The plaster skin of the ceilings were backed by chicken wire tied to iron battens running between 'I' sections that in turn carried the corrugated iron roofs.

In between the **Kneading and Press House** [30/73] and, to its north-east the **Acetone Recovery Stove** [24], are two brick piers [EH 20] which once supported a horizontal circular tank. To its north-east, and tipped against the earthwork traverse which surrounds the **Acetone Recovery Stove**, is a dump of ceramics used in chemical processing. The most numerous pieces are red earthenware Raschig rings [EH 21]. These rings comprise an outer ring about 9.5cm in diameter and 7cm tall and within them a circular piece of earthenware about 6.5cm in diameter and 5.5cm tall. Less numerous in the dump were fragments of circular plates, in a highly fired white clay, and pieces of large diameter earthenware pipes. The Raschig rings were probably stacked on these circular plates inside the large diameter pipes. Such an arrangement was commonly found in packing towers used to concentrate acids.

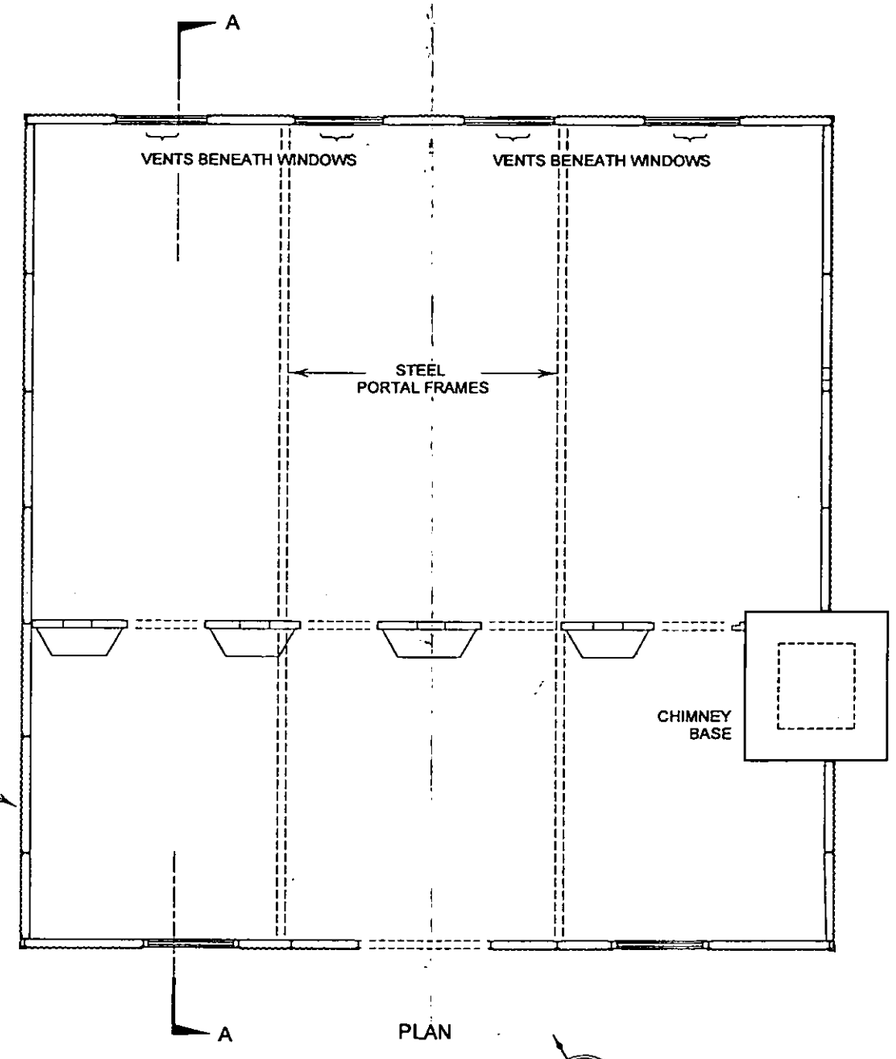
The **Acetone Recovery Stove** [24] was also known as the **Stove for Preliminary Drying and Extracting Solvents**, and its function is confirmed by a painted sign on the east gable 'DRYING AND EXTRACTING OF SOLVENTS'. Its function was to extract acetone vapour from freshly pressed cordite. It is a single-storey brick building 31ft 6in by 22ft (9.6m x 6.7m) with gable ends, the openings above the doors and windows supported by well-finished flat segmental brick arches. The roof is of a similar construction to the **Kneading and Press House** [30/73], and is supported by rolled steel joists. Externally it is clad in corrugated iron and internally the ceiling is plastered with a backing of chicken wire which is in turn tied to the joists. The stove was lit by timber-framed windows, two each on its north and south walls, and by small lights above the doors in each gable. Internally, it was separated into two uneven chambers, which were originally linked by a single door (now blocked) in the brick crosswall. Each chamber is entered through two pairs of double doors and between the doors is a

CORDITE DRYING STOVE, No 26
Smokeless Powder Factory
Chilworth Gunpowder Works, Surrey

Surveyed November 2002
Grid reference TQ 03646 48071
Drawn by Jonathan Clarke



SECTION A-A LOOKING EAST



PLAN

1 0 2 4 6 metres
3 0 10 20 feet

Figure 35 *Cordite drying stove [26]*

view hole, or squint, through which the contents could be monitored without entering the room. The doors are steel-framed. They are covered externally by corrugated iron sheets and lined internally with asbestos cement sheeting, both as a fire precaution and to retain heat. Bronze or brass screw locks on the doors allowed them to be tightly sealed. On the north wall of the eastern bay is a blocked circular opening, 0.68m (2ft 3in) in diameter, through which the vapour was probably drawn. The internal walls are bare brick, the lower portions of the walls are painted pink and upper portions are cream.

To the north-east of the **Acetone Recovery Stove** is the site of the **Washing House** [25]. This survives as a heavily eroded mound; internally the brick footings of the buildings remain. A slight raised bank extends from its south-west corner and probably marks the line of a footpath. Set into the south-west corner of the mound is a Second World War brick-faced type-24 **Pillbox** [M8] commanding the open ground to the south and west.

To the north of this feature there are two cordite drying **Stoves** [26 and 27] (Figure 35). The **Stoves** are identical single-storey rectangular buildings, measuring 52ft 6in by 33ft 2in (16m by 10.1m) in ground-plan. As well as the nearby woodland, which offered natural blast-proof screening, Chilworth mounds were constructed on three sides of either building, leaving the front entrance on their south sides clear for the tramway. As early examples of prefabricated, steel-framed structures they are of much constructional interest. Each is made up of four rolled-steel portal frames laterally braced by horizontal members, the whole clad in corrugated iron sheeting. The portals consist of two upright

Figure 36
Interior of cordite drying stove (BB94/10120). (c) English Heritage

members rigidly connected at the top by a hipped third member, which itself is made up of two I-sections spliced together. Throughout, gusset-plate connections are used, bolted through both the webs and flanges of the sections. The use of sloping portal frames enabled a large, column-free and securely roofed space for the drying process, although a central wall, transversely dividing each into two interconnecting compartments, seemingly offers some vertical support at the apex (Figure 36). The lower portion of this steel-framed partition is infilled with shallow (66cm 2ft 2in) high) brick piers, set between the four doorways. Similarly, the lower portion of the front and rear walls are infilled with plastered brickwork. This brickwork, with a sloping upper surface to facilitate cleaning, is pierced by rectangular openings, which presumably served as vents.

Each building was gently warmed by under-floor heating, although the form this took is now impossible to determine because it lies deeply submerged beneath accumulated ground water. To the rear is a now flooded outshot which probably housed a steam raising boiler. A brick stack, ornamented with oversailing courses at its top, and which projects well above the roofline in either stove, enhanced the circulation of air within and removed noxious fumes. Behind the corrugated iron shell, the walls were well insulated, using a fibrous material (possibly horse-hair) sandwiched between chicken wire. The chicken wire was itself tied to thin iron battens that extend horizontally between the vertical channels and I-sections framing the walls. This form of insulating construction was also employed for the ceiling of the **Cordite Kneading and Press House** [30/73]. Internally, the walls were plastered and painted to create a smooth washable surface. All of the windows were double-glazed and unopenable. To the east of **Stove** [27] is a linear earthwork about 50m in length, which probably represents the line of a footpath, this feature marks the easternmost extent of the factory in this area.

Prior to the construction of the Smokeless Powder Factory the valley bottom was open pasture except for the **Cottage** [18]. When this area was developed a series of well-spaced buildings, at a minimum interval of about 50m, were laid out across the valley floor. To the south-west and to the rear of the gunpowder **Incorporating Mills** [10, 11,12] is the site of the cordite **Kneading House** [31]. This building may be traced as a partly exposed concrete floor slab covered by gritless asphalt; projecting from this floor are a number of machinery mounting blocks. The eastern corner of this building was protected by a traverse which remains as an earthen mound. To its north-east are the sites of a group of three unidentified buildings. The first [EH16] is about 60m to the north-east of the **Kneading House** and comprises a large sub-rectangular earthwork mound 20m x 18m that stands about 0.5m high. On the north and south side of the platform there are two low ridges. No building is marked at this point on any of the available maps, the form of the mound, however, suggests that a building may have sat on it. About

50m to its north- east is a partly covered concrete floor slab [EH17] marking the site of another building. Historic air photographs and mapping show that this was the site of an eight bay structure with a central spine wall, which survived into the early 1970s. To its south-east, and connected by a gritless asphalt path is the site of the **Packing House** [13], its site is indicated by another partly exposed concrete floor slab covered by gritless asphalt.

To the north-east is a large pond, excavated some time between April 1964 (NMR 11432, 27 Apr 1964, Frame 087) and 1972 when the Ordnance Survey map was revised. The island for nesting birds at the centre of the pond was not surveyed.

Dominating the middle of the field is a single storey corrugated iron structure with gable ends [EH18] (*see* Figure 12). This is a three-bay structure divided by brick crosswalls. The eastern crosswall projects above the roof line, while the western wall is flush with the roof. The larger work rooms on the northern side of the building are lit by a row of single pane windows. Internally, the central room is divided from the southern outshot by a featureless brick wall, and the rooms to either side are divided by timber-framed walls. The eastern bay retains an original doorway between the main room and the outshot, and adjacent to it is a small window, or squint, from where operations in the room could be observed without entering. The ceilings of the eastern and central work rooms are lined with tongue and groove boarding and in the centre of the ceilings they have been crudely pierced with drilled holes about 1-inch (2.54cm) in diameter, perhaps to prevent the build-up of volatile fumes. Subsequent to the closure of the factory the building was converted into two cottages. Alterations at this time probably include the lowering of the western crosswall to the level of the roofline, the insertion of fireplaces and a chimney, and the construction of an earth closet on the eastern elevation. To its north were two **Cutting, Blending and Sorting Houses** [28 and 29]. The site of building [28] is a largely featureless concrete floor slab covered by gritless asphalt; a partly exposed floor slab reveals the position of building [29].

To the north-east of these structures along the eastern bank of the Tilling Bourne is a row of giant sequoias or wellingtonias, this species was introduced into England during the 1850s. No trees were shown in this area on the 1871 Ordnance Survey map, so the most likely date for the planting was probably during the construction of the Smokeless Powder Factory during the 1890s. At the Oare gunpowder works, Kent (Cocroft 1994, 20), wellingtonias were used to line the proof range. At Chilworth they may have been planted to screen the magazines to the west.

Admiralty Cordite Factory - see plan Sheets 4, 5, 7, 8, and (Figure 37)

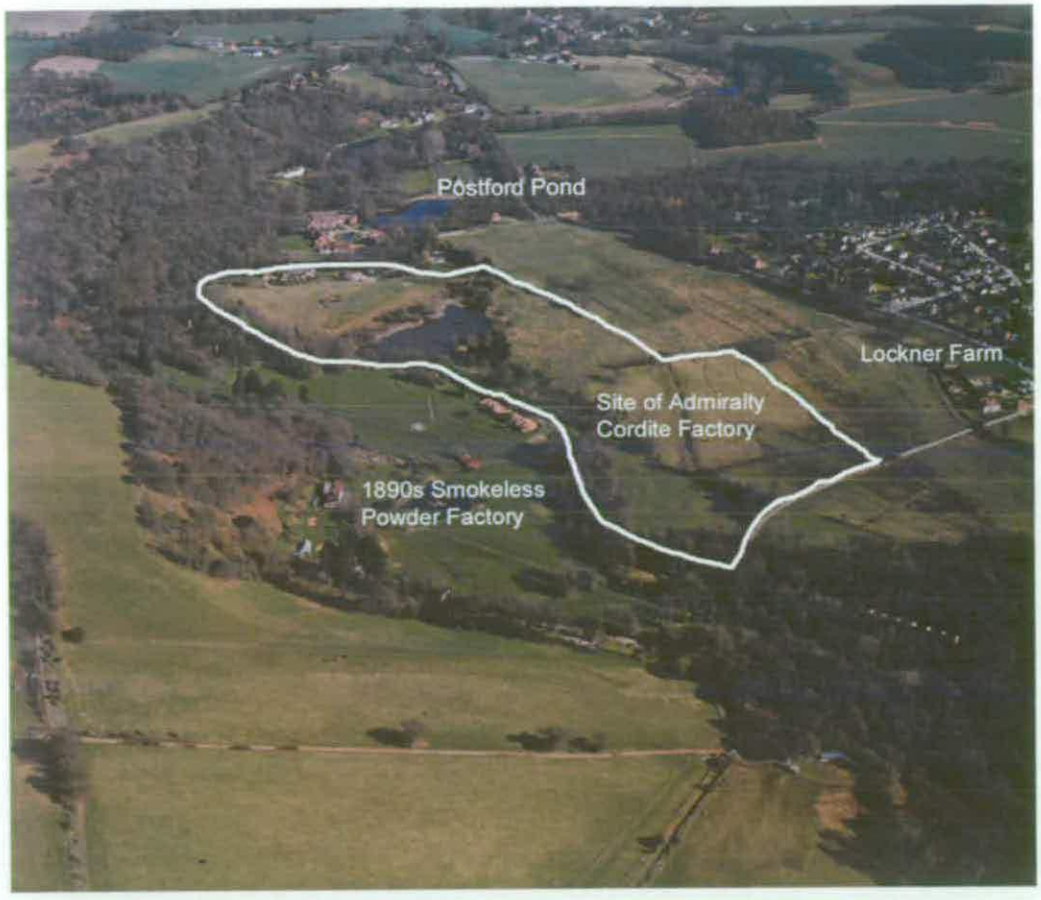


Figure 37
Site of the Admiralty Cordite Factory (NMR 23016/24). (c) English Heritage

The Admiralty Cordite Factory, laid out in 1915, was the last major development at the factory. The extension was set out on a greenfield site covering 9 hectares (22 acres) to the north of Lockner Farm and to the west of Postford Mill. Its southern boundary was drawn from Postford Pond to the corner of an existing field boundary, the factory perimeter then followed its line before it was projected on the same orientation to Lockner Farm Road. Today the line of the southern boundary may be followed westwards from Postford Mill Pond along the public footpath, delimited to the south by a concrete post and wire fence, which probably date from the First World War. This gives way to the pre-existing boundary that may be traced as a ditch with the remnant of a hedgeline at its western end where it meets a main north to south boundary. From this point there is modern fence line which roughly follows the line of the proposed boundary marked on the 1915 diagram. To the north the factory extension was bounded by the millrace New Cut. Prior to the war most of the area was open pasture except for the strip of land adjacent to New Cut which was wooded. Also wooded was the small field at the northern corner of the extension, which borders on to Lockner Farm Road. Late nineteenth century maps show this area covered by coniferous woodland, within it were two small buildings and a well. A linear earthwork, about 13m in length and a small sub-rectangular hollow, may mark the position of these buildings [A5]. A hedged or fenced

boundary is depicted along the line of the modern footpath. No other features are visible in this field, which is not surprising given that it was former woodland and considerable disturbance must have taken place to remove the trees and their stumps.

The extension to the factory was erected as a matter of wartime expediency to increase the factory's cordite production. The majority of the buildings were timber-framed and clad in corrugated iron, reflecting the need to bring the extension into production as quickly as possible. The foundations do, however, reveal minor variations in the form of the construction of the wooden buildings. The only buildings which appear to have been built in brick were the acetone **Recovery Stove** [A17] and the **Press House** [A21], which were probably brick-built due to the more hazardous nature of the processes carried out within them. Most of the production buildings were connected by a tramway.

The only contemporary plan of the Admiralty Cordite Factory is a proposal diagram drawn up in 1915 and preserved in the Duke of Northumberland's archives at Alnwick. This map is particularly valuable as it also shows the proposed functions for the majority of the buildings and these are used in the description and interpretation of the remains. No building numbers were given on the plan and the numbers used in this description, prefixed by the letter 'A', have been allocated for ease of identification. The general arrangement of the extension followed this proposal plan, although some minor details in the location and orientation of a number of the buildings do differ. This diagram also shows four buildings to the north in the area of the factory laid out in the 1890s, this probably implies that these buildings were incorporated into the 1915 scheme and formed part of the operational flowline of the new factory. The further buildings shown are the **Barrel Store** [18], and in the northern corner of the field two **Magazines** [79/6 and 81/7]. **Magazine** [6] is, however, described as the paste **Sieving House**; the **Drying Stove** [27] is also shown.

The extension may be divided into two areas the eastern and western fields. The former is poorly drained and covered by thick, tussocky grass, which was ungrazed at the time of survey. In the more poorly drained parts of the field there has been a build-up of marsh grasses and mosses which has further obscured parts of the surface. A pond and a marshy area to its east cover approximately one third of this field. These features appear to be a relatively recent development since the end of the Second World War. They have developed in an existing shallow natural valley which was dammed at its northern end by the seventeenth century embankment of the millrace New Cut. This area was originally drained by an 8-inch pipe, which passed beneath the millrace to emerge in the ditch to the east of the **Acetone Recovery Stove** [A24]. This drain has not been maintained thereby allowing the pond to form. The presence of fence posts projecting from the water in a line from **Recovery Stove** [A17] implies that the old ground surface remains intact beneath the pond.

The layout of the buildings indicates that the production flowline was from east to west (see analysis) and this arrangement is broadly followed in the description. In the north-east corner of the field the most substantial remnant is the concrete floor slab of the **Kneader House** [A23]. It is oriented south-east to north-west, which differs from the orientation shown on the proposal diagram. The south-eastern end of the **Kneader House** is probably indicated by a roughly square shaped mossy area, which when probed reveals a solid foundation beneath. To its east the location of the **Jelly Melting House** [A22] is similarly revealed. The site of the **Expense Magazine** [A24], to the east of the modern garden fence, lies beneath recent garden landscaping. To its south was the **Press House** [A21], a five bay structure with a barrel-vaulted roof probably covered by a corrugated iron roof (Crocker and Crocker 2000, 112). It too was converted into cottages after the closure of the factory and survived until the late 1980s when it was demolished and replaced by ***Postford Mill Cottages***. To the south are the remains of the **Still House** [A19], which comprise a large rectangular floor slab covered by grit-less asphalt. At its eastern end there are two circular brick foundations, which probably supported a couple of vertical vessels and close by are pair of brick supports for a horizontal circular tank. Further east was the **Acetone Store** [A20] whose site is now covered by an access road, garages, and store sheds. This was served by a new factory road, part of which survives as the access road to the house ***Girraween*** and ***Postford Mill Cottages***. On the opposite side of the stream is a heavily overgrown Second World War type-24 **Pillbox** [M9].

The only surviving building from the extension is the acetone **Recovery Stove** [A17]. This building is oriented south-west to north-east, which is contrary to the orientation shown on the proposal plan. This plan also shows a smaller **Recovery House** at its southern end; no trace of this structure was seen, but it may lie beneath the pond. The **Recovery Stove** is a single storey brick structure with a barrel shaped roof, which was probably originally covered by corrugated iron. The function of the stove was, as its name implies, to recover some of the expensive and volatile solvent, acetone, used in the manufacture of cordite. The stove was originally divided into four self-contained bays, each entered from double doors on the building's eastern side. The double doors to the northern bay survive, and typical of all doors to explosives buildings open outwards. The doors, although iron-framed, are hung on brass hinges to reduce the risk of sparking and are internally clad in asbestos cement sheeting. Adjacent to each door are the remains of a small viewing slot, or squint, through which the contents of the room, and perhaps a thermometer, could be viewed. After the factory closed the **Recovery Stove** was converted into two small cottages. During this phase of activity some of the existing doors were blocked and new windows and doors inserted; a fireplace and kitchen sink survive from this period.

To the east of the **Recovery Stove** was a line of three cordite drying **Stoves** [A15, A16 and A18]. If **Stoves** [A15 ands A16] were built their

sites probably lie submerged beneath the pond. The location of **Stove** [A18] may be equated with a level earthwork platform adjacent to an earthwork cutting used by the tramway. It was also proposed to place another **Stove** [A14] in this field, no trace was seen of this feature, as its approximate position is obscured by deep tussocky grass. Another unidentified building [A13] was shown to its west. This area, although fairly level, is covered by puddled mud from the footpath.

Along the northern boundary the **Blending House** [A11] may be traced as a partly buried concrete floor slab east of the hedgeline. On the proposal it was shown to the west of the hedge. To its east was **Stove** [A12], and although no floor slab is visible in this area, a level sub-rectangular platform bounded to the north by the perimeter fence and to the south by a tramway cutting may mark its site. Any close observation of the ground surface in this area is inhibited by the growth of dense tussocky grass. This field is bounded to the west by a hedgeline, which has been in place since at least 1871, with a stream to its east. By the end of the century a small roofed building [EH29], of unknown function, had been built to the east of the hedgeline, its location may be traced as a brick footing.

The western field, to the north of Lockner Farm, is poorly drained and prone to water logging and flooding, and is used for grazing horses. As a consequence, the grass in this area is relatively short and the earthwork remains are clearly visible. These plotted in the field correspond closely with the proposed layout of the extension shown on the 1915 map. No activity is shown on historic mapping in this field prior to the construction of the factory extension. The only features surveyed in the field which predate the extension are a number of shallow drainage ditches some of which are cut by the tramway system. The most prominent feature is a wide and usually water-filled ditch. At the western end of the field a wide, waterlogged linear depression feeds into this ditch, perhaps indicating a natural drainage line.

Along the northern boundary are the substantial concrete foundations of two cordite **Blending Houses** [A6 and A8]. Also in this field are the remains of three **Magazines** [A1, A7, and A9], each with differing foundations. The foundations of **Magazine** [A1] comprise a low concrete plinth on which a timber hut was set, impressions in the concrete indicate that it was clad in corrugated iron. **Magazine** [A7] is visible only as a vegetation mark, a roughly sub-rectangular area of short grass. The north-eastern corner of **Magazine** [A9] may be traced as an L-shaped concrete foundation. At the eastern end of the field is an unidentified building [A10] comprising a sub-rectangular concrete base. At its eastern end is a 0.80m projection which may indicate the presence of a porch on its northern side. Impressions in the concrete reveal that it was also clad in corrugated iron.

The main approach to the site for the workers was probably past Lockner Farm and down Lockner Farm Road. From the south the first buildings to be seen would have been the **Men's Mess Room** [A4] and the smaller **Women's Mess Room** [A2] and the attached **Box Store**. Between these buildings was the **Boot Store** [A3] which may have been used to hold the special magazine boots for use in the danger buildings. Traces of the **Men's Mess Rooms**, **Women's Mess Room**, **Box Store**, and **Boot Store** survive as low concrete plinths and projecting bolts on the interior indicate where the wooden base plate of the wall frame was secured. The floors in these buildings were probably supported on wooden joists.

Most of the production buildings were connected by a tramway, the course of which was shown on the 1915 diagram, and appears to have been a self-contained system with no links to other sections of the factory. The earthwork survey has been able to trace the tramway routes, either where the ground has been built up to form a slight embankment or where a cutting has been created. The ground works needed for the tramway were relatively slight, as the tramway carts were hand pushed and therefore did not exert a lot of pressure on the ground. In some areas there is no discernible trace of the tramway and it was probably simply laid on the existing ground surface. At a number of points the line of the tramway cut through existing field drains.
The proposed course of the tramway comprised two main routes, a northerly one and a southerly one. The northern line originally began at **Magazine** [A1]; the first section of this line has, however, been lost, although a broken piece of concrete near the main drain may indicate a bridging point. To the east the line may be followed as a low embankment past **Blending Houses** [A6 and A8]. To the south of **Blending House** [A11] the line of the tramway is lost in marshy ground and is picked up again as a cutting before it is lost beneath the pond.

In the north-east corner of the field the earthwork evidence suggests that the tramway followed a different route to that on the proposal plan. A curving cutting links the **Kneader House** [A23] to the **Still House** [A19], and a cutting to the north of the **Still House** may indicate the route of another line.

The southerly tramline may be followed westwards from **Stove** [A18] as a cutting for about 50m and then as a level area defined on its southern side by a single scarp to the hedgeline. Westwards, beyond the hedge line the tramline is traceable as a low embankment, past the main drainage ditch as a cutting and to the west of **Magazine** [A7] as a single scarp. After this point the line of the tramway is lost in marshy ground. The proposal diagram shows a loop linking the north and south lines, roughly to the east of buildings [A10] and [A11]; no sign of a line in this area was seen. A slight embankment to the east of **Blending House** [A8] and building [A10] may mark a connection between the southerly

and northerly tramlines, alternatively it may represent a former path. To the north of **Stove** [A18] in the eastern field is a linear cutting partly terraced into the slope which may mark a former tramline, its west end is lost in an area of marshy ground. To the south of this is another cutting, roughly oriented east to west, which may represent an additional tramline or alternatively the line of a footpath.

The Trees

No detailed survey of trees was undertaken as part of the work reported on here. Nonetheless, much of the woodland surrounding the remains of the mills results from the deliberate planting of selected species and may be regarded as a valid component of the archaeology of the site - as much as the mills' brick foundations or the tramways' embankments. In the area of the Middle Works many of the plantations are of coppiced alder, a favoured species for the manufacture of charcoal for gunpowder (Wardell 1888, 23). Also in the Middle Works, between **Incorporating Mills** [14 and 16], is a line of Yew trees, perhaps originally planted to form a dense blast screen; other yew trees in this area may indicate the remnants of similar screens. At the Oare Gunpowder Works, Faversham, Kent, yew trees were also noted in a similar position around the top of a cutting surrounding a process building (Cocroft 1994, 12). The most striking trees within the works are the giant seqoias, or wellingtonias, these specimen trees are native to California and were introduced into Britain in 1853 (Mitchell and Wilkinson 1982, 266). Their planting probably coincides with the acquisition of the factory by the Anglo-German consortium in 1885, and reflects the company's pride in its factory, also evident in the embellishment of some of the buildings of this date. A row of wellingtonias was planted at the eastern end of the new Smokeless Powder Factory, to screen a number of magazines that had been built to their north. Others were planted to the west of *Longfrey*, the residence of a number of the factory foremen, and an isolated tree was planted in the Middle Works to the south of the **Incorporating Mill** [20, 21, and 22]. At the Oare Works, wellingtonias were used to line the sides of works' proof range (Cocroft 1994, 14). Some of the planting perhaps needs to be considered in a wider landscape context. The clump of three Scots Pine trees to the east of **West Lodge** [46], may be the result of the desire of the lord of the manor, resident at Chilworth Manor to the north, to make the appearance of the valley more appealing.

5.PHASING AND ANALYSIS

The analytical description of the site presented below is based upon the surviving physical remains of the factory. The analysis is concerned with describing the topographic and technological development of the factory through time, and is underpinned by a wealth of historic maps and documentary sources, which have enabled many developments in the works to be determined with a remarkable degree of accuracy. Conversely, some periods, especially activities during the First World World, are poorly recorded.

For the purposes of this analysis the development of the powder works and its surrounding landscape has been split into ten main periods. These roughly coincide with the historical periods outlined in Section 3, although the seventeenth century activity has been grouped together under the early works. The theme of transport cuts across these chronological divisions, and is presented at the end of this section. Flowlines for the manufacture of gunpowder and cordite are presented as appendices, and should be consulted to show how different buildings related to one another in the production processes.

1 The pre-gunpowder works landscape

2 The early works

3 The eighteenth century

4 The early and middle nineteenth century

5 The late nineteenth century

6 The 1890s Smokeless Powder Factory

7 The First World War 1914-1919

8 The inter-war years

9 The Second World War 1939-1945

10 Post-war

Transport

Waterways

Road Transport

Tramways

1.The pre-gunpowder works landscape

The earliest human activity recorded in this section of the Tilling Bourne valley was in the vicinity of Postford Mill (now Albury Mill), where two prehistoric pits and a short section of ditch were excavated during an archaeological evaluation (Wessex Archaeology 1997, 5). Exploitation of the Tilling Bourne for milling began in the early middle-ages and has resulted in considerable alteration to the form of the valley and its watercourses. Successive remodelling of the valley has either removed or largely obscured the field evidence for its early form. The earliest focus for milling at Chilworth was on the western side of the causeway, which carries Blacksmith Lane across the valley bottom. This also forms the dam for a pond to the east, fed by the Tilling Bourne, that was used to power the mills on the causeway. In 1603 another mill was constructed by Thomas Steere to manufacture wire. This mill was probably sited to the south-west of the Blacksmith Lane causeway, perhaps on the site of the **Little Paper Mill** [EH 4]. For a mill to operate in this position a new millrace was required so a new upper channel was dug from the east, and was also fed from streams flowing off the southern side of the valley.

The original course of the Tilling Bourne is difficult to plot, and as with all streams and rivers through time it would have meandered across its flood plain. Also, given the width of the valley, the stream may have followed a braided course across the valley floor without a main tributary. Prior to human intervention the maximum extents of the stream's course were constrained by the natural valley slopes. Probably during the middle-ages, and perhaps coinciding with the construction of the causeway and mill pond, the main course of the Tilling Bourne was consolidated along the northern side of the valley, and in 1728 was shown as the 'Old River'. In addition to the Blacksmith Lane crossing, the valley is traversed by another causeway that carries Lockner Farm Road across the valley floor, before it ascends up towards Chilworth Manor. At the northern end of the causeway an ironstone culvert [BR 20] directs the stream below the causeway. Potentially, this causeway might have been used to create a mill pond, but there is no evidence from either the field remains or documentary sources that there was a mill at this site. Alternatively it might have been used to flood the meadows to the east to produce an early crop of grass.

A third crossing point was by a bridge, known locally as the **Packhorse Bridge** [BR 12]. It is also built out of local ironstone; the facing stones of the bridge appear to have either been stripped or fallen away and there is nothing in the present form of the bridge to indicate if it is of medieval or post-medieval date. The placing of a bridge at this point perhaps indicates that there was an established route across the valley. To the north linear earthworks in the woodland and a field boundary leading towards Chilworth Manor mark its route. To the south the form of the valley floor has been too greatly altered by the gunpowder works to trace

any former route ways. The remains of another stone bridge [BR 14] survive on New Cut; this leat was dug in the 1650s, so this bridge must date from that time, or later. A bridge is shown close to this position on the 1728 map, but it appears to be further to the east than [BR14], but no bridge is shown on the 1787 map (Althorp Papers P4 and P12).

The present profile of the valley is largely a consequence of human activity (*see* Appendix 1). One exception may be the hill slope between Powdermills Cottage and the **Packhorse Bridge** [BR12], which due to its steepness probably retains its natural form. To the east of the **Packhorse Bridge**, along the northern boundary of the powder works, a positive lynchet, formed by the ploughsoil being washed down hill, may be traced for about 300m before the boundary turns through a right-angle northwards. Beyond this point the land falls steeply towards the stream. In this area it is unclear if a number of lynchet –like features on this slope are a consequence of human activity or natural soil slippage of this sandy soil. The lower profile of this scarp was further modified in the late nineteenth century when a series of buildings were dug into its slope. Eastwards of ***Longfrey Cottage*** there is similar evidence for ploughing along the edge of the surveyed area. The wooded hillslope beyond ***Longfrey*** is very steep, and liable to periodic and dramatic soil slippage. No evidence for human activity was recorded in this area prior to the construction of the late nineteenth century magazines.

On the flatter southern side of the valley evidence for activity pre-dating the powder works is uncertain. To the west of Postford Pond the land is marshy and there is no visible evidence for agricultural activity except for grazing. To the north of Lockner Farm the valley side is more pronounced and immediately west of Lockner Farm Road a sharpening of the profile may be the result of ploughing creating a positive lynchet. The low earthwork bank running along the top of the scarp represents a former field boundary.

2 The early works

In late 1626 three gunpowder mills were established on Blacksmith Lane, on the sites of pre-existing corn and fulling mills, the area later being known as the Lower Works. These were probably located on the site of the later Printing Works [EH2], and given the subsequent alterations in this area it is unlikely that any archaeological remains of these early mills survive. In 1630 these mills were devastated by an explosion and in the course of rebuilding, one was relocated to the west to an area known as Steersland. This can be equated with the land on which Thomas Steere's wireworks had stood until 1606, and whose leat and site it probably reused. A major expansion of the gunpowder works took place in the mid-1630s under Samuel Cordwell and Edward Collins when they received an advance of £2000 from the crown for the construction of new mills. At the Lower Works four new mills were added

close to the new mill on Steersland, and a further two mills remained in operation on the causeway. As discussed above, the scarp to the north of the ***Rose Cottage/The Old Cottage*** may mark the line of the leat, but none of the earthworks represent the sites of mills. It was perhaps also around this time that the millpond, Chilworth Pond, to the east of Blacksmith Lane, was remodelled. A dam was built to its rear to prevent the pond flooding the land to the east and it was fed by the Tilling Bourne, which flowed along the foot of the northern escarpment. An unusual feature of this pond was that the stream draining the land to the east was diverted beneath it, a feature that has been retained by the 1980s fishpond. It was also probably during the 1630s that the mills of the Upper Works were established about 1.5 km to the east of Blacksmith Lane. The construction of these mills involved a massive civil engineering project to build a large curving dam to retain the Tilling Bourne and its tributary, Postford Brook, which entered from the south. To the north of Postford Pond (formerly known as Postford Brook Great Pond) is Waterloo Pond (formerly known as Pens or Paynes Pond), this was filled by ground water. Postford Pond was used to power four mills

Figure 38
Diagrammatic representation of the mills around Postford Pond in the early eighteenth century (By permission of the British Library, Althorp papers P4)

placed on the mill dam, Waterloo Pond powered a single mill and a sixth mill was built on Postford Brook to the south of Postford Pond (Figure 38). The area around Postford Pond lay outside the survey area, however, there are no surface features, which might be associated with these 1630s mills. This is not surprising, given the repeated remodelling of this area, including the recent demolition of Albury Mill and construction of the new office and housing development. Archaeological excavations during the development work failed to find any features that could be attributed to the seventeenth powder works (Wessex Archaeology 1996 and 1997).

The next major expansion of the works was in the 1650s stimulated by a periodic upturn in the demand for gunpowder caused by the outbreak of war with Holland in 1652. Under a partnership headed by Josias Dewye, the Middle Works to the east of Blacksmith Lane were laid out. This scheme again involved a large civil engineering project to construct new watercourses and mill buildings. The most sizeable part of this scheme was the construction of a new millrace, known as New Cut. This leat is approximately 1.5 km in length and takes water from the Tilling Bourne to the west of Postford and Waterloo Ponds. The leat is a carefully engineered channel, which is carried above the flood plain by an embankment up to 2-3m in height. Topographically the area of Middle Works lay between **Incorporating Mill** [16] to the west and the bridge abutments [BR 14] to the east. Sir Jonas Moore's survey of 1677 revealed that the Middle Works comprised five mills, four incorporating mills and a mill for grinding charcoal and sulphur. Coupled with the construction of these mills was the digging of the tailrace, which begins approximately below the bridge abutments [BR 14] and flows towards Blacksmith Lane. Although considerably altered by later activity the structure of the 1650s expansion provided the main framework of the works until the remodelling of the 1880s. Today New Cut still carries water from the east and the later mill sites to the east of Blacksmith Lane probably occupy the sites of their mid-seventeenth century predecessors.

The 1677 survey, discussed in the Historical Background above, provides a very detailed description of the works at this date, which comprised the Lower Works, Middle Works, and Upper Works. Shortly after the survey, Sir Polycarpus Wharton and John Freeman took a 21-year lease on the mills, with Polycarpus acquiring sole interest in the mills when Freeman died in 1684. Under his management the basic structure of the works remained unaltered, except for the construction of three new incorporating mills in 1688. By the end of the seventeenth century, despite Polycarpus's financial difficulties, the Chilworth gunpowder works was the largest in the country.

3 The eighteenth century

By the early eighteenth century the extent of the works had shrunk considerably from its peak at the end of the previous century. The layout of the reduced works are clearly depicted on a map drawn in 1728 (British Library Althorp Papers P4) for the Duchess of Marlborough; it is incidentally the earliest detailed plan of an English powder works (*see* Figure 2). To the east, the mills of the Upper Works around Postford Pond had closed and were shown as four open circles, indicating the sites of the mill wheels. At the western end of the site, the Lower Works to the west of Blacksmith Lane, had been converted into a paper works in 1704. The mill buildings of the Great Paper Mill, with three wheels, were shown at the northern end of the causeway, roughly at the site of the

later printing works [EH2]. At this time two channels were shown to the west of Blacksmith Lane instead of the single channel of today. The other paper mill, the **Little Paper Mill** [EH4], probably also occupied the site of two gunpowder mills and was powered by two water wheels, it lay to the north of the now demolished **Carpenter's and Coopers Shops** [2]. The earthworks in this area do not give a clear indication of its precise site, partly due to later developments along the crest of the valley, including the **Carpenter's and Coopers Shops** [2] and the present building that overlies this site. The paper mills were fed by an upper leat, which flowed approximately from the culvert [BR5]. Below the crest of the valley in an engineered embankment was probably originally dug to serve the early seventeenth century wire works. To the west of [BR5] and below ***The Old Cottage/Rose Cottage***, the form of the valley has been considerably altered by the gardens of these cottages encroaching on the valley side. To the north-west of ***Rose Cottage*** the well-formed and straightened valley side may mark the lower edge of this leat. Above this scarp is a level terrace up to 3m wide, which marks the line of the leat. To the north-west and perpendicular to the lower scarp two slight scarps might indicate the position of the tailraces below the **Little Paper Mill** [EH4].

To the south of the **Little Paper Mill** was the raw materials refining area. This comprised five principal buildings, a cooper's shop, saltpetre boiling shop, saltpetre earth house, and two buildings described as workhouses. One of these may be equated with the surviving cottages ***The Old Cottage/Rose Cottage***, or if not this actual structure then a building on its site. None of the other structures shown on the 1728 map survive above ground.

By the beginning of the eighteenth century the focus of powder production had moved to the east of Blacksmith Lane, in to an area known as the Middle Works. This extended eastwards approximately to the site of the bridge abutments [BR14], although no bridge was shown at this date. This section had been laid out in the 1650s, and it is probable that its layout was little altered from the previous century. In this section water to power the mills was brought over one kilometre from the east along New Cutt River, or New Cut. Moving eastwards from Blacksmith Lane, the Middle Works comprised a water-powered **Corning House** [8], which sat at the western end of New Cut. In this building powder from the incorporating mills was forced through parchment sieves, with carefully punched holes to produce consistently sized grains of gunpowder.

To the east of this building was the raw materials preparation area. The **Charcoal House** was probably used for the storage of charcoal produced elsewhere, close by was the **Coal** (charcoal) **and Brimstone** (sulphur) **mill**. The position of these buildings roughly equates with the visible brick foundations [16]. Sections of the foundations are made up

from ironstone, which may indicate the site of one of the seventeenth century mills. Further to the east were four powder mills and at the very eastern end another mill building and wheel were shown. This mill was shaded in yellow, and marked as the site where Francis Grueber was proposing to build a new mill. To the north of the mills, close to the **Pack Horse Bridge** [BR 12], and at approximately the site of the later **Magazine** [60] was a **Watch House**, where the men might retire to while the mills were operating. This layout appears to have remained static throughout the eighteenth century, the only significant change shown on map of 1787 (BL Althorp Papers P12), was the shading of the easternmost mill, indicating that Francis Grueber had carried through his proposal of 1728. In 1790 William Tinkler inherited the mills and surviving documents from this period discuss a 'new mill' being erected at this time. Due to the relatively small scales of the 1728 map and a map of 1813 (*see* Crocker and Crocker 2000, 76), it is not possible to locate its position.

Despite later alterations the basic structure of the early eighteenth century Middle Works survives on the ground today. Along its southern edge the area is defined by New Cut and to the north it is limited by the tailrace. As discussed above, due to the cost of digging and altering leats, once established, mill sites tended to remain in the same location. The early eighteenth mill sites may therefore correlate with the later mill sites at [14/15, 20/21/22, 27, and 31], and archaeological remains of the early mills may lie beneath the later brickwork.

4 The early and middle nineteenth century

Another useful touchstone in the development of the works is a sale map of 1813 (reproduced in Crocker and Crocker 2000, 76). This shows that the layout of the works remained virtually unaltered from the late eighteenth century, which in turn had changed little from the beginning of the century. During the years after 1813, but predating the Tithe Award Map of 1846, many new buildings were added. In part they may represent an expansion in the productive capacity of the works, but they probably also reflect a greater concern for safety as different processes were placed in separate buildings. To the west a new building was erected, which was later named as a **Press House** [12]. This was the first time that a dedicated press house was in operation at Chilworth, although the pressing process had probably been in use for some time and may have formerly been included in the **Corning House** [8].

Along New Cut, and to the rear of the incorporating mills, three small buildings were added these corresponding with [17, 28, and 30] later identified as **Charge Houses** or **Magazines**. These buildings were served by punts plying New Cut and would have been used to store gunpowder between the different manufacturing processes. About 90m to the east of the existing mills, a **Glazing Mill** [33] was added. In this

building the grains of gunpowder were rotated in barrels to produce a glaze (for some types of powder graphite was added) and to its east a **Packing House** [34] was built.

A record of the tonnage of gunpowder carried along the Wey Navigation during the nineteenth century (Crocker 1984, 12), shows that there was a steady increase from the late 1840s. Documentary evidence points to a substantial refurbishment of the works in the early 1860s, a period of time coinciding with a steep rise in the amount of powder carried along the Wey.

A group of structures that stand-out as being of particular significance are the No.3 steam-powered **Incorporating Mills** [20, 21, and 22], a relatively rare feature in privately owned mills at this date. These mills were in operation by 1865 (Crocker 1984, 10), freeing the works from the vagaries of seasonal droughts. The steam mills comprised a detached boiler and engine house to the west, and a pair of incorporating mills to the east. Power was transferred to the mills by means of an underfloor drive shaft, which ran beneath the mill beds. To its east was another steam powered **Incorporating Mill** [24 and 25], these mills were powered by a detached **Engine and Boiler House** [23]. A report on an explosion in these mills in 1883 (Explosives Inspectorate 1883) provided more information on the form of the mills, reporting that they were wooden with boarded sides and were powered by underfloor gearing.

In addition to the construction of new buildings, machines in existing mills were replaced, in 1864 Messrs J & E Hall of Dartford installed a new hydraulic press in **Press House** [31] and Filmer and Mason of Guildford supplied the works with a breaking down machine (Explosives Inspectorate 1879, 6). A Filmer and Mason nameplate on a cast-iron sluice adjacent to the **Glazing Mill** [33], may suggest that this building was also refurbished at this date.

It was perhaps also in the mid-1860s that the works expanded eastwards along New Cut, using its water for transport and power. To the east of the existing **Glazing Mill** [33], a **Stove** [35] and related **Boiler House** [36] were added. To their east two new water-powered process buildings were built the **Corning House** [39] and its associated **Wash House** [38], and at the very eastern end of the site the **Upper Glazing House** [40]. These mills took their water from New Cut and it was probably at this date that a new tailrace was dug at the base of New Cut's embankment from the **Upper Glazing House** [40], below the **Corning House** [39] before it turned sharply northwards into the Tilling Bourne. All the improvements discussed above were in place by 1871 when the area was remapped by the Ordnance Survey. Probably a few years later two new **Expense Magazines** [EH6 and 37] were added on New Cut. On the rear of [EH 6] the numerals '187- ' may be discerned,

the last numeral being obscured by lichen growth. They may have been built as a response to the more stringent requirements of the 1875 Explosives Act, which limited the amount of powder that could be held within a process building.

The picture of the works that emerges in the late nineteenth century is of a medium sized provincial powder works, comprising a mixture of buildings; some were double-storey brick structures, while most were probably timber or canvas clad single-storey structures. The study of historic mapping suggests that some buildings may have been over a century old, or at least sat on the footprint of earlier structures. Despite their apparent age many contained relatively modern machinery installed in the 1860s, and some such as the steam mills represented the most up-to-date technology available to powder makers.

5.The late nineteenth century

In 1881, after sixty years in the Sharp family ownership, the works were sold to Charles Marcus Westfield. Four years later he entered into partnership with a new firm, The Chilworth Gunpowder Company. The acquisition and subsequent remodelling of the factory in 1885 by the new company, a consortium which included many leading German gunpowder manufacturers, propelled the works from one of national standing to one of international repute. Work by the new company included the construction of two new ranges of steam-driven gunpowder incorporating mills (one with six mill bays and the other with eight), new drying stoves and storage magazines; an internal tramway system was also built to link many of the process buildings. Many of the existing buildings, and machinery within them, may also have been rebuilt or refurbished without leaving any historical or archaeological evidence.

The refurbished factory of the late 1880s is an amalgamation of British and German customs. The main framework of the factory, its topography and watercourses, was largely fixed; the spacing and size of the buildings were also closely regulated by the 1875 Explosives Act. Contemporary accounts of the factory confirm its technical excellence; these include the construction of a chronograph range used to test the strength and uniformity of different batches of explosives. These types of facilities were more typical of the new chemicals explosive factories, rather than works engaged in the production of mechanically milled gunpowder.

During this expansion the area occupied by the works almost doubled. The layout of the Middle Works appears to have remained largely unaltered. The remains of mills are heavily overgrown, and often moss covered, and it is not possible to tell if any were refurbished during the late nineteenth century. The most conspicuous change to the Middle Works was the laying of the tramway through this area along the northern

bank of New Cut, roughly along the line of the modern path. This allowed part-finished powder to be moved between the process buildings by either the tramway or by punt. Equally important was that it enabled coal to be brought to the steam-powered mills in this section. The tramway was feature of continental origin, with a gauge of 80 centimetres it is the earliest recorded metric gauge tramway in Britain.

Despite many of the mills continuing to be water-powered, by the late nineteenth century steam power contributed the greater part of the motive force in the factory. Hodgetts (1909, 344) stated that boilers and steam engines at the Chilworth Gunpowder Company provided 1500 horse power, whereas just 100 horse power was generated from water power. These totals also include the power generated at the company's other factory at Fernilee, Derbyshire, but give an indication of the dominance of steam power. In addition to powering the **Incorporating Mills** [1 and 52] their engine houses might also have been used to power to dynamos to produce electricity. It is uncertain which form of artificial lighting was used in the factory during the late 1880s, nor is it known when electric lighting was introduced. Edward Kraftmeier speaking in 1891 stated that 'they were quite satisfied with their present method of lighting, and if they did make any change, they should certainly go in for electric light' (SHC G132/5/13). Hodgetts (1909, 344) noted that the company was using electric arc and incandescent lamps. It is not known if any of the machinery was powered by electric motors at this time.

Topographically, the main expansion to the Middle Works in the 1880s was across the previously undeveloped valley floor and along the northern side of the valley. Initially the largest investment was in the new steam-powered **Incorporating Mills** [52], which were built at the far eastern end of the works adjacent to the existing **Upper Glazing House** [40]. These mills are constructed from mass concrete and brick walls and housed six-mill bays. Some of the building materials for these mills were brought from Germany, principally the rolled steel channels, which are marked with raised lettering 'Burbach'. They also housed the only machinery within the factory that was of undoubted German origin. An 1890s Krupp catalogue records that six gunpowder incorporating mills were supplied to the Chilworth Gunpowder Company; bolt holes in the surviving steel channels may be correlated with a drawing of one of these mills in this trade booklet (Eleutherian Mills, Hagley, pamphlet vol.35 no.5). These mills were known as suspended edge-runners. In this type of mill the runners were mounted to allow them to rise up-and-over any accumulated powder in the mill trough; a safety feature which would later allow larger quantities of gunpowder to be milled. Probably shortly after the construction of the new steam mills another group of **Incorporating Mills** [1] were built to the east. Despite being in a ruinous condition, their plan form is virtually identical to that of the 1885 mills, and indicates that similar mills were used there. The source of the

machinery within this mill is unknown, as are the origins of the machines installed elsewhere in the factory at this date.

To the north of the **Incorporating Mills** [52] was the site of the **Upper Glazing House** [40], later listed as a **Charcoal Mill**, which would be in keeping with the late nineteenth century activities in this area. To its north a new **Mixing House** [51], powered by an **Engine House** [50] to the west was built. In this building the ingredients of gunpowder (saltpetre, charcoal and sulphur) were mixed together in the correct proportions before being taken to the **Incorporating Mills**. Beyond the **Mixing House** a new **Charge House** [72] was added, probably to store powder between processes. Along Lockner Farm Road, three new buildings were constructed on its western side, a **Densismeter and Examining House** [48], a **Store** [49], and the **Store and Laboratory** [67 and 67a].

Prior to the 1880s the valley floor to the west of the **Incorporating Mills** [52], was featureless between the tailrace below New Cut and the Tilling Bourne to the north-west. The largest building constructed in the valley bottom to the north-west of the **Incorporating Mills** [52] was the **Press and Engine House** [55]. It was probably in this building that the cam presses were installed (see above). As there was no potential to exploit water power at this location they may have been powered by a stand alone steam engine. Approximately 90m to its west was an **Expense Magazine** [62] and then at further 90m intervals were two other **Expense Magazines** [60 and 61]. Another **Press House** [71] was also placed on the valley floor; this was originally surrounded on three sides by a protective mound, and was served by the tramway on its open northern side. Its position precluded the use of water to power its pumps; a small engine contained in a separate room from the press may have been used to provide power for this building.

It was also in the late 1880s that the valley side to the north of the Tilling Bourne was included within the factory area. Prior to the enlargement of the factory at this time the Tilling Bourne flowed at the base of the valley side. To provide more room for the construction of buildings the river was partly diverted through culverts beneath the new structures and directed into ponds created to provide material for the protective mounds surrounding the buildings. The Tilling Bourne is channelled beneath the causeway, which carries Locker Farm Road across the valley floor, through an ironstone-lined culvert [BR 20]. For nearly the first 200m of its course the river follows its original route, to the south of the site of the **Expense Magazine** [63], the line of the river has been diverted sharply to the south-west. The original line of the river may be followed for about 20m, before it disappears beneath the mound of [56] and re-emerges to the west, where it remains as standing water. The course of the river is then lost again beneath [57] and emerges further to the west as another piece of standing water. Beyond here a linear

hollow indicates its course before the Tilling Bourne was diverted for the final time into a culvert close to building [59]. As the river re-emerged it then followed its original path westwards beneath the **Packhorse Bridge** [BR12].

With the construction of buildings to the north of the Tilling Bourne the Chilworth Gunpowder Company made the optimum use of the local topography. The distance between explosives manufacturing buildings is carefully controlled by the 1875 Explosives Act. The permitted intervals may, however, be lessened if the buildings are surrounded by protective traverses. Part of the reason for entering into the elaborate channelling of the Tilling Bourne may have been to create sufficient distance between the new buildings erected to the north and structures built along the middle of the valley floor. As described above the valley sides are composed of a loose, virtually stone free loamy soil, which is comparatively easy to excavate. The company made full use of this and was able to dig into the hillslope to create building platforms. One building [54] was entirely dug into the hillslope, obviating the need for a protective mound, while in others the rear of the cut dispensed with the need for a protective mound.

The buildings set out along the northern edge of the factory were probably all originally built to serve the new brown powder facilities laid out in the late 1880s. Some of the functions ascribed to the buildings on a map of the Smokeless Powder Factory, which is thought to have been drawn in the early 1890s (SHC Z/10/1), suggest that they were soon included within the new smokeless powder works to the east. The 1896 Ordnance Survey map (Surrey, Sheets XXXII.5 and XXXII.6) shows that although there was a tramway link to the east, any truck would have to follow a fairly torturous route. No traces of the buildings remain, which suggests that they were timber-framed and covered either in corrugated iron sheeting or wooden boards. Their sites may, nevertheless, be traced by the survival of their protective mounds, low rear concrete revetment walls, and by probing for concrete floor slabs. In operation most of the buildings were either served by the tramway, while in others it appears that explosives were carried by to the buildings by hand, or possibly on hand-propelled carts.

Walking eastwards from the **Packhorse Bridge** [BR12] the first building encountered was an Expense Magazine [59]. To its east lay a building described as an **Expense Magazine** or **Stove** [58], which probably indicates that explosives might be dried in the building and then also stored there before they were required elsewhere. Next to it was the **Packing House** [57], where the explosives were packed into the appropriate packaging before being moved off site. Adjacent to this building was the **Cutting, Blending and Sorting House** [56], these activities are usually associated with cordite manufacture. They normally refer to cutting the cordite into the correct lengths, and then mixing the

different batches to ensure a uniformly consistent product was produced. By 1922 the function of this building had changed and it was referred to as a **Stove**. The remaining three buildings [63, 54, and 21] to the east were also **Stoves**, although two had other functions. Building [63] could also be used as an **Expense Magazine** and [54] was used as a **Blending House**. There is no obvious independent steam raising plant associated with these buildings. Steam to warm these buildings may have been conveyed by lagged pipes from the **Engine, Boiler and Washing House** [52].

6.The 1890s Smokeless Powder Factory

The Smokeless Powder Factory was laid out to the east of Lockner Farm Road on open pasture below ***Longfrey*** and in the surrounding woods. The new factory was the first purpose-built private cordite factory in the country and was a self-contained unit for the finishing of cordite paste supplied from other explosives factories, principally Nobel's factory at Ardeer, Scotland. The layout and functioning of the factory is clearly represented on a contemporary plan (SHC Z10) and although it is undated it is thought to date from the early 1890s. This arrangement remained essentially unaltered until the outbreak of the First World War (see below), when the area was resurveyed by the Ordnance Survey (OS 1920 Surrey XXXII.NW, revised 1913). The only addition from the 1890s was a small, now ruinous, brick structure [EH 19].

Immediately prior to the construction of the Smokeless Powder Factory in this area a new range of gunpowder **Incorporating Mills** [1] were constructed along New Cut close to Lockner Farm Road. These mills were almost identical in form to the surviving **Incorporating Mills** [52] except they comprised eight bays as opposed to six and were probably brick-built, rather than using concrete. To the rear was a boiler and engine house, as in the surviving mills, power was transferred, probably by a horizontal shaft, to the centre of the building. A recess in the rear wall of the mills probably marks where the shaft from the engine house meshed with the shaft running along the rear of the mills. Power was probably then transferred by leather belt drives to the individual mills. The use of this structure as a gunpowder mill was very short-lived and by the 1890s it had been integrated into the cordite factory. At this time the **Engine House** [20] retained its original function, but other parts of the building were assigned new uses, including a **Cutting House** [9], **Packing and Cutting House** [10], **Distillery** [11], and **Boiling Shed** [12].

The Smokeless Powder Factory essentially comprised two rows of buildings, one along New Cut and the other along the track on the north-west side of the valley leading to ***Longfrey*** and then beyond into Lidwell Copse, with a small number of structures on the valley floor. The main

production buildings were sited along New Cut. At the centre of the factory was the cordite **Kneading and Pressing House** [30]/73, divided by cross walls into ten transverse bays, a number of which are divided by central walls. The steelwork used in the bay walls and for lifting girders above the machines, in common with the 1880s gunpowder **Incorporating Mills** [52], was supplied by the German firm of Burbach. The quality of the brickwork reflected the high repute of the factory, the crosswalls were capped with terracotta coping tiles and the rear sloping buttresses of the central passageway exhibit a level of finish beyond the utilitarian (Figure 39). In this building cordite paste (a mixture of guncotton and nitroglycerine) was gelatinised using the solvent acetone to form cordite dough. The mixing machines used in the manufacture of cordite were very similar to those used in the baking industry. For a simplified flowline for the manufacture of cordite see appendix 2. Despite the sale of the machinery in 1922 the general arrangement and operation of the building may be suggested. Other contemporary descriptions of this building give more details about the functions contained within it. One describes it as the **Press, Kneading & Accumulator Houses, etc** (SHC Z10) and another as the **Kneading, Pressing, Motor and Engine Houses, also Expense Magazines** (Albury Estate *c*1892). Based on this evidence and its architectural form, it appears that to the rear the partly buried concrete footing was the central engine house. The power source for the engine is uncertain, the most likely alternatives are an oil engine or an electric motor powered by a remote generator. In the covered passageway two shallow wheel pits probably mark the position of flywheels, which were fixed to shafts which passed through the side walls perhaps into the motor rooms. Power for the machinery bays was then communicated by line shafting, the position of which is indicated by bearing box openings, some of which are bricked up, on the cross walls. The two tall bays adjacent to the motor rooms probably contained vertical presses for extruding the cordite paste. A tall narrow timber-lined bay at the north eastern end of the building may have contained a hydraulic accumulator to power the presses. The remainder of the open bays probably housed the cordite mixing machines, while the two bays at the western end of the building divided by a crosswall may have been expense magazines where cordite paste and dough was held between processes.

Figure 39
View of the Cordite kneading, pressing, motor and engine house No.30, showing the central passageway (AA044455). (c) English Heritage

After pressing, the long cordite strands were placed on trays and taken on the tramway, which ran along the base of New Cut's embankment, to the **Stove for Preliminary Drying** [24]. In this stove, which could be hermetically sealed, the cordite was gently warmed using steam pipes to drive off the excess acetone vapour. This vapour was then passed through a series of towers, counter current to a stream of sodium bisulphite solution to form a soluble salt. The acetone could then be recovered by distillation with sodium carbonate, and then distilled again to produce acetone for reuse (War Office 1938, 103). The towers were probably formed from the fragments of large earthenware pipes and packed with earthenware Raschig rings, which litter this area. The brick piers [EH 20] were likely also to have been part of this process plant and probably supported a horizontal chemical tank.

To the north the next building is identified as the **Washing House** [25]. It is unclear if this was involved in the manufacturing process, or if it was a washing and changing room for the workforce. After preliminary drying the cordite was moved to the stoves for final drying. There are two pairs of **Stoves** [2 and 3] and [26 and 27], the first two are well-built brick structures, located between the former gunpowder **Incorporating Mills** [1] and the **Kneading and Pressing House** [30/73], both have tall earthenware chimney-like vents, probably to draw off the acetone vapour. The other two stoves [26 and 27] lie at the far eastern end of the site. These stoves are constructed from rolled steel steel channels and 'I' beams, and are rare examples of small steel-framed industrial structures from the 1890s, indeed, they may have been uncommon when first erected. They also exhibit an unusual method of wall construction; their exteriors are clad in corrugated iron behind which is a layer of chicken wire which retains a horse hair insulating layer. On the interiors the chicken wire is also used to support the plaster lining of the walls and ceilings, a feature also found in other buildings of this date at Chilworth. This method of construction in late nineteenth century explosives factories appears to be unique to Chilworth and may also reflect the use of German constructional techniques. This building method is seen within the First World War German explosives factory at Kirchmöser, Brandenburg.

From the Stoves the dried cordite was probably taken to the **Cutting, Blending and Sorting Houses** [28 and 29] on the valley floor and then, perhaps, to the **Packing House** [13]. The cordite was moved to the group of buildings along the north-west side of the factory and accessed from a pre-existing track leading to ***Longfrey*** and beyond into Lidwell Copse. The structures in this area were generally set into the hillslope and shielded on their open sides by earth-filled corrugated iron Chilworth mounds. These buildings appear to have housed the later stages of the manufacturing process after drying. These included the blending of different batches, packing the cordite and storage in magazines.

7.The First World War 1914-19

On the eve of the First World War the works comprised the raw materials processing area to the west of Blacksmith Lane, the historic Middle Works, much of which had been modernised and extended during the late 1880s, and which was still manufacturing a variety of different types of gunpowder. To the east a new Smokeless Powder Factory had been laid out in the 1890s for the manufacture of cordite and possibly other types of smokeless propellants.

In what may be regarded as the historic areas of gunpowder production, the raw materials processing area to the west of Blacksmith Lane and the Middle Works to the east, no remains may be attributed to the First World War. In this area production might have been increased by the more intensive use of existing machinery and by the introduction of shift working, neither of which would leave any physical mark on the form of the factory. Within the 1890s Smokeless Powder Factory there are a number of buildings that may have been erected after the outbreak of war. They lay in the valley bottom to the rear of the gunpowder **Incorporating Mills** [1], one [EH 17] may be traced as a partly covered concrete floor slab with traces of grittless asphalt, [EH16] survives as an earthwork and [EH18] is a single-storey corrugated iron structure.

The most noticeable wartime addition was the Admiralty Cordite Factory erected at the eastern end of the site to the north of Lockner Farm (*see* Figure 37). This was a self-contained factory unit and comprised all the buildings necessary to carry out the finishing processes for the manufacture of cordite. As with the late nineteenth century cordite section, cordite paste was brought to Chilworth from other factories to be finished. The functions of most of the buildings in this area are marked on the 1915 proposal diagram, and in most instances these identifications tally with the evidence from the field remains.

The arrangement of the factory clearly shows that the production flowline (*see* Appendix 3) worked from east to west (for a brief discussion of the manufacture of cordite *see* War Office 1938, 99-105). The proposal diagram also shows a number of buildings within the existing cordite area, which implies that they were used by the new extension. The double-storey cottage [18/85] was shown as a **Barrel Store** and may have been used to hold spare acetone barrels. In the north east corner of the site, **Magazines** [6/81 and 7/82] are shown, although **Magazine** [6/81] was shown as a **Paste Sieving House**. This would imply that cordite paste was stored in the row of magazines along this hillside. In the **Paste Sieving House** the cordite was probably kneaded, to mix in any nitroglycerine which had separated out during transport, and then passed through a sieve into a bag. At this point in the process the cordite was known as 'paste'. The bags were then conveyed down a path, perhaps in a cart, to the **Kneader House** [A23].

In the **Kneader House**, sometimes also known as an incorporating house at other factories, the cordite paste was put into a machine resembling a commercial bread dough machine. During this process the paste was blended (for approximately 3 hours with the solvent acetone) brought from the **Acetone Store** [A20]. At the end of this period a quantity of mineral jelly, from the **Jelly Melting House** [A22], was added as a stabiliser and the mixture blended for a further 3 hours. At the end of this process the mixture was known as cordite dough.

From the **Kneader House** the paste may have been moved by tramway to the **Expense Magazine** [A24] or directly to the **Press House** [A21] if one of the pressing bays was free. In the **Press House** vertical hydraulic presses were used to squeeze the cordite dough into strands of differing diameters depending on their intended use. At Chilworth, where the emphasis was on the production of naval cordite, it was probably pressed into thicker strands that were hand cut to the required length and then laid in trays for movement by tram to the acetone **Recovery Stove** [A17].

Acetone was an expensive solvent, which used many scarce raw materials in its production; it therefore formed an essential part in the economic running of the factory, and of the wider war effort, to recover as much of the solvent for reuse as possible. In a process similar to the one described above, trays of cordite were stacked in one of the four sealed bays of the **Recovery Stove**, where they remained for up to a week heated by steam pipes. During this process the acetone vapour was drawn by suction into the **Recovery House**, where it was combined with a stream of sodium bisulphite solution to form a soluble salt. In the **Still House** [A19] the acetone was recovered by distillation with a solution of sodium carbonate, it was then given a final distillation before it was ready for reuse.

From the **Recovery Stove** the cordite was moved by tram to one of the five drying **Stoves** [A12, A14, A15, A16, and A18]. Depending on the gauge of the cordite it might take between 7 and 40 days to complete drying. As the **Stoves** were unloaded the workers would probably mix the contents of the trays together in order create a uniformly consistent product. The practice may have differed slightly in each factory. At the Royal Gunpowder Factory, Waltham Abbey, for example cordite from ten trays was mixed to form a 'case', about 30 cases forming a 'blend', eight blends were then mixed to form a 'lot'. At Chilworth some mixing was done in the **Blending Houses** [A6, A8, and A11], which may also have been used for packing the cordite into boxes. The finished cordite was then stored in one of the three **Magazines** [A1, A7, and A9]. **Magazine** [A9] is not connected to the tramway system, which might suggest that it was used to hold rejected cordite. The 1915 proposal diagram shows the northern and southern tramlines terminating at Lockner Farm Road, suggesting that cordite was brought from the magazines and loaded on

to trucks for dispatch. From here it was sent either to Chilworth railway station, or directly by road to one of the Admiralty filling factories, where the propellant charges were assembled.

Lockner Farm Road was probably also the main entry and exit point for the workforce, and in the south-west corner of the field are the sites of **Women's and Men's Mess Rooms** [A2 and A4]. Conveniently situated adjacent to these buildings was the **Boot House** [A3] where special safety boots for working in the explosives, or danger, buildings were probably kept. For health and safety reasons eating, drinking and smoking was prohibited within explosives handling areas, hence the necessity for the **Mess Rooms**. The relatively small size of the **Women's Mess Room** [A2] suggests that men considerably outnumbered women even in the wartime workforce.

To operate the factory required a number of different sources of power. The tramway given its relatively small size, the slightness of its remains, and practice elsewhere in the factory probably relied on human muscle power. Electricity would have been required in the **Kneader House** to turn the mixers and in the **Press House** to power pumps to produce hydraulic power. Electricity was also used to light the factory. At this date the **Stoves**, and probably all the other buildings, would have been heated by steam pipes rather than by electric heaters. If steam was used for heating the site would have been criss-crossed with a network of lagged steam pipes, probably carried on wooden posts. There was no power generating plant in the area of the Admiralty extension, it must therefore have relied on existing sources. The nearest identified steam raising source was the engine for the new **Incorporating Mills** [1] to the north-west of this area. Its steam raising capacity might both have been used to provide heating and to generate electricity. Existing steam raising plants elsewhere in the factory might also have been used to generate electricity (Hodgetts 1909, 344).

8.The inter-war years

An appreciation of the activities on the site after the closure of the factory is important in order to understand the present form of the site and its surface remains.

At the end of June 1920 the factory was put into voluntary liquidation and two years later the site and its contents were sold by auction. Many of the older and more specialised structures were fired - to remove any traces of explosives - or demolished, but a significant number of buildings were retained and many converted into cottages. To the west of Blacksmith Lane, in the former raw materials processing area, most of the buildings survived and by 1934 were occupied by a poultry food mill. The only losses in this area appear to have been two small buildings [42 and 43], which were associated with the Chronograph

Range. In the area of the Middle Works, based on evidence from the 1934 Ordnance Survey map and a 1947 air photograph, the settlement of Tin Town may have comprised up to twenty cottages located in former explosives buildings, on the site of an earlier building, or newly built. In many instances, scatters of mid-twentieth century pottery, glass, and

Left ***Figure 40*** *1950s view of ?Magazine [60] while in use as a dwelling. (c) Mr & Mrs Moseling*

Right ***Figure 41*** *Tin Town residents during the 1950s. (c) Virginia McIntyre*

other domestic rubbish corroborate the cartographic and photographic evidence. Buildings that appeared to have been converted into dwellings, include the **Dusting House** [8], **Press House** [71], **Expense Magazines** [58-61 and 63], and at the eastern end of this section the **Store** [49], **Engine House** [50], and the **Blending House** [65] (Figures 40 and 41). In the centre of Middle Works, in addition to the conversion of four process buildings, the **Glazing House** [33], **Packing House** [34], **Stove** [35], and the **Boiler House** [36], four new cottages were also built [EH 23-26] (Figure 42). Other buildings, such as the **Incorporating Mills** [52] and the adjacent **Mixing House** [51], remained roofed into the 1930s, but it is not known if they were put to new uses.

Figure 42 *Air photograph showing the cottages in the central section of the works in the late 1940s (CPE/UK/2034 Frame 3056, 26 Apr 1947) English Heritage (NMR) RAF Photography*

To the east the Admiralty Cordite Factory, which had been built during the First World War, was largely cleared, although at its eastern end a number of buildings were retained. Most of the buildings erected during the war were probably timber-framed and clad in corrugated iron. The two buildings, which survived were both brick built; at the eastern end of the site the five-bay **Press House** [A21] was converted into cottages and survived into the 1980s. To its west the four-bay acetone **Recovery Stove** [A17] was converted into two dwellings, which probably remained

occupied until the 1960s. To the south half the **Stove** [A18] remained standing into the 1930s.

To the north west of the Admiralty Cordite Factory was the 1890s Smokeless Powder Factory. In this area there were widespread demolitions. To the west of the Tilling Bourne all of the factory buildings were demolished, including the **Magazines** [14-17], and the buildings to the north-east of ***Longfrey***, the **Blending House** [4], **Packing House** [5], **Paste Sieving House** [6], and **Magazines** [7 and 82]. Below these structures most of the buildings in the valley bottom were also cleared. These included a number of unidentified explosives manufacturing buildings [31], and [EH 16 and 17], and the **Packing House** [13], and to their east the **Cutting, Blending and Sorting Houses** [28 and 29], and the **Washing House** [25]. The one building to survive in this area was a single-storey, corrugated iron building [EH 18], which had probably been erected during the First World War, and was subsequently converted into two dwellings. It is not known if the late eighteenth or early nineteenth century **Cottage** [18], which had latterly been used as a store, was brought back into use as a dwelling.

The principal survivals in this area are along the western side of New Cut, where six out of the nine original buildings still stand. None of the buildings in this area display any evidence of conversion to dwellings, although a number remain in use as stables. The largest building to be lost in this area was the late nineteenth century gunpowder **Incorporating Mills** [1], these were mainly brick-built and many of the bricks have been robbed for reuse elsewhere. To its east the two **Stoves** [2 and 3] remain substantially intact, except that most of their interior timber work has been removed. Further eastwards are the ruined remains of a small two-bay building [EH20] probably built during the First World War, it was roofless by 1934. The largest surviving building in the area is the eleven-bay cordite **Kneading and Press House** [30/73]; this structure retains its original form except for recent stable partitions. Immediately to the east was a small chemical plant for the extraction of acetone, which was demolished except for two brick piers [EH 20], and further to the east again is the virtually unaltered **Stove** [24]. Continuing eastwards the next structure was the **Washing House** [25], which had been cleared by 1934. At the eastern end of the factory were two more **Stoves** [26 and 27], they are steel-framed and clad in corrugated iron, as with the other buildings in this area they display no evidence of later alterations.

9. Second World War

During the Second World War, the Tilling Bourne's valley was fortified as part of the GHQ Line in an attempt to slow down the advance of the German army in the event of an invasion. The remains within the area of the former gunpowder works represent just part of this former defensive line (Figure 43).

Figure 43
The Tilling Bourne valley looking west showing the position of the Second World War defences within the formor powder mills site (NMR 230167/7) (c) English Heritage

The valley floor of the Tilling Bourne was generally impassable for mechanical vehicles, due to silty waterlogged ground and the courses of many deep channels and streams. These factors reinforced the importance of the two causeways, which crossed the valley, Blacksmith

Lane in the west and Lockner Farm Road to the east. The causeway across Blacksmith Lane was defended by a **road block** [M1] and a **fortified cottage** [M2], both now removed. On Lockner Farm Road the southern side of the bridge [BR24] over New Cut, was defended by a **road block** [M4]. A concrete block survives on the western side of the track and there was probably a corresponding block to the east, between which a rail or stout timber could be slotted. This causeway was also protected by the **Pillbox** to the north-east [M6], and possibly by a Home Guard **Section Post** [M5] on the rising ground to the north-west. The derelict traverse of **Magazine** [21] may have provided further cover for defending forces.

The valley bottom was dominated by the rising ground to the north. In addition to the existing cover offered by vegetation and hedgelines, a series of strong points, in the form of pillboxes, were added. The defences in this area appear to have been arranged as a series of parallel lines, the line running through the powder works site representing the lowest line. As described above in the *Historical background*, some of the circular pillboxes erected in this section of the GHQ Line by Mowlems are unique to this area, one lies within the survey area [M3]. This was sited to command a minor bridging point across the valley, the **Packhorse Bridge** [BR12]; it in turn was supported by a higher circular pillbox (TQ 0298 4774) to its north, which lies outside of the survey area. To the east of Lockner Farm Road the defensive line dropped down into the factory area, and on the north side of the track leading to ***Longfrey***, two standard brick-faced Type-24 **Pillboxes** [M6 and M7] were built to command the open ground of the valley bottom. The line then descended into the valley bottom where **Pillbox** [M8], was dug into the earthwork traverse of the **Washing House** [25]. From this position the pillbox could control clear ground between it and the pillbox to the west [M7]. The line may be followed eastwards to another **Pillbox** [M9], to the north of ***Giraween***. To its east, Mill Lane leading to Albury Mill was also defended with road blocks, which have subsequently been removed. The empty traverses and derelict buildings of the factory might also have been incorporated in the defensive line as *ad hoc* protected positions.

10. Post War

In the immediate post-war period there were no known additions in the former powder works area. The greatest changes to factory area took place in the late 1950s and early 1960s when most of the buildings of Tin Town were demolished. A demolition firm undertook the clearance work, and in most cases the buildings were pulled down and the resulting debris appears to have been moved off site. The sites of the buildings then appear to have been graded, which removed any surface trace of the structures. Once the buildings had been cleared, the central area of the powder works, owned by Guildford Borough Council, became a public open space. To the east in the early 1960s a new house

Longfrey Cottage was built. Probably also around this time in the area of the Middle Works, the course of the Tilling Bourne was straightened between approximately the **Magazine** [56] and the temporary bridge [BR11].

About 1980 at the western end of the site a large angling lake was dug to the east of Blacksmith Lane. It may have been at this time that a new bypass channel was dug between bridge [BR11] and the bridge [BR10] to its west. Another channel was dug in 2001 to the west of the site of **Magazine** [60], during the repairs to the **Packhorse Bridge** [BR12].

Transport

Waterways

The Wey Navigation between Guildford and London was the key transport route used by the powder works for bringing in raw ingredients, materials and tools needed to operate and repair the mills, and for moving most of the finished gunpowder to market. The Act of Parliament to make the River Wey navigable from Guildford to Weybridge on the Thames and then on to London was passed in 1651 with the improvements being completed by 1653. The bulkiest ingredient was saltpetre, which usually made up 75% of a typical mix of gunpowder. Saltpetre was brought up to or just below London Bridge, where it was transhipped on to a barge for its journey up the Wey. By the eighteenth century most saltpetre was obtained from the East India Company. Saltpetre for private gunpowder was purchased directly from the Company, while saltpetre for use in government powder was supplied by the Board of Ordnance from its store at Deptford. Sulphur was also imported from abroad, principally Sicily and arrived by the same route. The third ingredient charcoal, or wood for charring, might be brought from London or by cart from local woods.

During his association with Chilworth in the early eighteenth century, Thomas Coram supervised the building of a new barge to carry raw materials and finished gunpowder to and from Guildford. Construction of the barge commenced in the summer of autumn of 1728 and was complete by February 1729. A few details about this barge may be deduced from the documents, it was fitted out with sails, had a deck beneath which barrels could be placed, and on its deck was some form of living accommodation (Fairclough 1999, 63-69). A typical journey from London to Guildford took about three days, for part of its journey it might rely on sail power while on other sections the barges were hauled by horses. Coram's accounts mention two wharfs at Guildford, Town or Meal wharf and Dapdune wharf, in the parish of Stoke, which is now owned by the National Trust and is open to the public. It was also the latter which was usually used by the powder barges, and there were facilities to store saltpetre and gunpowder with the added advantage that it lay some distance from the town centre. The Wey Navigation was

extended southwards in 1763 as the Godalming Navigation and a new wharf was built at Shalford, just 4 km from the mills. The mills, however, continued to use Dapdune wharf until the early nineteenth century. Following legislation in 1718, which restricted the storage and movement of gunpowder in London and Westminster, Francis Grueber entered into an agreement in 1721 with a number of other gunpowder makers to erect a magazine in Ripple Level Marsh, Barking Creek, Essex (Crocker *et al* 2000, 82). From here powder would be taken to sea coastal vessels for transport to customers in Scotland and Wales. In 1737 Thomas Pearse, who later owned the Chilworth works, was a partner in the construction of a new magazine at Liverpool, which was in 1751 moved further away from the port to Liscard. Thames-side magazines remained important to the Chilworth works and in 1887, probably due to the recent expansion of the works, permission was sought to moor a floating magazine at Lower Hope, off East Tilbury Marshes, Essex (PRO BT356/8835).

Road transport

Despite being on a tributary of the River Wey the Tilling Bourne was not navigable and the mills had to rely on road transport to link them to the Wey Navigation. Until the early nineteenth century the mills used Dapdune wharf to the north of Guildford, about 6km from the mills. After this date they used a new wharf at Shalford on the Godalming Navigation, which was only 4km from the mills. To supply the Portsmouth dockyards road transport was also used.

Specially modified wagons were required to transport gunpowder, these included features to prevent sparking such as copper, brass or bronze fittings, leather coverings over ferrous components, and a hide covering to protect the contents. Thomas Coram, during his brief association with the mills in the late 1720s, supervised the construction of a covered wagon for use by the company (Fairclough 1999, 61). Special features of this wagon included hide coverings and leather sewn across ironwork to prevent sparking. It is, however, not known if the cart was sent to Chilworth or Faversham.

Tramways

Accompanying the massive refurbishment of the factory by the German led consortium in the late 1880s, was the construction of a tramway system to move materials around the site. The tramway was laid to a continental 800mm gauge and was the first metric gauge tramway in Britain. Prior to the late 1880s, the area of the nineteenth century works had been relatively compact, with the main process buildings linked by New Cut along which punts were used to transport powder between the expense magazines and mills. The 1880s expansion increased both the capacity of the works and the area of land occupied by the factory,

especially to the north. The trams, which were small four-wheeled trucks or bogies, were hand-pushed by men or boys. They were used to move coal, raw materials, and powder between the different process buildings. Typically the powder trucks would be kept separate from those used to move coal and other materials around the site. The construction of the powder trucks followed the principals laid down for danger buildings; they were of timber, any metal fittings were of non-ferrous metals, bronze, brass or copper, or they might use leather and were probably canvas covered.

Another feature of the refurbished works was the increased use of steam power. At least two steam mills [20, 21, and 22] and [24 and 25] were in operation from the 1860s. However, it was from the 1880s when the reliance on steam power increased, with the construction of a steam raising plant to the rear of the1880s brown powder mills [52], and another built slightly later behind the incorporating mills [1] to the east of Lockner Farm Road. In addition to directly harnessing steam power to drive the attached mills, they may also have been used to remotely power other buildings, and perhaps to turn dynamos to generate electricity for lighting and machinery. All these activities required more coal. On 31 December 1888, the Chilworth Gunpowder Company and the South Eastern Railway signed an agreement regarding a tramway siding at Chilworth and Albury station, situated to the south of the works (Crocker 1994, 183). The standard gauge siding allowed coal to be brought in greater quantities and then transferred to the work's internal tramway system. Once transferred the coal laden trucks were pushed, downhill, along a tramway line to the works. The line of the tramway may be followed as the public footpath which leads from the Chilworth Primary School to the powder works. It is on a slightly raised earthwork embankment; at the end closest to the works a few iron fence posts

Figure 44
1880s tramway bridge [BR16] crossing New Cut (AA044439). (c) English Heritage

remain. At the end by the school was a weighbridge and passing loop line, no trace of these features remain.

Traces of the tramway may be found across the site and include the remains of civil engineering features, such as low earthwork embankments and hollows to create a level track bed. More tangible remains, include the remains of two swing bridges across New Cut [BR 13 and 16] (Figure 44) wooden sleepers, some still with fixing spikes, and lengths of rail, the cross-sections of which suggest that they were imported from Germany (Crocker 1994, 188).

5. Survey and research methods

The ground survey was carried out within Ordnance Survey National Grid co-ordinates, using Trimble Global Positioning System equipment and a Leica TC805L total stations theodolite.

A permanently-marked survey base station was established and a Trimble dual-frequency Global Positioning System (GPS) receiver was set up over it in order to bring in European Terrestrial Referencing System (ETR89) latitude/longitude co-ordinates via the OS active station GPS network. A further six permanent survey stations across the site were marked with nails and survey ground markers. In the open areas, away from vegetation cover, the archaeological and topographic detail was plotted using a roving GPS receiver. Across the remainder the traverses were observed with a Leica TC805L total stations theodolite between the permanently marked survey stations and topographic and archaeological features recorded.

All the GPS data was processed using Trimble Geomatics Office (TGO) software and the OS National GPS network website in order to convert to OS National Grid values, and transferred to an AutoCAD.dwg file via KeyTERRA-FIRMA (KTF) software. All the theodolite data was also processed using KTF and added to the .dwg file.

Details of peripheral areas were derived from Ordnance Survey Land-Line data and are reproduced with permission of the Ordnance Survey under licence number GD03085G. These sections are centred on the former raw materials area to the west of Blacksmith Lane, Chilworth School, Lockner Farm, and the buildings around Waterloo Pond. The complete site plan is about 1.75m in length, for ease of use it has been broken down into eight bound A3 sheets. Complete plans have been deposited with Guildford Borough Council and the National Monuments Record.

Five of the principal surviving process buildings - the 1880s Gunpowder Incorporating Mills [52], Expense Magazine [EH6], Smokeless Powder Factory Stove [2], Cordite Kneading, Pressing and Engine House [30/73], and Stove [27] - were surveyed using hand tapes and the results were drawn up in Microstation. In addition to the drawn surveys, record sheets were compiled for all the significant features within the site, and these were correlated against available cartographic, documentary and photographic sources. The site was also recorded by colour ground photography, to complement the photography already held by the National Monuments Record, Swindon. The site was also photographed from the air in March 2002 and March 2003. Ground and air photographs taken during the survey have been deposited with the

National Monuments Record, where they may be consulted by appointment.

All readily accessible secondary historical sources were consulted and these are listed in the bibliography and sources. Primary document files were also consulted at the Public Record Office, Kew and at the Surrey Local History Centre, Woking, these are also listed in the bibliography and sources.

The report was complied in Adobe Pagemaker, Version 7.

6. ACKNOWLEDGEMENTS

The survey of the site of Chilworth gunpowder works was carried out in partnership with Guildford Borough Council. Alison Davidson oversaw the commissioning and completion of the project for the council. Local parish interest in the site is maintained by the Chilworth Gunpowder Mills Working Group comprising - Professor Alan Crocker, Glenys Crocker, Alison Davidson, Chris Hayward (until 2001), Councillor Mike Lunnon, Dr Maurice Moss, Andrew Norris, Kim Owen, and Elizabeth Owen. We are grateful to them for their support throughout the project. Emily Brants, Surrey County Council Site and Monuments Record, provided information on the archaeological excavations around Postford Pond in the 1990s. David Rose, of the *Surrey Advertiser*, also helped in locating historic photographs of the site, which appeared in the paper in 2002.

English Heritage is also grateful to Mr Richard Melhuish, Mr Ross Nye, the Parker family, and Mr Simon Tandy for allowing access to their land. We also acknowledge Mrs Virginia McIntrye and Mr Ernest Moseling for consenting to the use of their photographs in the report.

Wayne Cocroft, Cathy Tuck and David McOmish undertook the archaeological ground survey and Philip Sinton drew the site plans and some of the figures. Jonathan Clarke, Andy Donald, and Joanna Smith carried out the architectural surveys. Mike Hesketh-Roberts and Steven Cole took the ground photographs of the site and Damian Grady took the air photographs. The report was written and compiled by Wayne Cocroft and edited by David McOmish.

7. OUTLINE CHRONOLOGY

1603 Thomas Steere's wireworks opened

1606 Wireworks forced to close

1626 East India Company established the powder mills at Chilworth

1636 George Collins and Samuel Cordwell appointed as sole powder producers to the King

1641 Act 16 Charles I brings the end to the gunpowder monopoly

1642-49 The Civil War

1648 by early 1648 Samuel Cordwell was dead and the mills were being worked by his brother Robert

1650 Late June or July Robert Cordwell died

The First Dutch War 1652-1654

1652 Josias Dewye was probably manufacturing gunpowder at Chilworth by this date

1655 Vincent Randyll, George Duncombe and John Woodroff masters of the powder mills

The Second Dutch War 1665-1667

The Third Dutch War 1672-1674

1672 February the Ordnance Board agreed to lease the mills for 11 years

1673 28 December Vincent Randyll died

1677 Written survey of the mills by Sir Jonas Moore, Ordnance Board surveyor

1677 November Sir Polycarpus Wharton and John Freeman leased the mills for 21 years

1688 Sir Polycarpus erected three new incorporating mills

1698 Sir Polycarpus' lease on Chilworth expired

1704 Lower Works converted to a paperworks

1717 Five mills blew up

1730 Francis Grueber (senior) died

1731 Thomas Pearse acquired the Chilworth gunpowder mills

1746 Thomas Pearse entered into partnership with William Stevens

1753 Benjamin Pryce joined the partnership

1754 Thomas Pearse was in financial difficulties and assigned his estates and effects to Benjamin and Edward Pryce

1759 From about this date Edward Pryce was working the Chilworth mill alone

1766 Edward Pryce entered into partnership with Isaac Dent

1780s Isaac Dent was working the mills

1790 Isaac Dent died and left the gunpowder works left to William Tinkler

1790 New incorporating mill erected

1796 Chilworth Manor was bought by Edmund Hill powder maker of Hounslow

1813 Chilworth Manor was purchased by William Tinkler

1819 Powder mills leased to John Sharp, he was later joined by his brother Thomas and the company traded as J & T Sharp and subsequently as J, T & S Sharp when John's son Samuel joined the business

1830s Lower paper mills closed

1849 South Eastern Railway Reading and Reigate branch line opened, and Chilworth and Albury railway station

1881 15 September Mr Charles Marcus Westfield purchased the works from Messrs Sharp

1885 30 March Chilworth Gunpowder Company Limited formed and acquired the site from Marcus Westfield

1886 Postford Mill destroyed by fire

1891 Chilworth Gunpowder Company exhibited at the Royal Naval Exhibition

1892 Work began on the construction of the smokeless, or cordite, powder works

1895 26 November Unwin's printing works, Blacksmith Lane, destroyed by fire

The First World War 1914-1918

1915 Admiralty cordite factory established

1916 20 January Board resolved to raise another £100,000 in share capital

The inter-war period 1918-1939

1920 16 June company wrote to employees announcing the closure of the works

1920 30 June company resolved to be wound up voluntarily

1922 Explosives factory and gunpowder works site sold and broken up at auction

1927 27 October final winding up meeting of the Chilworth Gunpowder Company Ltd

The Second World War 1939-1945

1940 Anti-invasion GHQ stop-line of pillboxes and other obstacles constructed along the Tilling Bourne valley

Post War 1945-2002

1963 Tin Town demolished and cleared

1982 Most of the area of the Middle Works was designated as a Scheduled Monument

1999 The Scheduled area was extended to include most of the 1890s Smokeless Powder Works and the First World War Admiralty Cordite Factory

8. ACCIDENTAL EXPLOSIONS

1628 Minor explosion 6 barrels of gunpowder lost

1630 October ?serious damage to three mills

1652 Explosion in a gunpowder drying stove

*c.*1670 5 mills blown up in 6 months

1683 Accidents which resulted in blowing up of mills and loss of barges

1717 or 1718 Five mills destroyed in an explosion

1755 Explosion in the Middle Works, body blown over the papermills

1760 or 1761 two workers at the paper mills killed by an explosion in the gunpowder works, the paper mills were seriously damaged.

*c.*1763 St Martha's church tower was claimed to have been brought down by an explosion

1778 Explosion in corning house, 3 men killed

1780 Two or more killed

1810 Explosion

1845 50lb of unfinished powder explodes, little damage

1864 Explosion in press house No.31, 2 men killed

1864 Explosion of 40lb of powder in engine mill, 1 man injured

1864 Explosion on Godalming Navigation, 2 men killed

1874 3 August, explosion at incorporating mill, 1 man killed

1879 Explosion at press house No.31, 2 men killed

1883 Explosion at incorporating mill Nos. 24 and 25, 1 man injured

1887 Explosion in incorporating mill

1901 12 February, explosion in black powder corning house No.39, 6 killed

10. A NOTE ON THE EDGE-RUNNER MILLSTONES

Figure 45
Edge-runners S21-28 set up as an ornamental feature (AA038344). (c) English Heritage

A typical edge-runner mill comprised three millstones, a horizontal bedstone and two vertically set edge-runners and could be powered by horse, water, or steam power. The water-powered mills were usually arranged around a central wheel pit, generally powering a mill to either side, but in some instances a wheel might drive up to four mills.

Edge-runner mills were used in a number of the process buildings, including for the initial pulverisation of the ingredients, charcoal, sulphur, and to a lesser extent for the preparation of saltpetre. They were most closely associated with the incorporation, or intimate mixing, of the three ingredients. In England, by the late seventeenth century edge runners were being used to pulverise the charcoal and sulphur, before the ingredients were incorporated in water-powered pestle mills. Crocker and Fairclough (1998) have described the transition to the use of edge-runners for incorporation, which became one of the hallmarks of the British gunpowder industry. For the powder makers to invest in obviously costly machinery, both in its construction and transportation, must indicate that conversion to edge-runner mills brought about increases in capacity and in the quality of the powder produced. Some of the added advantages that edge-runners might produce, included the twisting effect of the stones in their wooden frame as they rotated on their bedstone which aided the pulverisation and mixing of the ingredients. Secondly, the pressing action of the heavy stones, each weighing about 3 tons, had the effect of binding the ingredients more tightly together. The general prohibition of pestle mills by legislation in 1772 (12 George III, Chapter 61), also suggests that contemporaries regarded edge-runner mills as being safer than pestle mills.

Two of the earliest possible references for the use of stone edge-runners are associated with Sir Polycarpus Wharton, occupier of the Chilworth

mills 1677-98. One tantalising reference to mills 'much differing from the common sort' may indicate that he was using edge-runners as early as the 1680s in his works at Wooburn, Buckinghamshire. At his mills at Sewardstone, Essex, a mortgage deed of 1707, referred to a 'stone mill moving by water', but given Sir Polycarpus' financial difficulties in the late 1690s, the stone mills had probably been installed at least a decade earlier in the early 1690s (Crocker and Fairclough 1998, 27-9). The Chilworth mills were clearly using pestle mills in 1677, when Sir Jonas Moore carried out his survey of the works, and they appear to have been retained throughout Sir Polycarpus' occupation and by his successor Francis Grueber. By 1735 the works had passed to Thomas Pearse, and in July of that year, a visiting American, Robert Hunter Morris, commented that 'We saw four pair of large bed stones and as many bed Stones for them to run on. The runners were 6 foot diameter and the bed stones something bigger. These stones were not yet put up' (Crocker and Crocker 2000, 32). An inventory of the works in 1753 (Crocker *et al* 2000, 94-97) confirmed that the works had adopted edge-runners throughout for the production of gunpowder. In total thirty-nine stones were recorded at this time, representing thirteen mills.

To the east of Blacksmith Lane, scattered amongst the sites of the water-powered incorporating mills of the Middle Works, are at least 29 edge runner millstones, some broken. These are marked on the plan by the prefix 'S' and are described and listed in Table 2. Some of the stones appear to lie where they have been casually dumped, while others have been deliberately set into the ground. All the gunpowder millstones are limestone and their diameters are remarkably consistent falling between 1.71m and 1.76m (5 ft 7ins and 5ft 9 ins), and measure between 0.35m and 0.45m (13¾ ins and 17¾ ins) in width. Only one stone falls outside this range, with a diameter of 2.12m and it is suggested that this may have been a bed stone. Two stones [S1 and S2], which lie close to Powdermills cottage are of granite, and are therefore unlikely to have been associated with the powder mills, due to the risk of grit being introduced into the powder.

Most of the stones visible on the surface appear to be edge-runners; generally the edges of these stones have been smoothed by turning on the bedstone, the sides of the stones are usually left roughly dressed. The majority exhibit an asymmetric profile caused by the twisting motion of the mill, and due to the fact that the edge of the stone closest to the centre of the bedstone will be travelling faster than the outer edge. Typically at the centre of each stone was hole 0.30m (12ins) square into which a timber cross member was fixed. Alternatively in some stones was a cast iron axle bearing, secured with wooden wedges, with a central octagonal hole into which the horizontal axle was fixed. Another method of securing the central axle appears to have been with a metal plate fixed to the stone by bolts set in lead.

Only two stones have been definitely identified as bed stones. Stone 4 has a square central hole surrounded by four mounting bolts set in lead. The central part of the stone is slightly raised and is surrounded by a running area 0.42m in width. Around the outer edge of the stone is shallow lip onto which a kerb was fitted to retain the powder while it was being milled. The other bed stone has a larger diameter than the edge-runners, at 2.12m. It too has a slightly raised central area, and six sawn-off bolts set in lead surround the central hole.

Figure 46
partly buried edge-runner [Stone 16], showing its retooled surface (AA044436). (c) English Heritage

On two stones traces of tooling was observed on their running edges. On one stone [Stone 16] (Figure 46), the tooling probably represented the redressing of a used asymmetric stone, which then hadn't been reused. The other stone [Stone 25] appears to have been unused. It may have been a new stone, which was never installed, alternatively the running edge may have been shod in iron thereby protecting the tool marks. In a report on an explosion in 1883 in Incorporating Mills [24 and 25] it was noted that the stone edge-runners were shod with iron tyres (Explosives Inspectorate 1883, 2-3). This type of mill may represent a transitional form between stone mills and the later nineteenth century cast iron, or steel, incorporating mills.

In the steam-powered incorporating mills [20,21, and 22], two heavily overgrown mill beds remain in place. The one to the west appears to be composed of brick and cement, to the east is smashed stone [Stone 29]. The presence of the brick and mortar base may suggest that the mills in this building were of iron and that one rested on the brick and mortar base, while the other perhaps rested on a reused mill stone.

One of the many innovations introduced by the Anglo-German Chilworth Gunpowder Company were the steel suspended edge-runner incoporating mills. A Friederick Krupp Grusonwerk catalogue from 1894, which survives in the Hagley Collection at Wilmington, Delaware, confirms that 6 mills were supplied to Chilworth in 1885 (Eluethurian Mills, Hagley, pamphlet vol.35 no.5). These were placed in the new steam-powered mills [52] and similar edge-runner mills were probably installed in the new eight bay incoporating mills [1] in the eastern section of the factory.

Table 2 *Description and dimensions of millstones*

Number	Diameter	Thickness	
1	1.20m	0.30m	The stone is cut from granite and therefore is unlikely to have been associated with the manufacture of gunpowder. It retains a central cast iron hub plate 0.34m in diameter with a central spindle hole 0.9m in diameter.
2	1.20m	0.30m	The stone is cut from granite and therefore is unlikely to have been associated with the manufacture of gunpowder. It retains a central cast iron hub plate 0.34m in diameter with a central spindle hole 0.9m in diameter.
3	1.79m	0.35m	Edge-runner split in two, circular hole at centre 0.24m in diameter, around the central hole are five small holes originally about 0.04m sqaure, one retains traces of lead which sugges they were used to mount a plate. On one side of the stone was a wedge shaped cut, width 0.125m, depth 0.07m, length 0.13m. The side of the stone with the fixing holes is dressed to roughly smooth finish, while the opposite side has been left rough. Lies adjacent to number 4. Photograph AA038342.
4	1.79m	0.32m	Base stone, crinoidal limestone, split in two, centre hole 0.30m sqaure, around it are four mounting bolts and at each corner holes used to secure a metal plate. The centre of the stone is raised 0.02m above the bed on which the runners turned, the diameter of this raised area is 0.59m. The runners turned in an area about 0.42m in width around the outer edge was a small raised lip and groove cut into the edge of thestone, where a (probably cast-iron) skirt was fitted fixed. Lies adjacen to 3. Photograph AA038342.
5	1.73m	0.32m	Edge-runner, intact, lying at an angle, with circular hole at centre 0.305m, both faces have a smoothed finish. Lies adjacent to 6.
6	1.72m	0.465m	Edge-runner, intact, lying horizontally, central hole 0.305m

Number	Diameter	Thickness	
7	1.72m	0.45m	Edge-runner, intact, lying horizontally, centre hole 0.335m square, both faces roughly finisged. Adjacent to 9.
8	1.75m	0.43m	Edge-runner, intact, set vertically, centre hole 0.33m sqaure, either side rough finish,. Adjacent to 8.
9	1.75m	0.45m	Edge-runner, broken in two, half set vertically, centre hole 0.33m square, either side rough finish. Adjacent to 8.
10	-	-	Two stones lying horizontally, too badly smashed to obtain dimensions. Adjacent to 11.
11	2.12m	?	Bedstone, centre hole 0.25m square, raised central area 0.71m in diameter, with 6 cut-off bolts set in lead. Lies adjacent to10.
12	1.72m	0.43m	?Edge-runner, centre hole 0.25m square, lying horizontally exposed face smoothed. Cast-iron axle bearing 0.22m square, central hole octagonal 0.17m across. Lies close to 13.
13	1.71m	0.44m	?edge-runner, centre hole 0.30m, lying horizontally, exposed face smoothed. cast-iron bearing 0.22m square, central hole octagonal 0.17m across. Lies close to 12.
14	1.76m	0.42m	?edge-runner, centre hole square 0.32m x 0.315m, set at an angle, exposed face smoothed. Adjacent to 15.
15	1.82m	-	?Edge-runner, centre hole 0.31m square, set at an angle, exposed face smoothed. Adjaent to 14.

Number	Diameter	Thickness	
16	-	-	Partly buried, tool marks are visible on the running edge of the stone, they may indicate that the stone was refaced and never reused or that it was iron shod. Associated with 17.
17	-	-	Partly buried, centre hole square, associated with 16, 18-20
18	-	0.42m	Partly buried, associated with 16, 17, 19, 20
19	-	0.44m	Partly buried, set vertically, associated with 16-18, and 20
20	-	0.42m	Partly buried, set vertically, associated with 16-19
21	-	-	Partly buried, set vertically, associated with 22-28. Photographs AA038344, AA038345
22	1.72m	0.45m	?Edge-runner, set vertically, partly buried, centre hole 0.29m square, central cast-iron bearing 0.265m square central hole octagonal 0.155m across, remains of wooden packing around cast-iron bearing. Associated with 21, 23-28.
23	1.70m	0.44m	Edge-runner, set vertically, partly buried, centre hole 0.29m square. Associated with 21-22, 24-28.
24	1.72m	0.44m	Edge-runner, set vertically, partly buried, centre hole 0.32m square. Associated with 21-23, 25-28.
25	1.73m	0.54m	Edge-runner, set vertically, partly buried, centre hole 0.30m square, one side of stone has smooth finish, other left rough, tooling marks visible on face of the stone, which might either indicate that it is an unused stone or that it was shod in iron. Associated with 21-24, 26-28.

Number	Diameter	Thickness	
26	1.70m	0.44m	Edge-runner, set vertically, partly buried, centre hole 0.30m square, face of runner smooth uneven wear. Associated with 21-25, 27, 28.
27	1.70m	0.44m	Edge-runner, set vertically, partly buried, centre hole 0.295m square, smooth uneven wear on face of stone; cast-iron axle bearing 0.26m square, octagonal centre hole 0.155m across, width 0.50m. Associated with 21-26, and 28
28	1.70m	0.45m	Edge-runner, set vertically, partly buried, cnetere hole 0.30m square, one side of stone smooth tool finish other left rough, smooth uneven wear on face of stone. Associated with 21-27. Photograph AA038346.
29	?	0.41m	Base stone, split into four pieces, situated insitu in the eastern side of steam incorporating mills [20, 21, 22].

11. A NOTE ON THE BURBACH IRON AND STEELWORKS

The majority of the structural steel sections used in the late 19th-century factory buildings at Chilworth were supplied from the German manufacturer Burbach. The Burbach Iron and Steelworks began in June 1856, with the foundation of the *Saarbrucker Eisenhuttengesellschaft – Société en participation des Forges de Sarrebruck* by Luxembourg industrialists and Members of Parliament. The following year, the works comprised a blast furnace and puddling plant (with 20 puddling and six welding furnaces), and the next few years saw rapid growth, with the construction of additional blast furnaces and a coking plant for the production of steel rails (www.saarstahl.de/englisch/unserrunternehmen/geschichte/burbach.htm). It is not clear precisely when the company began rolling structural sections for the engineering and building market, but in 1867, at the Paris Universal Exposition, they exhibited a 47ft long rolled iron beam with a 15-inch web. This was way beyond the technological capability of contemporary English or American practice, one contemporary remarking 'there was unmistakable evidence in the Exposition of the readiness of the European ironmasters to grapple with difficulties in the way of rolling shapes, from which at present the American maker would shrink' (Hewitt, 1863, 3). By 1872 Burbach were employing some 1,550 workmen and annually producing 422,000 hundred weight of rolled structural shapes (Thurston 1876, 65). The following year the company featured at the Vienna International Exhibition, but instead of boasting their dimensional feat-making, they exhibited a range of beams and girders that were both useful and economic to produce. One American commentator at the 1873 Exhibition noted that 'The finest display of rolled girders and angle-iron of large sizes is made by the Burbach Furnace Company, (Luxemburger Bergweks and Saarbrucker Eisenhutten-Actien-Gesellschaft zu Burbach,)'. Until this time, Burbach were almost certainly rolling structural sections in wrought iron.

At the 1875/76 World Fair in Philadelphia, Burbach once again took the technological lead, exhibiting their rolled steel girders. Given the grade 'Premium Quality', these rank amongst the earliest rolled-steel I-sections ever produced (it was not until the early 1880s that American manufacturers began experimentation, and in Britain, it was not until 1886 that Dorman, Long & Co. of Middlesbrough began commercial production) (Malcolm 1990, 34). From 1885, The Burbach Iron and Steelworks became one of Germany's leading manufacturers of structural steels, exporting their products around the world.

Much of the structural iron and steel used in late 19th-century British buildings came from the continent, since British manufacturers were often unable to match the sizes, prices and delivery times offered by Belgian, French and German producers. By far the greatest single

exporter to Britain was Belgium, which caused much alarm to British interests. In 1894, one architectural magazine could observe:

> 'Let us look around in our own city, in London and elsewhere, and note the vast amount of steel and iron in the form of girders which now enters into the construction of all modern buildings. Where do all these girders come from? Why, from Belgium.' (*The Architect and Contact Reporter* 1894, 8))

Although Burbach supplied the steel-work for the Ritz Hotel, London (1903-5) – one of the earliest fully steel-framed buildings in the metropolis – we have, at present, only comparatively little archaeological evidence for the use of Burbach steel elsewhere. Documentary evidence suggests that significant quantities were imported through the company's London agents, Otto Gossell of Cannon Street, and Zeitz & Co. of Lime Street. Chilworth almost certainly represents one of the earliest applications of Burbach sections in Britain, and indeed some of the earliest surviving buildings to use structural steel (Clarke 2000).

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G85/2/1 (2) Map from sales particulars of Chilworth Manor, 1813

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13. PHOTOGRAPHY

Ground Photography

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Job number 94/1400, 14 July 1994, M Hesketh-Roberts

BB94/10096 Cottage, view from south east

BB94/10097 Cordite packing house (stables), view from north east

BB94/10098 Cordite packing house (stables), view from north east (colour)

BB94/10099 Cordite kneading and press house, location, view from east

BB94/10100 Cordite drying stove, view from south west

BB94/10101 Cordite drying stove, view from south

BB94/10102 Cordite drying stove, interior, north room from south west

BB94/10103 Cordite drying stove, interior, south room from south east

BB94/10104 Eastern cordite stove, rear view from north east

BB94/10105 Cordite press and kneading house, view from east

BB94/10106 Cordite press and kneading house, view from east (colour)

BB94/10107 Cordite press and kneading house, south side east bay

BB94/10108 Cordite press and kneading house, south side east bay (colour)

BB94/10109 Cordite press and kneading house, view along rear, from south west

BB94/10110 Cordite press and kneading house, view along rear, from south west

BB94/10111 Cordite press and kneading house 4th bay from west, interior, from north west

BB94/10112 Drying and extraction of solvents building, from south west

BB94/10113 Drying and extraction of solvents building, interior, view from north west

BB94/10114 'Longfrey' works housing, view from south east

BB94/10115 'Longfrey' works housing, view from south east

BB94/10116 'Detail of corrugated iron 'Chilworth mound'

BB94/10117 Chargehouse, view from south west

BB94/10118 View of brown powder incorporating mills 1885, from east

BB94/10119 View of brown powder incorporating mills 1885, detail of bay, from south west

BB94/10120 View along tunnel between incorporating mill bays, from south

BB94/10121 View along north elevation of incorporating mill building, from north west

BB94/10122 Tramline swing bridge, view from west

BB94/10123 Old Manor house, Chilworth, former manager's house, from north

BB94/10124 Old Manor house, Chilworth, former manager's house, from south

BB94/10125 Office and laboratory, view from north east

BB94/10126 Site of saltpetre refining and charcoal house, from north

BB94/10127 West Lodge, Blacksmith Lane, view from west

BB94/10128 West Lodge, Blacksmith Lane, view from south west

BB94/10129 Copy of 'A Damanble invention' notice board

BB94/10130 Works' 'Magazine Cottages', Old Manor Lane, Chilworth, from south east

Order 2K/05463, 5 March 2003, Steve Cole

AA038339 Exterior. Magazine [EH6], detail showing south east corner from east

AA038340 Exterior. Lower Press House [12], detail showing rear wall from east

AA038341 Exterior. Lower Press House [12], rear wall from east, detail

AA038342 Exterior. Millstones, edgerunner [3] in foreground and [4] bedstone, from west

AA038343 Exterior. Culvert [BR4] from east

AA038344 Exterior. Millstones 21-28 from east

AA038345 Exterior. Millstones 21-28 from east (with scale pole)

AA038346 Exterior. Millstone 28

AA038347 Exterior. Glazing House [33] detail of leat and sluice from south

AA038348 Exterior. Glazing House [33] detail of maker's plate on sluice

AA038349 Exterior.1880s tramway swing bridge [BR16], from south west

AA038350 Exterior. Magazine [37] from south west

AA038351 Exterior. Corning House [39] fropm north west

AA038352 Exterior. 1880s incorporating mills [52] from east

AA038353 Exterior. 1880s incorporating mills [52] detail of bays from south east

AA038354 Exterior. 1880s incorporating mills [52] detail of underfloor area from west

AA038355 Exterior. 1880s incorporating mills [52] detail of central recess in rear wall

AA038356 Exterior. Second World War Pillbox [M3] from west

AA038357 Exterior. Packing House [57] from south east

AA038358 Exterior. Packing House [57] from south east

AA038359 Exterior. Blending House [54] from south east
AA038360 Exterior. Blending House [54] from north east

AA038361 Exterior. Gunpowder incorporating mills [1], detail of central recess on rear wall, from north west

AA038362 Exterior. Gunpowder incorporating mills [1], detail of bolt

AA038363 Exterior. Gunpowder incorporating mills [1], view of north eastern basement area from north west

AA038364 Exterior. Gunpowder incorporating mills [1], detail showing steps leading down into of north eastern basement area

AA038365 Exterior. Stove [2] north east

AA038366 Exterior. Stove [2] detail showing serving hatches from north east

AA038367 Interior. Stove [2] view from entrance, east

AA038368 Interior. Stove [2] view showing entrance and serving hatches from south west

AA038369 Exterior. Stove [3] from south west showing tall vent

AA038370 Exterior. Building [EH18] from north

AA038371 Exterior. Wellingtonias from south east

AA038372 Exterior. Pillbox M8 and remains of Washing House [25], from west

AA038373 Exterior. Cordite incorporating and press house [30], from south west

AA038374 Exterior. Cordite incorporating and press house [30], view showing rear entrance from north west

AA038375 Exterior. Cordite incorporating and press house [30], view showing rear entrance from north east

AA038378 Interior. Cordite incorporating and press house [30], view showing press bay from south

AA038379 Interior. Cordite incorporating and press house [30], detail of roof construction, south west bay

AA038380 Exterior. Cordite drying stove [24], from east
AA038381 Exterior. Cordite drying stove [24], detail showing door from east

AA038382 Exterior. Cordite drying stove [24], detail showing painted sign over central window from east

AA038383 Exterior. Cordite drying stove [24], detail showing door fastening from east

AA038384 Exterior. Dump of Raschig rings to west of cordite drying stove [24]

AA038385 Exterior. Cordite drying stove [26], from south

AA038386 Exterior. Cordite drying stove [26], from south east

AA038387 Exterior. Cordite drying stove [27], detail showing entrance doorway from south east

AA038388 Exterior. Cordite drying stove [27], rear from north west

AA038389 Exterior. Cordite drying stove [27], detail showing Chilworth mound from south east

AA038390 Exterior. Packing House [5/79], from south east

AA038391 Exterior. Packing House [5/79], detail of entrance from east

AA038392 Exterior. Magazine [6/80], from south west

AA038393 Interior. Magazine [7/81], from south west

AA038394 Interior. Magazine [7/81], detail of entrance from south east

AA038395 Exterior. Magazine [7/81], from north west

AA038396 Exterior. Factory Magazine [82], from north east

AA038397 Exterior. Acetone recovery store [17], from south west

AA038398 Exterior. Acetone recovery store [17], west elevation, detail from west

AA038399 detail Exterior. Acetone recovery store [17], west elevation, from west

Order 2K/05491, 27 March 2003, Steve Cole

AA044432 Exterior. Foundations of Incorporating mills [16] from Bridge [19], from N

AA044433 Exterior. Part of ?Boiler house for steam Incorporating Mills [20, 21, 22, from E

AA044434 Exterior. Spark arrestor for Steam Incorporating Mills [20, 21, 22], from S with scale

AA044435 Exterior. Spark arrestor for Steam Incorporating Mills [20, 21, 22], from S without scale

AA044436 Exterior. Edge runner [Stone 16], with tool marks from W

AA044437 Exterior. Row of corrugated iron columns [EH11] from E

AA044438 Exterior. New Cut from Footbridge [BR 15] looking W.

AA044439 Exterior. 1880s tramway bridge [BR 16], from E

AA044440 Exterior. Expense Magazine [37] and New Cut, looking E

AA044441 Exterior. Site of Corning House [39], from NW

AA044442 Exterior. 1880s Incorporating Mills [52], from S

AA044443 Exterior. 1880s Incorporating Mills [52] from SW

AA044444 Exterior. Packhorse Bridge [BR 12], from W

AA044445 Exterior. Pillbox [M3], from W

AA044446 Exterior. Packing House [57], from SE

AA044447 Exterior. Cutting, Blending, and Sorting House [56] from SW

AA044448 Exterior. Blending House [54], from SW

AA044449 Exterior. Road block [M4], Lockner Farm Road, from S

AA044450 Exterior. Pillbox [M6], from W

AA044451 Exterior. Magazine [16/76], from W

AA044452 Exterior. Cottage/Store [18], from W

AA044453 Exterior, Rear of Cordite Incorporating House [30/73], from N

AA044454 Exterior, Rear of Cordite Incorporating House [30/73], from N

AA044455 Exterior, Cordite Incorporating House [30/73], detail showing central passageway, from NE

AA044456 Exterior, Front of Cordite Incorporating House [30/73], from SW

AA044457 Exterior. Pillbox [M8] and site of Washing House [25], from N

AA044458 Exterior. Pillbox [M8], detail

AA044459 Exterior. Pillbox [M8], detail

AA044460 Exterior. Pillbox [M8], detail

AA044461 Exterior. Rear of Cordite Drying Stove [27], from NW

Order 2K/05494

Waterworks Cottage, Blacksmith Lane, Chilworth, St Martha

AA044462 Exterior. View from S.

Order 2K/05493, 27 March 2003, Steve Cole

War Memorial, St Martha, Surrey

AA044463 Exterior. View from S.

AA044464 Exterior. East face, detail showing plaque

Order 2K/05492, 27 March 2003, Steve Cole

St Thomas's Church, New Road, Chilworth, St Martha

AA044465 Exterior. Church (formerly Greshambury Institute) from SW.

AA044466 Exterior. Church (formerly Greshambury Institute) from S.

AA044467 Exterior. Church (formerly Greshambury Institute) from SW.

Air photography

The National Monuments Record, Swindon, holds historic air photographs of the site dating from the late 1940s. These photographs are relatively high altitude vertical photographs and were mainly taken for mapping purposes, but, nevertheless, form an important record of the development of the valley over the last fifty years. As part of the survey project the site was photographed twice from the air in March 2002 and March 2003, the resulting oblique photographs are listed below.

March 2002

TQ0247/1 NMR21578/08 Middle Works, from SE

TQ0247/2 NMR21578/09 Middle Works, from E

TQ0247/3 NMR21578/11 Middle Works, from E

TQ0247/4 NMR21578/12 Middle Works, from NE

TQ0247/5 NMR21578/14 General view from W

TQ0247/6 NMR21578/15 General view from W

TQ0247/7 NMR21573/14 Middle Works, from S

TQ0247/8 NMR21573/15 Powder mills fishery from S

TQ0247/9 NMR21573/16 Powder mills fishery from E

TQ0247/10 NMR21573/17 Middle Works, from SW

TQ0247/11 NMR21573/19 General view from SW

TQ0247/12 NMR21573/20 General view from SW

TQ0347/1 NMR21578/01 Postford Pond from E

TQ0347/2 NMR21578 02 Albury mill and Admiralty Cordite factory from NE

TQ0347/3 NMR21578/03 Smokeless powder factory from N

TQ0347/4 NMR21578 04 Smokeless powder factory general view from W

TQ0347/5 NMR21578/05 Eastern end of Middle Works from W

TQ0347/6 NMR21578/06 Eastern end of Middle Works from SW

TQ0347/7 NMR21578/07 Eastern end of Middle Works from S

TQ0347/8 NMR21578/10 Eastern end of Middle Works, near vertical from SW

TQ0347/9 NMR21578/13 Middle Works from N

TQ0347/10 NMR21573/01 Incorporating Mills 52 from NW

TQ0347/11 NMR21573/02 Incorporating Mills 52 from W

TQ0347/12 NMR21573/03 Smokeless powder factory, Building 30 from SE

TQ0347/13 NMR21573/04 Smokeless powder factory, from E

TQ0347/14 NMR21573/05 Smokeless powder factory, Building 30 from NE

TQ0347/15 NMR21573/06 Smokeless powder factory, Building 30 from N

TQ0347/16 NMR21573/07 Smokeless powder factory, Longfrey, from N

TQ0347/17 NMR21573/08 Smokeless powder factory, Building 30 from NW

TQ0347/18 NMR21573/09 Smokeless powder factory, Longfrey, from S

TQ0347/19 NMR21573/10 Smokeless powder factory, Cottage 18, from SW

TQ0347/20 NMR21573/11 Incorporating Mils 52 from NW

TQ0347/21 NMR21573/12 Incorporating Mills 52 from W

TQ0347/22 NMR21573/13 Middle Works from S

TQ0347/23 NMR21573/18 Incorporating Mills 52 from S

TQ0347/24 NMR21573/21 Middle Works from SE

TQ0347/25 NMR21573/22 Postford Pond from S

TQ0448/1 NMR21573/23 Payne's Pond and Postford Pond from E

TQ0448/2 NMR21573/24 Payne's Pond and Postford Pond from E

March 2003

TQ0247/13 NMR23016/01 Raw materials processing area from W

TQ0247/14 NMR23016/02 Raw materials processing area from SW

TQ0247/15 NMR23016/03 Raw materials processing area from S

TQ0247/16 NMR23016/04 Raw materials processing area from S

TQ0247/17 NMR23016/05 Raw materials processing area from SE

TQ0247/18 NMR23016/06 Raw materials processing area from SE

TQ0247/19 NMR23016/07 General view from W

TQ0247/20 NMR23016/08 General view from W

TQ0247/21 NMR23016/09 General view of raw materials processing area from S

TQ0247/22 NMR23016/10 General view from NW

TQ0247/23 NMR23016/11 General view from W

TQ0247/24 NMR23016/12 General view from W

TQ0247/25 NMR23016/13 General view from SW

TQ0347/26 NMR23016/14 Smokeless powder factory near vertical

TQ0248/12 NMR23016/15 General view from N

TQ0247/26 NMR23016/16 General view from W

TQ0247/27 NMR23016/17 General view from W

TQ0247/28 NMR23016/18 General view from W

TQ0347/27 NMR23016/19 General view from E

TQ0347/28 NMR23016/20 General view from E

TQ0347/29 NMR23016/21 Smokeless powder factory from N

TQ0347/30 NMR23016/22 Smokeless powder factory from N

TQ0347/31 NMR23016/23 Smokeless powder factory from NW

TQ0347/32 NMR23016/24 Smokeless powder factory from NW

TQ0347/33 NMR23017/01 Incorporating Mills 52 from E

TQ0347/34 NMR23017/02 Smokeless powder factory from N

TQ0247/29 NMR23017/03 Chilworth Manor

TQ0248/13 NMR23017/04 St Martha's church from S

TQ0347/35 NMR23017/05 Cordite incorporating mills from S

TQ0248/14 NMR23017/06 St Martha's church from SW

TQ0248/15 NMR23017/07 St Martha's church from SW

TQ0347/16 NMR23017/08 Cordite incorporating mills from W

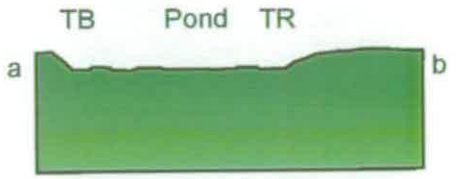
TQ0347/37 NMR23016/09 Cordite incorporating mills from W

TQ0347/38 NMR23017/10 Longfrey from S

TQ0347/39 NMR23017/11 Incorporating mills 52 from SW

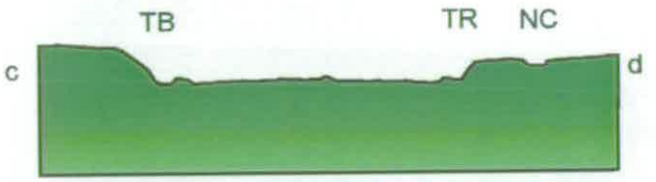
Appendix 1
Sections across the Tilling Bourne Valley

Section 1

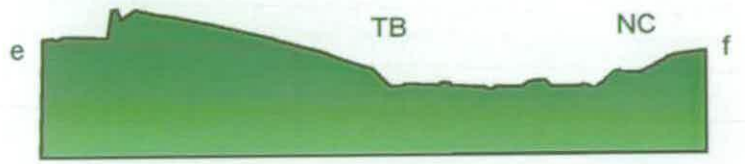


TB Tilling Bourne
NC New Cut
TR Tail Race

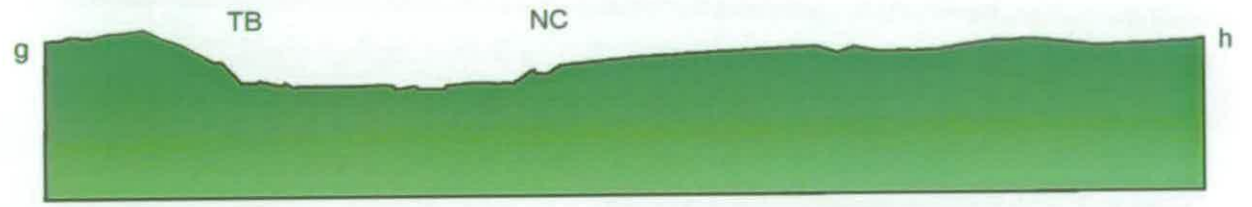
Section 2



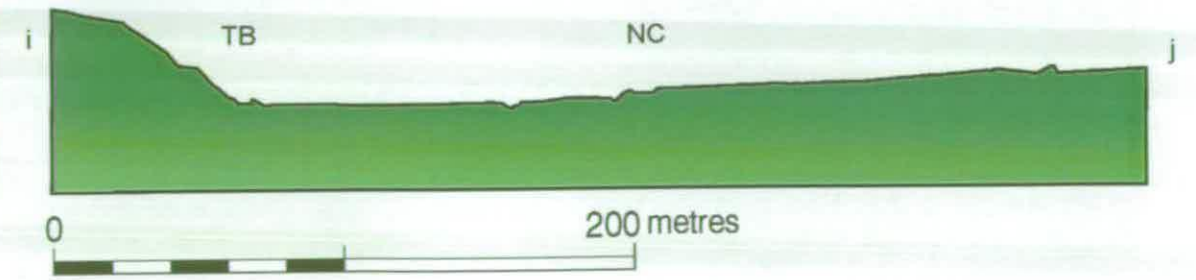
Section 3



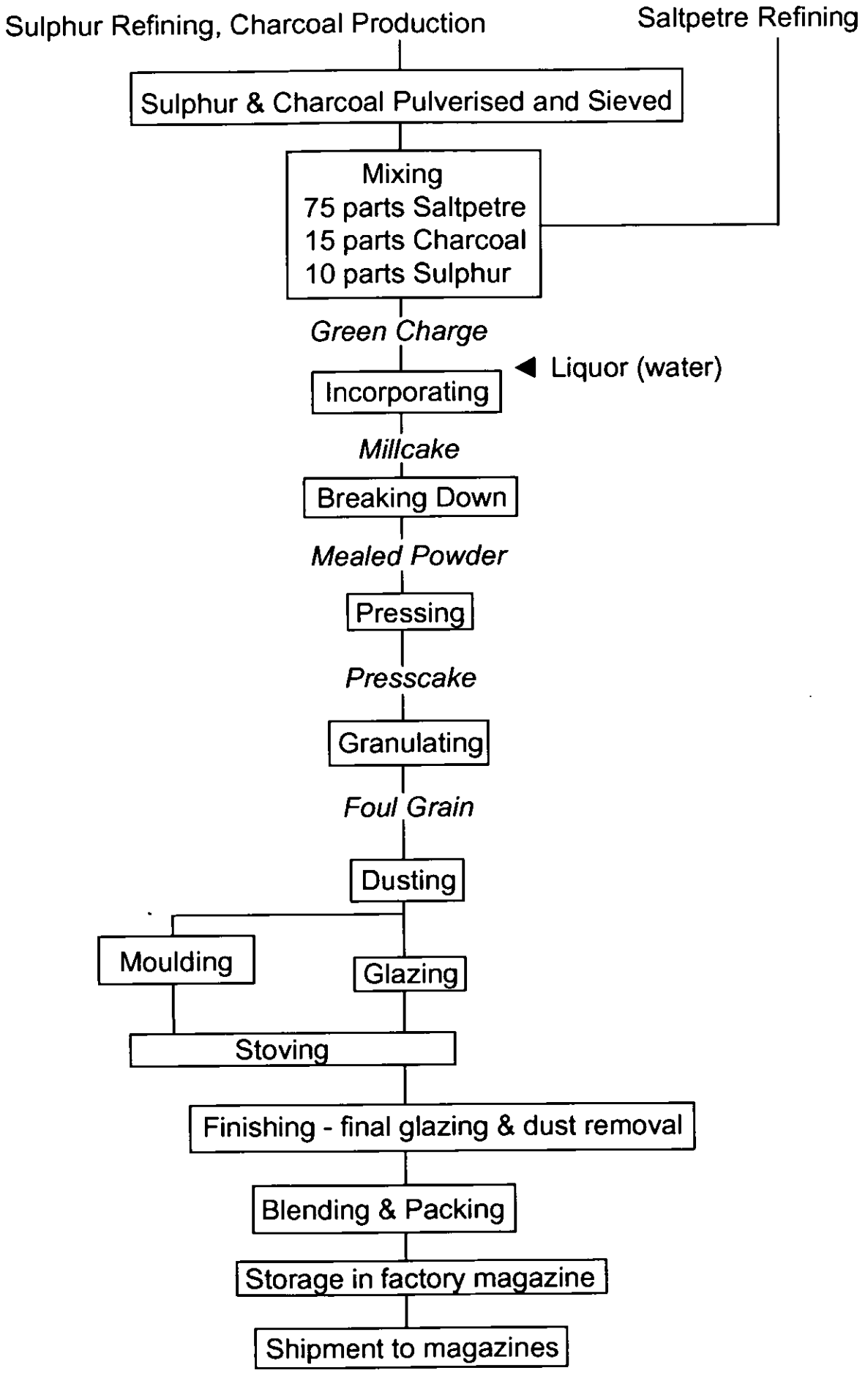
Section 4



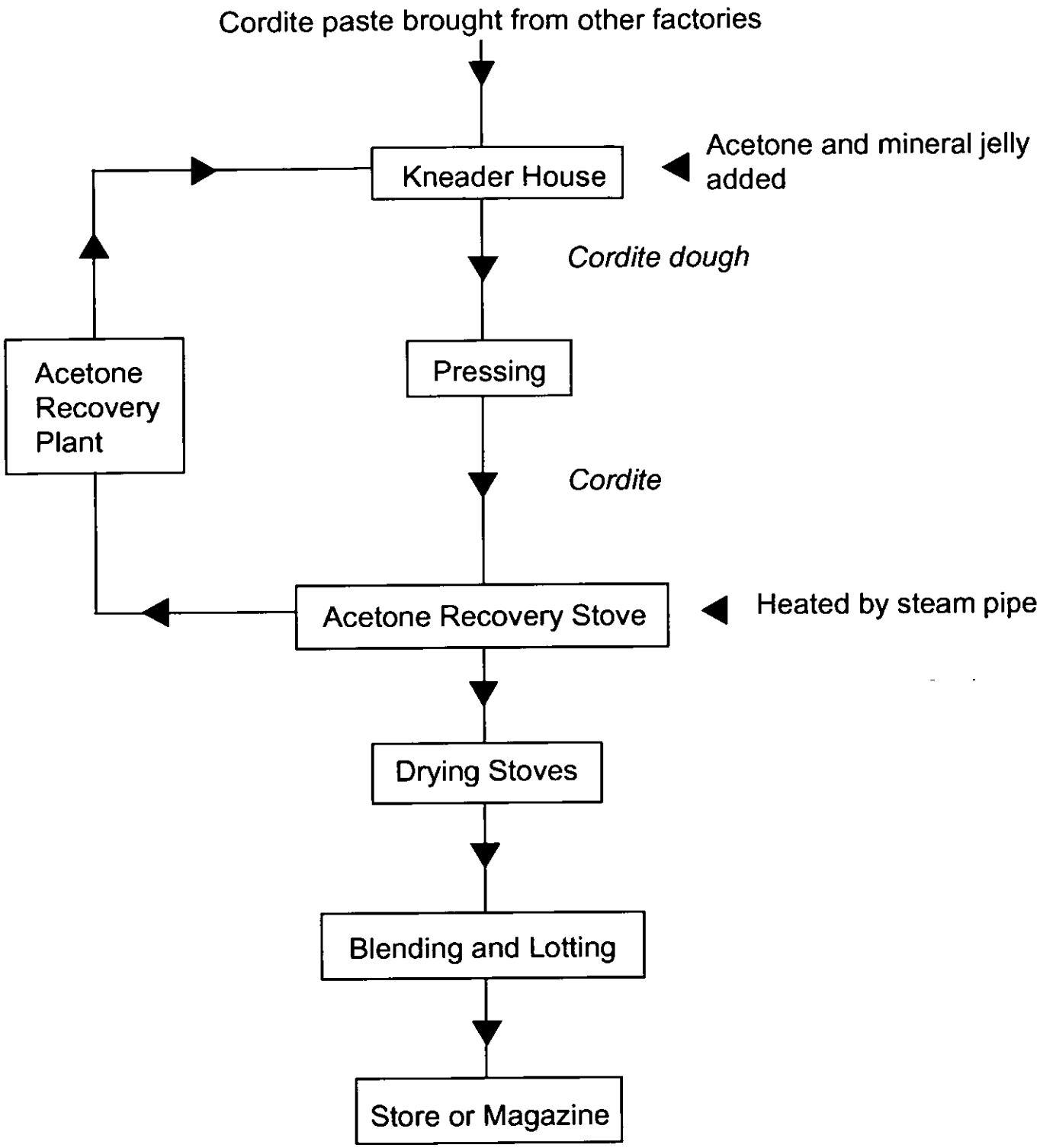
Section 5



Appendix 2
Flow diagram to illustrate the manufacture of gunpowder



Appendix 3
Flow diagram to illustrate the manufacture of cordite



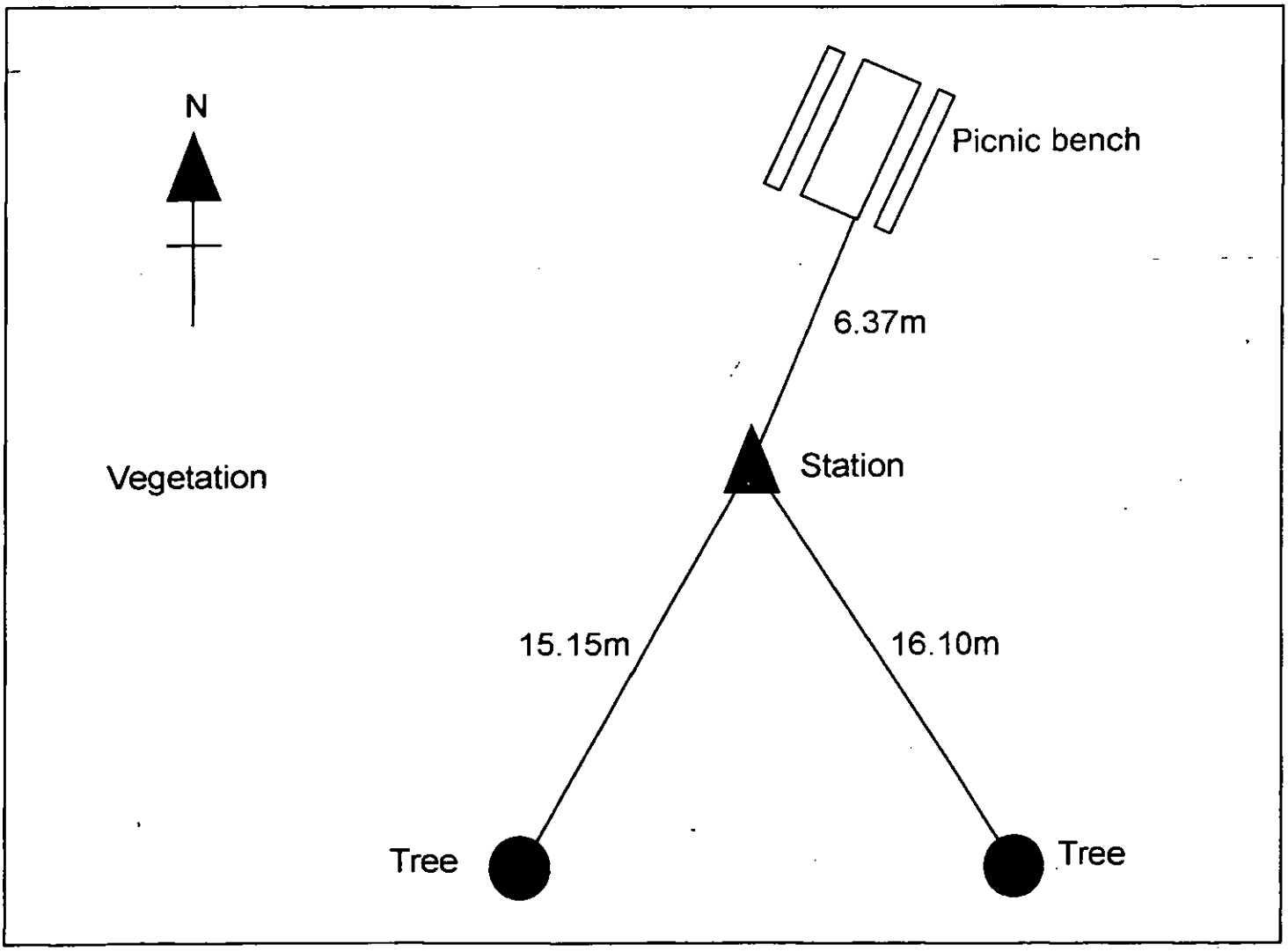
Chilworth Gunpowder Works Survey Station Information

Station no: 06	Surveyors: CT, WDC

Type of mark: Metal ground marker	Office of origin English Heritage Cambridge
Date of survey: December 2002	Neg. no. N/A

Station description:

The station is located at the centre of the site beyond the end of the path which leads down from Chilworth School. The station is fixed by a metal ground marker set flush with the ground.



Co-ord scheme	Eastings	Northings	Height
OS National Grid	503010.247	147518.872	44.569

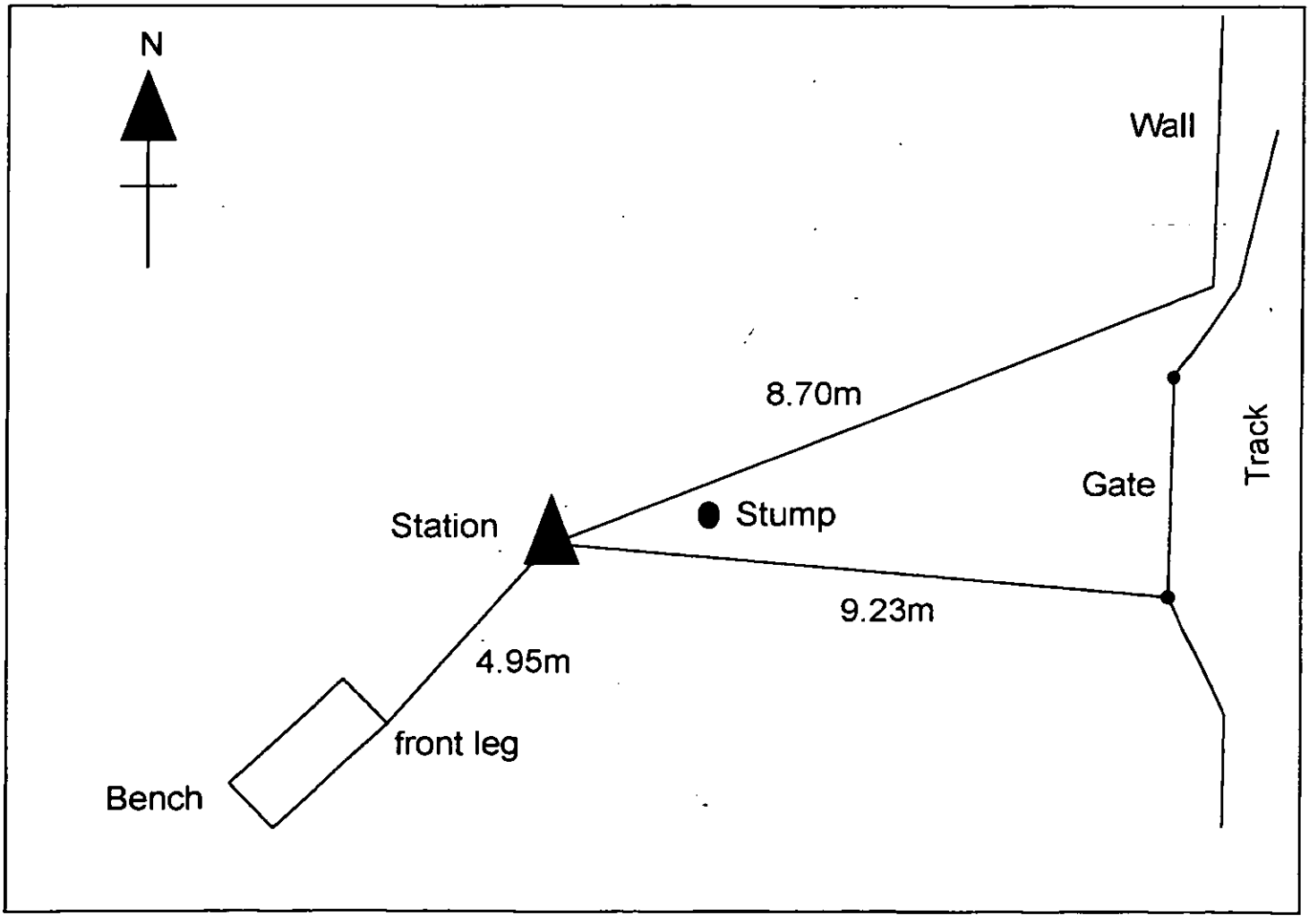
Chilworth Gunpowder Works Survey Station Information

Station no: 03	Surveyors: CT, WDC

Type of mark: Metal ground marker	Office of origin English Heritage Cambridge
Date of survey: December 2002	Neg. no. N/A

Station description:

The station is located to the west of the track, Lockner Farm Road, within the area owned by GBC. The station is fixed by a metal ground marker set flush with the ground.



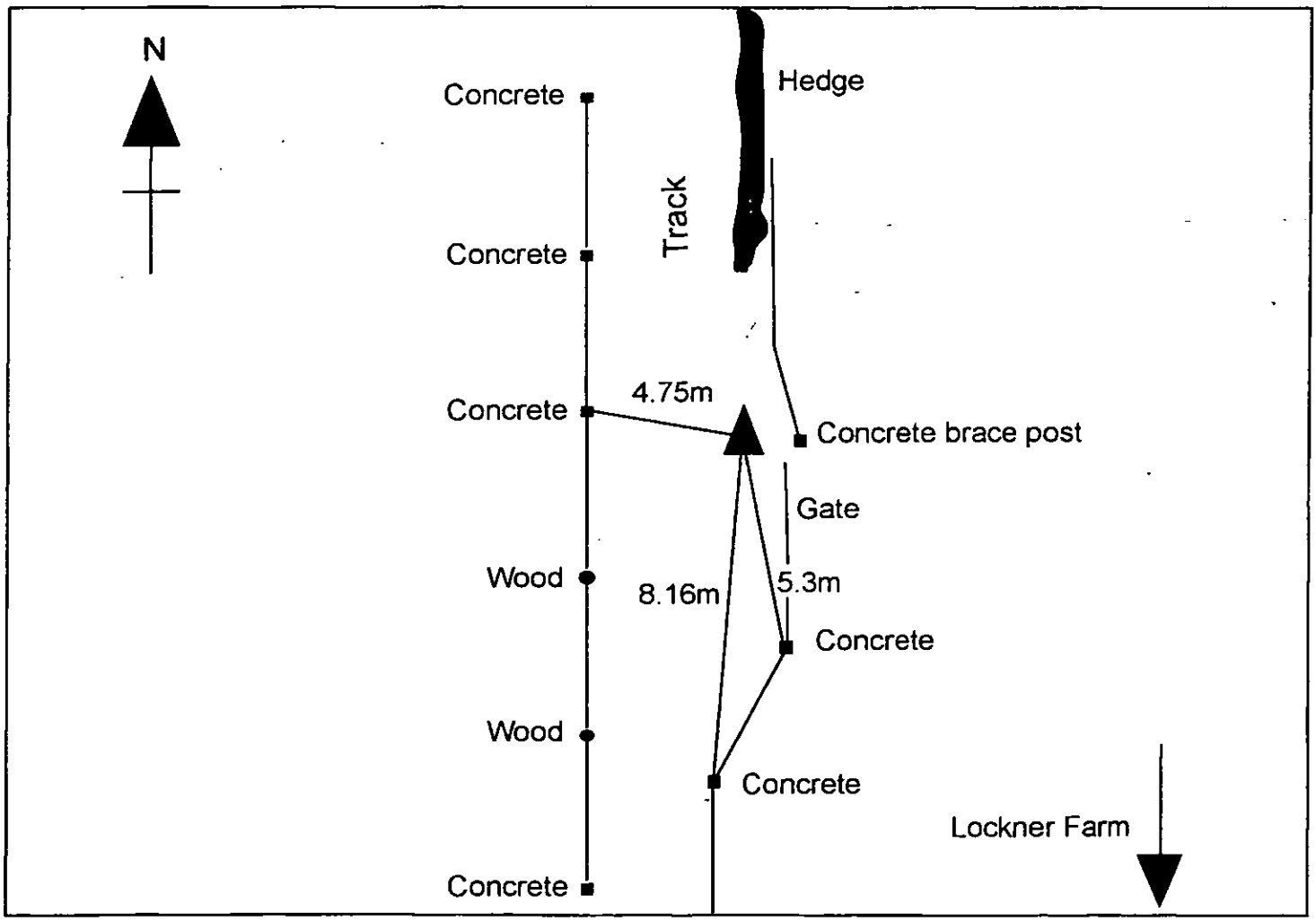
Co-ord scheme	Eastings	Northings	Height
OS National Grid	503225.286	147673.072	45.240

Chilworth Gunpowder Works Survey Station Information

Station no: 04	Surveyors: CT, WDC
Type of mark: Metal ground marker	Office of origin English Heritage Cambridge
Date of survey: December 2002	Neg. no. N/A

Station description:

The station is located to the east of the track, Lockner Farm Road, below Lockner F and adjacent to a farm gate. The station is fixed by a metal ground marker set flush with the ground.



Co-ord scheme	Eastings	Northings	Height
OS National Grid	503413.451	147605.221	51.506

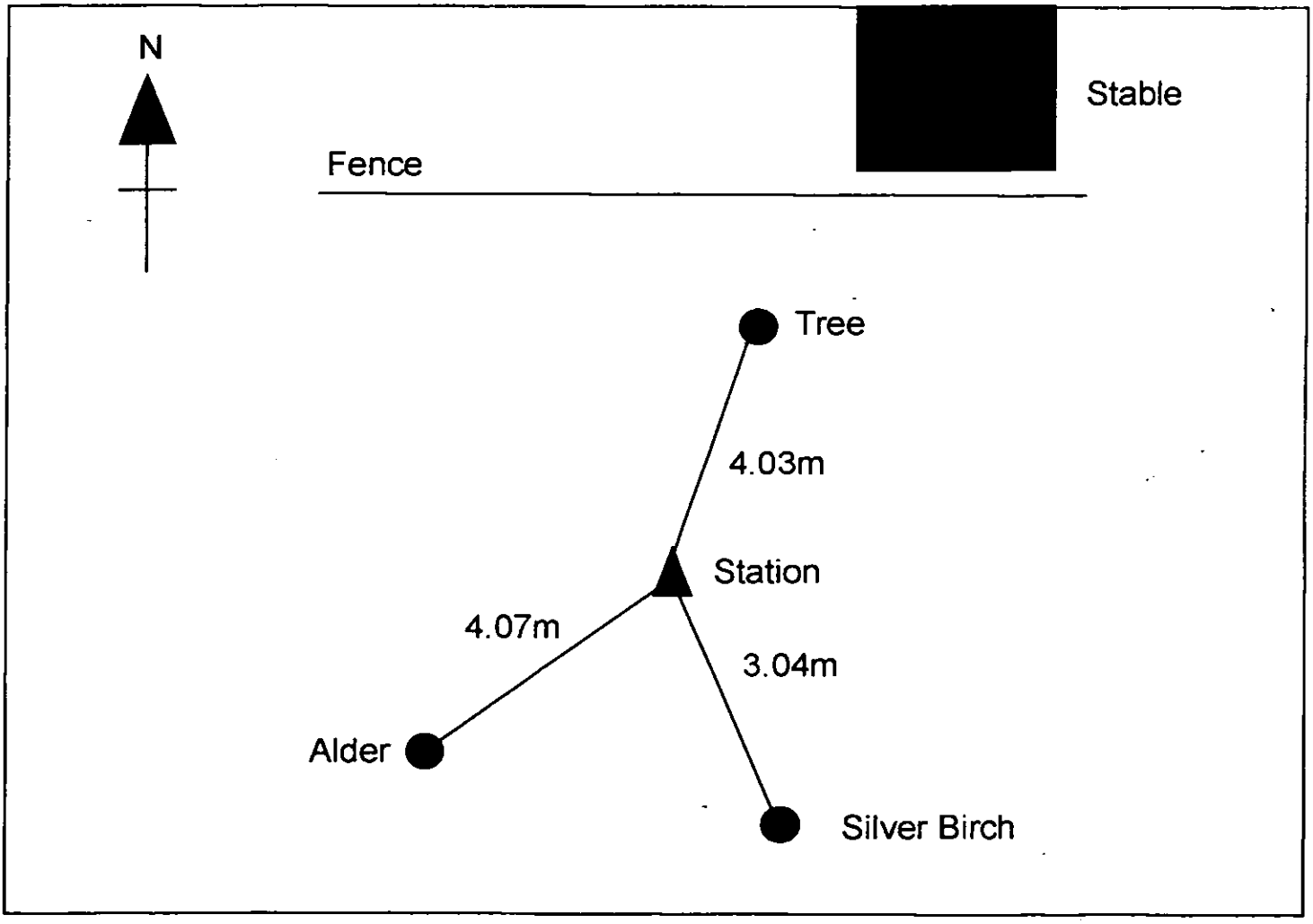
Chilworth Gunpowder Works Survey Station Information

Station no: 05	Surveyors: CT, WDC

Type of mark: Metal ground marker	Office of origin English Heritage Cambridge
Date of survey: December 2002	Neg. no. N/A

Station description:

The station is located on the northern side of the valley on level ground below a modern stable. The station is fixed by a metal ground marker set flush with the ground.



Co-ord scheme	Eastings	Northings	Height
OS National Grid	503099.262	147610.142	50.632

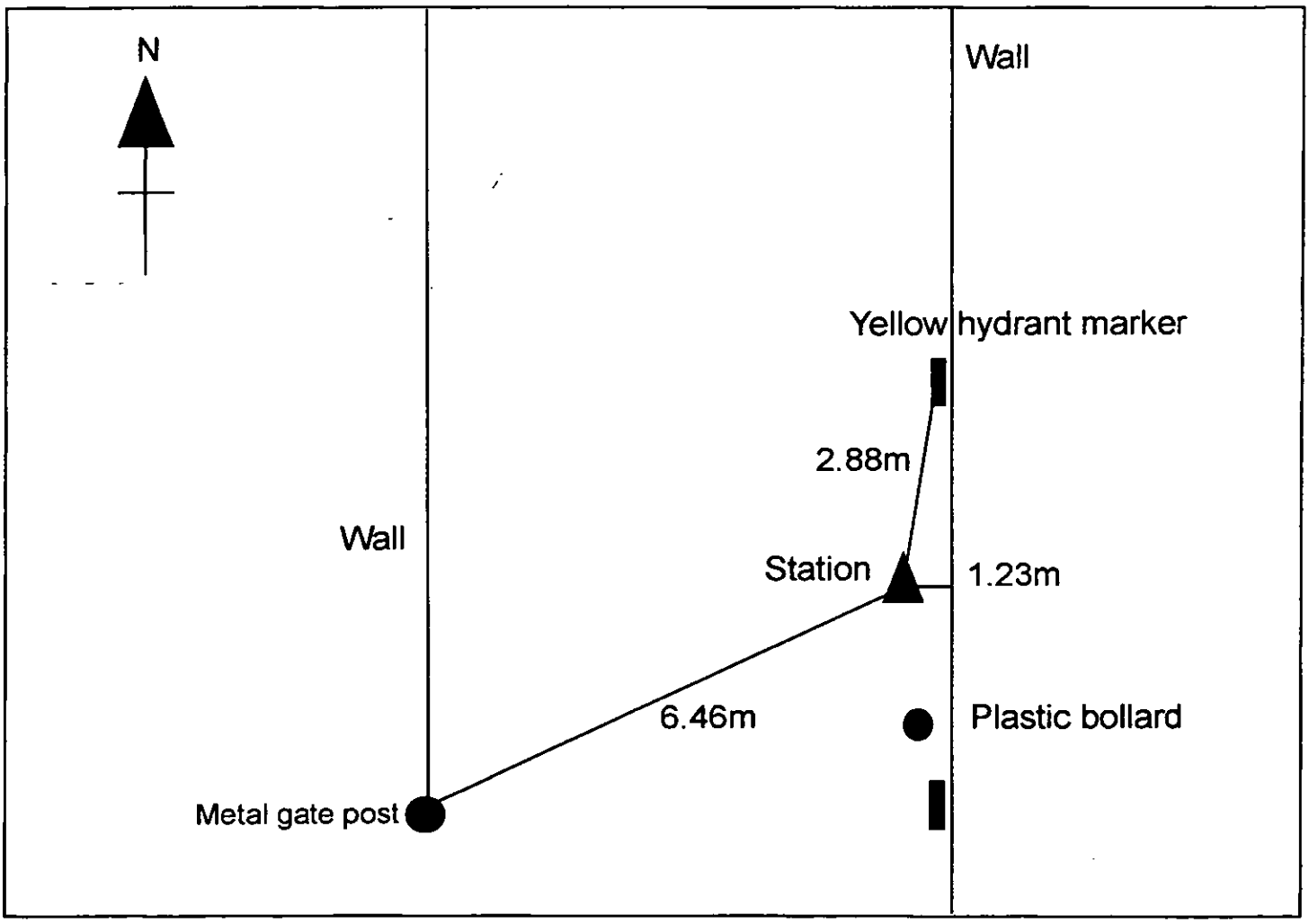
Chilworth Gunpowder Works Survey Station Information

Station no: 07	Surveyors: CT, WDC

Type of mark: Nail in road	Office of origin English Heritage Cambridge
Date of survey: December 2002	Neg. no. N/A

Station description:

The station is located on Blacksmith on the eastern side of the causeway, to the south of Waterworks Cottage. The station is marked by a survey nail in the road.



Co-ord scheme	Eastings	Northings	Height
OS National Grid	502467.802	147486.041	44.223

ENGLISH HERITAGE

Chilworth Gunpowder Works
Surrey

Sheet 1 | Sheet 2 | Sheet 3 | Sheet 4 | Sheet 5 | Sheet 6 | Sheet 7 | Sheet 8

Section 1 a
Halfpenny Lane
Chilworth Old Mill
Powdermills Cottage
Waterworks Cottage
West Lodge
b
The Tile House
Blacksmith Lane
Section 2 c
d
Chilworth School
Percy Arms
Section 3 e
f
Section 4 g
Section 5 i
h
Lidwell
Colyers Hanger
Lidwell Copse
Albury Mill
Postford Pond
Girraween

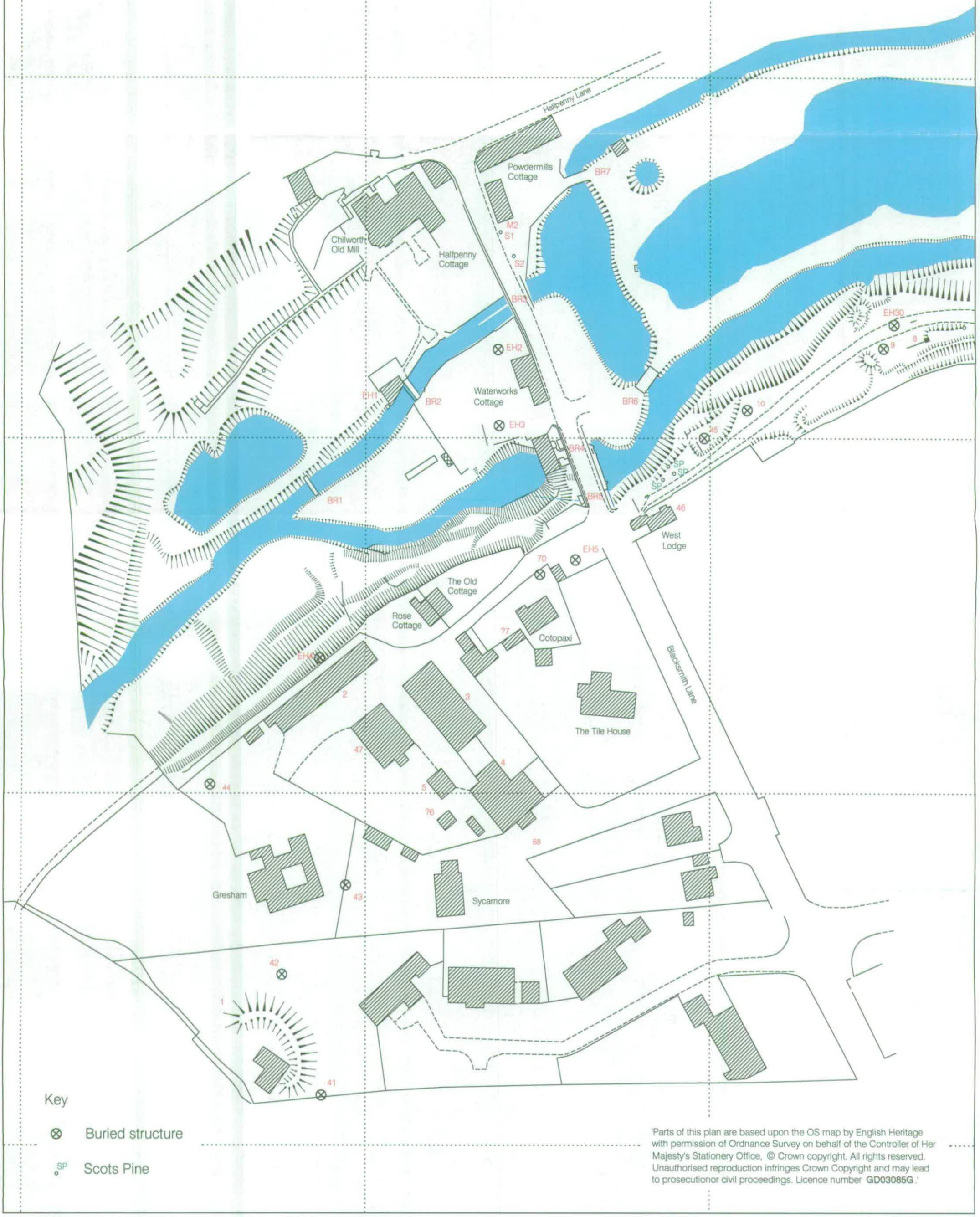
0 50 100 metres

English Heritage | Sheet 1

Chilworth Gunpowder Works

The Lower Works

Scale 1:1000



Key

⊗ Buried structure

SP Scots Pine

English Heritage	Sheet 2
Chilworth Gunpowder Works	
The Middle Works	
Scale 1:1000	

English Heritage Sheet 3

Chilworth Gunpowder Works

The Middle Works

Scale 1:1000

Key

⊗ Buried structure

Dump

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English Heritage	Sheet 4
Chilworth Gunpowder Works	
The Middle Works	
Scale 1:1000	

A8
A13
EH29
A6
A10
A7
A9
A2
A3
A4
Lockner Farm Road
Lockner Farm
A248

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Key

⊗ Buried structure

English Heritage	Sheet 5
Chilworth Gunpowder Works	
The Admiralty Cordite Factory	
Scale 1:1000	

English Heritage	Sheet 6
Chilworth Gunpowder Works	
The Smokeless Powder Factory	
Scale 1:1000	

Key

- Wellingtonia
- Dump

Key

⊗ Buried structure

W Wellingtonia

Dump

English Heritage	Sheet 7
Chilworth Gunpowder Works	
The Smokeless Powder Factory	
Scale 1:1000	

Lidwell

Colyers Hanger

Lidwell Copse

Tilling Bourne

New Cut

7/82

6/81

BR34

EH22

5/80

4/79

BR33

78

BR35

M8

25

27

26

A23

29

28

24

EH21

BR30

BR31

EH20

EH18

BR32

30(73)

EH19

A17

A18

A12

A11

English Heritage	Sheet 8
Chilworth Gunpowder Works	
The Admiralty Cordite Factory	
Scale 1:1000	

A22

A24

21

A19

A20

M9

Spedition House

Albury Mill

Postford Pond

Girraween

Not surveyed

Key

⊗ Buried structure

ENGLISH HERITAGE

NATIONAL MONUMENTS RECORD

The National Monuments Record is the public archive of English Heritage. It contains all the information in this report - and more: original photographs, plans old and new, the results of all field surveys, indexes of archaeological sites and historical buildings, and complete coverage of England in air photography.

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